Komponenty karbonátových hornin

SKELETÁLNÍ ALOCHEMY

Bioklasty

- Původně termín pro fosilii, která byla transportována, fragmentována a abradována
  - součást organického detritu
- Dnes v karbonátové petrologii používán vágněji pro všechny fosilie ve výbrusech
  - fragmentární
  - kompletní (biomorfy)
- Bioklast = skeletální alochem

Potenciál pro zachování bioklastů

- Záznam karbonátových bioklastů ve vápencích je řízen

(1) Primární mineralogií skeletu

(2) Tafonomickými a diagenetickými procesy

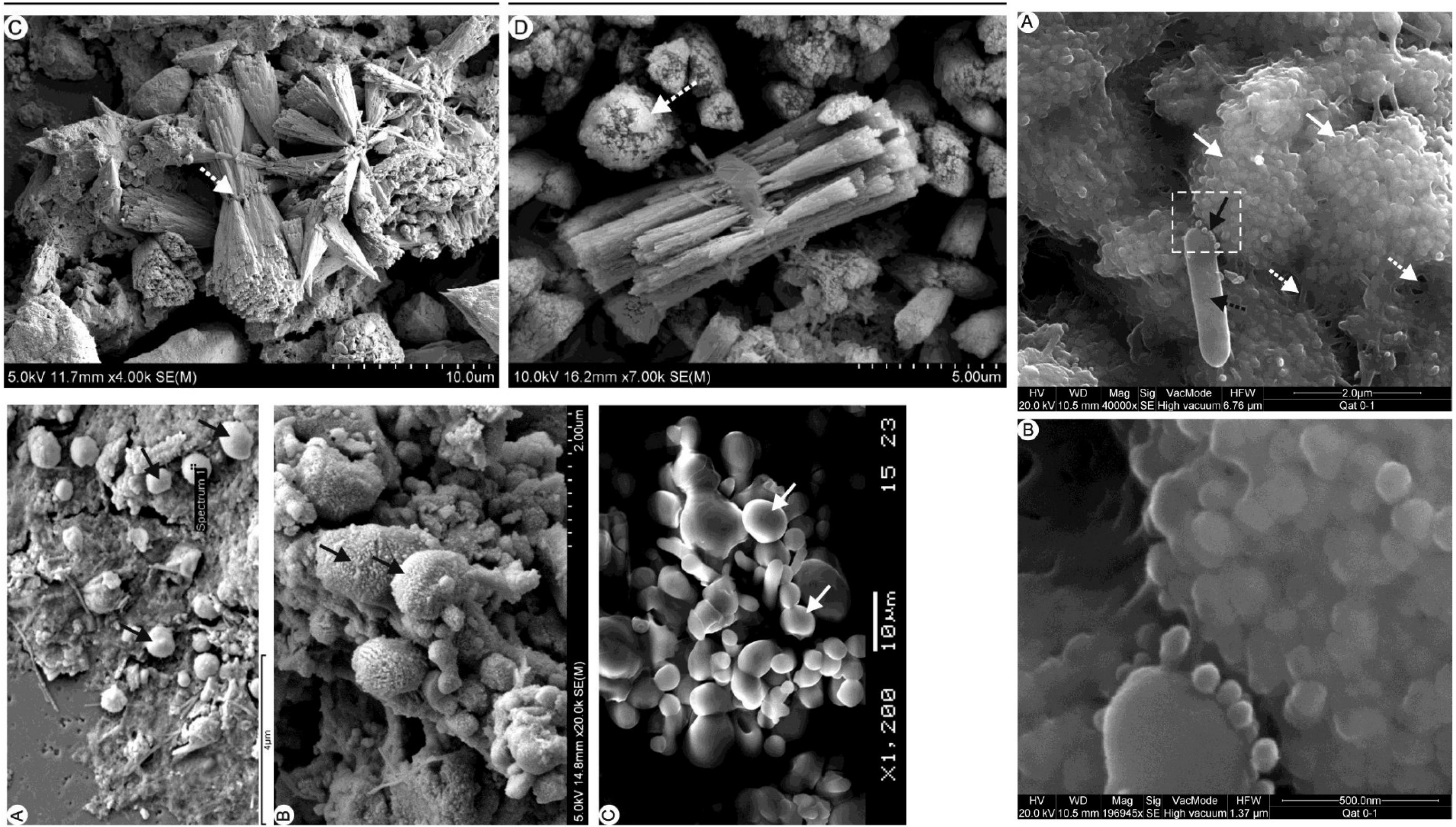
Význam bioklastů

- Nepostradatelné pro určení stáří sedimentů
- Indikativní pro depoziční prostředí
- Významné ukazatele paleoenvironmentálních a klimatických podmínek
- Protože je původní mineralogie většiny karbonátových fosilií známa nebo může být relativně snadno odvozena, může být jejich míra a styl diagenetických přeměn využit pro rekonstrukci diagenetického vývoje sedimentu

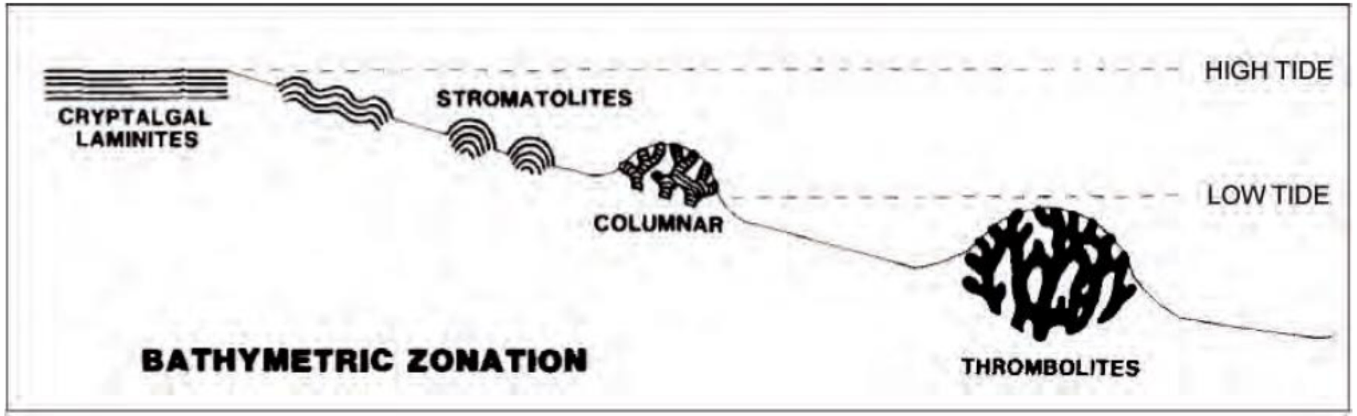
Organizmy produkující karbonát v horninotvorném množství

Viry

- Všudypřítomné
- Přibývá dokladů o jejich biomineralizaci, resp. jejich funkci coby jádra drobných karbonátových krystalů

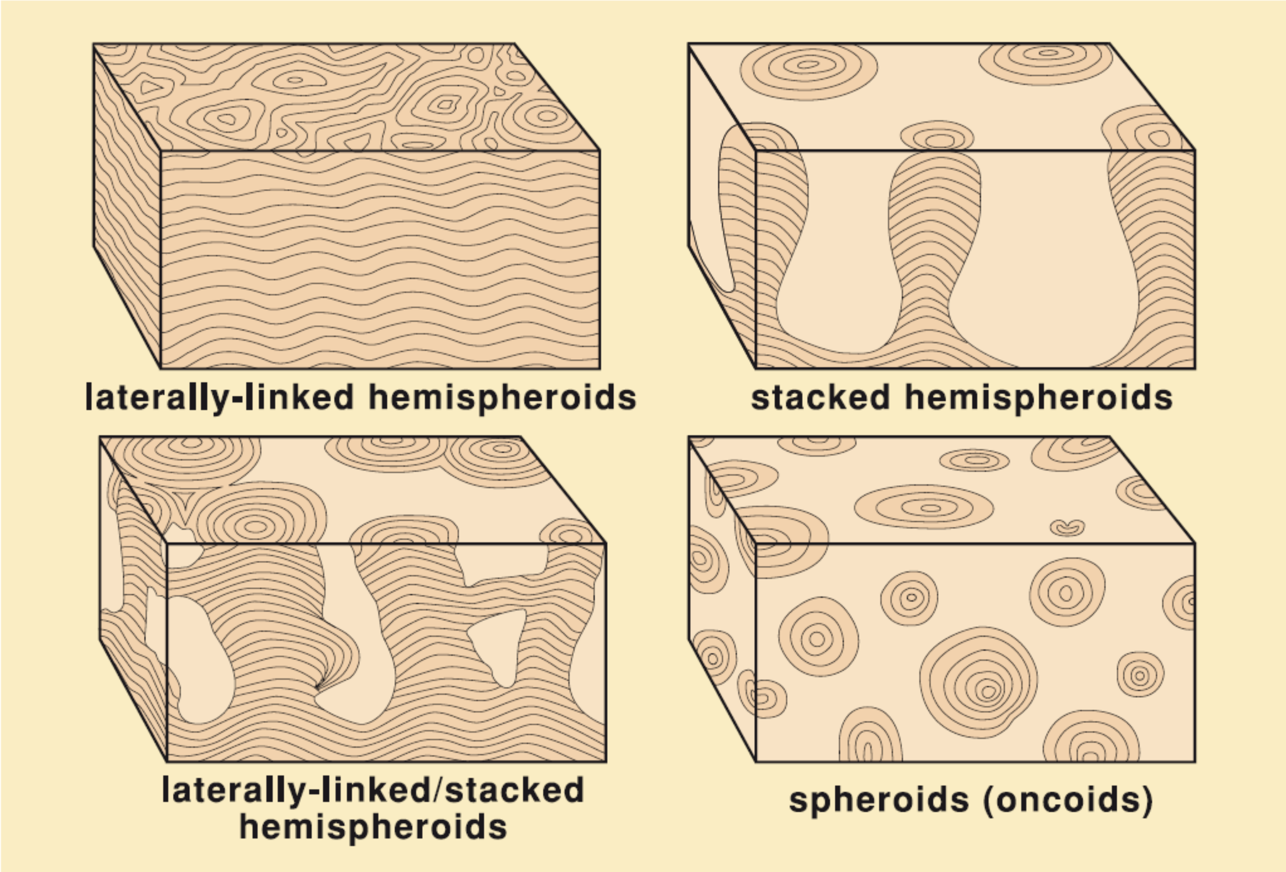


Bakterie



Obr. 8. Schema batymetrické zonality mikrobialitů ilustrující přednostní výskyt stromatolitů v intertidálních a subtidálních prostředích zatímco thrombolity se preferenčně vyskytují v subtidálním prostředí. Růstová morfologie mikrobialitů je kontrolováná dostupným akomodačním prostorem. Mění se od planárních krust přes malé dómovité struktury přes sloiupcovité formy k dómovitým kupám. Podle Pratta a Jamese (1982) a Hoffmana (2010).

Bakterie - stromatolity



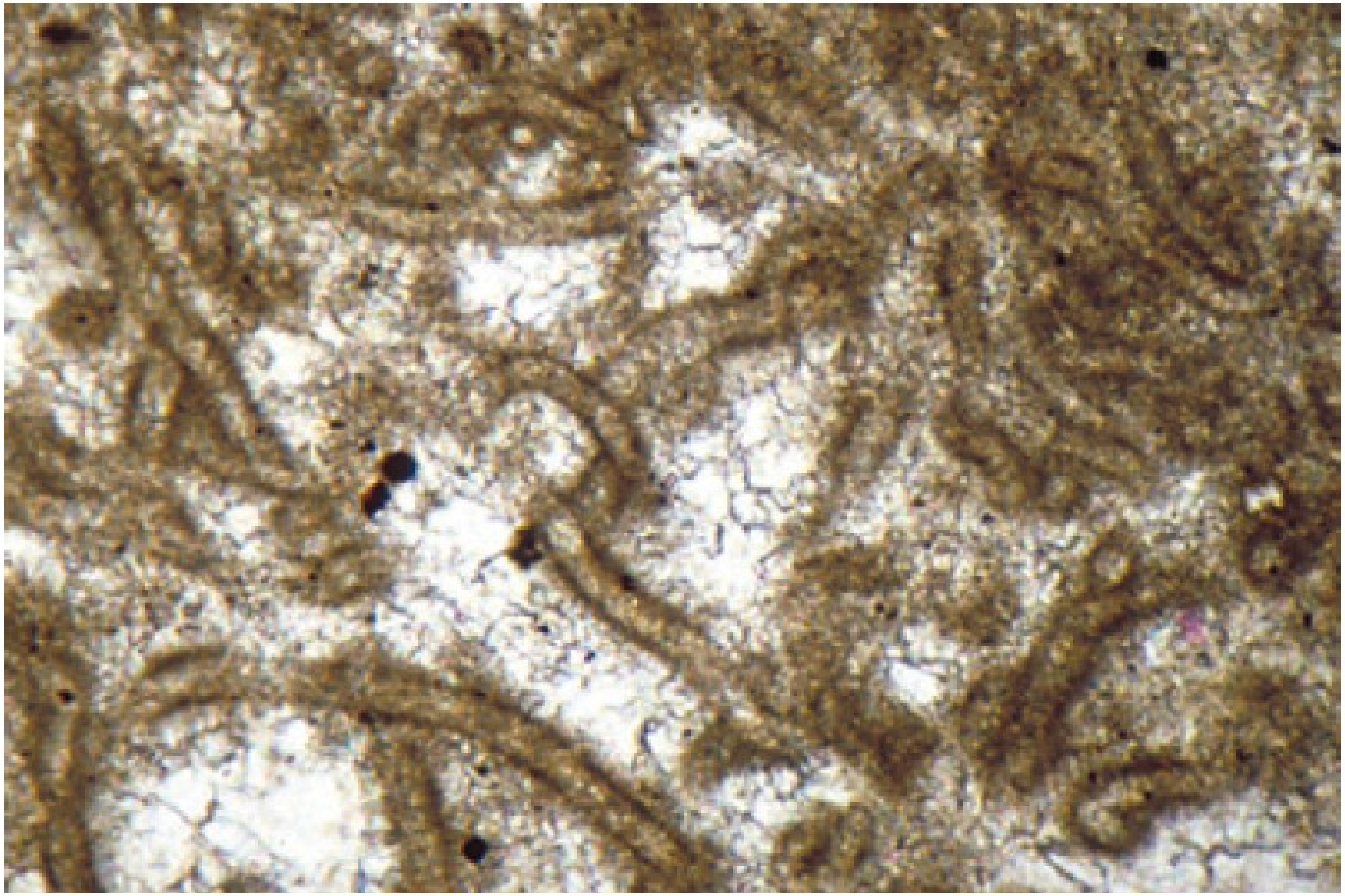
		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates	Silica
Cyanobacteria		o	●	o			
Pyrrhophyta:	Calciodinoflagellata		●				
Chrysophyta:	Diatoms						●

Up. Devonian (top Frasnian) Simla-Blue Ridge Fm., Alberta, Canada

A close-up view of a *Girvanella* oncoid displaying well developed tubular structure. Note the interfingering of individual filaments and the selective precipitation of dense, micritic carbonate around the filament sheaths. It is necessary to view thin sections at maximum magnifications in order to see such filamentous structures and demonstrate a probable microbial origin for particular pisoids.

Girvanella

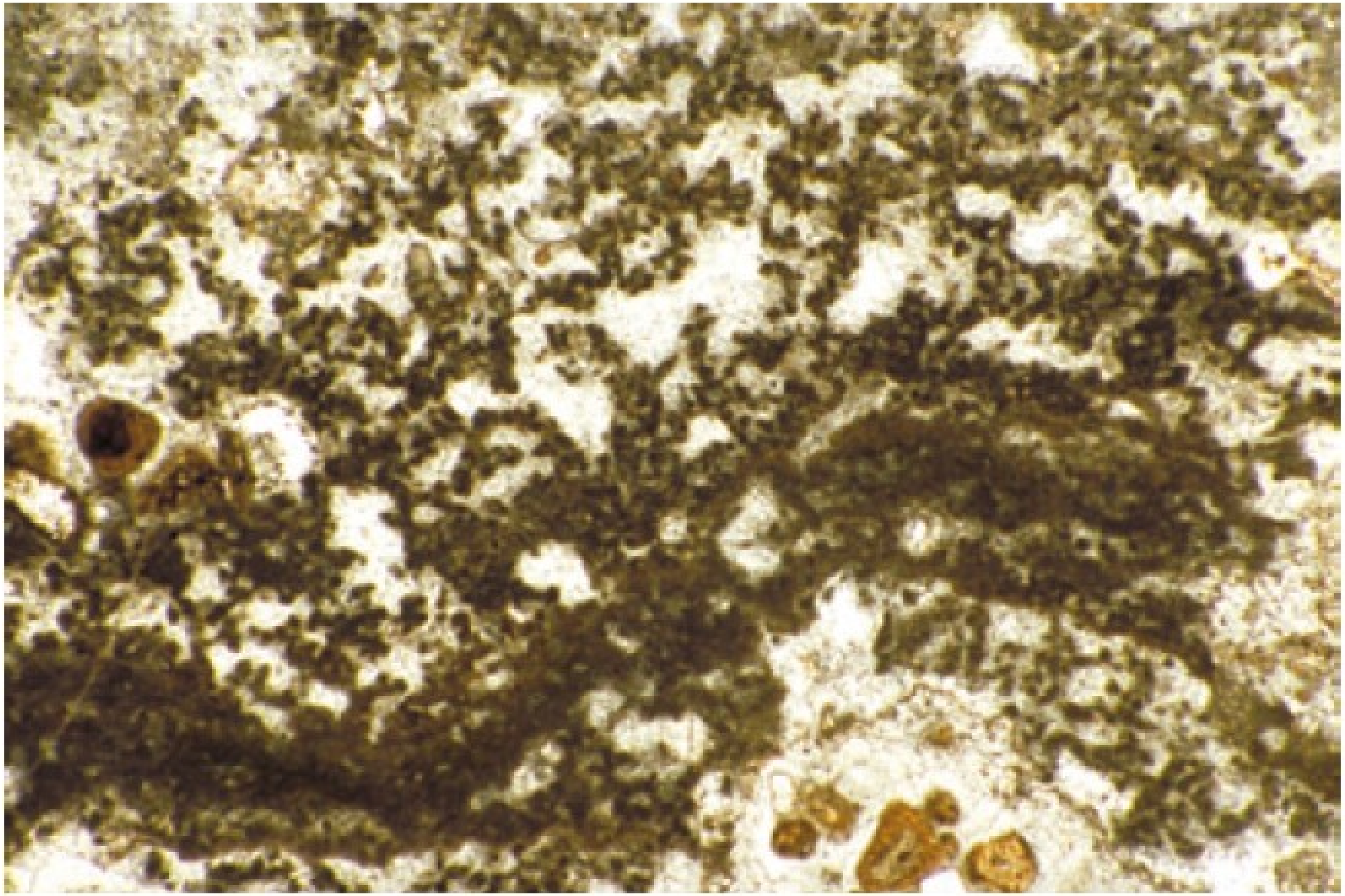
PPL, HA = 0.55 mm

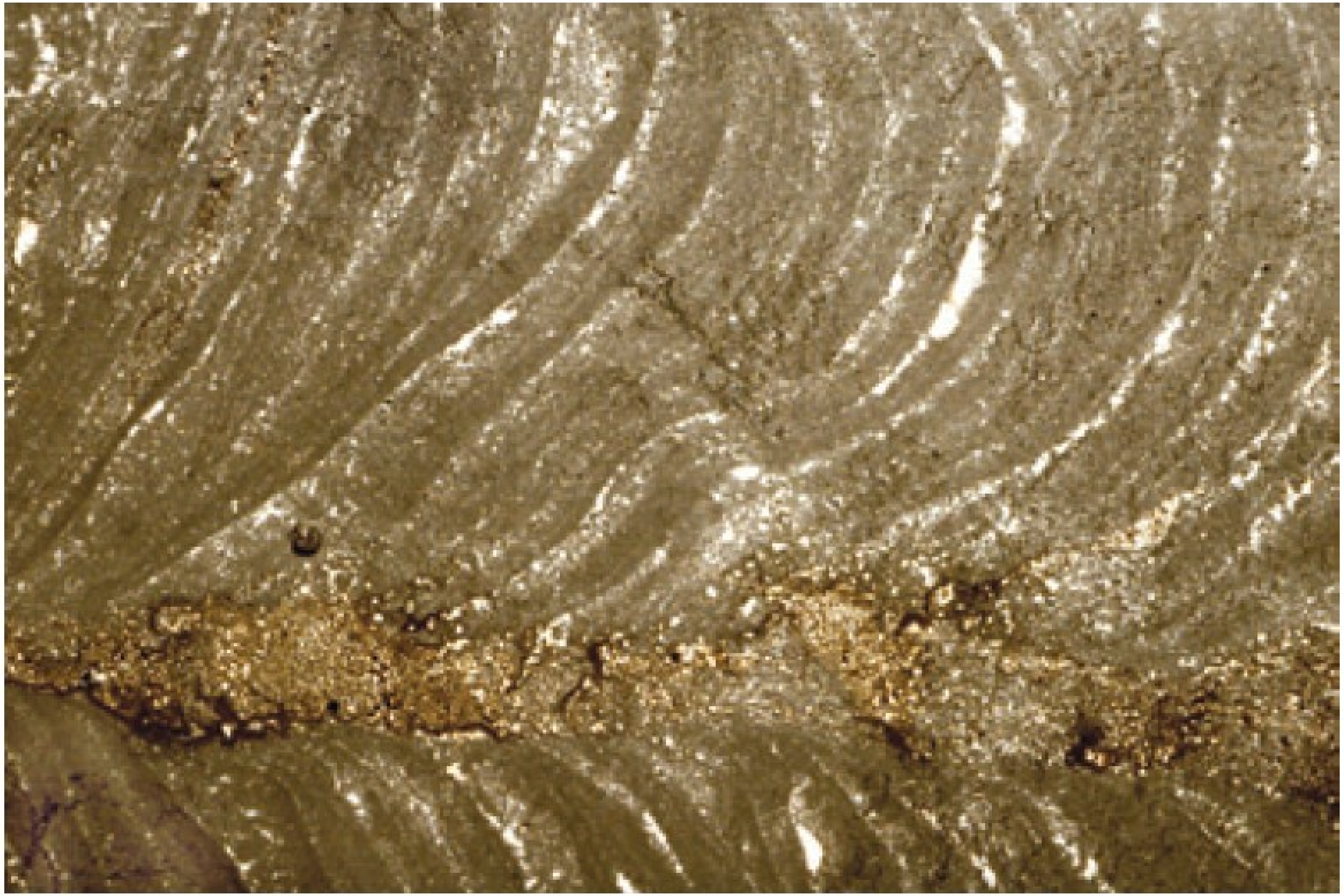


Recent sediment Deep Lake, Yorke Peninsula, South Australia

A stromatolite from a hypersaline lake (a coastal salina). Note microbial peloids and encrusted filaments forming small, incipient branching structures. Peloidal "shrubs" normally are not so well preserved, but more typically disaggregate, contributing to the peloid content of such mat deposits.

PPL, HA = 3.5 mm





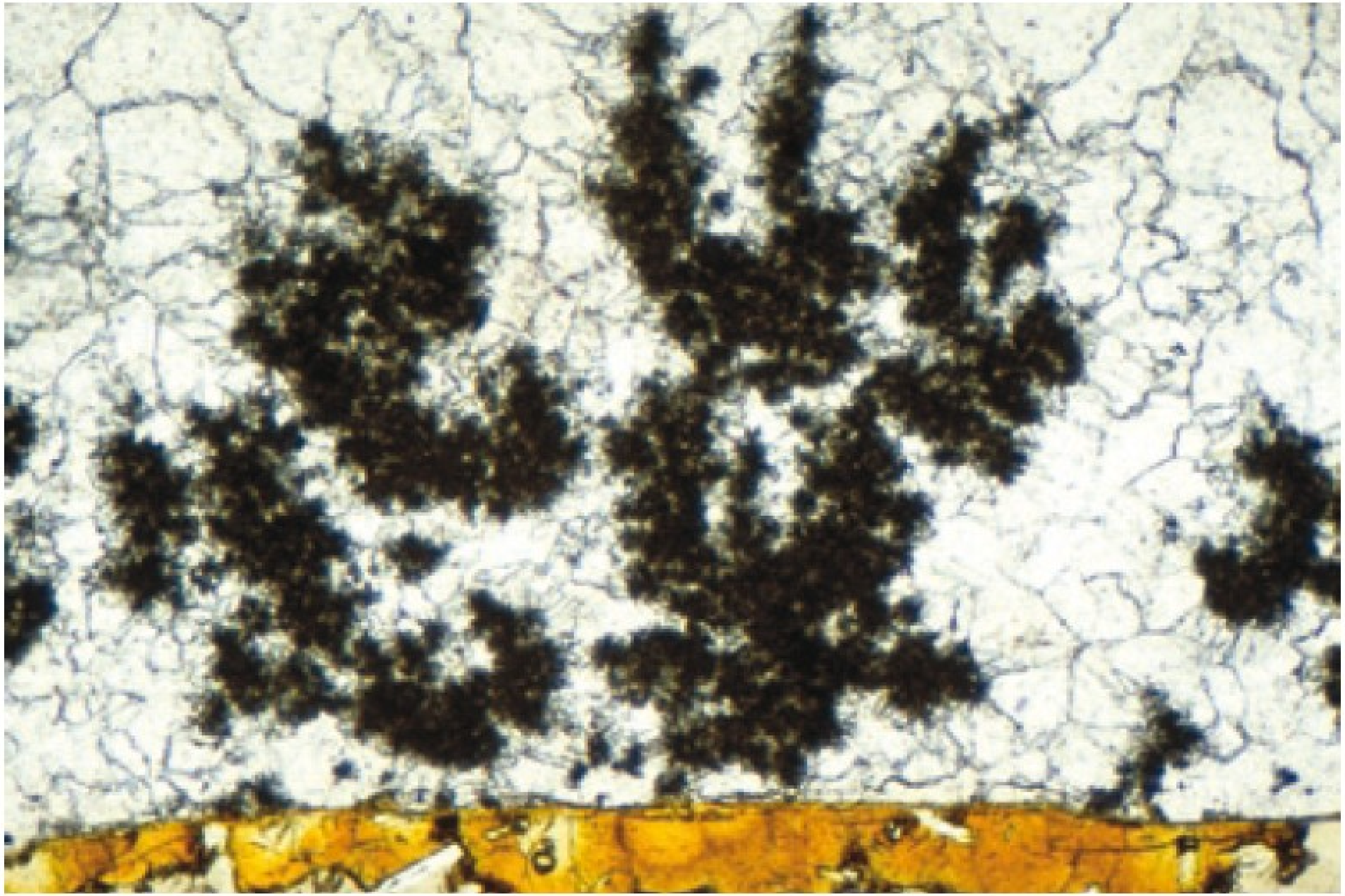
Precambrian, northern Wisconsin

A columnar, stromatolitic boundstone or biolithite (original up direction toward the right). Digitate or columnar stromatolites are typically of subtidal origin, unlike the nearly planar mats of previous images that form primarily in intertidal settings. The lamination in both types of mats, however, results mainly from alternating episodes of microbial growth and entrapment of transported sediment. Sample from Robert Laury.

PPL, HA = 16 mm

Oligocene Deborah Volcanic Fm., Oamaru, Otago, New Zealand

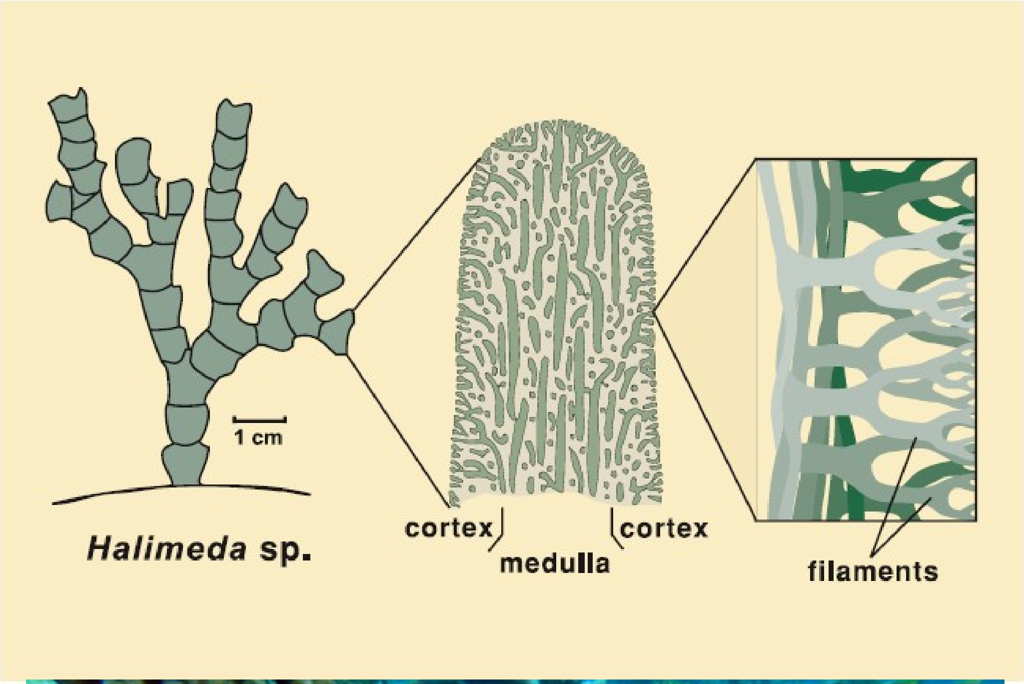
These are peloidal, calcitic, probably microbial branching growths that formed in association with basaltic pillow lavas. The microbes grew atop glassy, zeolitic, pillow rinds (the yellow material at the bottom of the photograph) and extended into open inter-pillow cavities. These shrub-like growths were later encased in sparry calcite cement, but where uncemented they commonly fall apart, generating large volumes of small micritic peloids.



PPL, HA = 2.4 mm

Zelené řasy

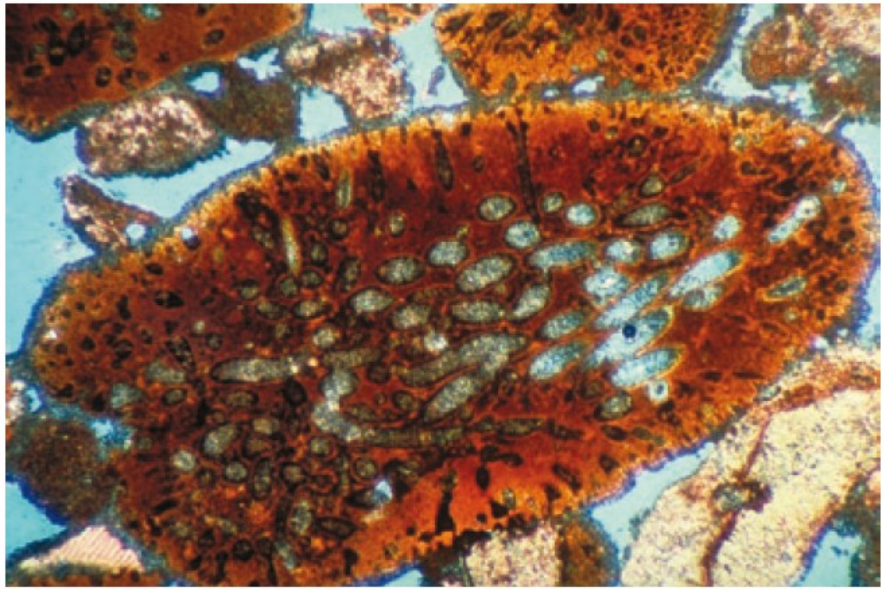
- Halimeda – významný recentní producent karbonátu (aragonitu)

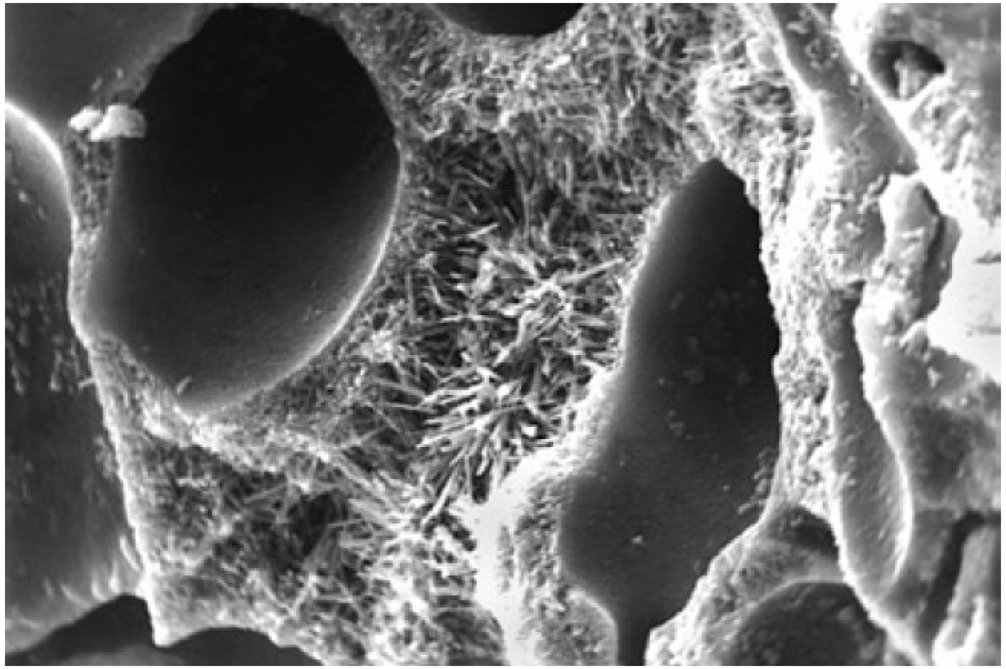


Holocene sediment (beachrock), Grand Cayman, Cayman Islands, B.W.I.

A complete single plate shed by *Halimeda* sp., a green alga (left side in picture above). Note the characteristic yellowish to reddish-colored material that is filled with minute aragonite needles and a series of tubules (utricles) — large ones in the center of the grain (mainly oriented parallel to the long axis of the grain) and smaller ones near the edges (oriented largely perpendicular to the grain margins). The tubules have been partially filled with syndepositional marine cement.

PPL, BSE, HA = 2.4 mm

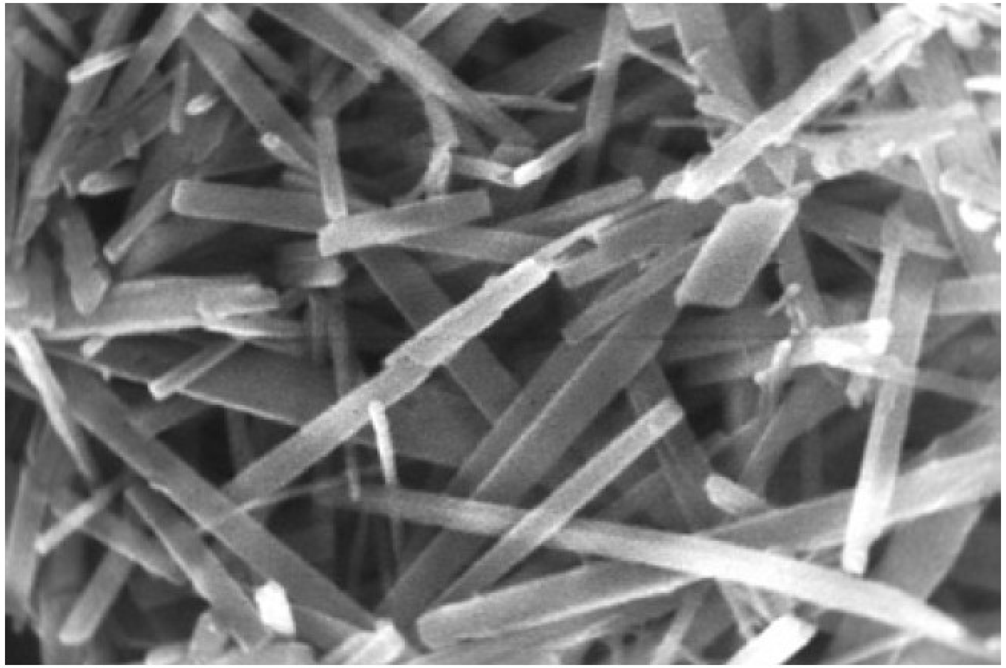




Recent sediment, Belize

An SEM image showing a cross section through a broken *Halimeda* sp. plate. Note the tubular passageways (utricles), originally occupied by plant tissues and intervening calcified areas (equivalent to the brownish-colored areas in previous photographs). The calcified areas consist of abundant, interlocked, predominantly randomly-oriented aragonite needles that constitute the preservable portion of the *Halimeda* plate.

SEM, HA = 113 µm



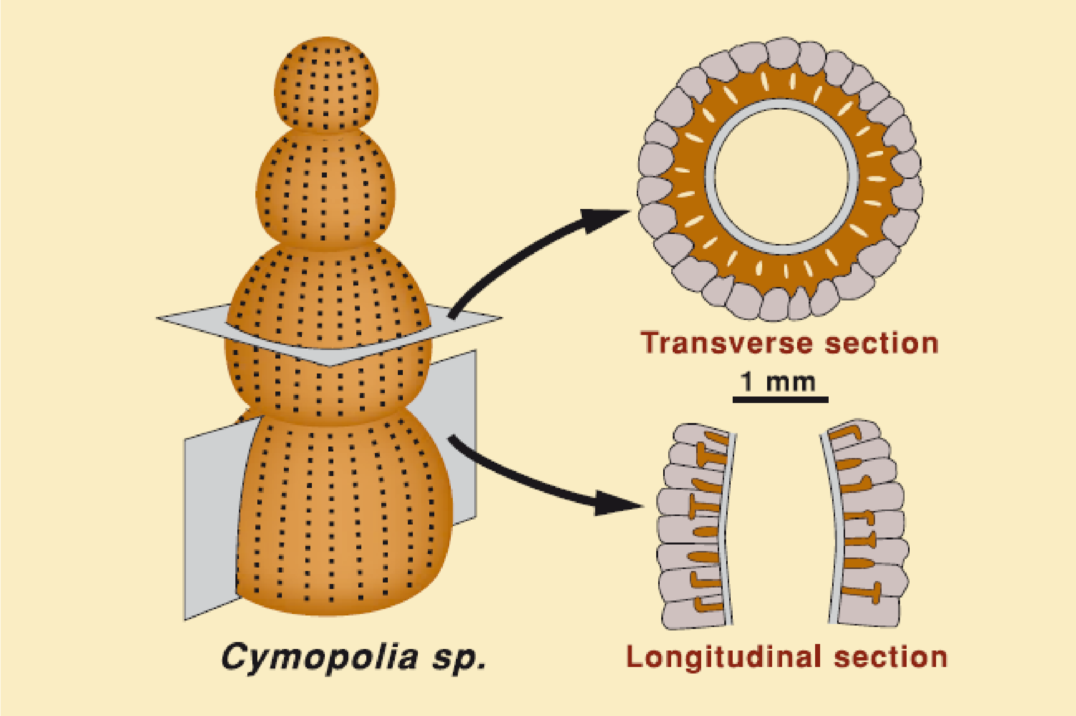
Recent sediment, Belize

A higher magnification SEM image of a *Halimeda* sp. plate showing details of the interlocking aragonite needles seen in the previous photograph. Needles such as these are found in many species of green algae including *Penicillus*, *Udotea*, *Halimeda* and others. When the algae decompose, the needles may be scattered and add significantly to the local production of clay-sized particles (carbonate mud). The porous structure, the unstable mineralogy and the small crystal size make it likely that *Halimeda* plates will be substantially altered during diagenesis.

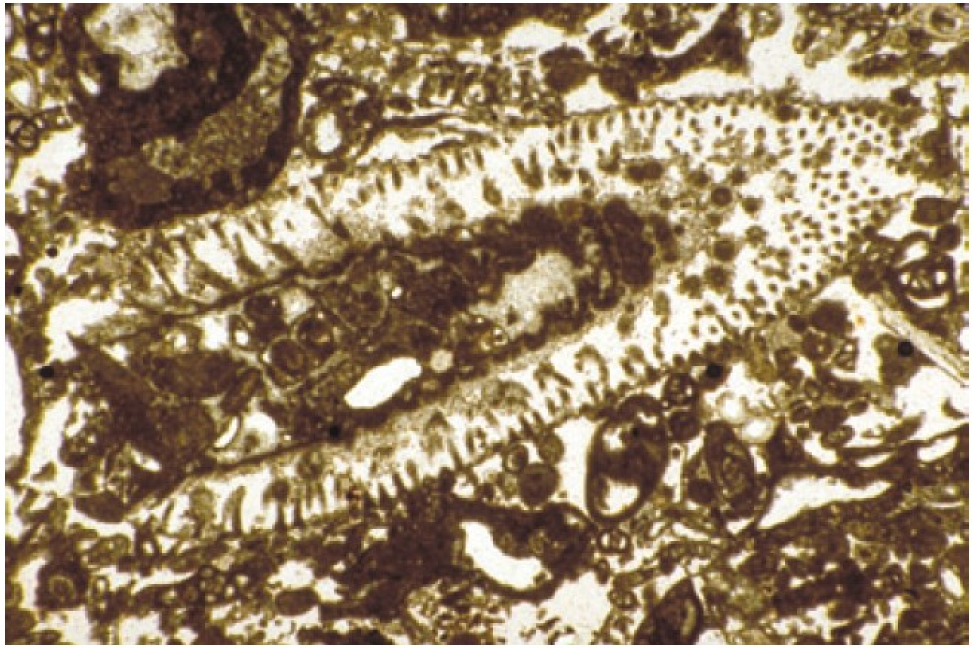
SEM, HA = 11.3 µm

Zelené řasy

- Dasykladátní řasy



		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite
Cyanobacteria		o	●	o	
Pyrrhophyta:	Calciodinoflagellata		●		
Chrysophyta:	Diatoms				
	Coccolithophorida		●		
Chlorophyta:	Dasycladaceae	●			
	Udoteaceae	●			
	Gymnocodiaceae	●			
	Charophyceae		●	●	
Rhodophyta:	Solenoporaceae	●			

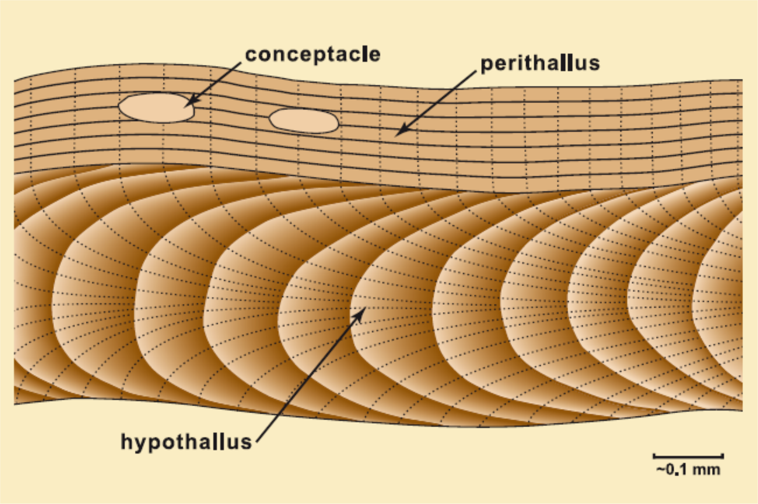


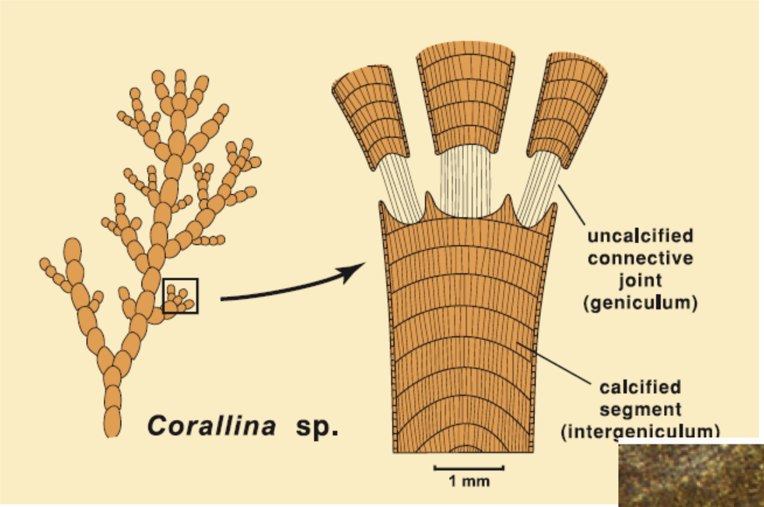
Oligocene Suwanee Ls., Citrus Co., Florida

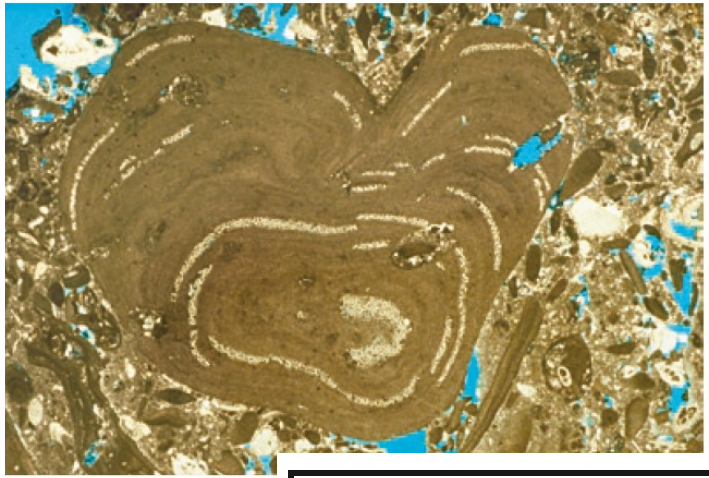
A probable dasycladacean green algal grain. Note the infilling of original pores and outlining of the grain with micritic sediment or precipitates that allows recognition of the grain. In the absence of such "pore casting" of the structure prior to dissolution, the origin of this grain would probably not be discernable.

PPL, HA = 5 mm

Červené řasy





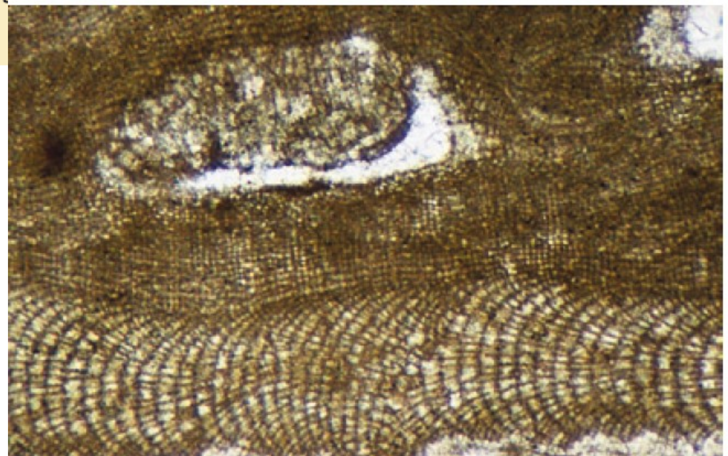


Oligocene Lower Coralline Limestone Fm., Malta

An irregularly-shaped crustose coralline red algal nodule (termed a rhodoid) showing characteristic fine-scale cellular structure with distinct, lighter-colored rows of small, spore-bearing reproductive bodies (sporangia).

- Koralinní řasy

		Aragonite	Low-Mg Calcite	High-Mg Calcite	A
Rhodophyta:	Solenoporaceae	●			
	Squamariaceae	●			
	Corallinaceae			●	



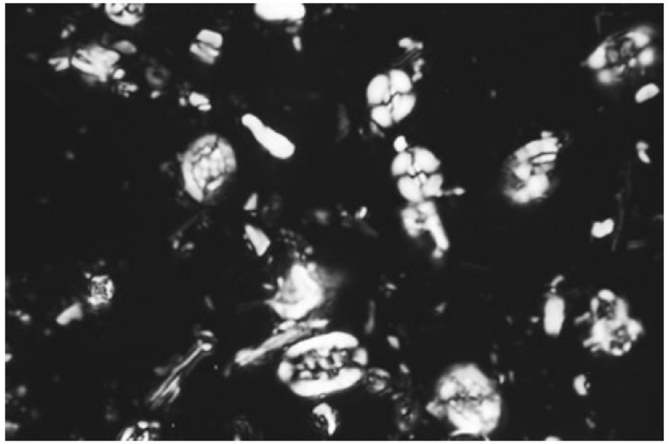
Pliocene-Pleistocene limestone, Boca Grandi, Aruba

A crustose coralline red algal grain showing differentiation of cellular structure — the hypothallus in the lower part of the photograph and the perithallus with a reproductive organ (termed a conceptacle) in the upper part. The regular, and extremely small-scale boxwork structure of both layers is the most diagnostic feature for recognition of red algae.

Pelagické organizmy

Kokolitky

- Řasy ze skupiny Haptophyta – jedni z nejvýznamnějších producentů karbonátů (**kalcitu**) v pelagickém prostředí od křídy



Up. Cretaceous (up. Maastrichtian) chalk, ODP Leg 171B, Hole 1052E, Blake Nose, Atlantic Ocean

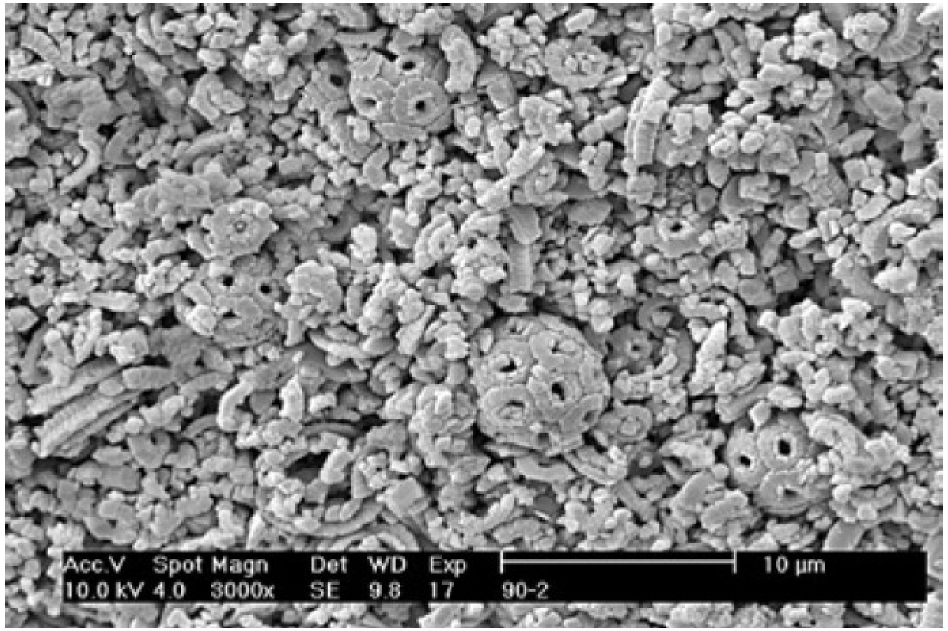
A high-magnification view of a smear mount. Note the distinctive oval outlines and pseudo-uniaxial crosses formed by the radial arrangements of calcite crystals in these minute coccoliths. A number of different coccolith types are clearly distinguishable. Photograph courtesy of Jean M. Self-Trail.

XPL, HA = 50 µm

Lo. Paleocene (Danian) Ekofisk Fm. chalk, Danish North Sea

An SEM image of a deep shelf chalk that shows an unusual mix of whole coccospheres of *Prinsius* sp., intact coccoliths, and fully disaggregated coccolith crystal elements. The extensive porosity (~45%) is common in clay-poor coccolith chalks that have not been deeply buried and is, at least partly, due to the diagenetically stable nature of primary sediment composed of virtually pure calcite with little or no aragonite admixture. This is an excellent example of the sediment-forming capabilities of coccolithophores. Sample courtesy of Maersk Olie og Gas A.S.

SEM, HA = 38 µm



16 µm

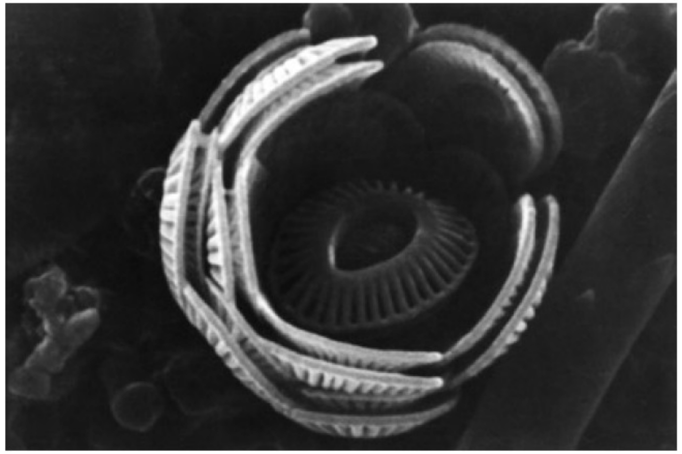
Recent sediment, North Atlantic Ocean, 54°N

An SEM image of the calcareous heterococcolith, *Coccolithus pelagicus*. Note the more robust construction and lesser number of coccoliths on this coccosphere as compared with the previous example. Photograph courtesy of Jeremy R. Young.

SEM, HA = ~19 µm

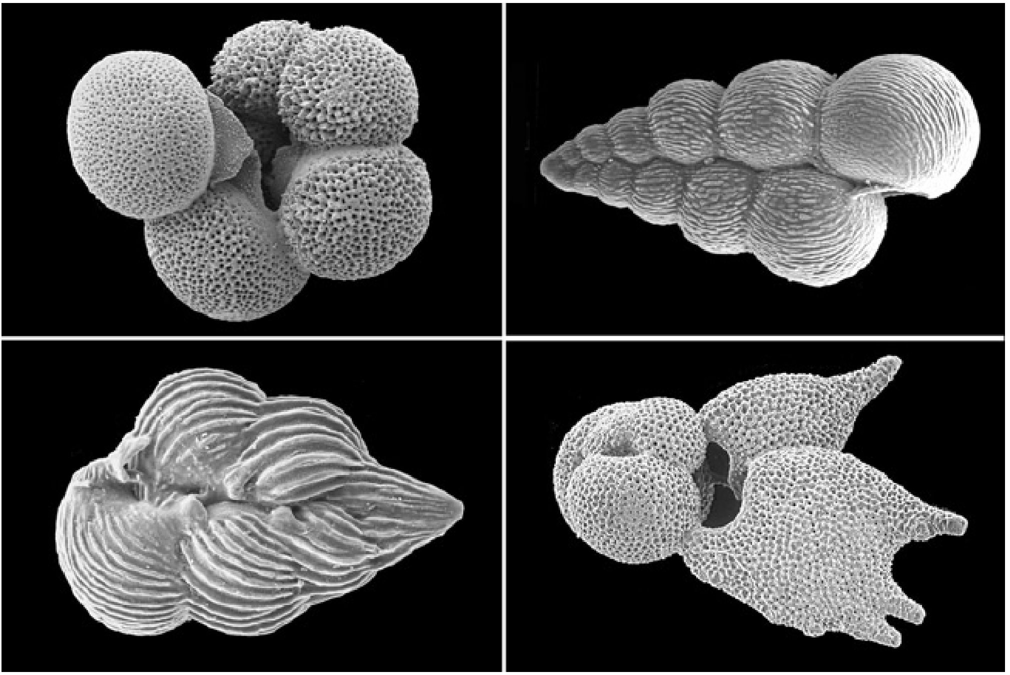
Recent sediment, southern Belize lagoon, Belize

An SEM image of a broken coccosphere of *Emiliania huxleyi* with several missing coccoliths. This view clearly shows the interlocking of adjacent coccoliths to form a complete coccosphere.



Foraminifery

- **Planktonické od jury**

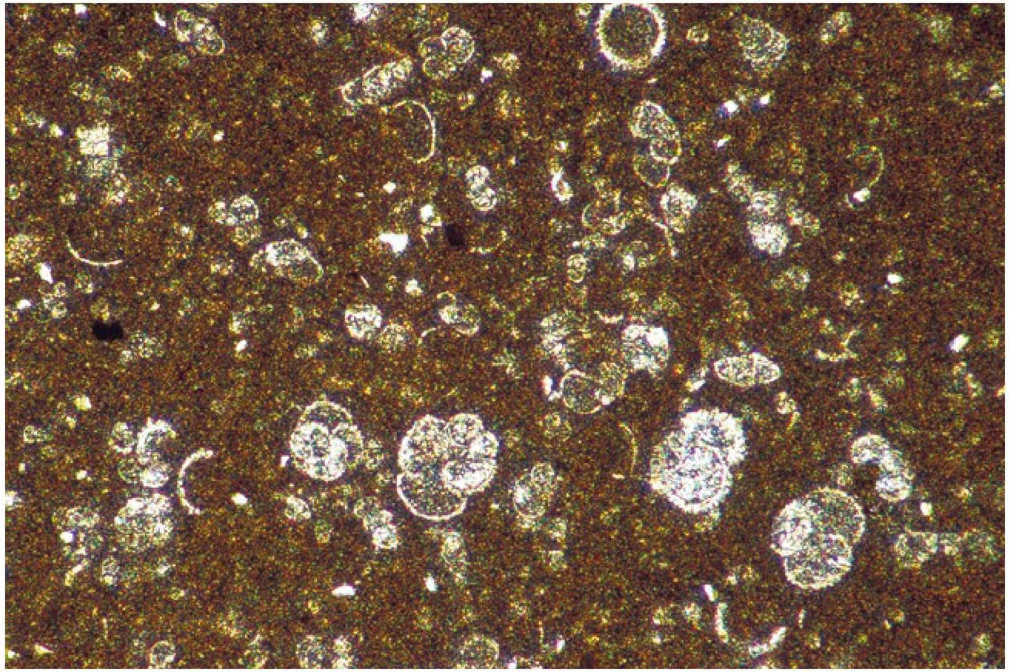


SEM views of calcareous planktic foraminifers

UL: Up. Paleocene, North Atlantic. *Parasubbotina variospira*. HA = ~170 µm
UR: Up. Cretaceous (Maastrichtian), Alabama. *Heterohelix crinata*. HA = ~400 µm
LL: Up. Cretaceous (Maastrichtian), North Atlantic. *Pseudoguembelina excolata*. HA = ~325 µm
LR: Up. Pliocene, Eastern equatorial Pacific. *Globigerinoides sacculifer*. HA = ~1000 µm

All photographs courtesy of Richard Norris.

	Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates	Sil
Foraminifera	o	●	●			



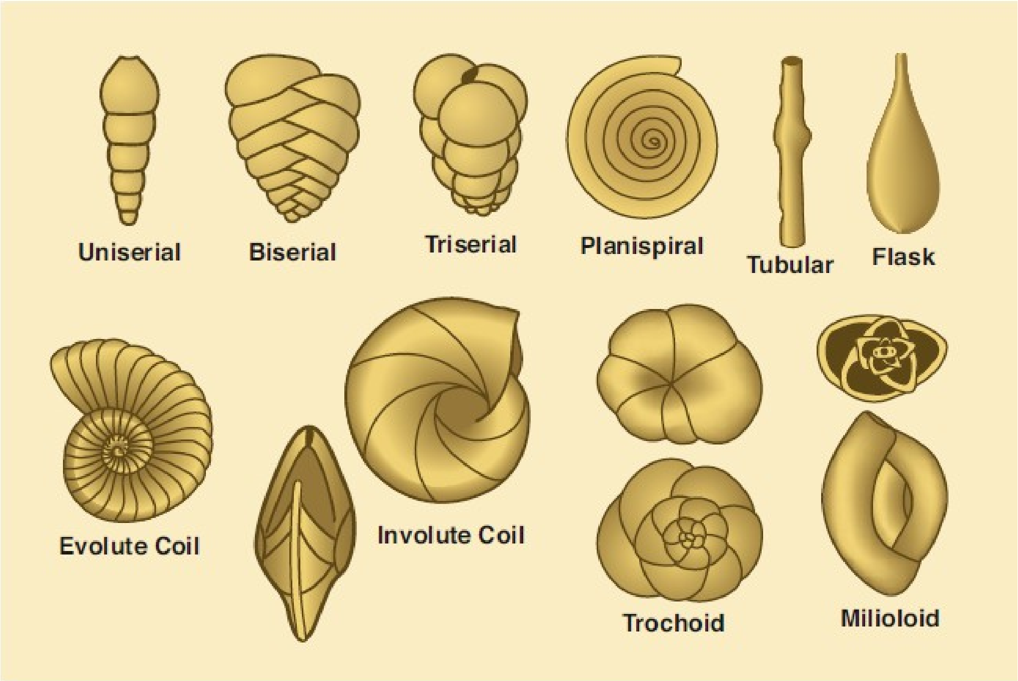
Lo. Tertiary Amuri Ls., Marlborough, New Zealand

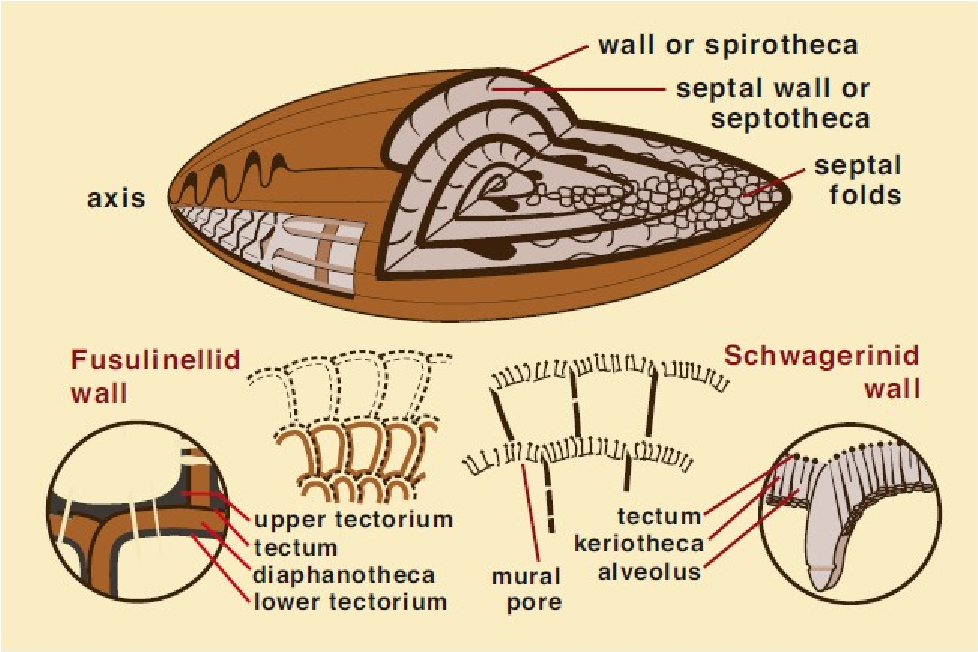
A low-magnification view of a typical planktic foraminiferal (globigerinid) biomicrite. Such deposits are distinguished from calcisphere limestones by the fact that most of the grains show multiple chambers (and even the grains showing a single chamber probably represent tangential cuts through one chamber of a multi-chambered organism).

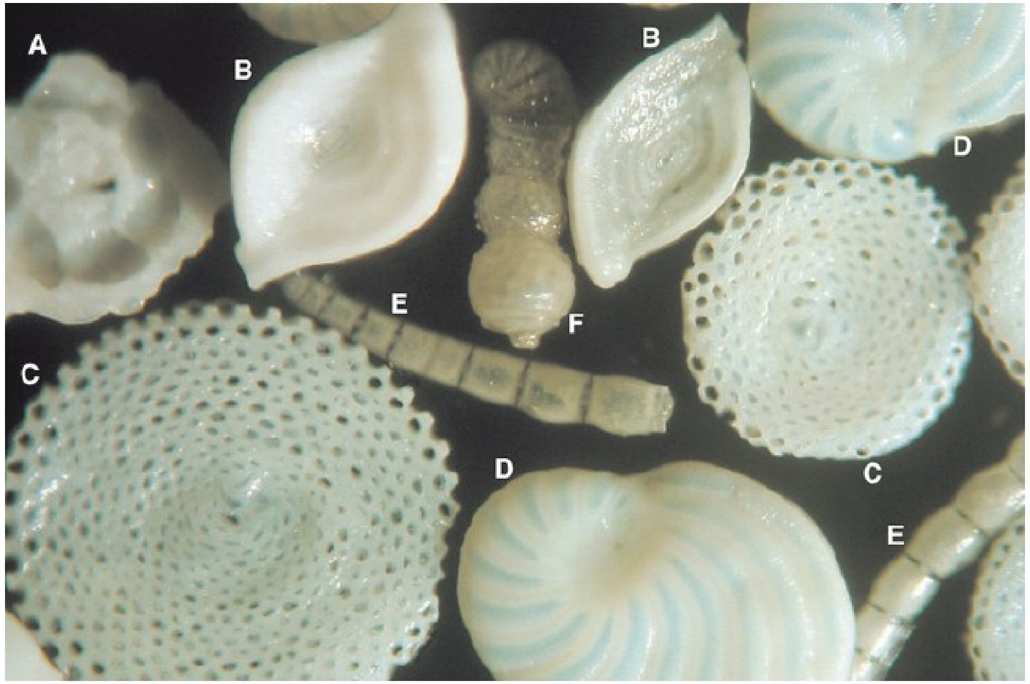
PPL, HA = 2.0 mm

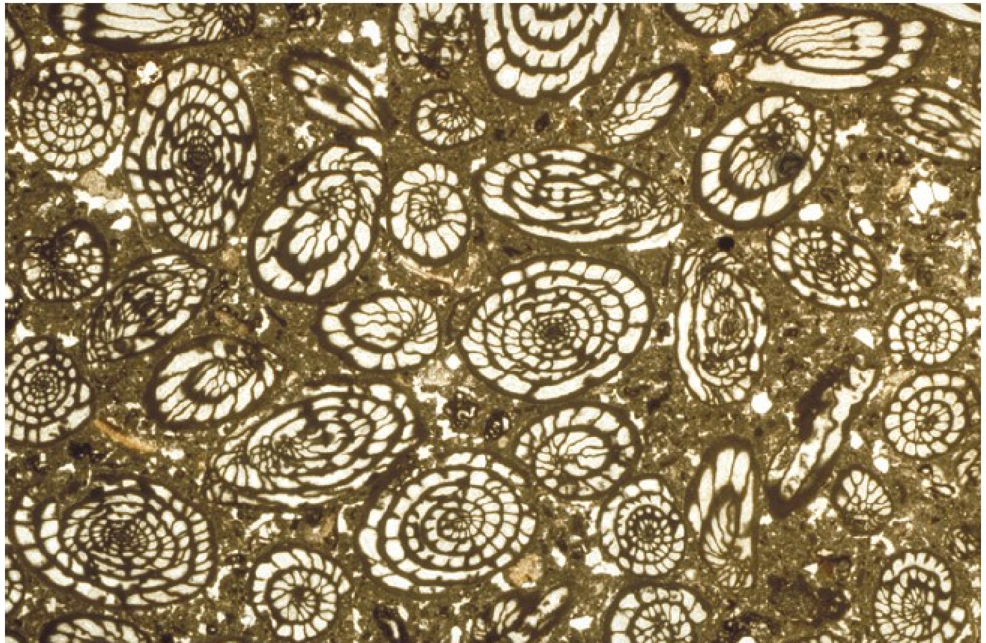
- Planktonní karbonátoví producenti v oceánech známí až od jury, s masivním rozvojem v křídě
- Hlavní zdroj karbonátu v pelagickém prostředí před jurou neznámý – velká otázka pelagické karbonátové produkce v paleozoiku (pouze periplatformní kal, vznikající dezintegrací bentických organizmů, hlubší části oceánů nad CCD bez karbonátů? / neznámí producenti, kteří se příznivě nezachovali?)

- **Bentické fusuliny – nepelagické**



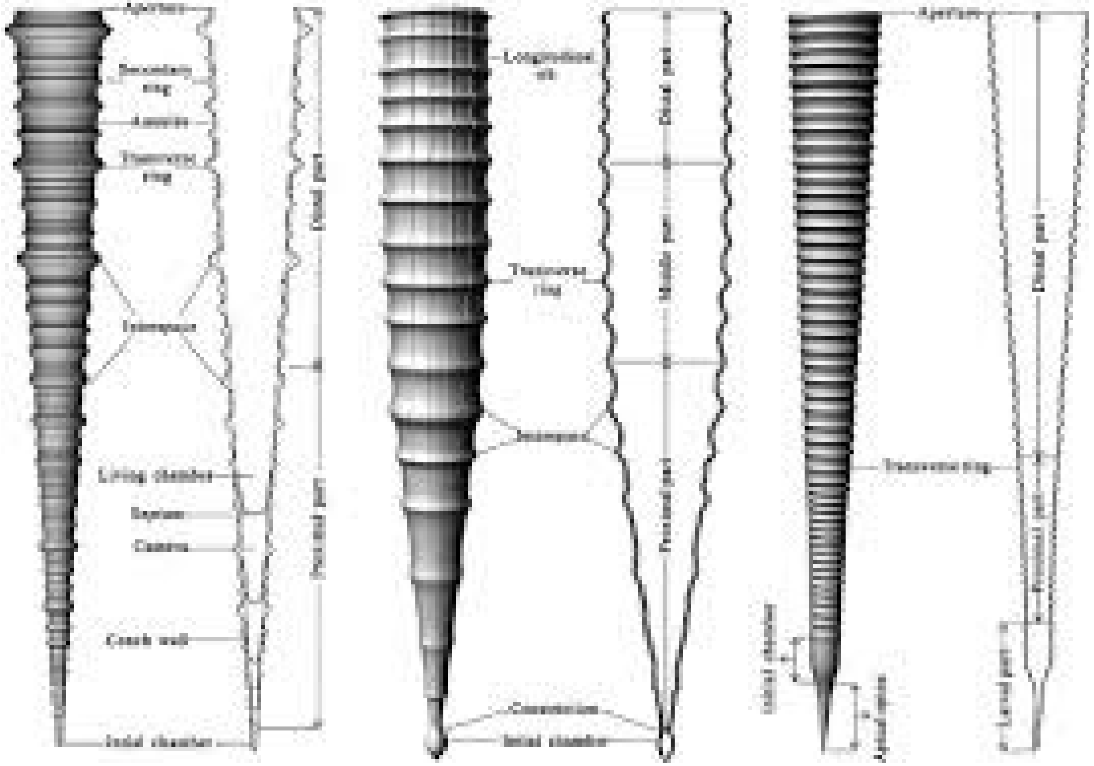






Tentakuliti

Aragonitové či HMG kalcitové



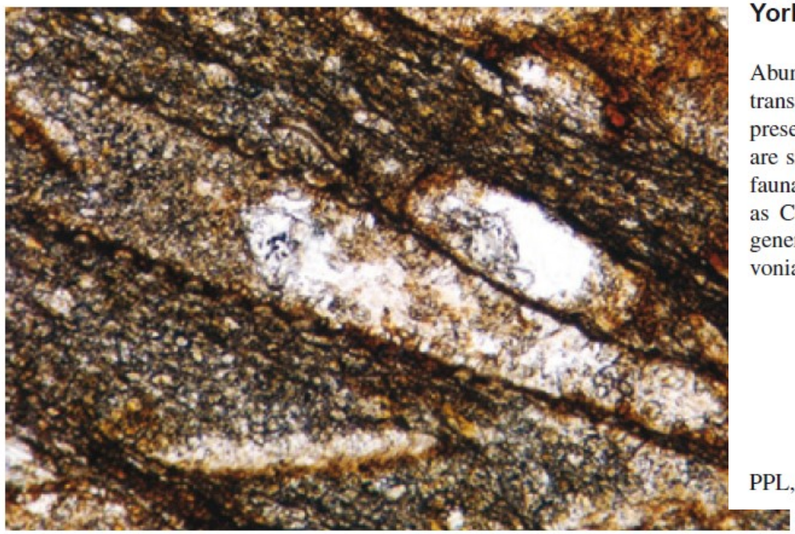
Devonian, unidentified unit, U.S.A.

Close-up macrophotograph of a calcareous sandstone with a tentaculite exposed on a bedding plane. Note the conical shape and the pronounced transverse ribbing on the exterior of the small shell.

Mac, HA = ~8 mm

Devonian Tentaculiten Knottenkalk, Frankenwald, Bavaria, Germany

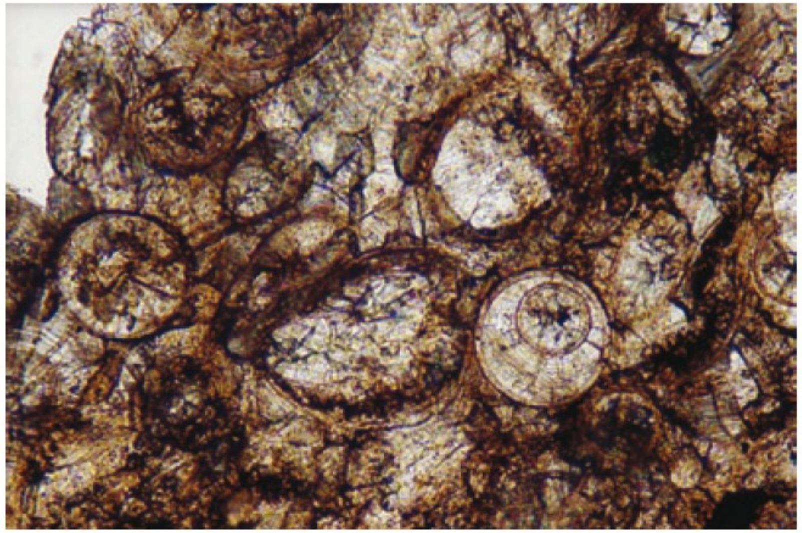
A slice through part of a tentaculite parallel to its long axis, showing the conical shape and characteristic crenulate or corrugate exterior (the tentaculite is the grain that extends diagonally from the upper left corner to the lower right corner of the image). These fossils are similar to *Styliolina* except for the external ornamentation, and are classed by some as belonging to the worms; others place them with the mollusks.



PPL, HA = ~1.5 mm

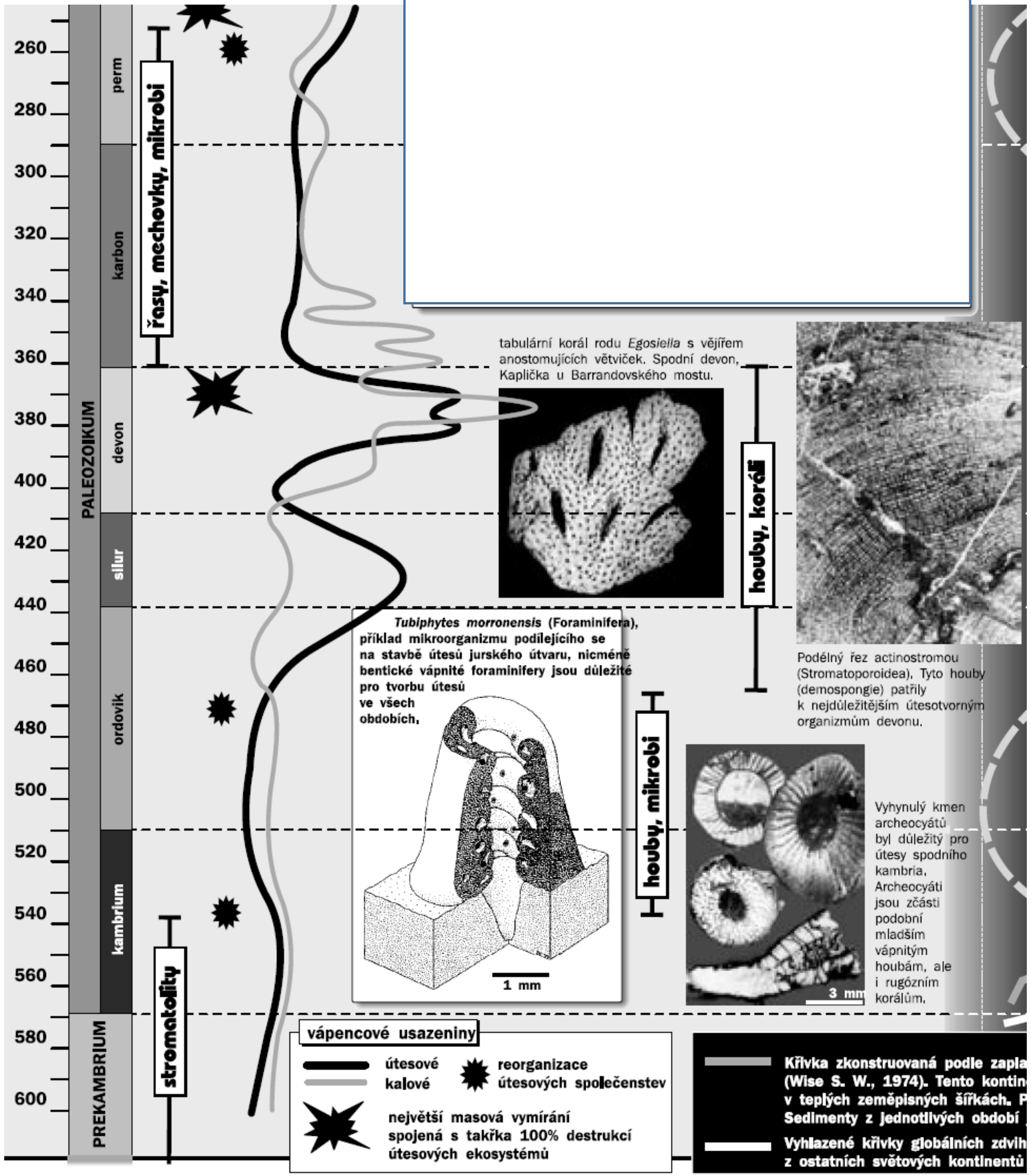
Up. Devonian Genundewa Ls., New York

Abundant examples of *Styliolina fissurella* in transverse section. Note the very thin, but well preserved walls. These conical microfossils are similar to tentaculitids and have unknown faunal affinities; they are sometimes grouped as Conulariids. *Styliolina* and other similar genera are important rock-formers in the Devonian.



PPL, HA = ~1.1 mm

Bentické útesotvorné organizmy



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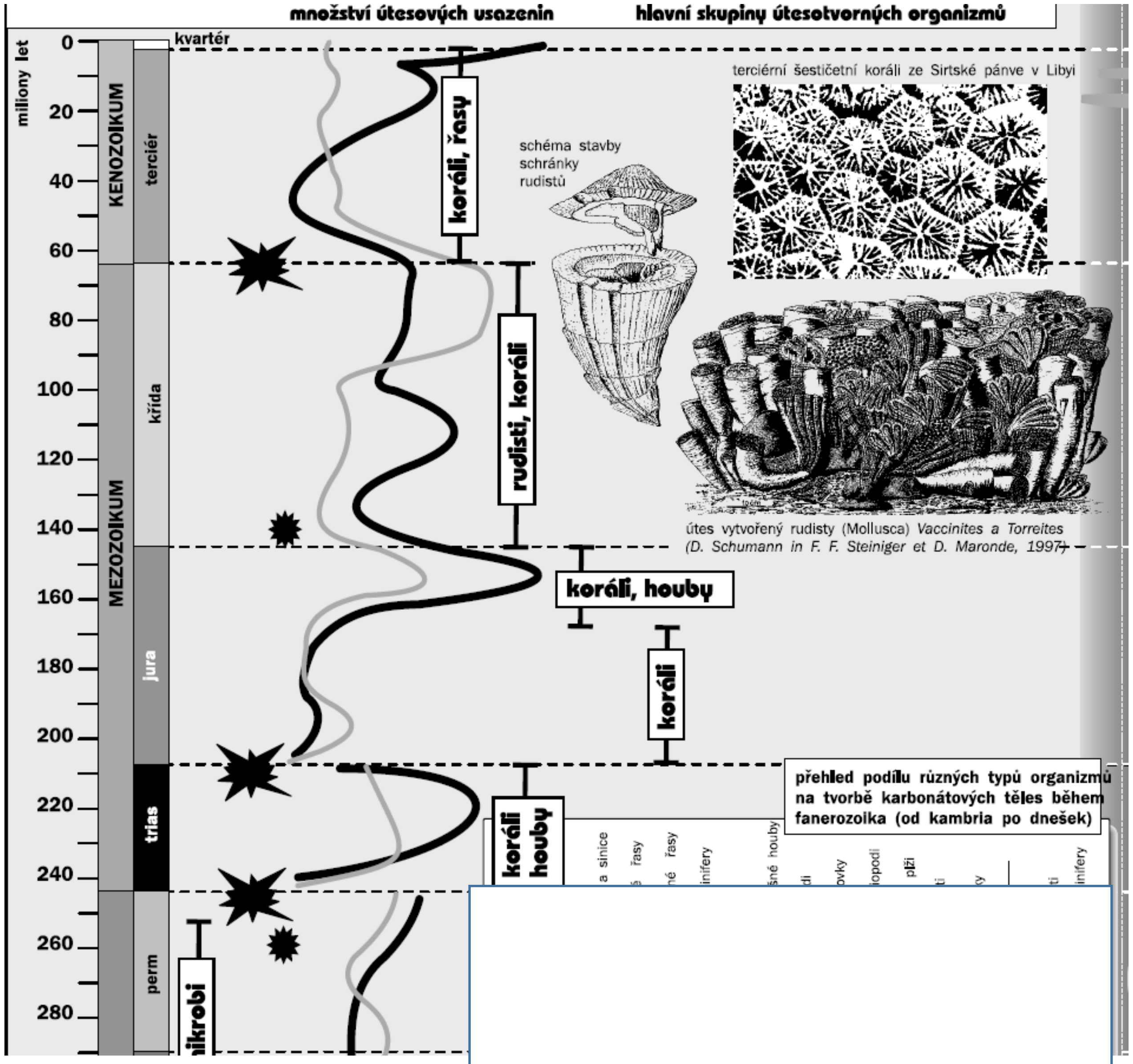
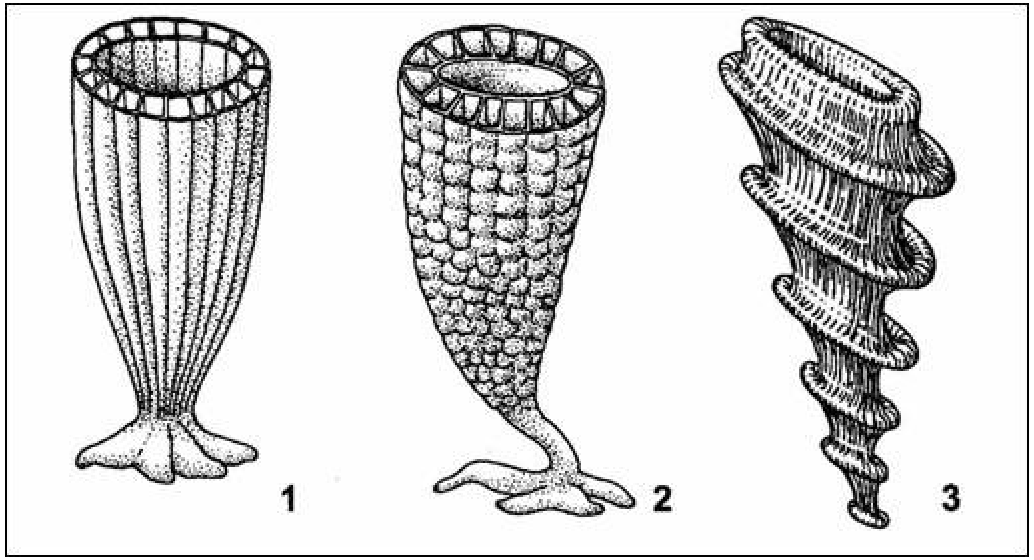
520
540
560
580
600
PREKAMBRIUM
PALEOZOIKUM
perm
karbon
devon
silur
ordovik
kambrium
řasy, mechovky, mikrobi
houby, koráli
houby, mikrobi
stromatolity
tabulární korál rodu *Egosiella* s vějířem anostomujících větviček. Spodní devon, Kaplička u Barrandovského mostu.
Podélný řez actinostromou (Stromatoporoidea). Tyto houby (demospongie) patřily k nejdůležitějším útesotvorným organizmům devonu.
Tubiphytes morronensis (Foraminifera), příklad mikroorganizmu podílejícího se na stavbě útesů jurského útvaru, nicméně bentické vápnité foraminifery jsou důležité pro tvorbu útesů ve všech obdobích.
1 mm
Vyhynulý kmen archeocyátů byl důležitý pro útesy spodního kambria. Archeocyáti jsou zčásti podobní mladším vápnitým houbám, ale i rugózním korálům.
3 mm
vápencové usazeniny
útesové
kalové
reorganizace útesových společenstev
největší masová vymírání spojená s takřka 100% destrukcí útesových ekosystémů
Křivka zkonstruovaná podle
(Wise S. W., 1974). Tento
v teplých zeměpisných šířkách.
Sedimenty z jednotlivých období
Vyhlazené křivky globálních
z ostatních světových kontinentů



množství útesových usazenin
hlavní skupiny útesotvorných organizmů
miliony let
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
kvartér
KENOZOIKUM
terciér
MEZOZOIKUM
křída
jura
trias
perm
koráli, řasy
rudisti, koráli
koráli, houby
koráli
koráli houby
mikrobi
schéma stavby schránky rudistů
terciérní šestičetní koráli ze Sirtské pánve v Libyi
útes vytvořený rudisty (Mollusca) *Vaccinites a Torreites* (D. Schumann in F. F. Steiniger et D. Maronde, 1997)
přehled podílu různých typů organizmů na tvorbě karbonátových těles během fanerozoika (od kambria po dnešek)

Archeocyáti

- Struktura na pomezí porifer a rugóz



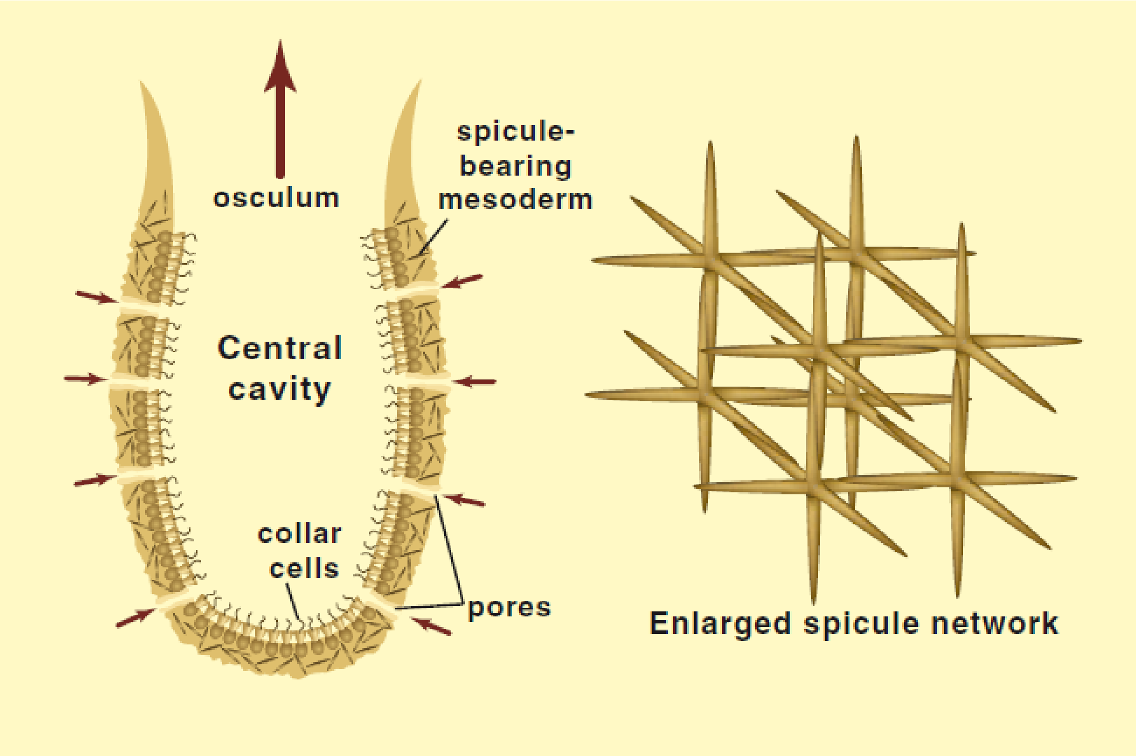
		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphate
Sponges:	Demospongea		o			
	Calcarea		●			
	Sphinctozoa	●	●			
	Stromatoporoidea	o	●	●		
	Chaetetida	●	●			
	Archaeocyathida		●			
	Hexactinellida					

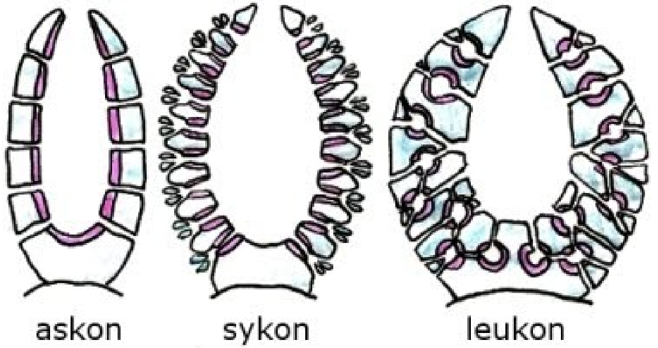
Lo. Cambrian (Tommotian) Pestrotsvet Fm., southeastern Siberian Platform, Russia

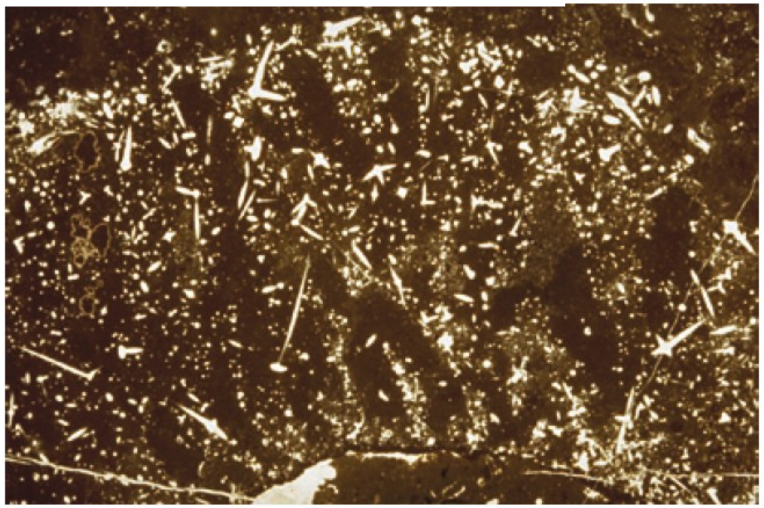
Three regular archaeocyaths encrusted with *Renalcis* and encased in marine cement. The cup-shaped, double-walled, perforated skeletal material and central cavity are well represented in this view, as are the septa that provide structural support. Sample from Noel P. James.

PPL, HA = 16 mm

Porifery







Lo. Jurassic (mid. Liassic) limestone, Central High Atlas region, Morocco

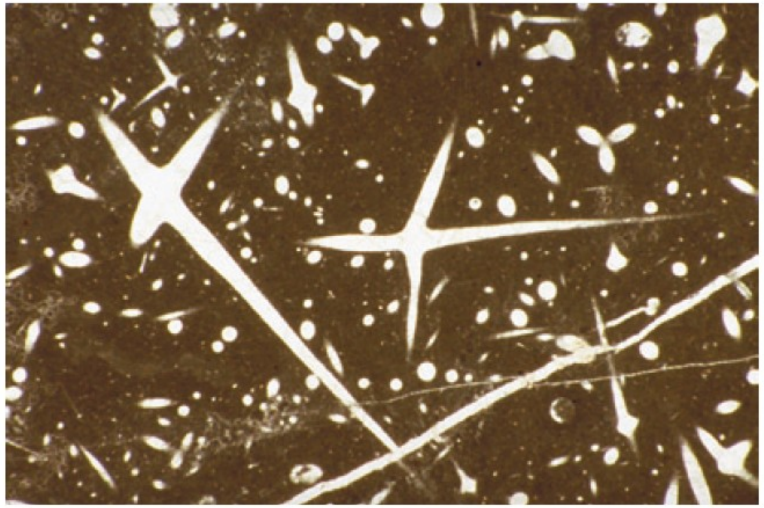
Exceptional wall preservation of a sponge showing an in-place spicule network and intervening pores passing through the wall (later infilled with dark micrite). The exterior of the sponge is at the top of this photograph and the well-defined central cavity is at the bottom. Note the variations in size and shape of spicules within a single sponge.

PPL, HA = 25 mm

Up. Permian Middle reef complex, Djebel Tebaga, Tunisia

Calcareous sponges were major framework components of Permian and Triassic reefs, in part because of the demise or decline of many competitive groups. These finger-like calcareous sponges from the reefs of Tunisia show labyrinthine, chambered walls and relatively distinct central cavities. The skeletal structure here too is visible largely due to infill or precipitation of micritic material.

PPL, HA = 11 mm

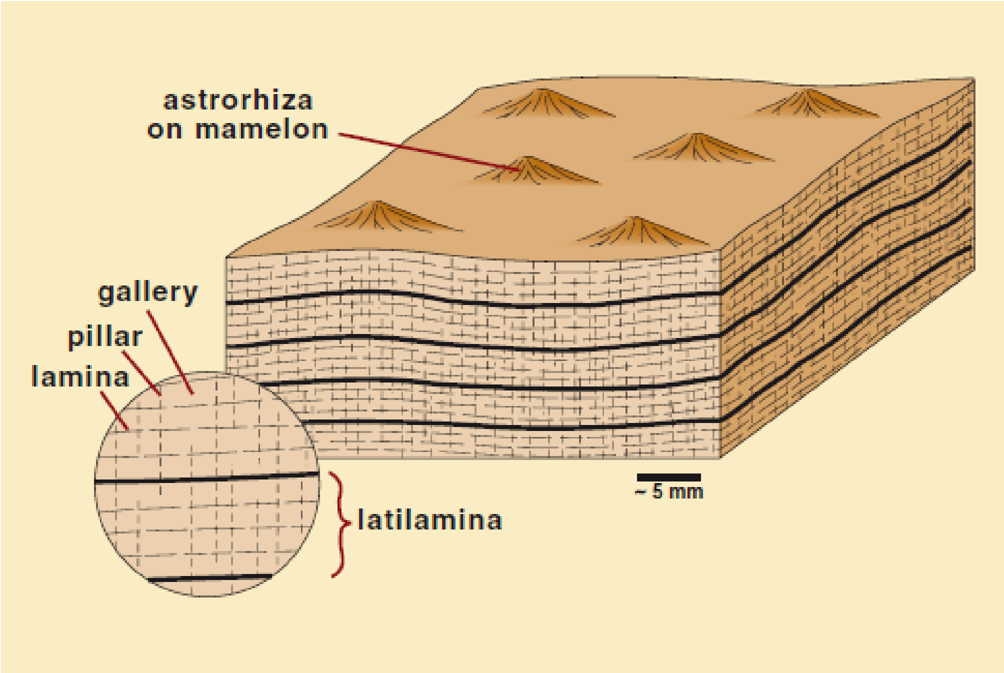


Lo. Jurassic (mid. Liassic) limestone, Central High Atlas region, Morocco

A magnified wall structure view of the sponge shown in the previous image. The now-calcitic multi-axoned spicules embedded in the walls compose a loose meshwork of unfused rigid elements that serve to strengthen the porous, predominantly organic spongin material that constitutes the main part of the wall

PPL, HA = 5.5 mm

		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates	Silica
Sponges:	Demospongea		o				●
	Calcarea		●				
	Sphinctozoa	●	●				
	Stromatoporoidea	o	●	●			
	Chaetetida	●	●				
	Archaeocyathida		●				
	Hexactinellida						●



Stromatopory

Mid. Ordovician Black River Gp., Lowville Fm., Kingston, Ontario, Canada

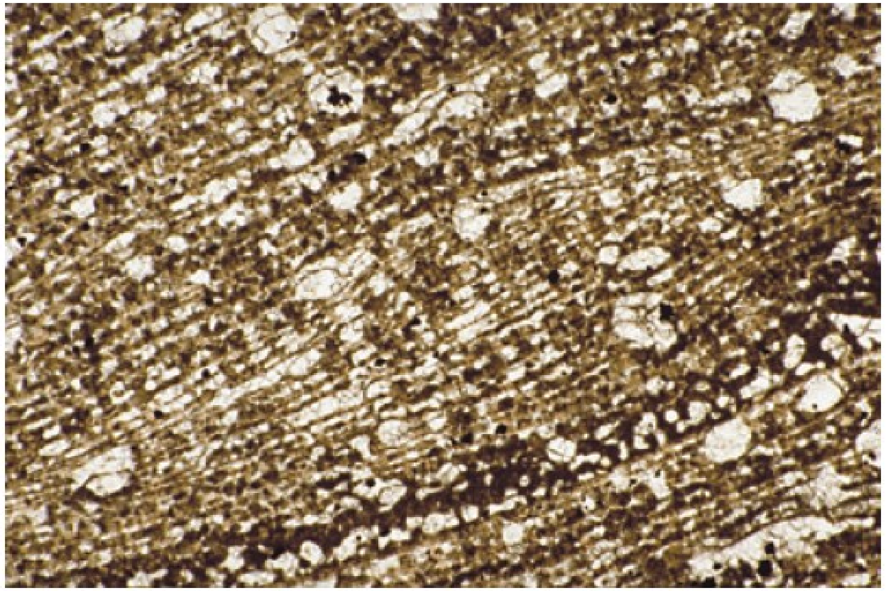
An early stromatoporoid — *Stromatocerium* sp. The skeleton shows strong development of vertical pillars and large, horizontally elongate galleries. The pillars have undergone substantial neomorphism. Sample from Noel P. James.

PPL, AFeS, HA = 5.2 mm

Up. Devonian Lime Creek Fm., Cerro Gordo Co., Iowa

A laminar stromatoporoid, *Stromatopora incrustans*, with well preserved, and very characteristic, latticework fabric with mid-scale reticulate microstructure. The horizontal laminae and vertical pillars of the latticework are clearly visible, as are the varied gallery shapes. Note the very large astrorhizal canals punctuating the skeletal structure. The excellent structural preservation implies originally calcitic mineralogy.

PPL, HA = 6 mm

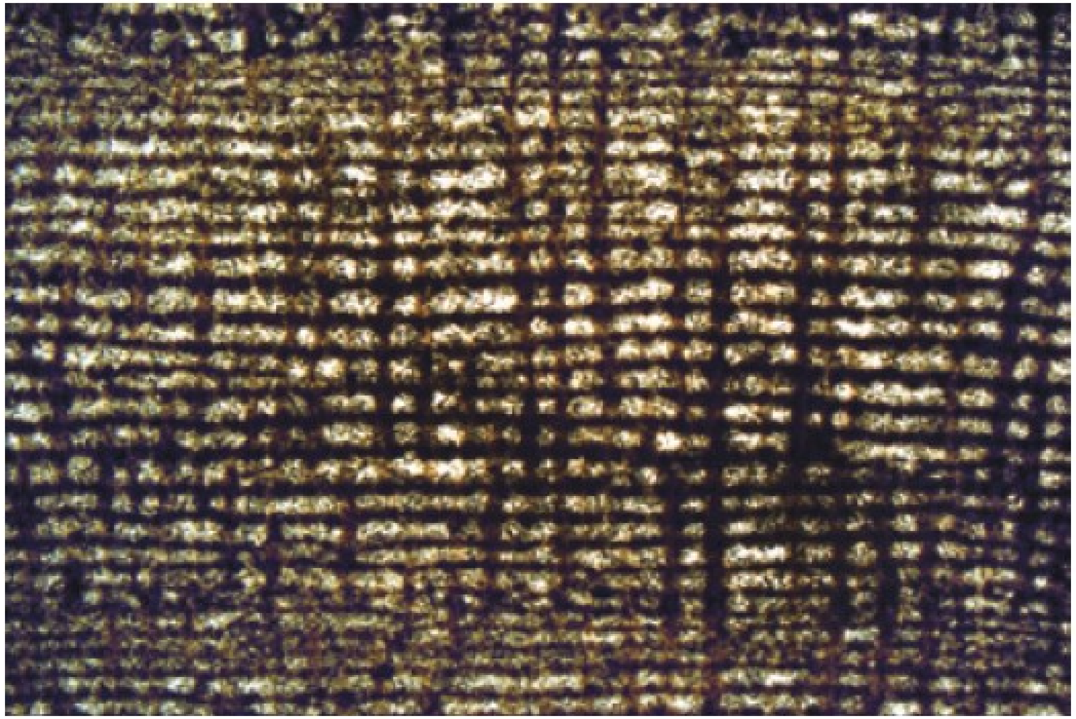


		Aragonite	Low-Mg Calcite	High-Mg Calcite	A		
Sponges:	Demospongea		○				
	Calcarea		●				
	Sphinctozoa	●	●				
	Stromatoporoidea	○	●	●			
	Chaetetida	●	●				
	Archaeocyathida		●				
	Hexactinellida						●

Up. Devonian Shell Rock Fm., Nora Mbr., Cerro Gordo Co., Iowa

This vertical section through the skeleton of *Actinostroma expansum* is composed of long pillars that are connected by colliculi. The colliculi are horizontally aligned, giving the impression of continuous laminae in longitudinal thin sections; however, transverse (tangential) thin sections reveal the "hexactinellid" pattern formed by the colliculi where they radiate from pillars (colliculi are horizontal rods protruding from pillars). *Actinostroma* has compact microstructure. Photograph courtesy of Carl W. Stock.

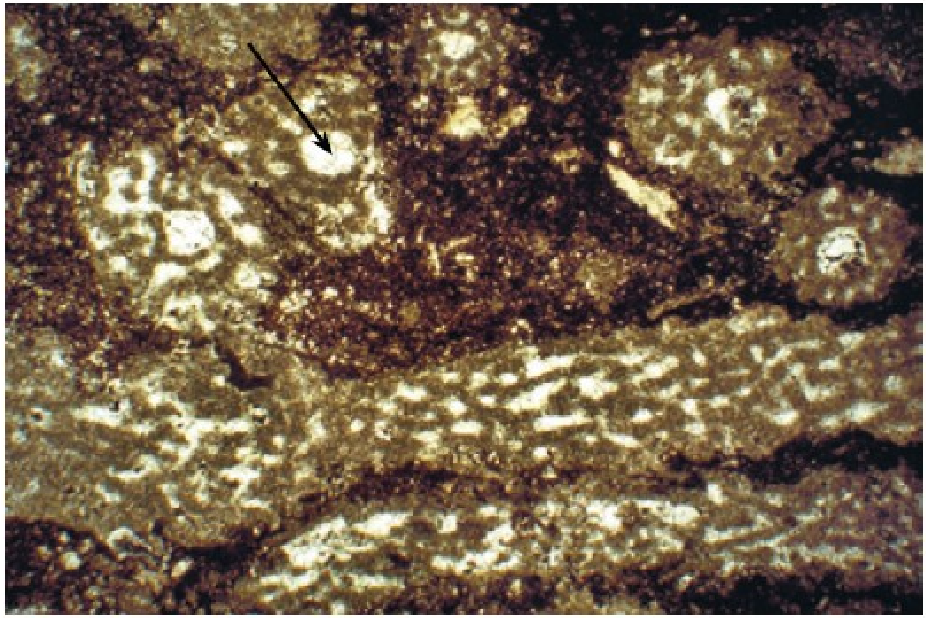
PPL, HA = 9.0 mm

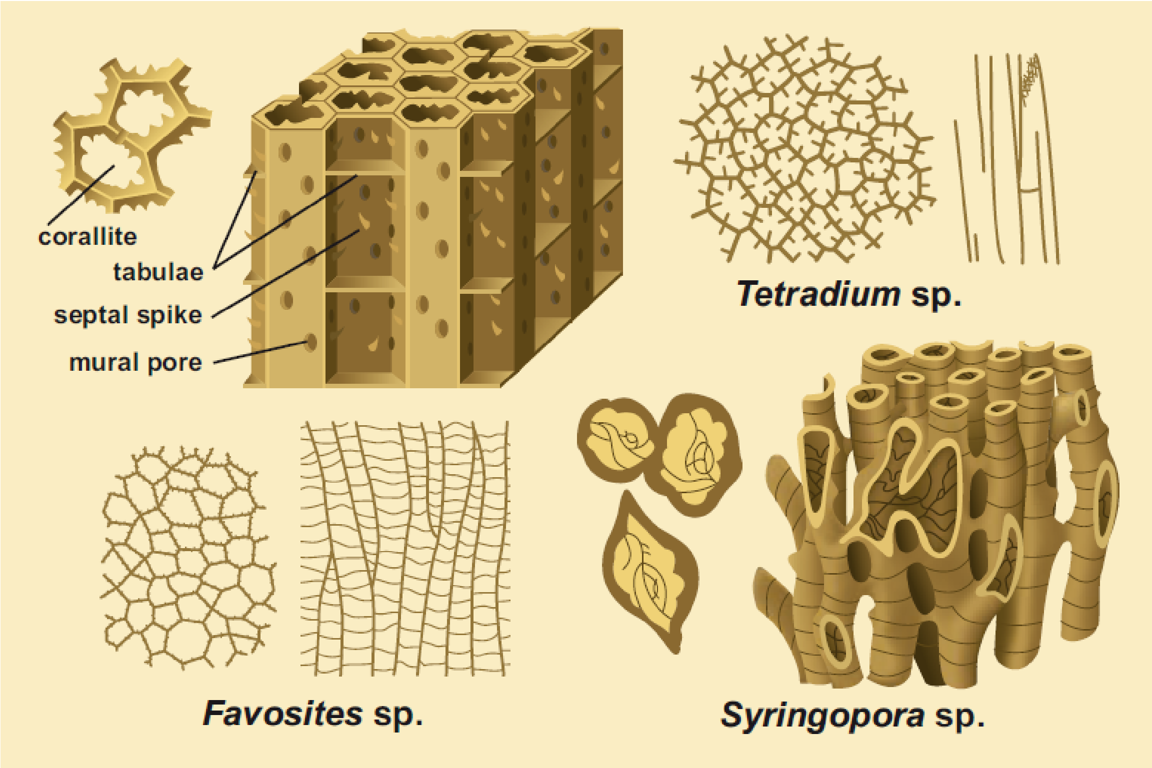


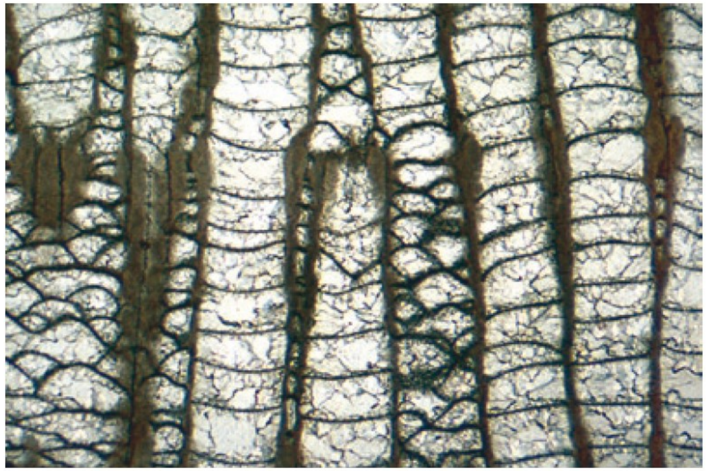
Up. Devonian Shell Rock Fm., Nora Mbr., Cerro Gordo Co., Iowa

Here several specimens of *Amphipora* are surrounded by an organic-rich matrix. The skeletons are small and twig-like. Both longitudinal sections and cross sections can be seen here. The internal skeletal structure is irregular, but in some specimens an axial canal with a circular cross section is developed; several of the upper specimens display this structure (for example, at arrowhead). Photograph and caption courtesy of Carl W. Stock.

PPL, HA = 11 mm



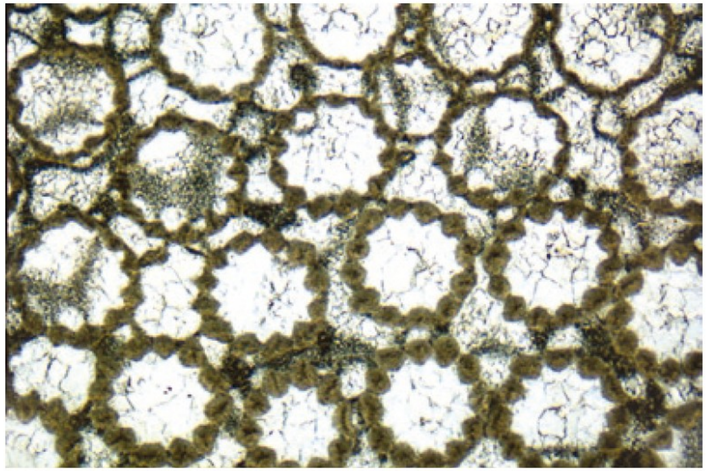




Up. Ordovician Keel Fm., Pontotoc Co., Oklahoma

The tabulate coral *Propora thebesensis* (Foerste) — Order Heliolitida. This longitudinal section shows that the calcite of the corallite walls is composed of septal trabeculae (fiber bundles). The microstructure within the thinner tabulae and coenenchymal dissepiments is not distinct. Photograph courtesy of Graham Young.

PPL, HA = 7.5 mm



Up. Ordovician Keel Fm., Pontotoc Co., Oklahoma

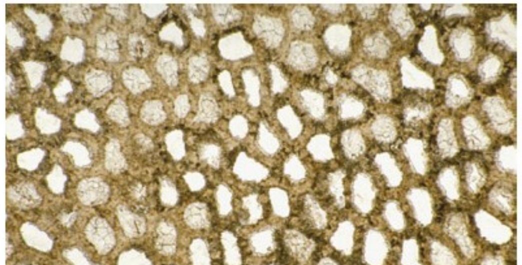
The tabulate coral *Propora thebesensis* (Foerste) —Order Heliolitida. This transverse section shows a contrast between the thickened and unthickened parts of the skeleton. Septal trabeculae are well developed in the thickened parts. Photograph courtesy of Graham Young.

PPL, HA = 5.5 mm

Pennsylvanian Magdalena Gp., El Paso Co., Texas

The well preserved margin of a colony of *Chaetetes* sp. Long classified as tabulate corals, this group is now definitively placed with the sponges by most current workers. The sponge assignment is based on the discovery of possible modern relative, *Acanthochaetetes wellsi*, that has the spicules and soft tissues typical of demosponges. Spicules are not yet known in fossil chaetetids, however, so we have continued to include this group with the tabulate corals for now. The skeleton of *Chaetetes* is known to have been high-Mg calcite.

PPL, HA = 8.0 mm



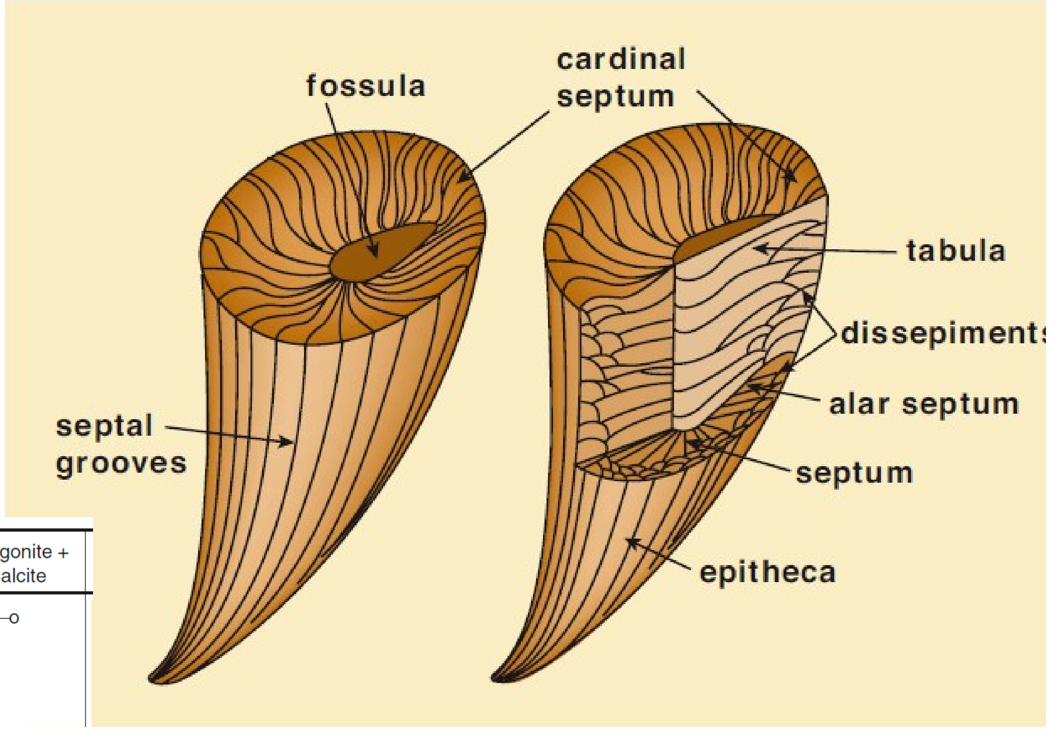
Pennsylvanian Magdalena Gp., El Paso Co., Texas

This transverse section of a colony of *Chaetetes* sp. shows the simple, interlocked, non-septate living chambers of this colonial organism. Chaetetid colonies range from sheet-like encrustations to upright columns and some colonies reach a diameter of three meters.

Tabulátní koráli

		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite
Corals:	Octocorallia	○	○	●	○
	Rugosa		●	○	
	Heterocorallia		●		
	Tabulata	○	●	○	
	Scleractinia	●			

Rugózní koráli



		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite
Corals:	Octocorallia	○	○	●	○
	Rugosa		●	○	
	Heterocorallia		●		
	Tabulata	○	●	○	
	Scleractinia	●			

Pennsylvanian limestone, north-central Texas

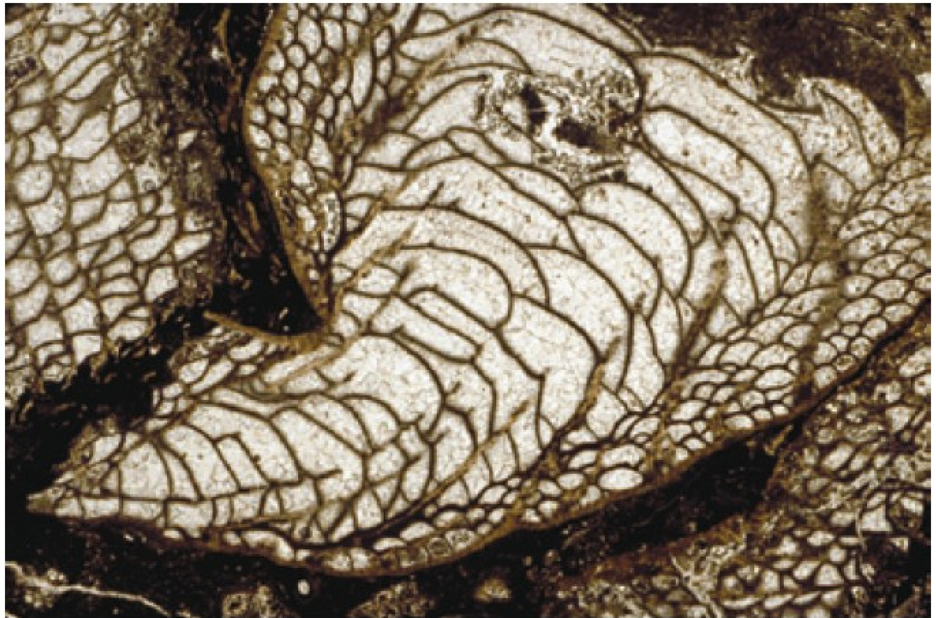
Longitudinal and transverse sections through a solitary rugose coral, probably *Zaphrentites* sp. The transverse section shows half of the cup-shaped corallite with radiating, brownish calcite septal walls. The longitudinal section shows the conical (horn shaped) outline of a solitary rugosan, with thick septal partitions and thinner supporting dissepiments.

PPL, HA = 20 mm

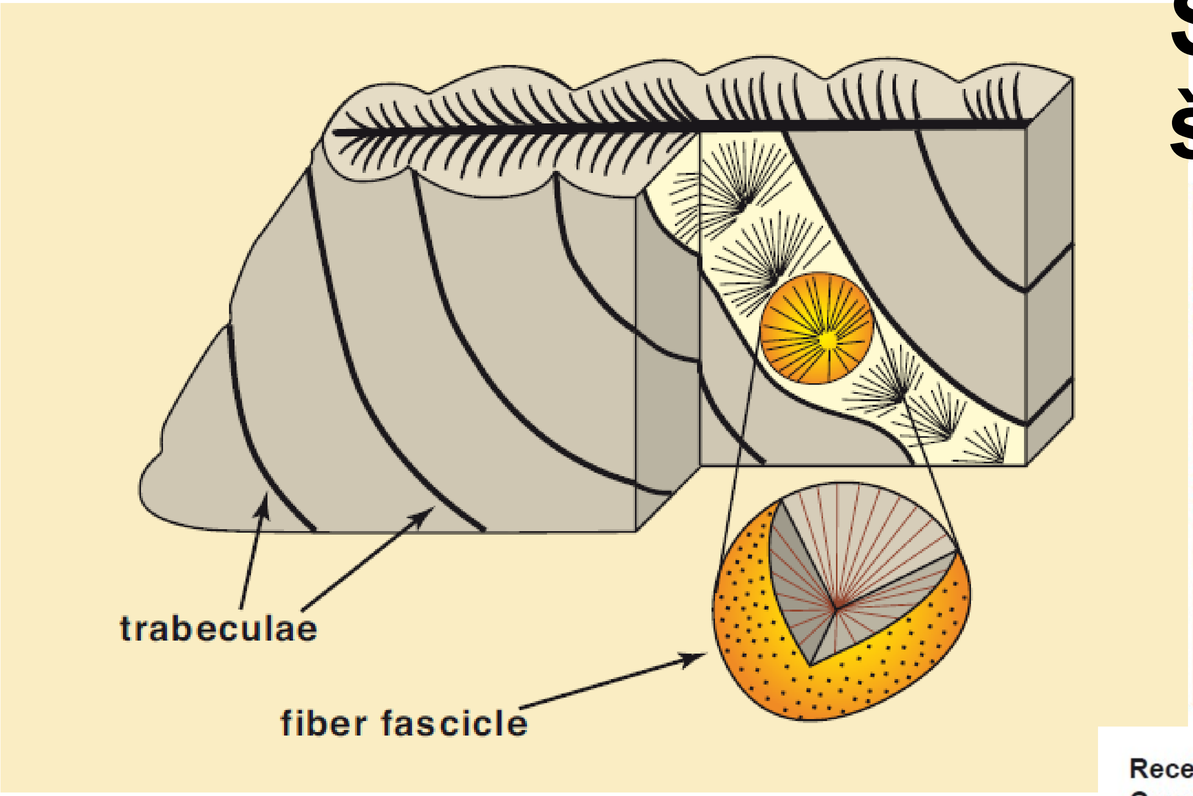
Carboniferous limestone, England, U.K.

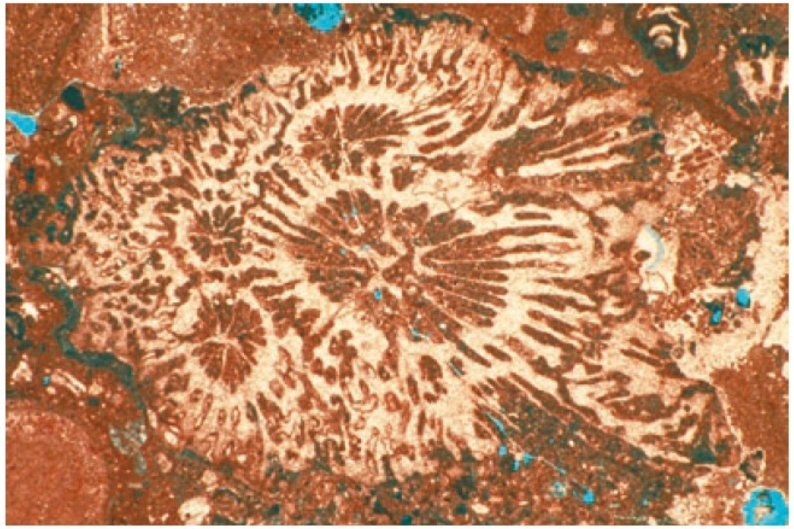
A longitudinal section through a solitary rugose coral (with fragment of additional rugosans on each side). This cut nicely shows the horn-shaped skeleton with septa that paralleled the long-axis and a complex series of curved dissepiments and more planar tabulae that provided internal support.

PPL, HA = 16 mm



Skleraktinia (po-paleozoické šestičetné koráli)





Up. Cretaceous (Maastrichtian?) limestone, Paxos, Ionian Islands, Greece

This fragment of a roughly 65 million year old colonial scleractinian coral has been completely neomorphosed. It remains quite recognizable as scleractinian coral material, however, because the skeletal outlines have been preserved through infilling by micritic sediment matrix. Commonly, such poor preservation of internal structure of septa and walls can be a criterion for recognition of scleractinian corals and help to distinguish their remains from those of other (calcitic) groups of corals and bryozoans.

PPL, BSE, AFeS, HA = 9.0 mm

Recent sediment, Grand Cayman, Cayman Islands. B.W.I.

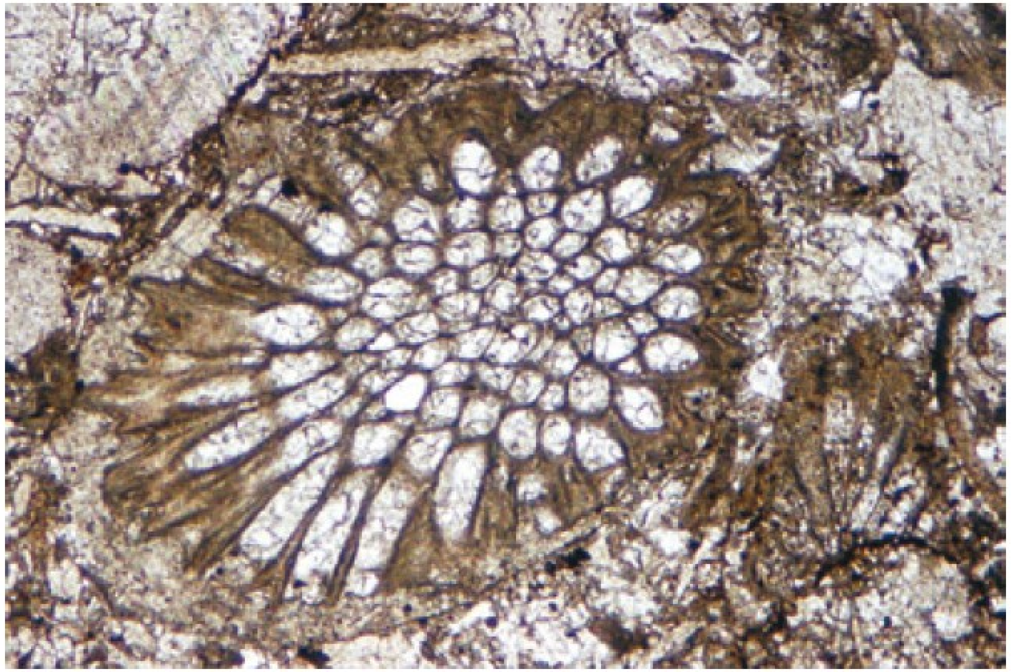
A fragment of a modern, colonial scleractinian coral, *Siderastrea radians*, showing the tightly packed arrangement of adjacent corallites and the pattern of radiating septa. The aragonitic septal structure of this coral is still pristine.

PPL, BSE, HA = 16 mm

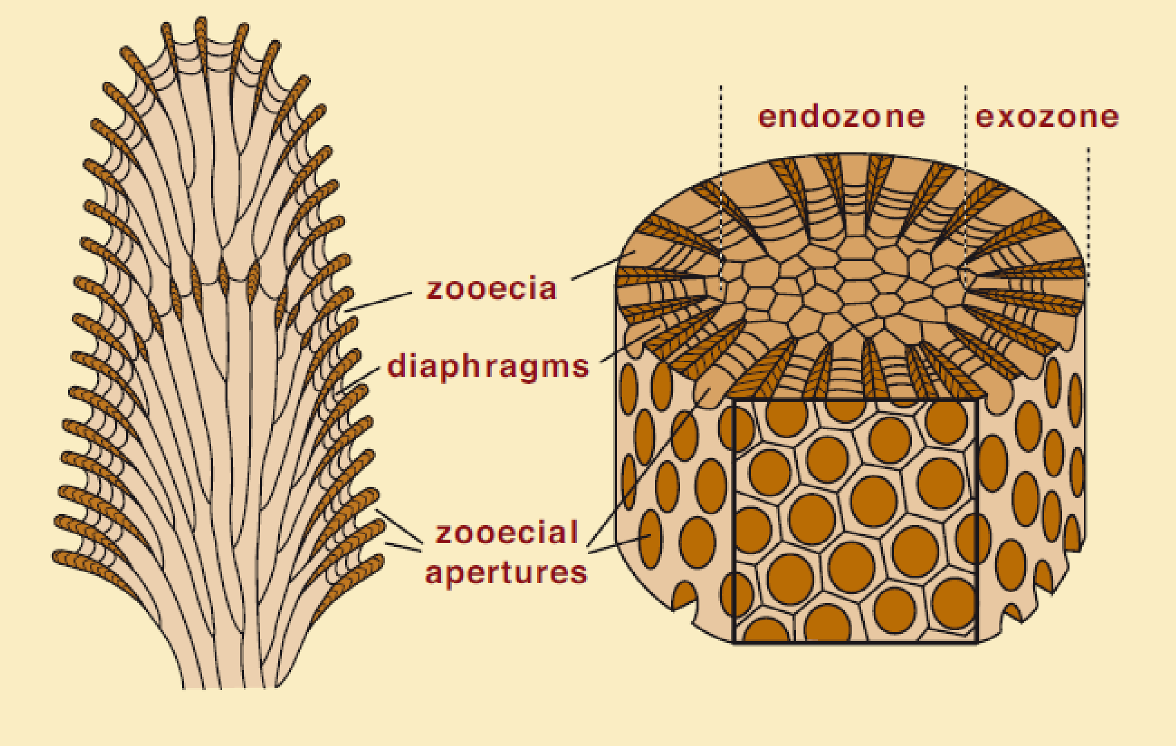
		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite
Corals:	Octocorallia	o	o	●	o
	Rugosa		●	o	
	Heterocorallia		●		
	Tabulata	o	●	o	
	Scleractinia	●			

Up. Silurian Tonoloway-Keyser Ls., Mifflin Co., Pennsylvania

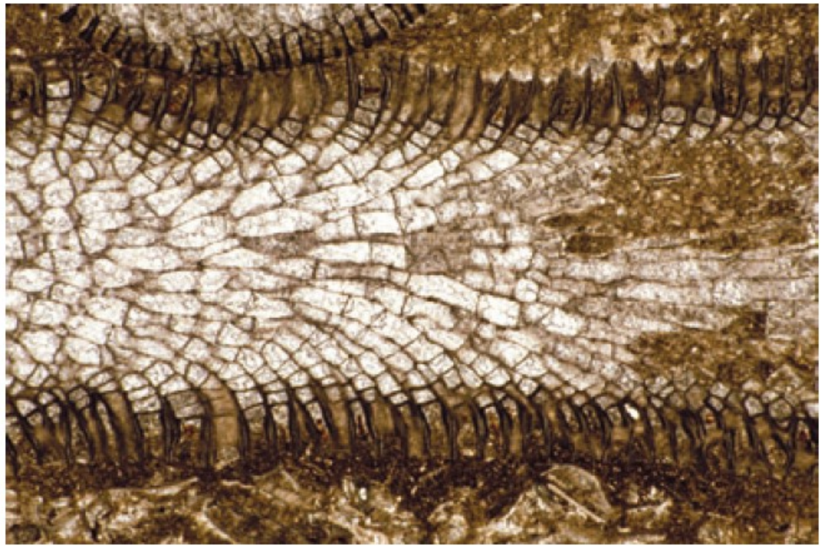
A trepostome bryozoan with acanthorods and a few mesopores. If you look closely, you can see a few preserved diaphragms in the zooecia near the top of the specimen. Diaphragms can be destroyed prior to diagenesis if the clast is



	Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates
Bryozoa	o	●	o	●	o



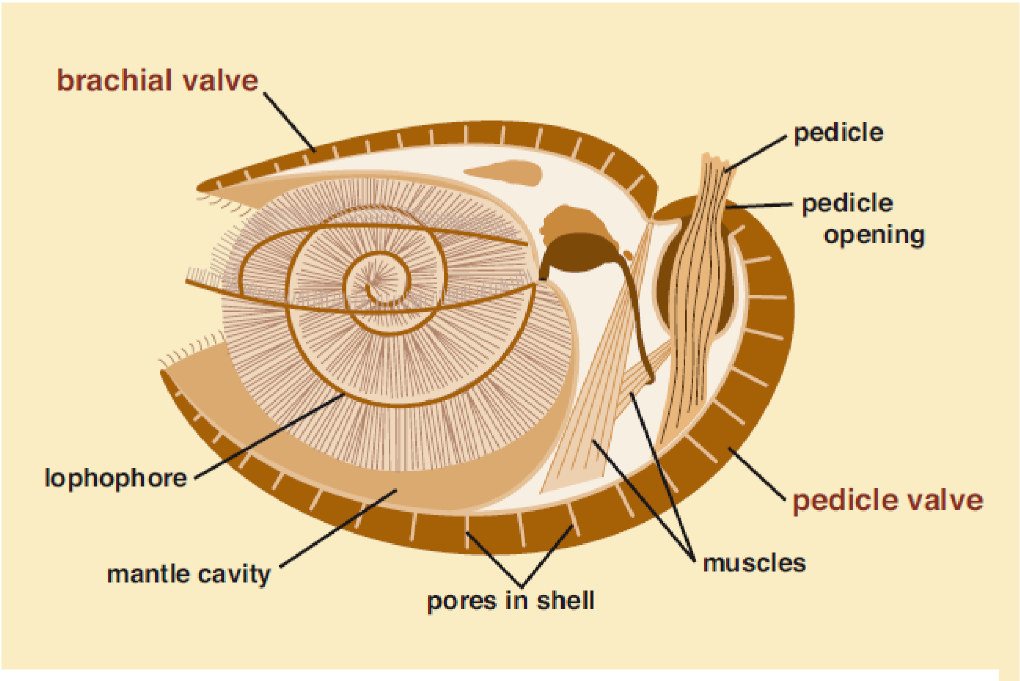
Mechovky



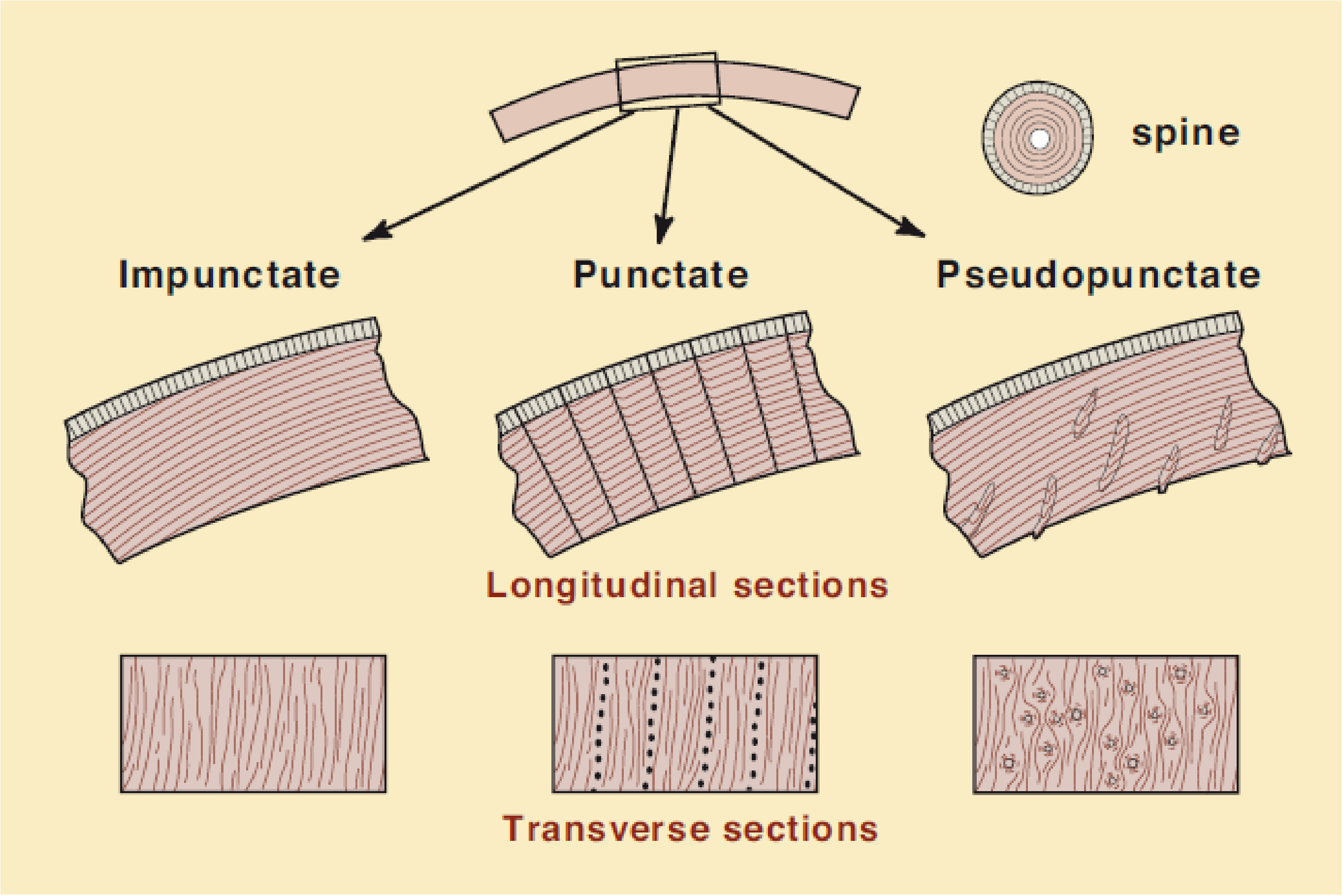
Up. Ordovician (Cincinnatian) Fairview Fm., Hamilton Co., Ohio

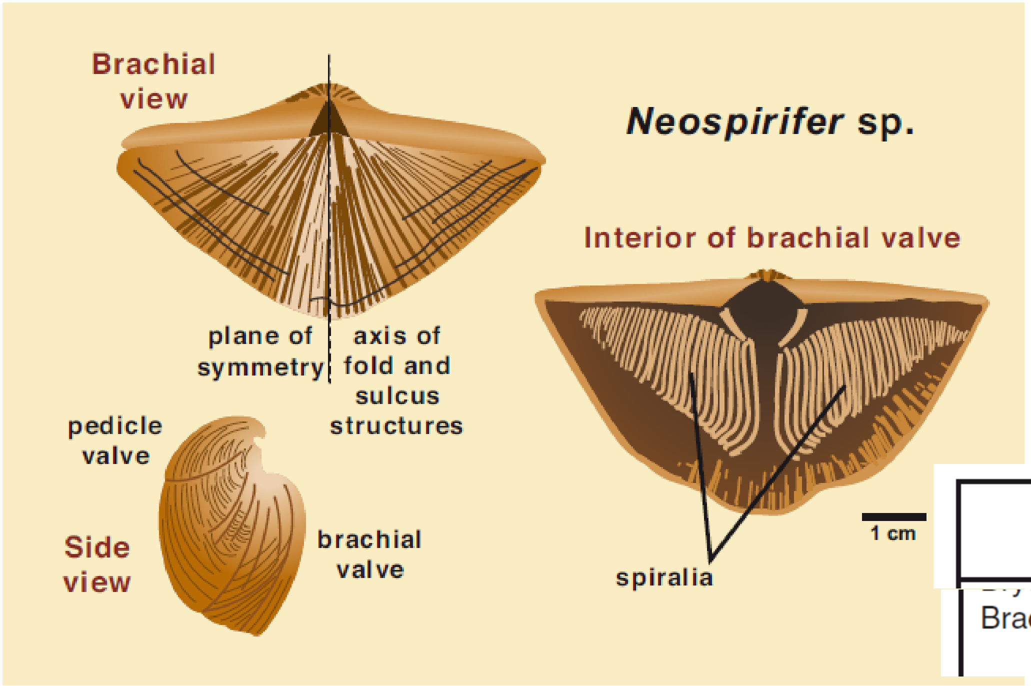
A longitudinal section through a trepostome bryozoan branch (possibly *Heterotrypa* sp.). The zooecia contain numerous diaphragms, a characteristic of trepostomes. Note the excellent preservation and finely fibrous lamination of the walls showing the outward-thickening of zooecial walls. Other common trepostome bryozoan features visible in this example are acanthorods embedded in the zooecial walls (the light lines) and a few mesopores. A part of the interior (endozone) of the bryozoan was destroyed by boring or later diagenesis (brown, finely crystalline calcite at right).

PPL, HA = 8.0 mm

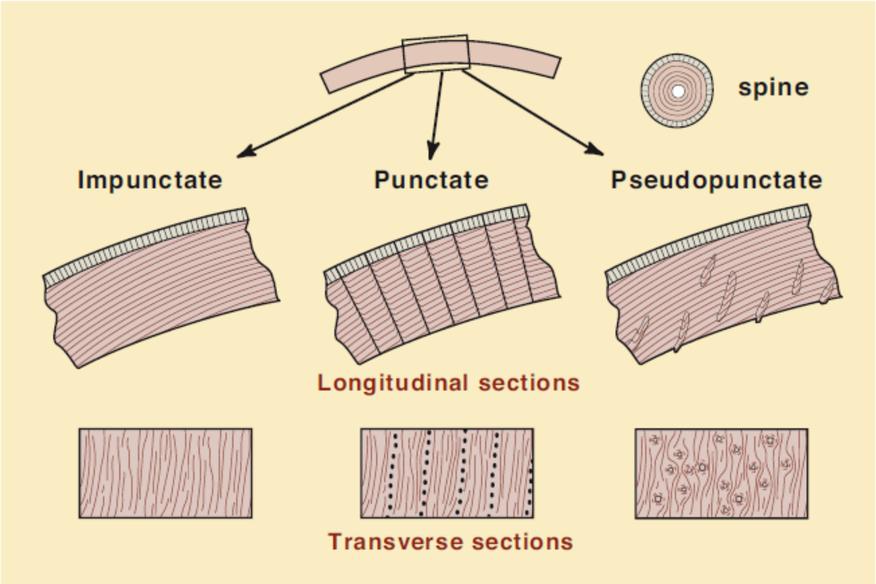


Brachiopodi





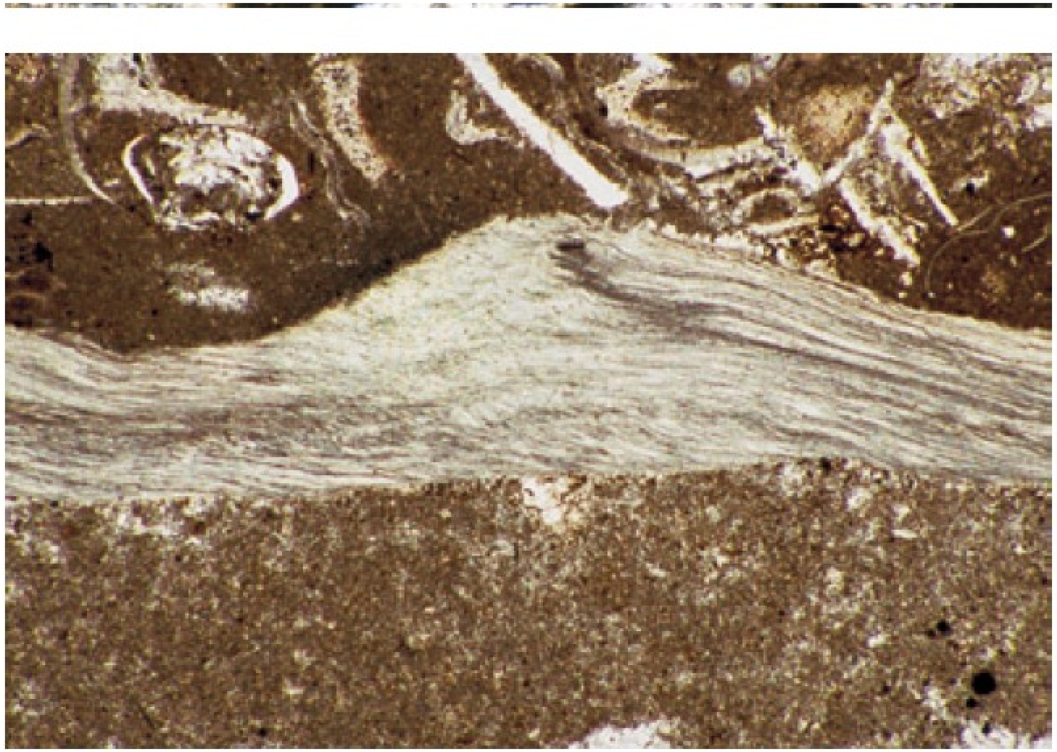
		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates
Brachiopoda:	Articulata		●	o		
	Inarticulata					●

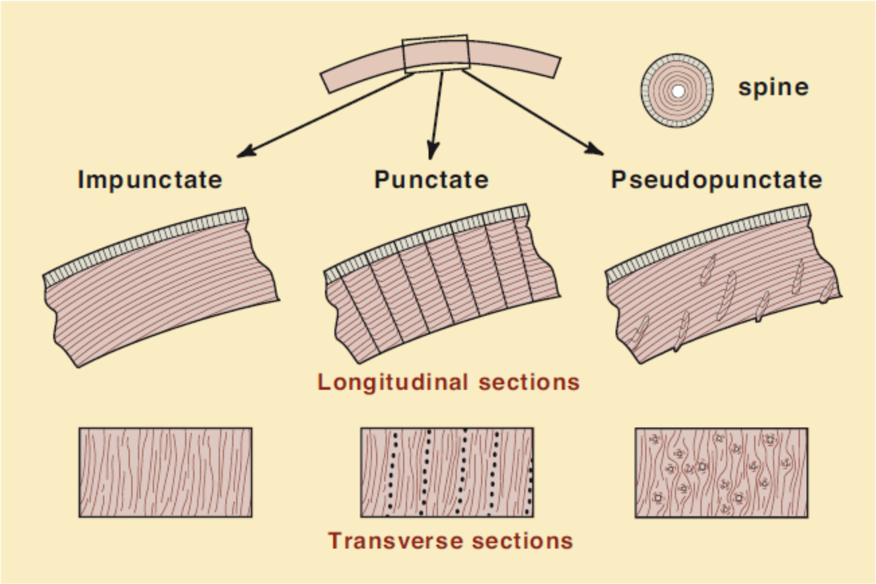


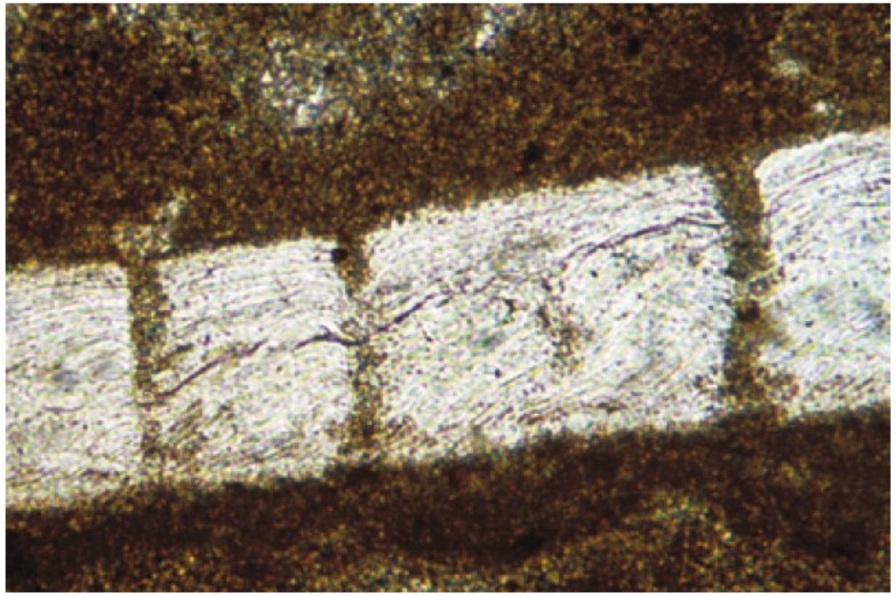
Up. Ordovician limestone, Kentucky

An example of an impunctate shell wall in the brachiopod *Platystropha cypha*. This shell has an extremely thin (or diagenetically altered) primary layer and a thick secondary layer. Note the typical low-angle fibrous structure and the substantial lateral variations in shell thickness.

PPL, HA = 3.0 mm



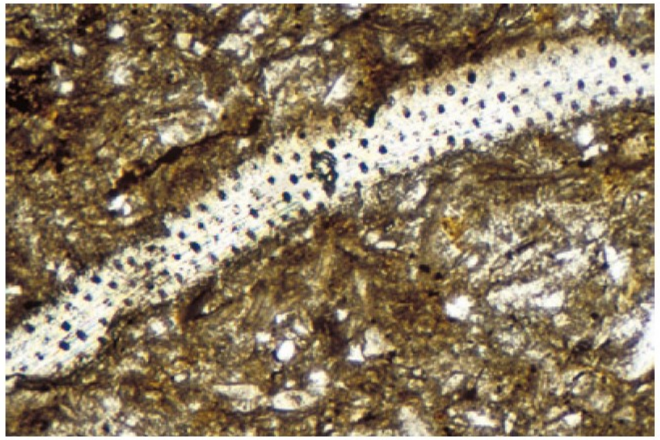




Up. Permian Middle reef complex, Djebel Tebaga, Tunisia

An enlarged view of a punctate brachiopod wall. Clearly, the individual punctae completely penetrate the shell wall and, once again, have been made visible through the infiltration or precipitation of micrite in the openings. In life, small finger-like projections of the body covering (mantle) extended through these openings.

PPL, HA = 3.5 mm



Up. Permian (Ufimian?) Schuchert Dal Ss., Jameson Land, East Greenland

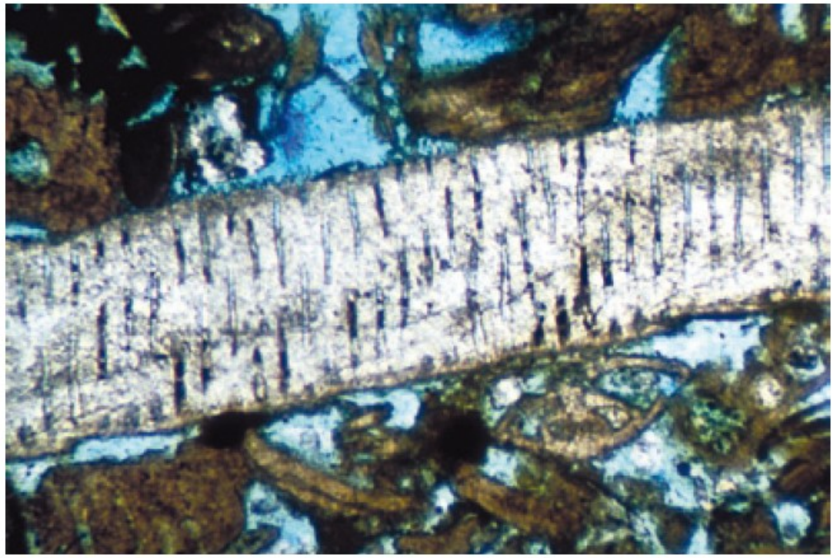
An oblique or tangential cross section through a punctate brachiopod that shows circular to elliptical shapes of the punctae (now seen as micrite-filled former pores).

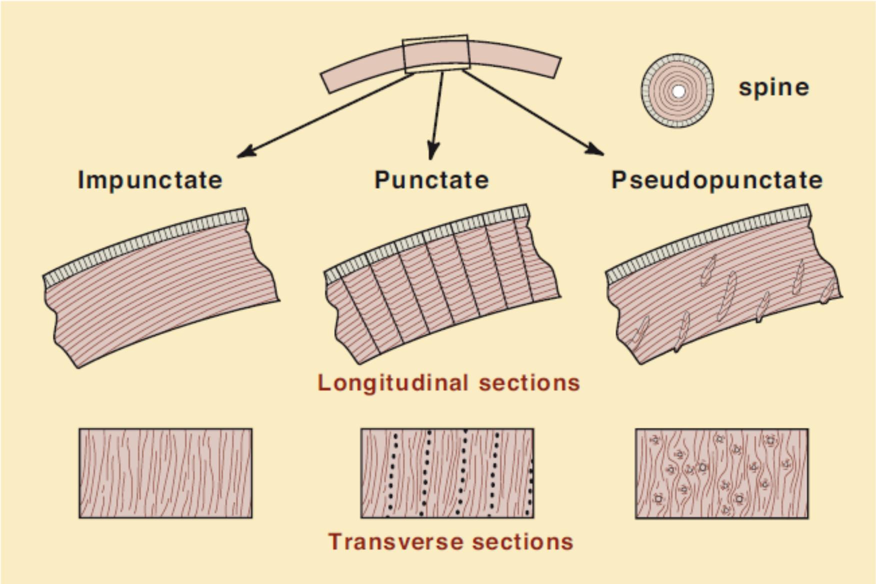
PPL, HA = 2.0 mm

Miocene Mount Brown Beds, Canterbury, New Zealand

An example of a punctate brachiopod shell. The vertical punctae were holes that penetrated the shell wall from the interior almost to the outer surface of the shell. They are easily visible here because they have been filled with micritic material (most likely precipitated *in-situ*). Although other organisms (trilobites, ostracodes and a few bivalves, for example) also have pores that may completely penetrate the shell wall, the combination of the low-angle fibrous wall structure and punctae is diagnostic for the recognition of brachiopod material.

PPL, BSE, HA = 2.0 mm





Up. Permian (Kazanian?) Wegener Halvø Fm., Jameson Land, East Greenland

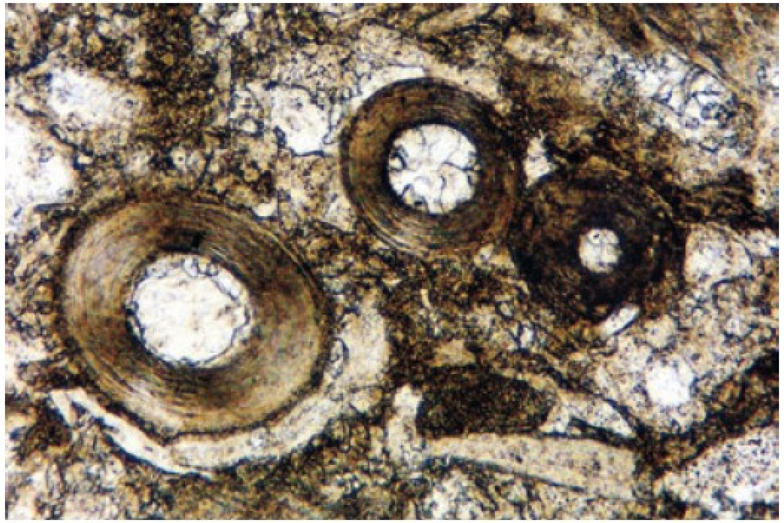
A detailed view of a pseudopunctate brachiopod shell. Although pseudopunctae, at first glance, may look like true punctae, they are quite different. They are stacked columns of cone-shaped plications or granular zones in the fibrous structure of the secondary wall layer. They mimic pores (punctae) but were never actually open spaces. They are unique to brachiopods; however, they are found in only a few groups, primarily the strophomenids.

PPL, HA = 2.4 mm

Up. Permian (Kazanian?) Wegener Halvø Fm., Jameson Land, East Greenland

Several groups of brachiopods were extensively "armored" with long spines, most of which are broken off during transport and deposition of the shells. This example shows a brachiopod shell with a portion of an attached spine.

PPL, AFeS, HA = 2.0 mm

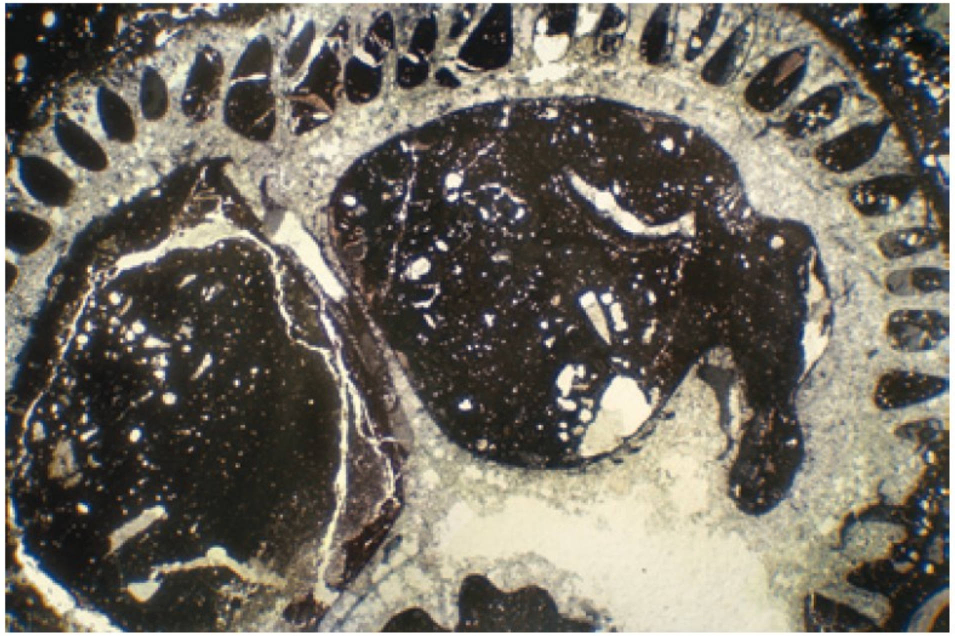


Lo. Carboniferous Glencar Ls., County Sligo, Ireland

Individual broken productid brachiopod spines in a shelf limestone. Here, three brachiopod spines lie in close proximity to each other. Each displays a characteristic hollow center and concentric, two-layer wall structure — a margin-parallel fibrous inner zone, and a thin, radially-oriented, fibrous outer zone. The oriented crystal structure in both layers produces a distinctive "pseudo-uniaxial cross" under cross-polarized light (a hint of which is even seen in this view).

PPL, HA = 0.8 mm

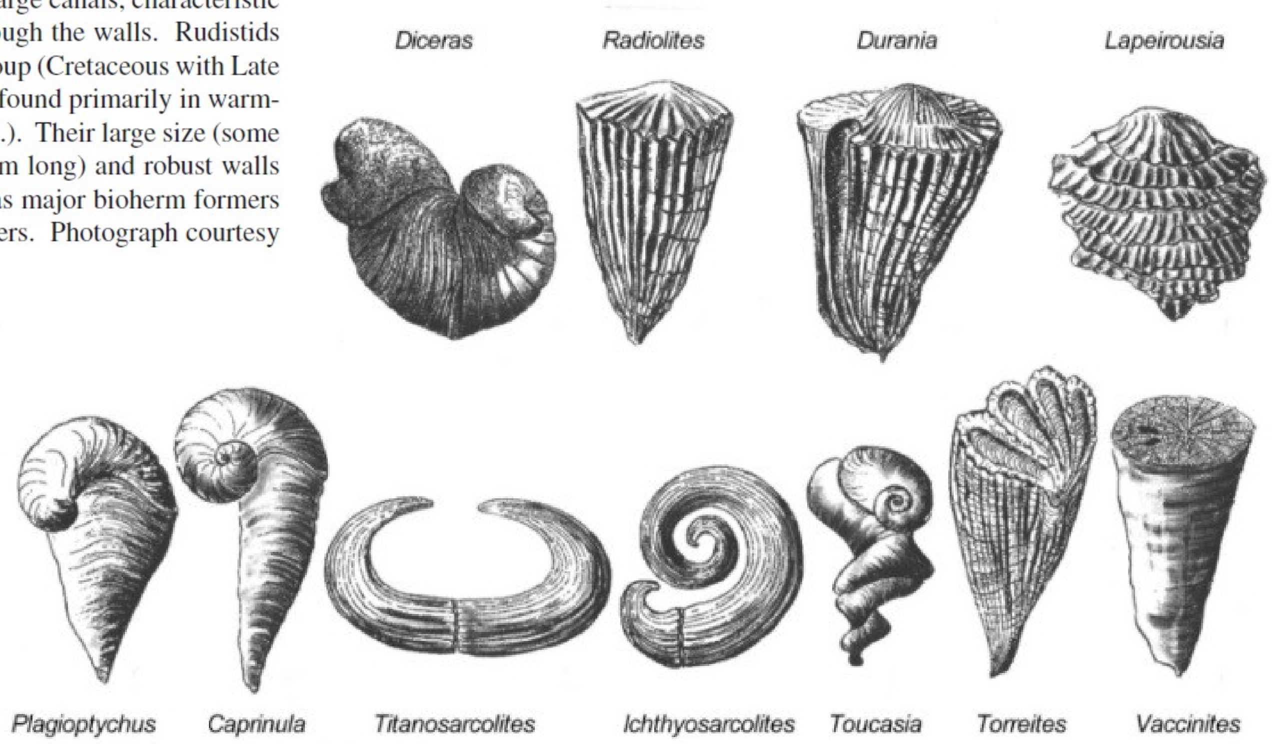
Měkkýši – bivalvia - rudisti



Lo. Cretaceous Rodessa Fm., subsurface, Duke Field, Houston Co., Texas

Arguably the most aberrant of all bivalves are the pachydont rudistids. This image shows a transverse cut through an intact, thick walled, horn shaped, lower valve of *Planocaprina* sp., a caprinid rudistid — large canals, characteristic of caprinids, run through the walls. Rudistids were a short-lived group (Cretaceous with Late Jurassic precursors), found primarily in warm-water areas (0-35° lat.). Their large size (some are greater than 30 cm long) and robust walls enabled them to act as major bioherm formers and sediment producers. Photograph courtesy of Robert W. Scott.

PPL, HA = 13 mm

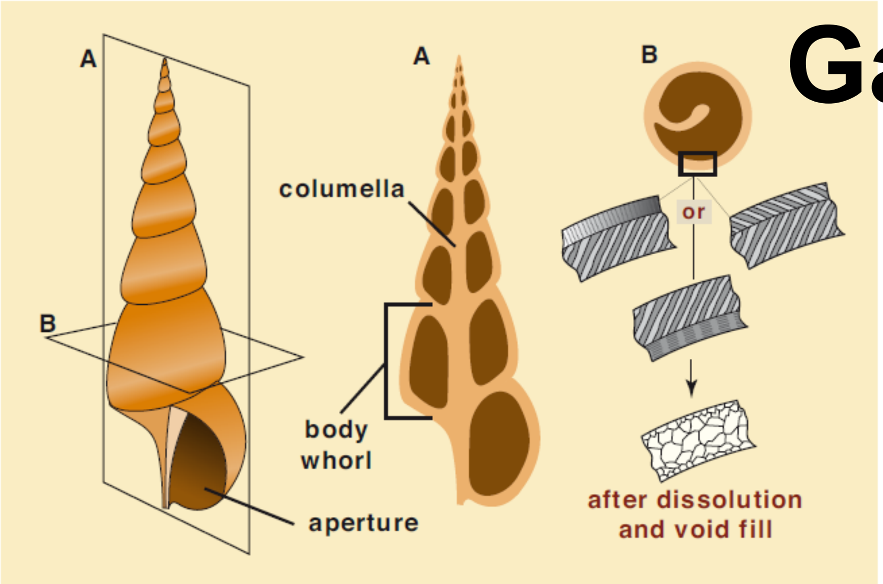


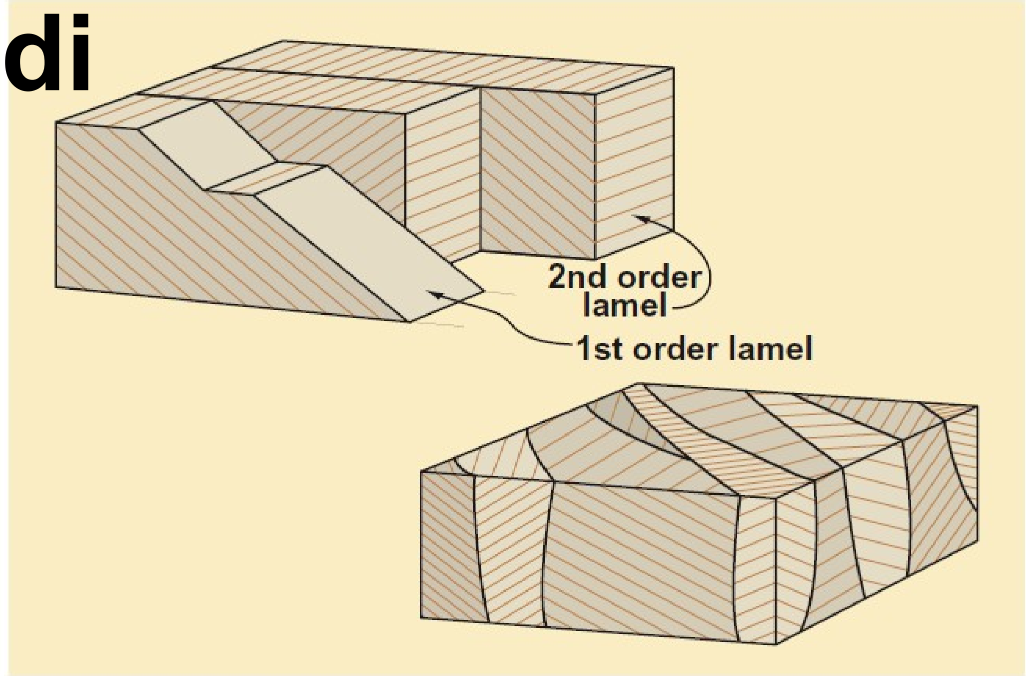
Další významné karbonát produkující organizmy

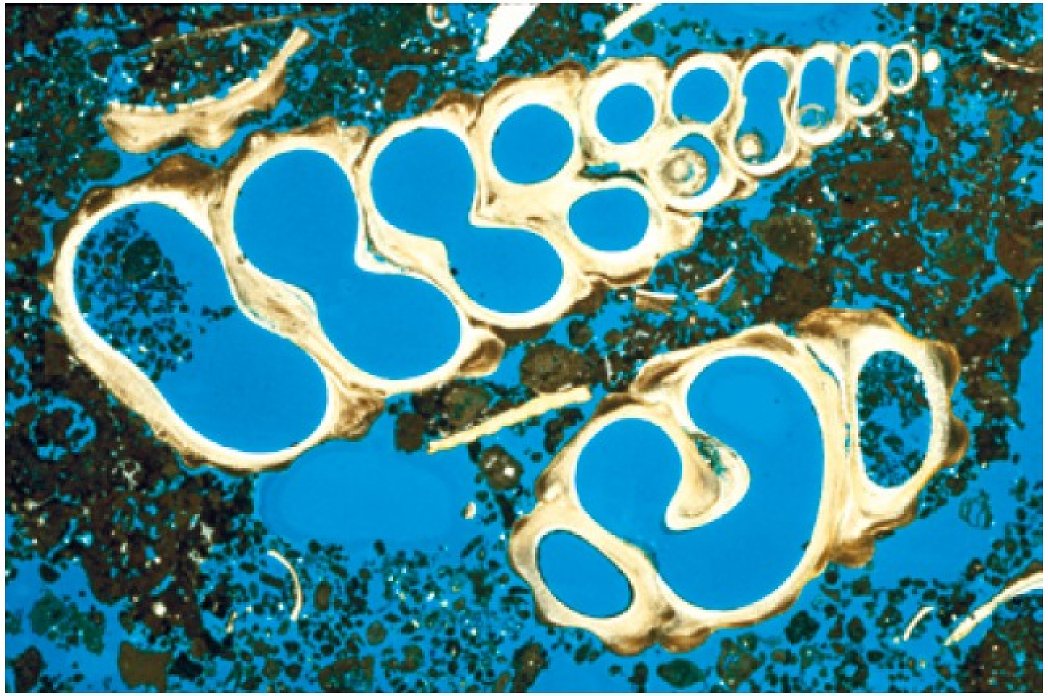
Měkkýši

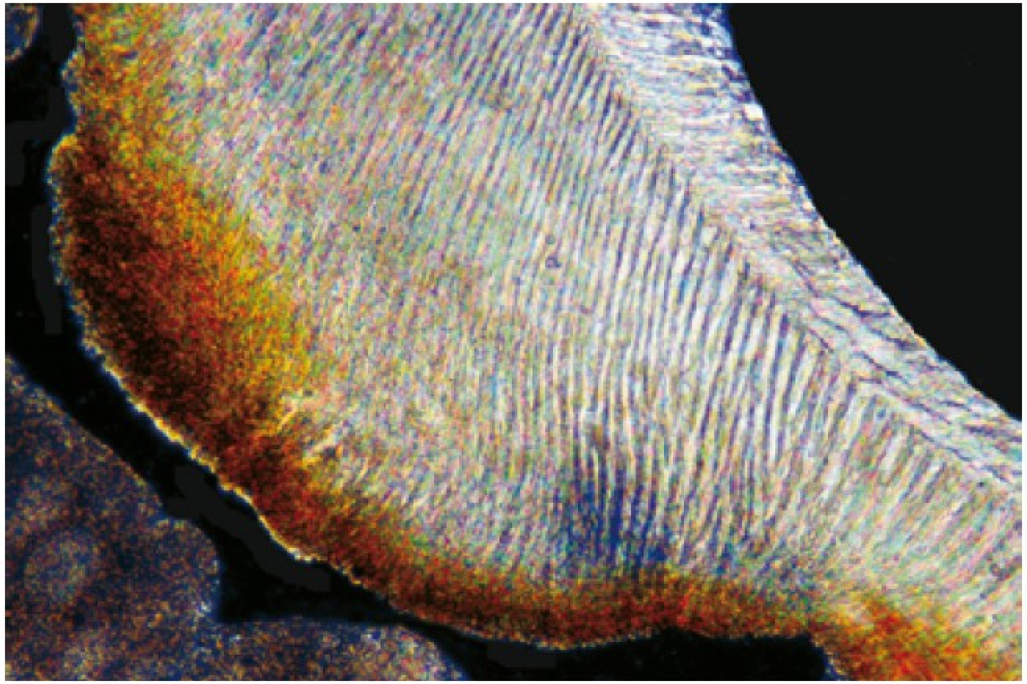
		Aragonite	Low-Mg Calcite	High-Mg Calcite	Aragonite + Calcite	Ca-Phosphates	Silica
Mollusca:	Monoplacophora	●			●		
	Polyplacophora	●					
	Scaphopoda	●					
	Bivalvia	●	●		●		
	Gastropoda	●	●		o		
	Nautiloidea	●	o		o		
	Ammonoidea	●	● Aptychus				
	Belemnoidea				●		

Gastropodi

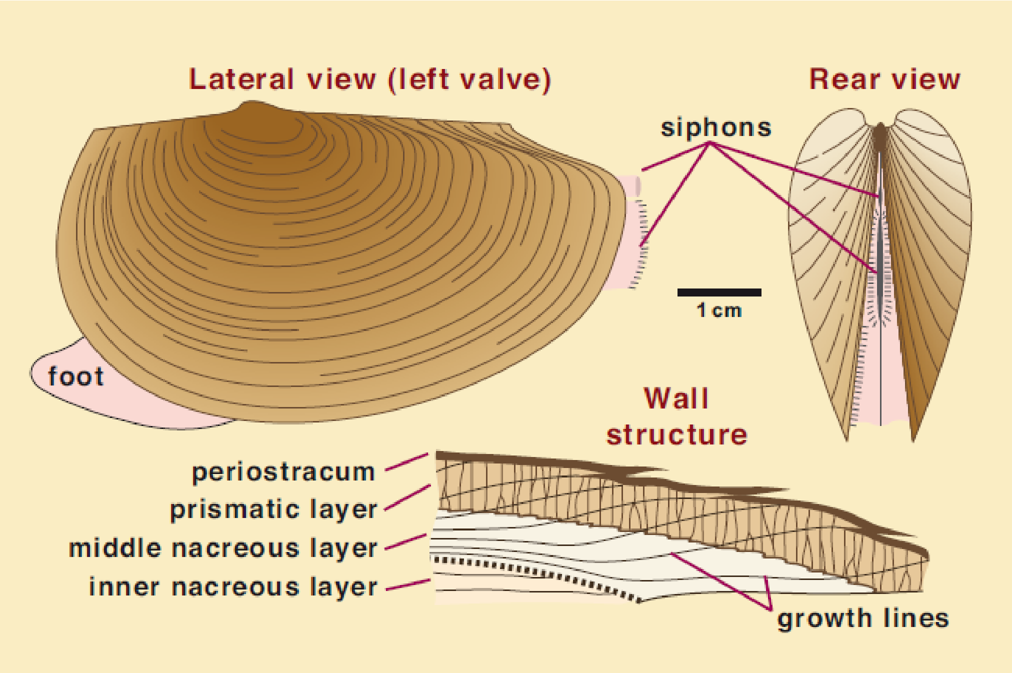

A
B
A
B
columella
body
whorl
aperture
or
after dissolution
and void fill


2nd order
lamel
1st order lamel

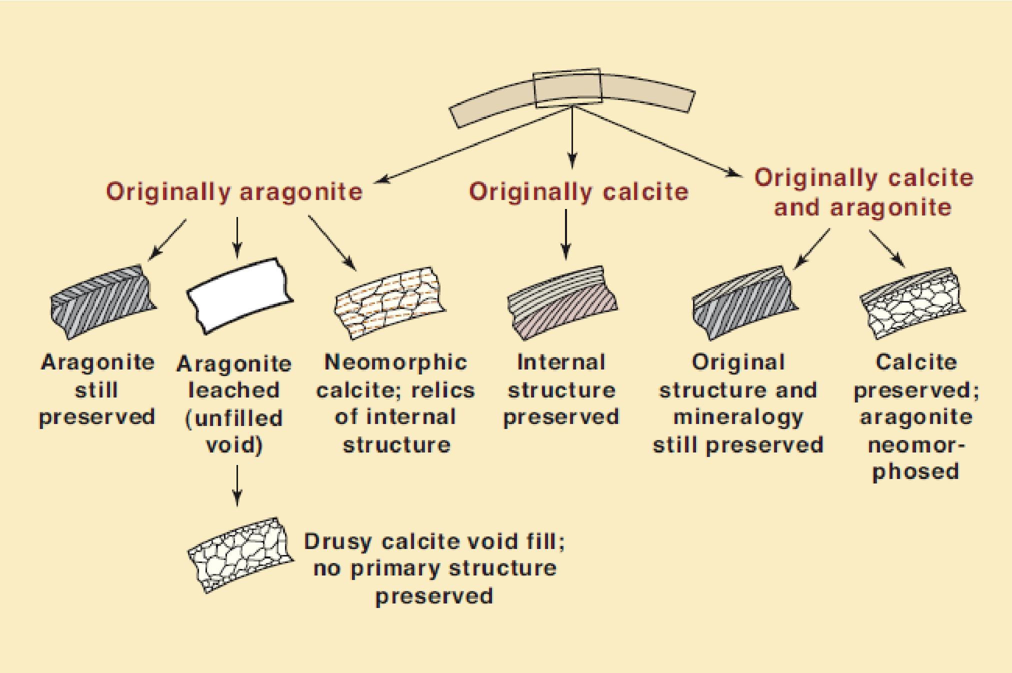




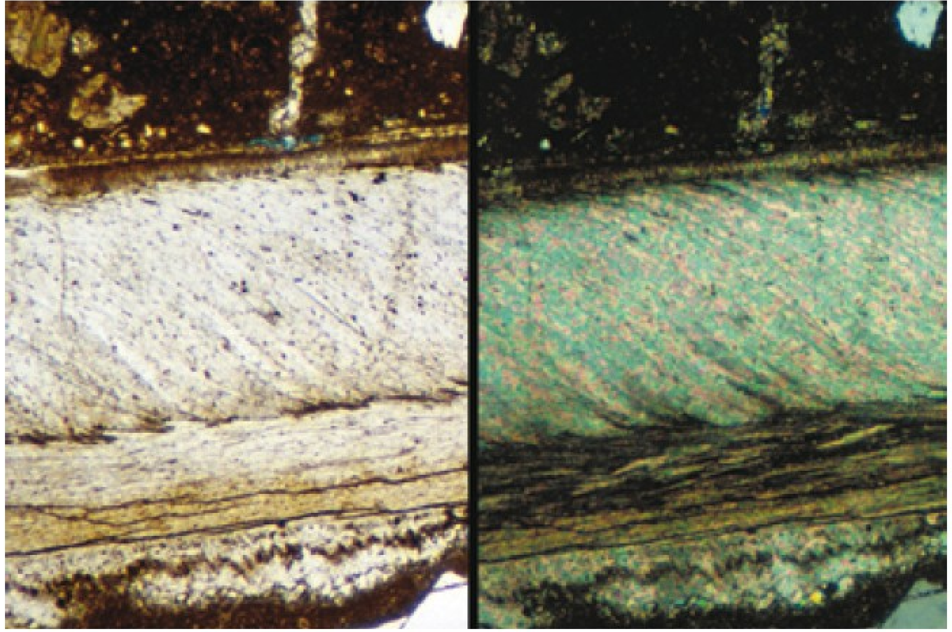
Bivalvia



Lateral view (left valve)
Rear view
siphons
1 cm
foot
Wall structure
periostracum
prismatic layer
middle nacreous layer
inner nacreous layer
growth lines



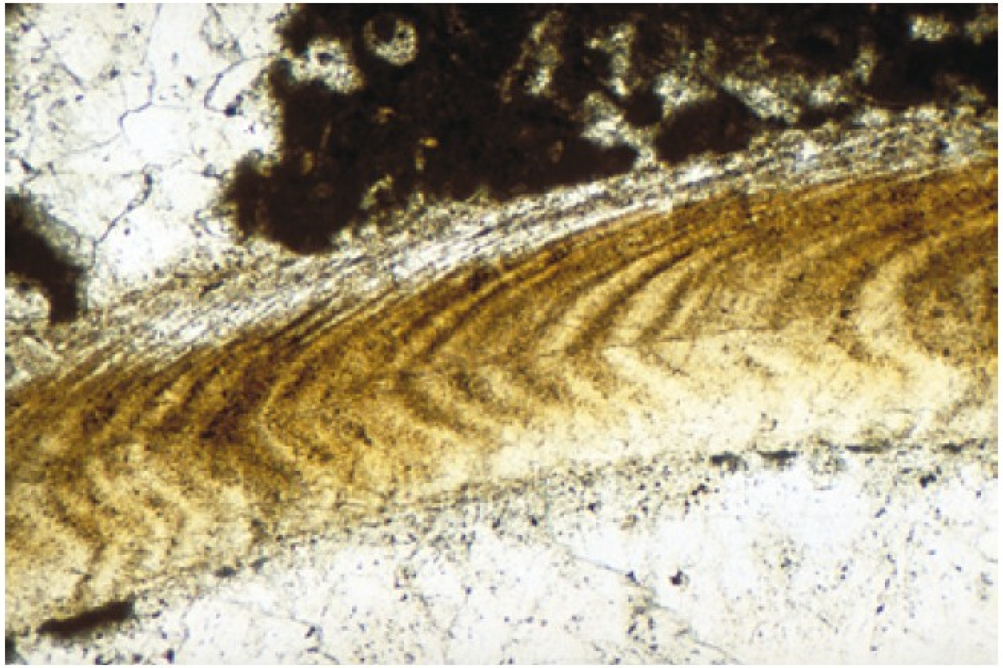
Originally aragonite
Originally calcite
Originally calcite and aragonite
Aragonite still preserved
Aragonite leached (unfilled void)
Neomorphic calcite; relics of internal structure
Internal structure preserved
Original structure and mineralogy still preserved
Calcite preserved; aragonite neomorphosed
Drusy calcite void fill; no primary structure preserved



Oligocene Nile Gp., Westland, New Zealand

A multi-layered bivalve shell showing at least two types of foliated wall structure. Multiple layers with different foliation orientations, as seen here, add considerably to the structural strength of bivalve shells. The foliated structure depicted here is calcitic; essentially the same structure in aragonitic layers is termed "nacreous" fabric. Foliated structure is found in mollusks, brachiopods, some bryozoans, and some worm tubes.

PPL/XPL, HA = 1.0 mm each



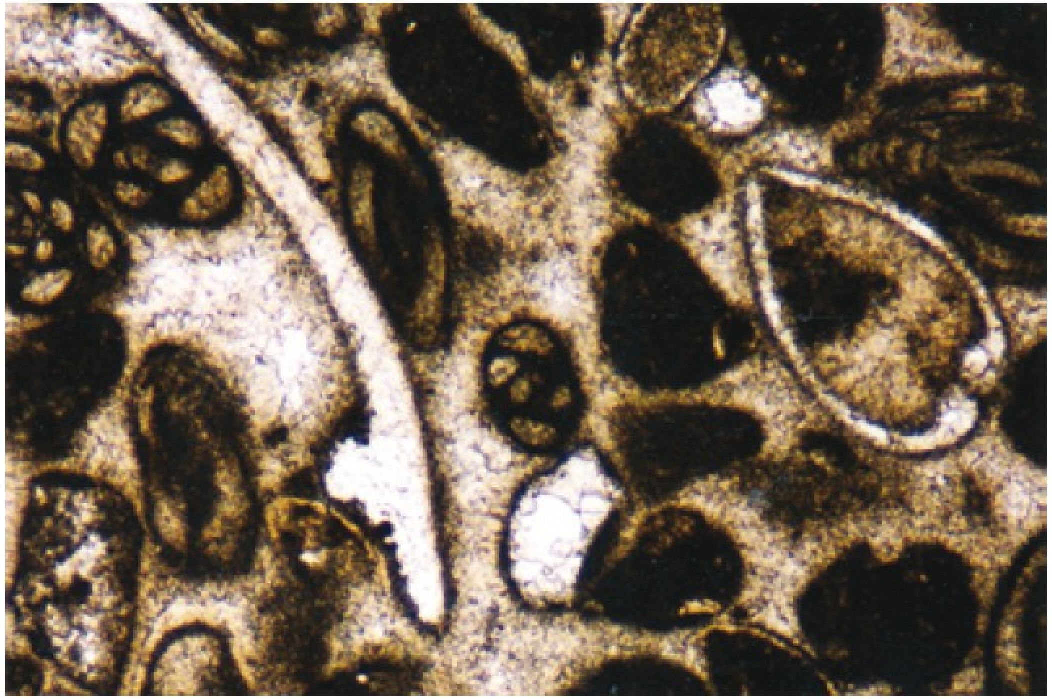
Cretaceous (Albian-Cenomanian) El Abra Ls., San Luis Potosi, Mexico

A shell of *Toucasia* sp. (a thin-shelled rudistid bivalve) showing differential fabric preservation in a two-layer wall structure. The outer layer was originally calcitic; the inner layer aragonitic. Note organic remnants in the calcitic layer and absence of remnants in the neomorphosed formerly aragonitic layer, the edge of which is marked by contact with micrite and miliolid grains.

PPL, HA = 8.0 mm

Zachovaná struktura

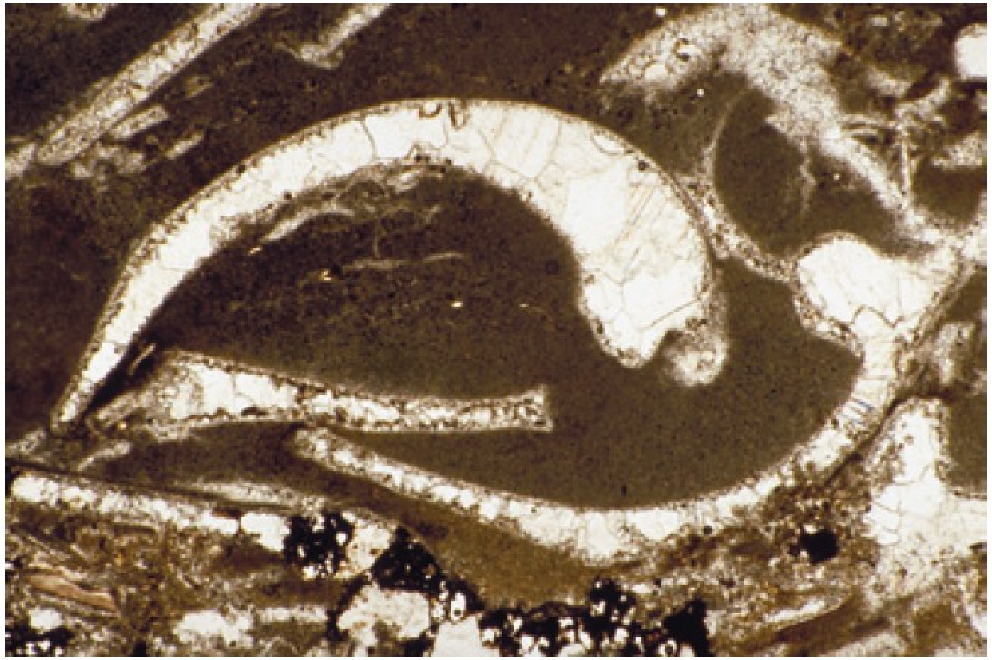
Rozpuštění aragonitové schránky a nahrazení kalcitem



Lo. Cretaceous Cupido Fm., Coahuila, Mexico

Two additional examples of bivalves showing neomorphic alteration (inversion) of their originally aragonitic shells. The alteration here, as in the example above, involved dissolution of aragonite and reprecipitation of more stable calcite spar. This obliterated all relict internal shell structure, so grains are identifiable only on the basis of characteristic shapes (symmetrical shells with distinctive hinge structures) outlined by micrite envelopes. The numerous miliolid foraminifers also present have better-preserved wall structure than the mollusks because of their originally high-Mg calcite test composition.

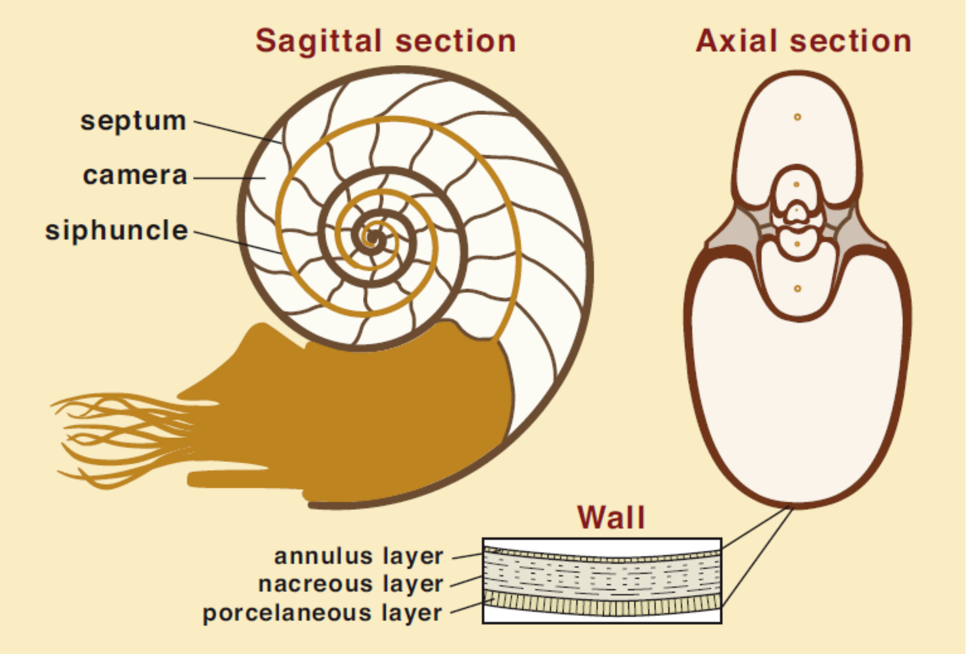
PPL, HA = 2.0 mm



Mid. Triassic Muschelkalk, Western Silesia, Poland

This is an example of the normal appearance of formerly aragonitic bivalve shells after diagenetic alteration. The bivalve shells were dissolved and the molds were later filled with sparry calcite. The bivalve origins remain clear, however, based on shell shapes — smoothly curved and thickening toward the still discernible hinge structures. Less complete fragments would provide greater identification problems.

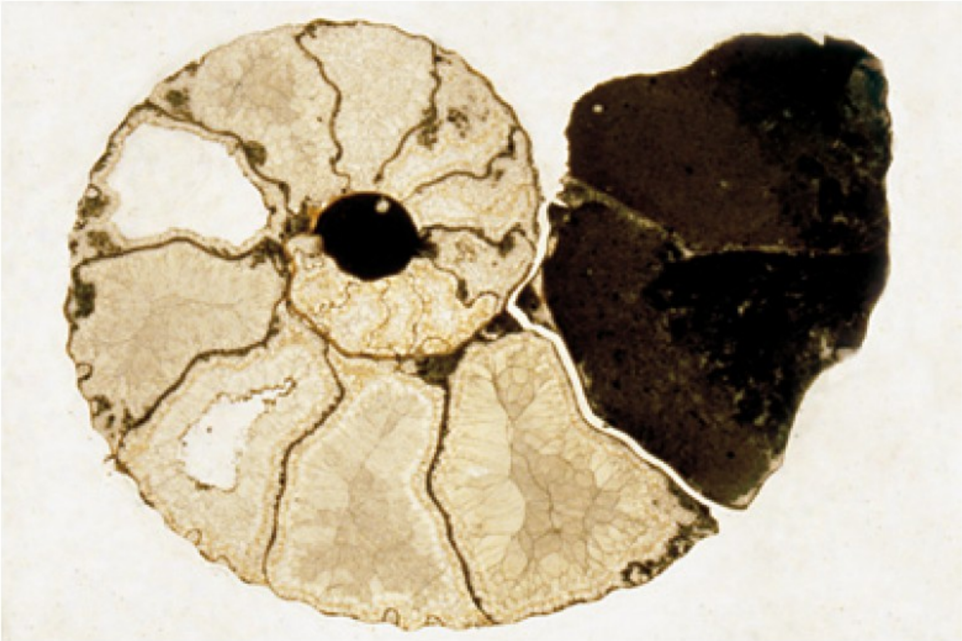
PPL, HA = 7.0 mm



Lo. Carboniferous Dartry Ls., near Sligo, Ireland

A cut through a nautiloid cephalopod with well-preserved internal chambers. The uniformly curved septa and the trace of a siphuncle (the ovoid feature toward the left of center) serve as distinguishing features of nautiloid material. Although the calcareous wall structure is not well preserved, the wall areas have a dark color that may represent preservation of at least a fraction the organic matter that once was a component of the shell wall.

PPL, HA = 25 mm



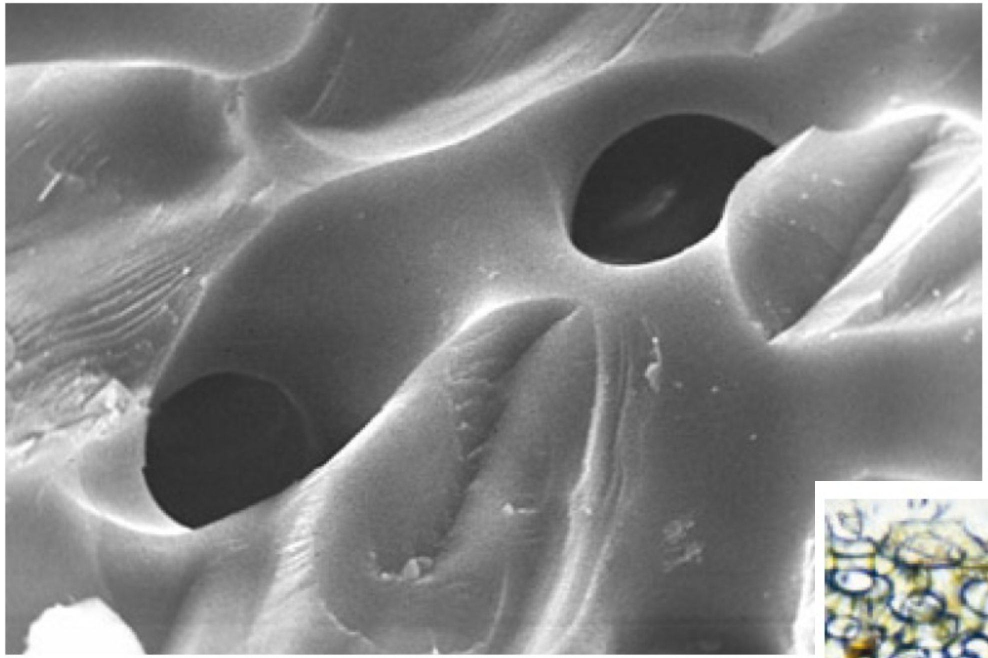
Up. Cretaceous Carlisle Shale (?), South Dakota

A low-magnification view of a sagittal section through a complete ammonite — *Acanthoceras* sp. The spiral, chambered form, the large size, and the thin walls with remnants of brownish organic matter all serve to identify this a coiled cephalopod. The wavy or plicate septa distinguish this as an ammonite (rather than a nautiloid that would have non-plicate septa).

PPL, HA = 35 mm

Cephalopodi

Echinodermata

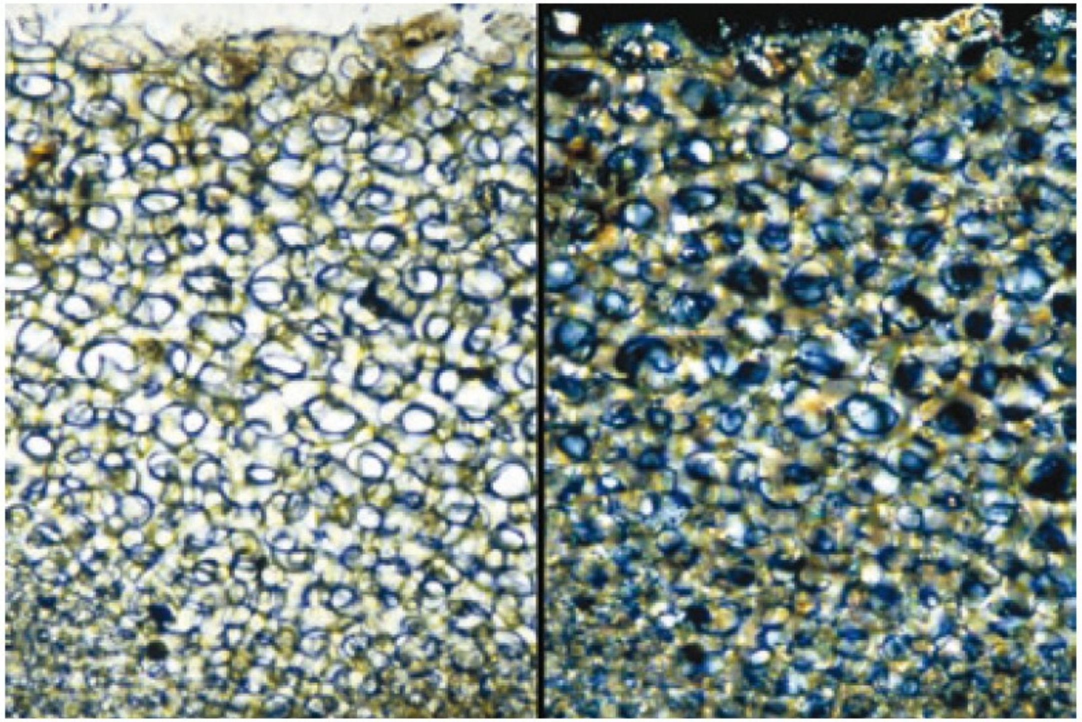


Recent sediment, Belize

An SEM image of a fractured piece of echinoid wall. It illustrates the massive construction of echinoid tests and the network of large pores which transect the structure. In many cases, the intraplate pore space exceeds 50% of the total volume of the plate. Despite the single crystal appearance of the plate, it consists of a mass of microcrystals so small that they are only visible at extreme magnifications.

HMG kalcit

Porézní stavba destiček (struktura stereomu)



Recent echinoid, Florida Keys, Florida

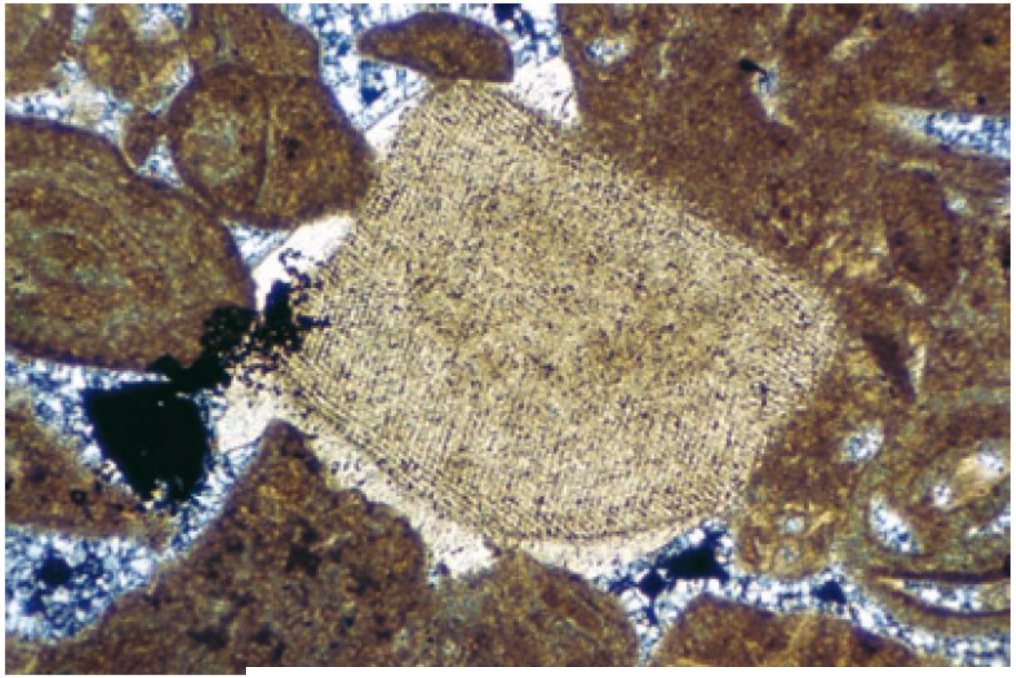
A close-up view of a single echinoid plate. Note predominantly single-crystal extinction (also termed unit extinction) of each plate as well as regular spongy or "holey" fabric produced by tunnels through the otherwise solid high-Mg calcite plates. During diagenesis, these pores typically are either filled with syntaxial calcite cement (in which case they become virtually impossible to see) or with micritic matrix, organic matter or other contrasting material that allows the pores to remain visible.

PPL/XPL, each HA = 3.2 mm

Up. Eocene Ocala Gp., Citrus Co., Florida

A large echinoderm fragment with characteristic single-crystal or unit extinction and uniform "honeycomb" microtexture (small pores filled with micrite). Also note the fact that the grain is surrounded by calcite overgrowths that formed in optical continuity with the grain and predate later silica cement. The irregular shape and lack of a central canal help to distinguish it from a crinoid columnal.

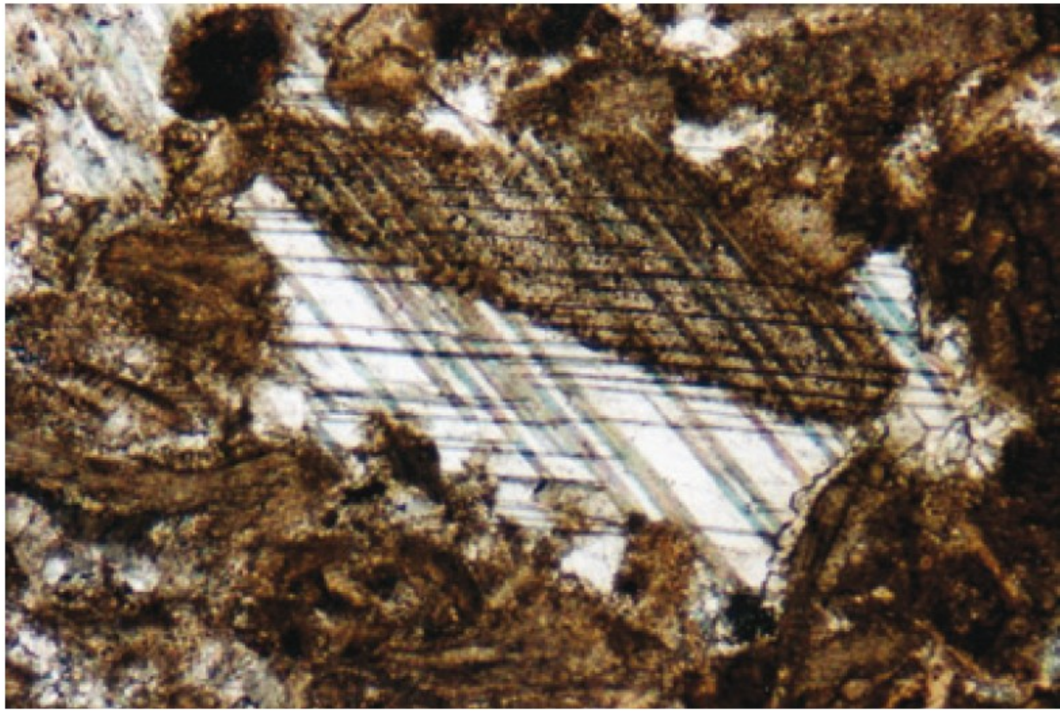
XPL, HA = 2.7 mm

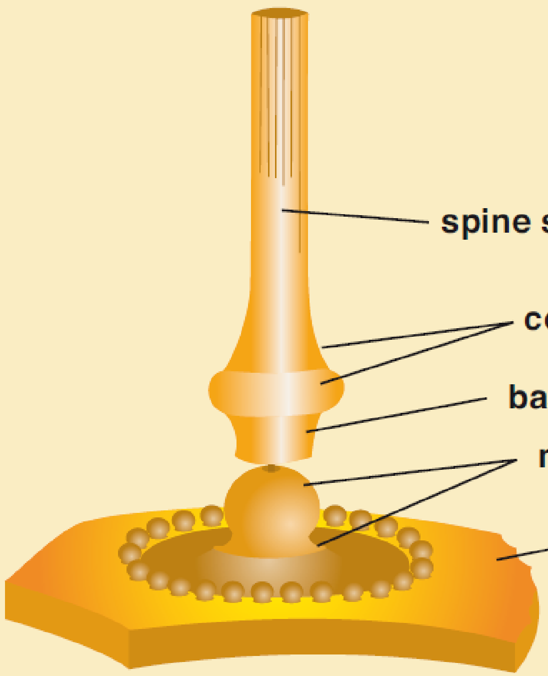


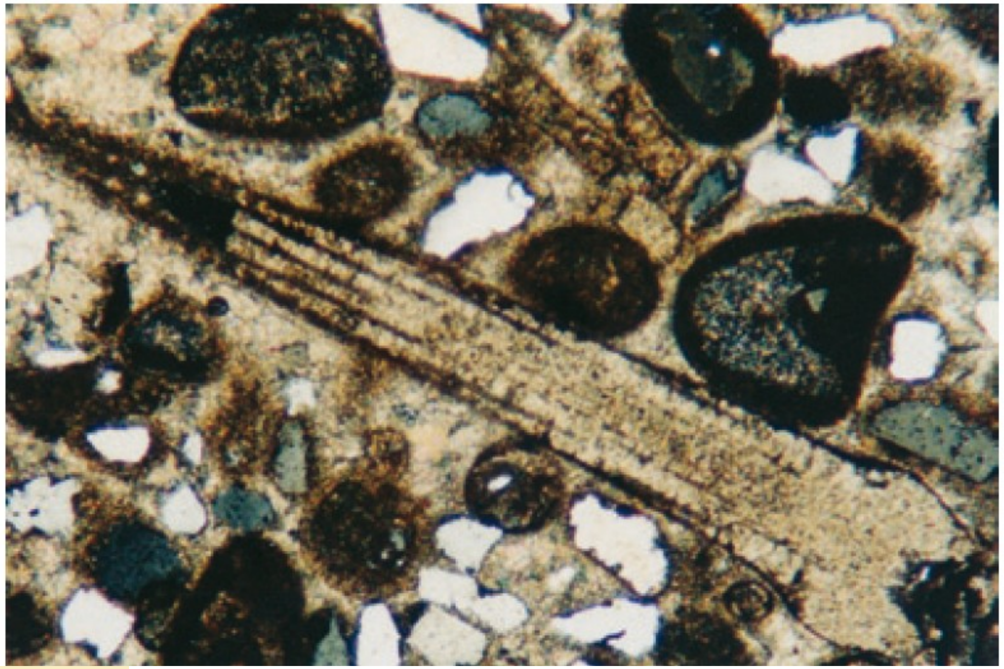
Up. Silurian Tonoloway-Keyser Ls., Mifflin Co., Pennsylvania

An echinoderm fragment with optical single-crystal structure and a large overgrowth in optical continuity (syntaxial cement). The optical continuity is especially apparent here because the twinning lamellae of the calcite crystal are continuous from grain to cement.

PPL, HA = 2.1 mm







Lo.-Mid. Pennsylvanian Bloyd Fm., Mayes Co., Oklahoma

A longitudinal section through an echinoid spine. Note the bulbous attachment socket at one end and the elongate, ribbed, tapering spine itself. As with other echinoid grains, the entire spine acts like a single calcite crystal with unit extinction. The external ribbing visible on the spine in the SEM above reveals the origin of the micrite-filled stripes that parallel the long axis of the thin-sectioned spine.

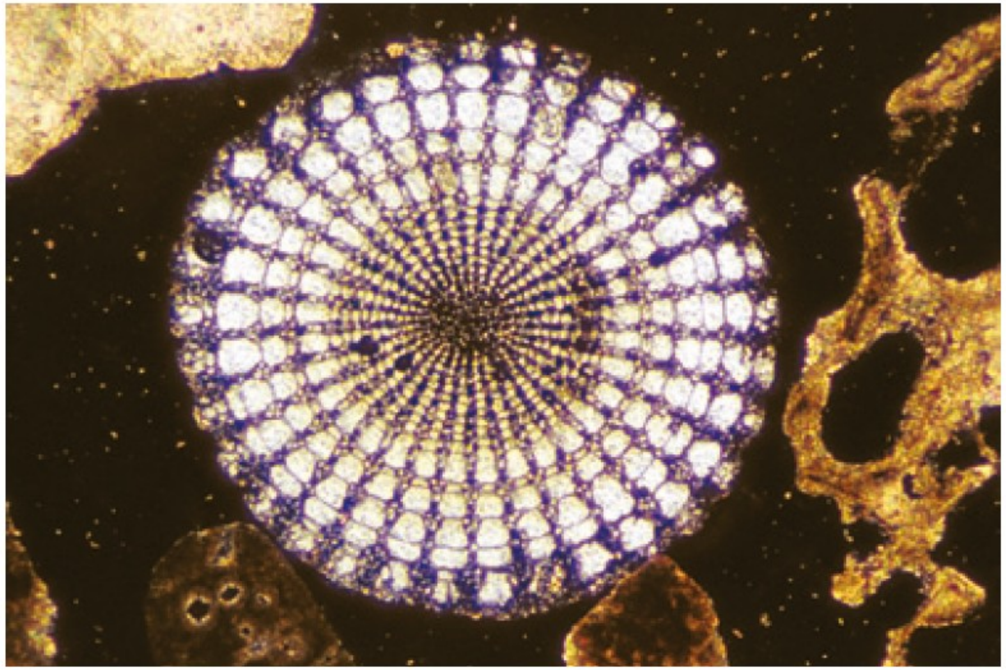
XPL, HA = 1.8 mm

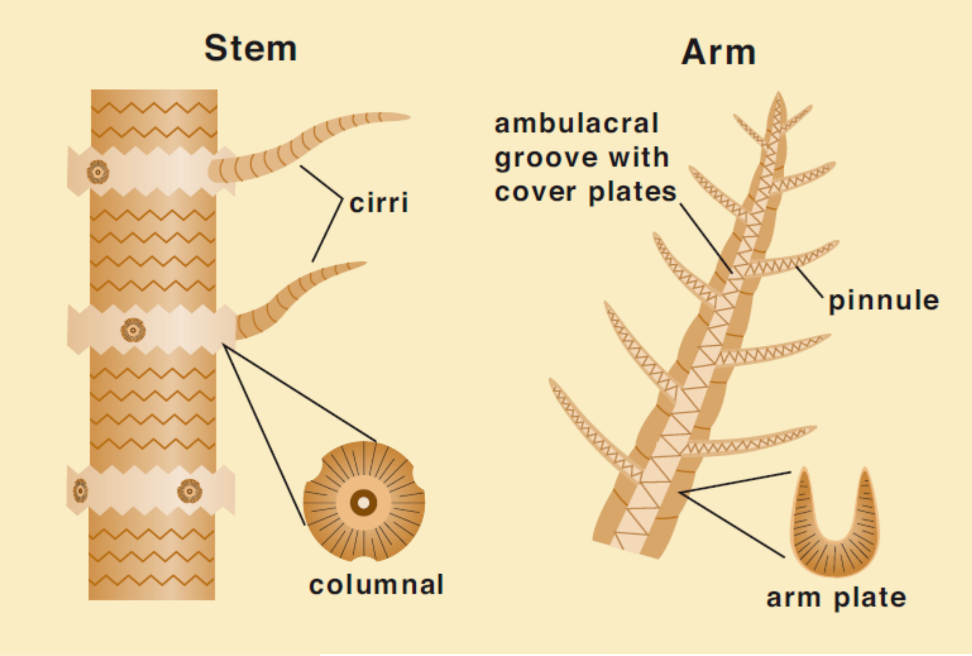
Recent sediment, Cary Cay, Belize

Cross section of an echinoid spine showing single-crystal optical behavior (unit extinction) and a very characteristic lacy or flower-like pattern produced by the regular, radial arrangement of large pores within the spine.

Echinoidi

XPL, HA = 2.1 mm

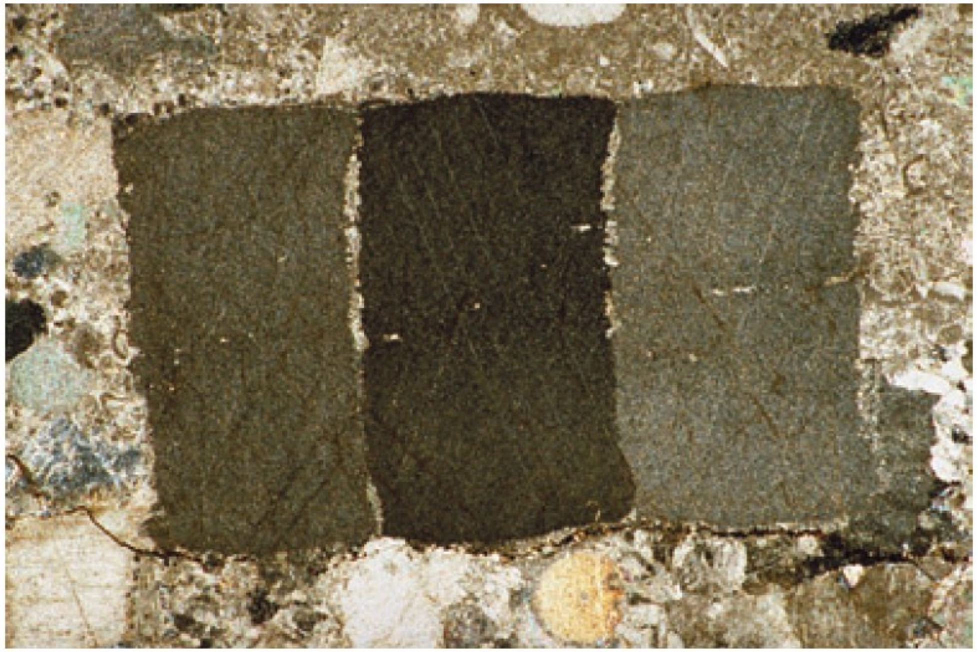




Lo. Mississippian Lake Valley Fm., Otero Co., New Mexico

A longitudinal section showing three articulated crinoid columnals with slightly varying unit extinction. The poker-chip shape of the columnals is clear, but the section is sufficiently off-center that it misses the lumen (axial canal).

XPL, HA = 8 mm

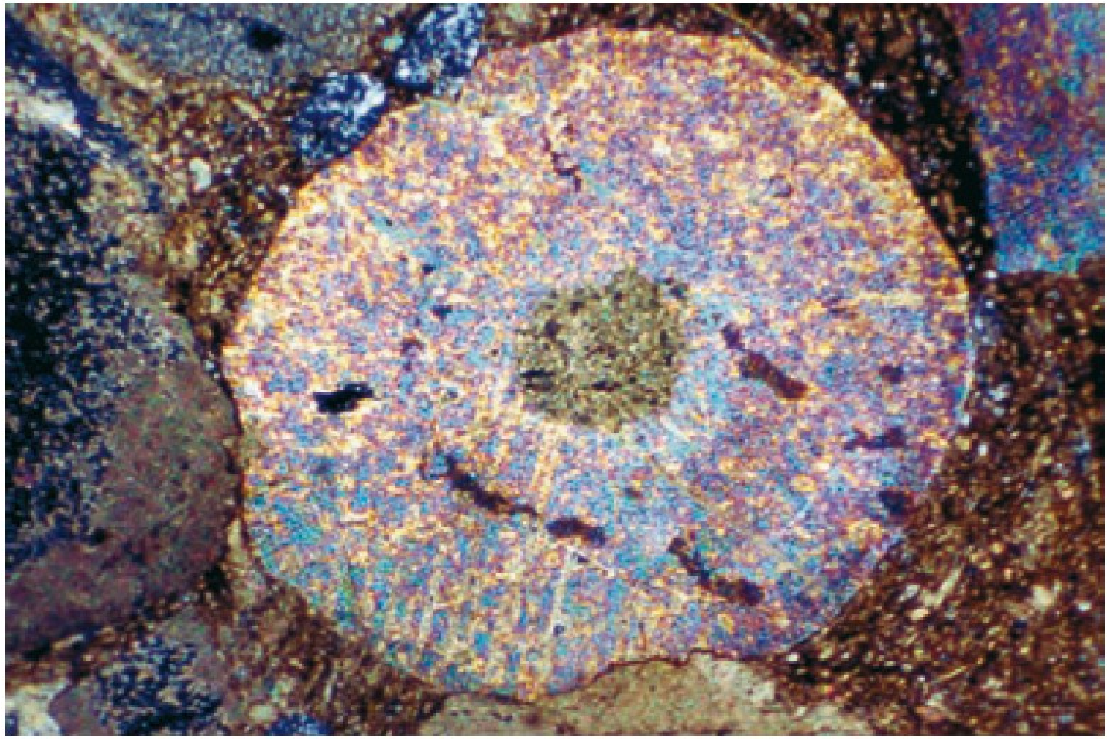


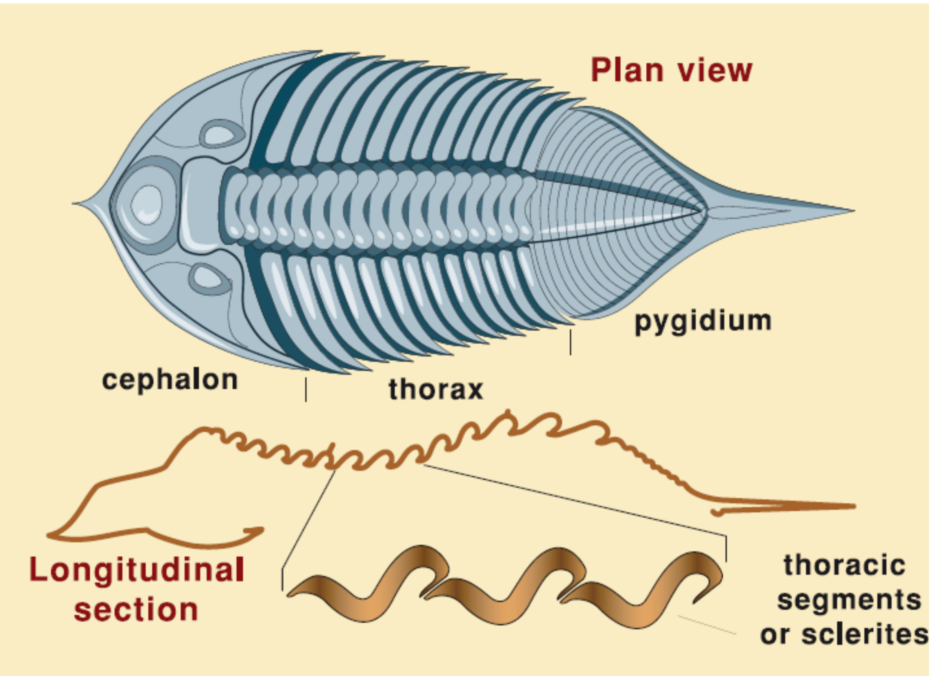
Pennsylvanian Marble Falls Ls., Burnet Co., Texas

A crinoid showing the unit extinction (single-crystal extinction), traces of pore structure, and the axial canal common to this group. The grain has been substantially altered by cementation within pores, by organic boring (and filling of those borings with micrite), and by pressure solution along grain margins. All three of these alteration processes can complicate grain identification.

Krinoidi

XPL, HA = 3.5 mm

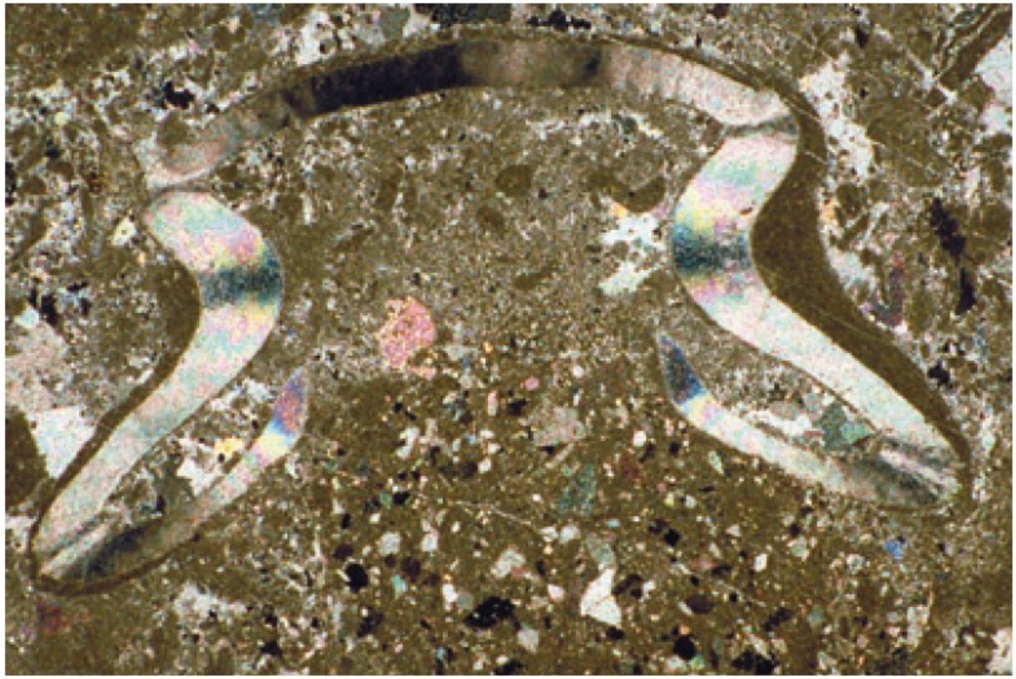




Lo. Ordovician El Paso Gp., Franklin Mountains, Texas

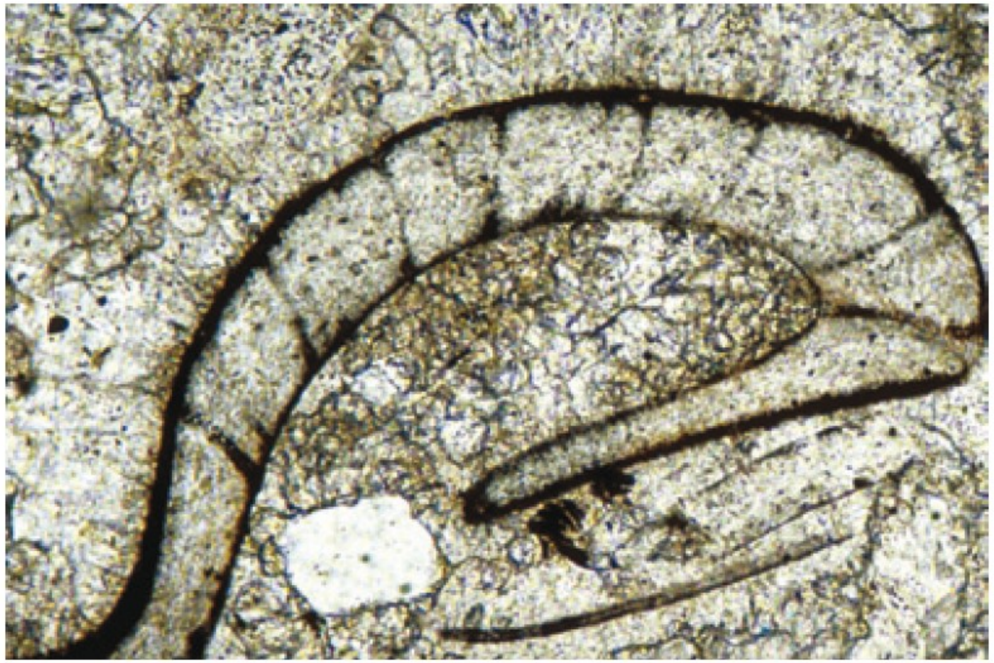
Same field of view as previous photograph. Note the characteristic extinction bands that sweep through the grain as the stage is rotated under cross-polarized light. Such extinction behavior results from the uniform orientation of minute calcite prisms perpendicular to the carapace margin.

XPL, HA = 6 mm



Trilobiti

- Hlavně Ca fosfáty, v mensší míře LMg kalcit



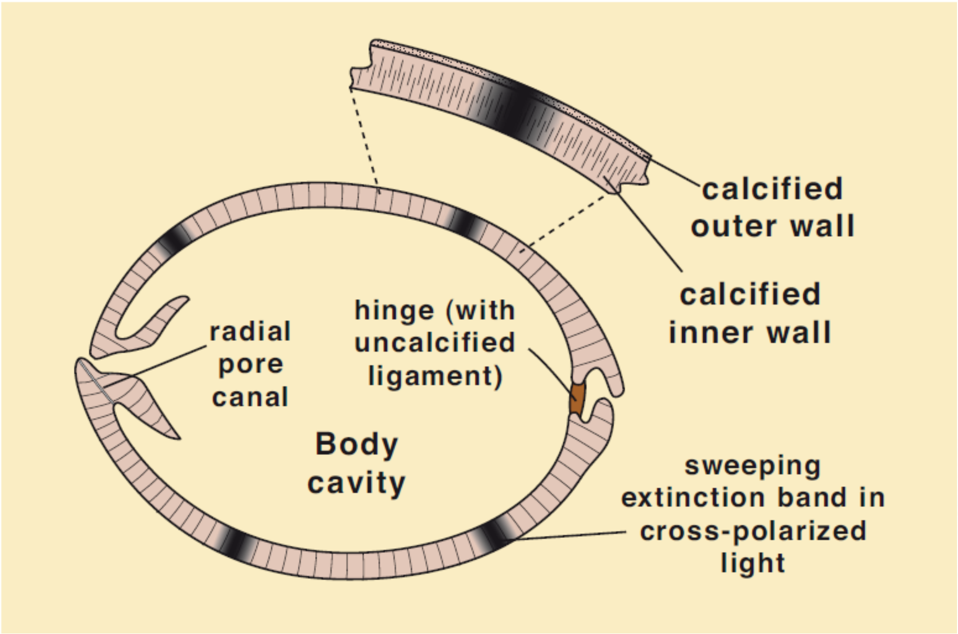
Mid. Ordovician Simpson Gp., Oil Creek Fm., Murray Co., Oklahoma

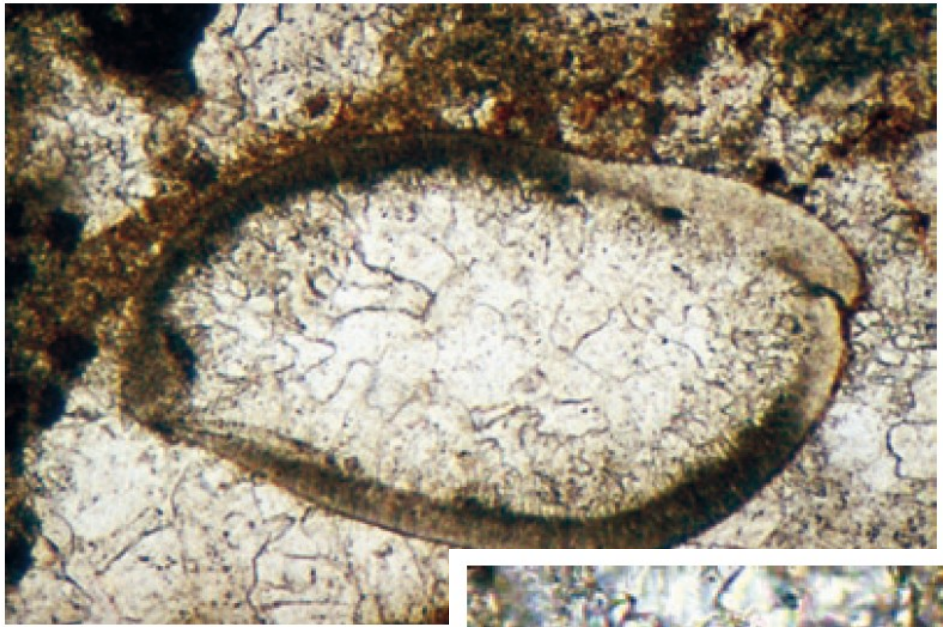
A curved trilobite fragment with a characteristic shepherd's crook shape. Note variations in carapace thickness along the length of the grain. Micritic encrustations on the surface of the grain extend into the exterior portions of carapace pores (canaliculi), enhancing their visibility relative to areas filled with later, clear calcite cement.

PPL, HA = 1.2 mm

Ostrakodi

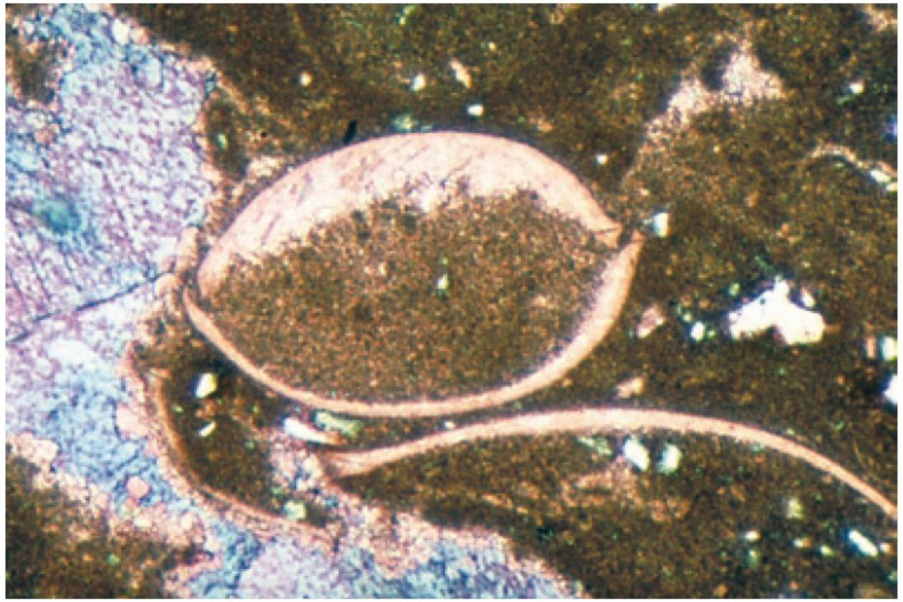
- Hlavně LMg kalcit, v menší míře HMg kalcit





Up. Devonian (Frasnian) Pillara Ls., Canning Basin, Western Australia

A whole ostracode carapace. The shell shows the homogeneous to radial-fibrous shell structure characteristic of this group which also affected the precipitation of early-stage "syntaxial" cements in the carapace interior. Note also the overlap of the two valves.



Up. Permian Zechstein Z1, Bolechowice, Poland

Ostracode carapaces from a marginal marine setting. The complete ostracode shows overlap of valves and a geopetal internal sediment fill.

PPL, AFeS, HA = 1.6 mm