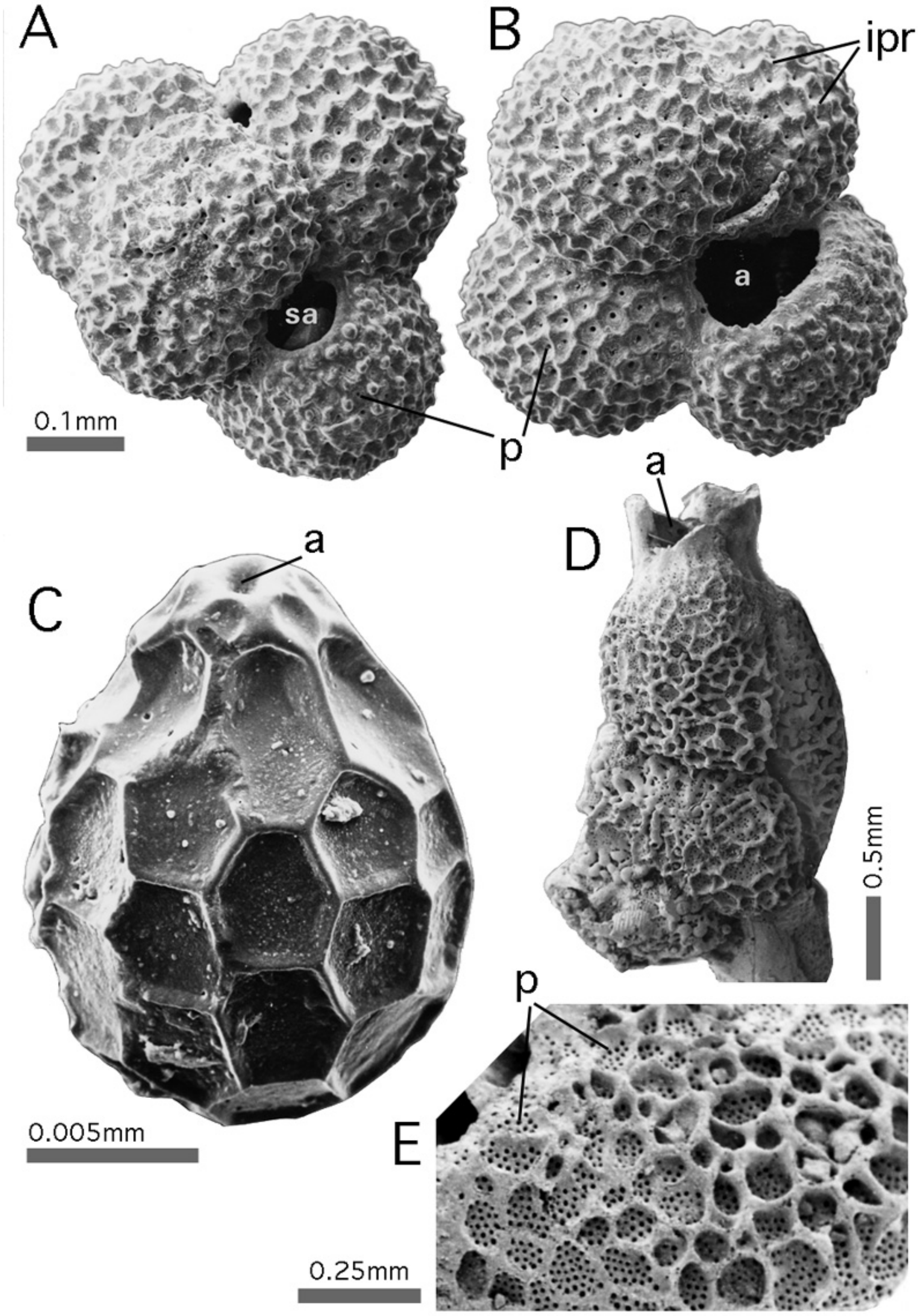


Figure 28: Cancellate ornament in planktic and benthic forms.
A-B: *Globoturborotalites tenella* (PARKER), dorsal view showing supplementary apertures. The cancellate pattern is produced by interpore ridges. **C:** *Favulina hexagona* (WILLIAMSON) showing a very regular pattern. **D-E:** *Carpenteria utricularis* (CARTER) showing a more irregular pattern of ridges delimiting areoli with many pores. All from the Gulf of Aqaba. Recent.
a: aperture; **ipr:** interpore ridge; **p:** pores; **sa:** supplementary aperture.

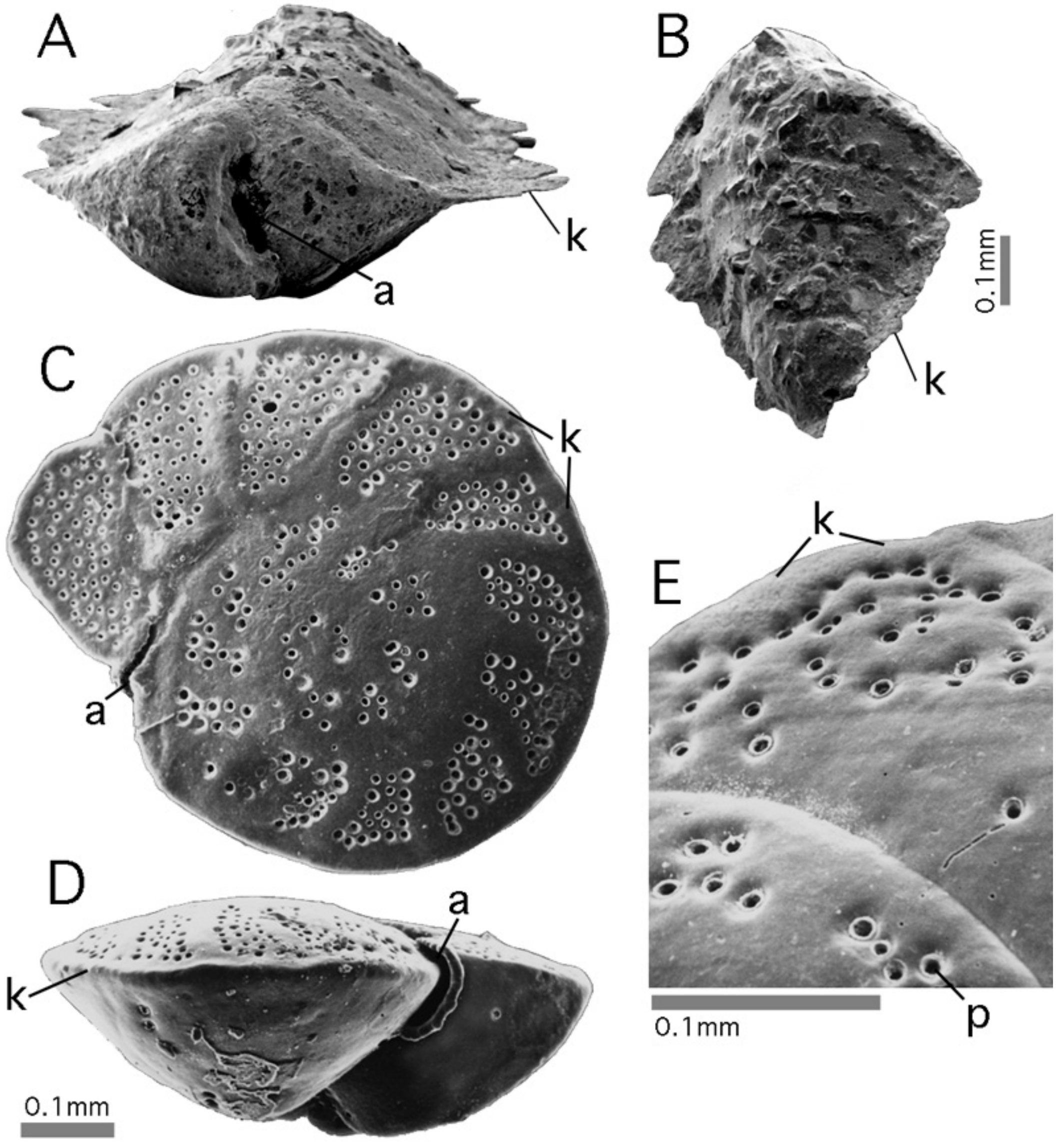
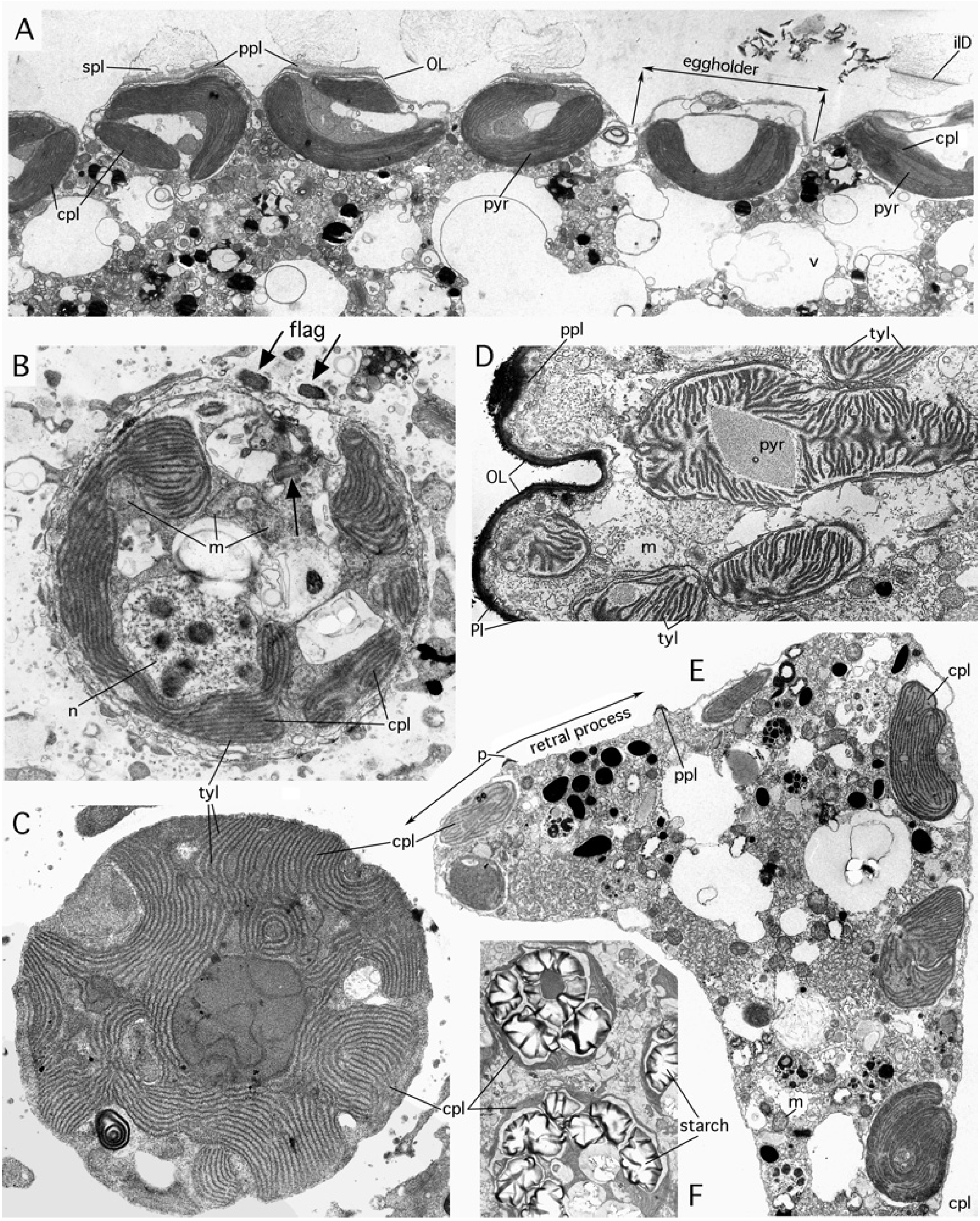


Figure 29: Carina (keel).
A-B: *Spiroplectammina* cf. *taiwanica* (CHANG), apertural view and side view. **C-E:** *Paracibicides edomica* PERELIS et REISS, dorsal (spiral) view, peripheral view and detail of perforation pattern along the peripheral carina on the dorsal surface. Note the interiomarginal, extraumbilical - equatorial position of aperture. All specimens from the Gulf of Aqaba. Recent. SEM graphs.
a: aperture; **k:** carina (keel); **p:** pore.

Figure 30: Chloroplasts of foraminiferal symbionts. Gulf of Aqaba. TEM graphs courtesy S. REBER-LEUTENEGGER. ▶
A: Bacillarian (diatom) symbionts below lateral chamber wall, housed in eggholders, below pore mouths, of *Amphistegina lobifera* LARSEN. x 4,700. **B:** dinophycean (dinoflagellate) symbiont of *Amphisorus hemprichii* EHRENBERG. Note sections of short flagellae (**arrows**) permitting active movement of the symbiont within the lacunar system of the host, to regulate its access to light. The nucleus with its (polyploid) chromosomes visible during the interphase unusual among eucaryotes but characteristic for dinophyceans. x 9,400. **C:** rhodophycean (red algal) symbiont of *Peneroplis planatus* (FICHTEL et MOLL). x 11,300. **D:** Bacillarian symbiont of *Assilina ammonoides* (GRONOVIUS), ultrathin section oblique-tangential to the lateral surface of achamber. Note the loose stacking of the thylacoids in the chloroplast, a characteristic of symbionts of *Assilina*. x 7,550. **E:** *Elphidium craticulatum* (FICHTEL et MOLL), ultrathin section through a protoplast of a chamber including one of its retral processes (double arrow), showing free chloroplasts in the host chamberplasm, a characteristic of symbiont husbandry. x 3,800. **F:** Rhodophycean symbionts of *Peneroplis planatus* (FICHTEL et MOLL) from Elba in the Mediterranean. Note starch grains covering the pyrenoid and filling most of the symbiont's mass. The starch grains may also appear as free grains in the host chamber plasm and represent seasonal food storage for the host. x 3,800.
bD: basal pore disc; **cpl:** chloroplast; **flag:** flagellum with its base; **ilD:** interlamellar disc of pore; **m:** mitochondrium; **n:** nucleus; **OL:** organic lining; **p:** pore; **Pl:** plasmalemma; **ppl:** pore plug; **pyr:** pyrenoid; **spl:** (mineralized) sieve plate; **tyl:** thylacoid; **v:** vacuoles.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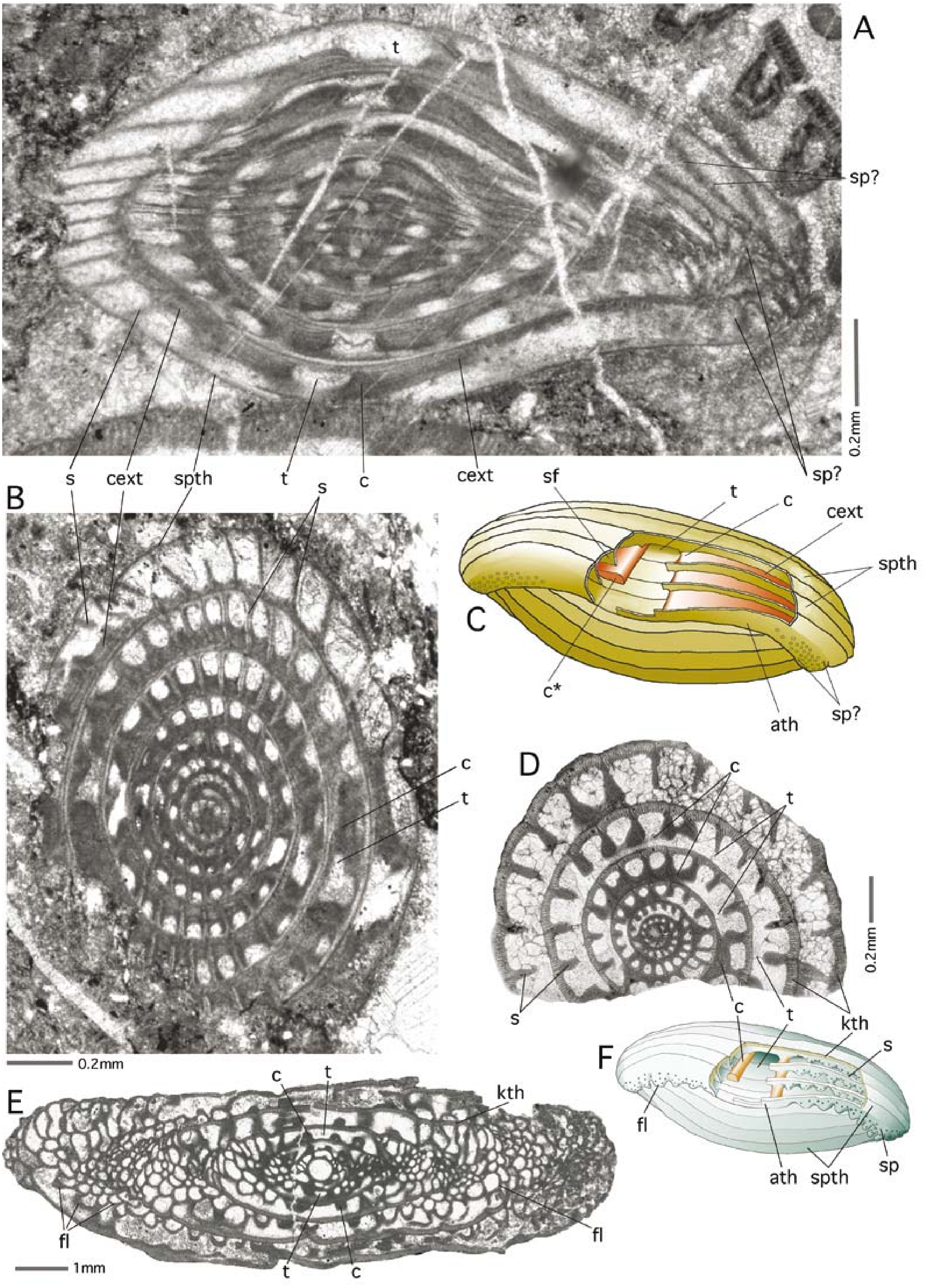
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◀ **Figure 31:** Chomata.
A-C: *Eowedekindellina* sp. Permian, Iran, ALLEMANN collection, oblique, subaxial and subequatorial sections, transmitted light micrographs, and model. Note poleward extension of chomata forming a basal layer. **D-F:** ordinary chomata in *Triticites* sp., equatorial and axial sections, transmitted light micrographs and model. Lower Permian, Spitzbergen. Note in D the sector-wise appearance and disappearance of the chomata due to the slight obliquity of the section.
ath: antetheca; **c:** choma; **c*:** cutoff choma stressing the uncertainty about the connection between the choma and the antetheca; **fl:** fluted septa; **kth:** keriotheca; **s:** septum; **sp:** septal pores; **spth:** spirotheca; **t:** tunnel.

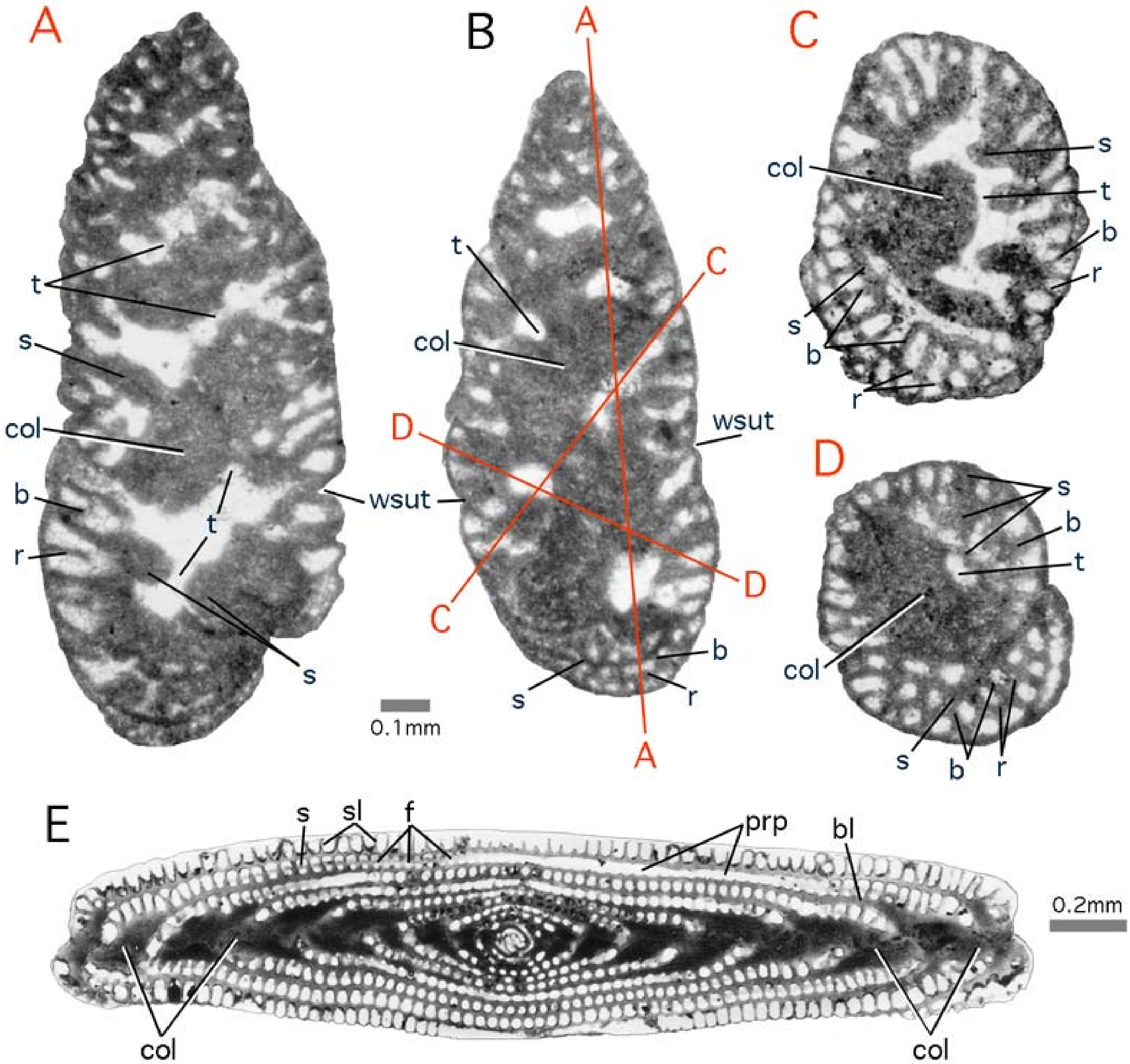


Figure 32: Columellas. Transmitted light micrographs.
A-D: *Kurnubia palastiniensis* HENSON. Upper Jurassic, Northeastern Morocco. **A:** transverse section near and almost parallel to the axis of coiling; **B:** axial section; **C-D:** oblique sections. Position of sections relative to the axial section marked by red lines. **E:** *Borelis schlumbergeri* (REICHEL), axial section. Gulf of Aqaba. Recent. Note double columella in planispiral-fusiform shells.
b: beam; **bl:** basal layer; **col:** columella; **f:** foramina; **prp:** preseptal passage; **r:** rafter; **s:** septum; **sl:** septulum; **t:** tunnel; **wsut:** whorl suture.

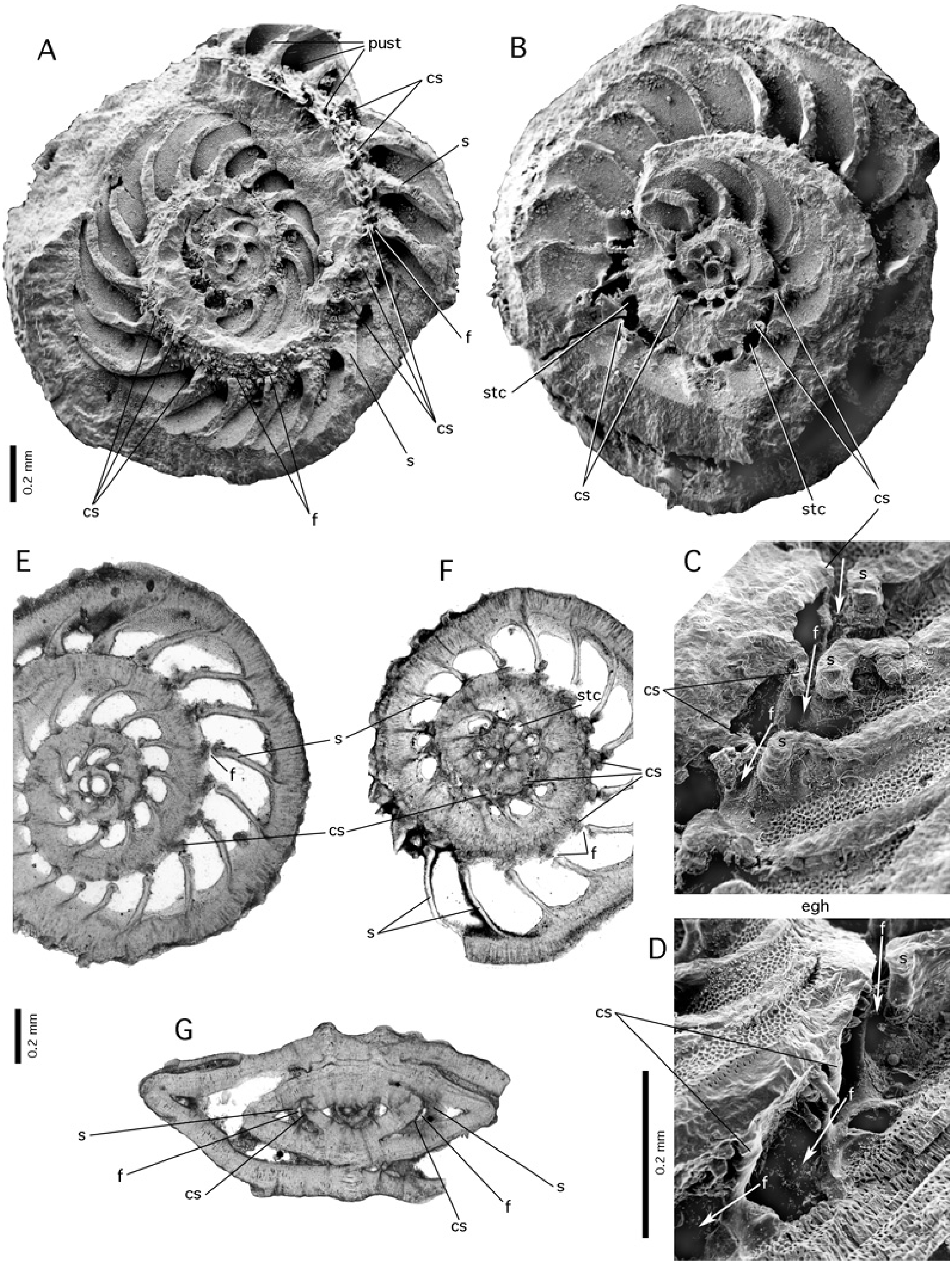


Figure 33: Countersepta.
A-D: *Amphistegina tuberculata* BERMUDEZ, Dominican Republic, Upper Miocene, SEM stereographs showing the split halves of a megalospheric shell. **A:** dorsal side in ventral view, **B:** ventral side in dorsal view, with details in **C** and **D**. **E-G:** *Amphistegina lopeztrigoi* PALMER, thin slides in transmitted light micrographs, Eocene, Florida. Generic and specific name are unclear and need revision. **E:** centered section perpendicular to the coiling axis; **F:** section perpendicular to the coiling axis located below the megalosphere; **G:** poorly centered axial section.
cs: counterseptum; **egh:** eggholder; **f:** main foramen; **pust:** pustules covering successive faces; **s:** septum of main chambers; **stc:** stellar chamberlets.

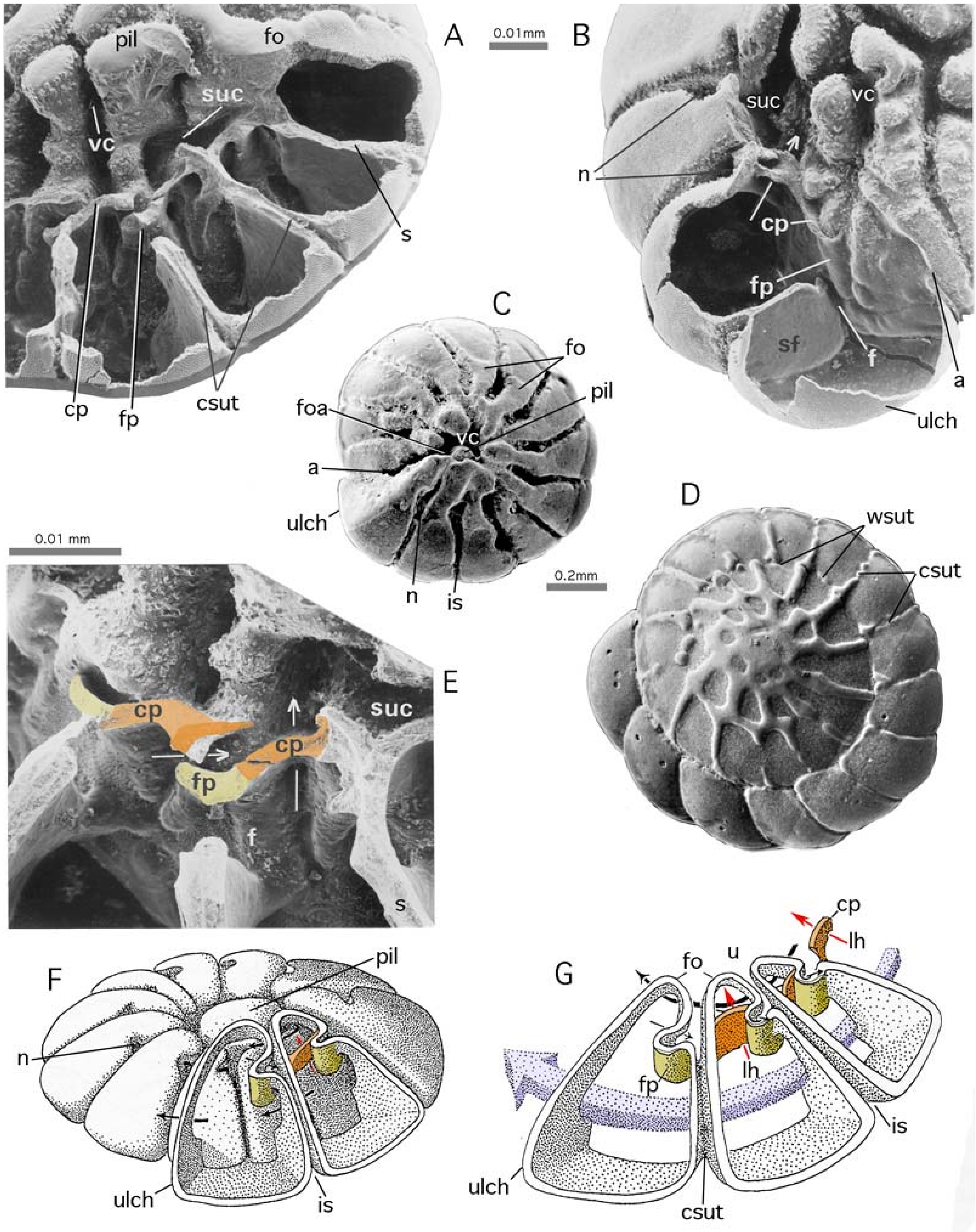


Figure 34: Cover plate and foramenal plate in *Challengerella bradyi* BILLMAN *et alii* from the Gulf of Aqaba. Recent. SEM graphs.
A-B: dissected specimens in oblique ventral view. **C:** young specimen, ventral view. Note incipient umbilical pile against which the foliar walls are beginning to fuse, covering the spiral interlocular space. **D:** dorsal (spiral) view of adult megalospheric specimen. **E:** Detail showing foraminal and cover-plates. Colours corresponding to those used in the models. White arrow: loop-hole. **F:** general model showing position of plates and communications. Note position of loop-hole (red arrow). **G:** Detail of umbilical structures in last three chambers. Note the separation of streaming chamber plasm through successive foramina (blue arrow) and circulation in the umbilical interlocular space (black arrow) by the umbilical structures. Models schematic, not to scale, after HOTTINGER, 2000.
a: aperture; **cp:** coverplate; **csut:** chamber (septal) suture; **f:** foramen; **fo:** folium; **foa:** foliar aperture; **fp:** foramenal plate; **isp:** interlocular (intrasepal) space; **lh:** loop-hole; **n:** notch; **pil:** umbilical plug; **s:** septum; **sf:** septal flap; **suc:** spiral umbilical interlocular space, transformed into spiral canal when covered by foliar extensions; **u:** umbilicus; **ulch:** ultimate chamber; **vc:** funnel (vertical canal); **wsut:** whorl (spiral) suture.

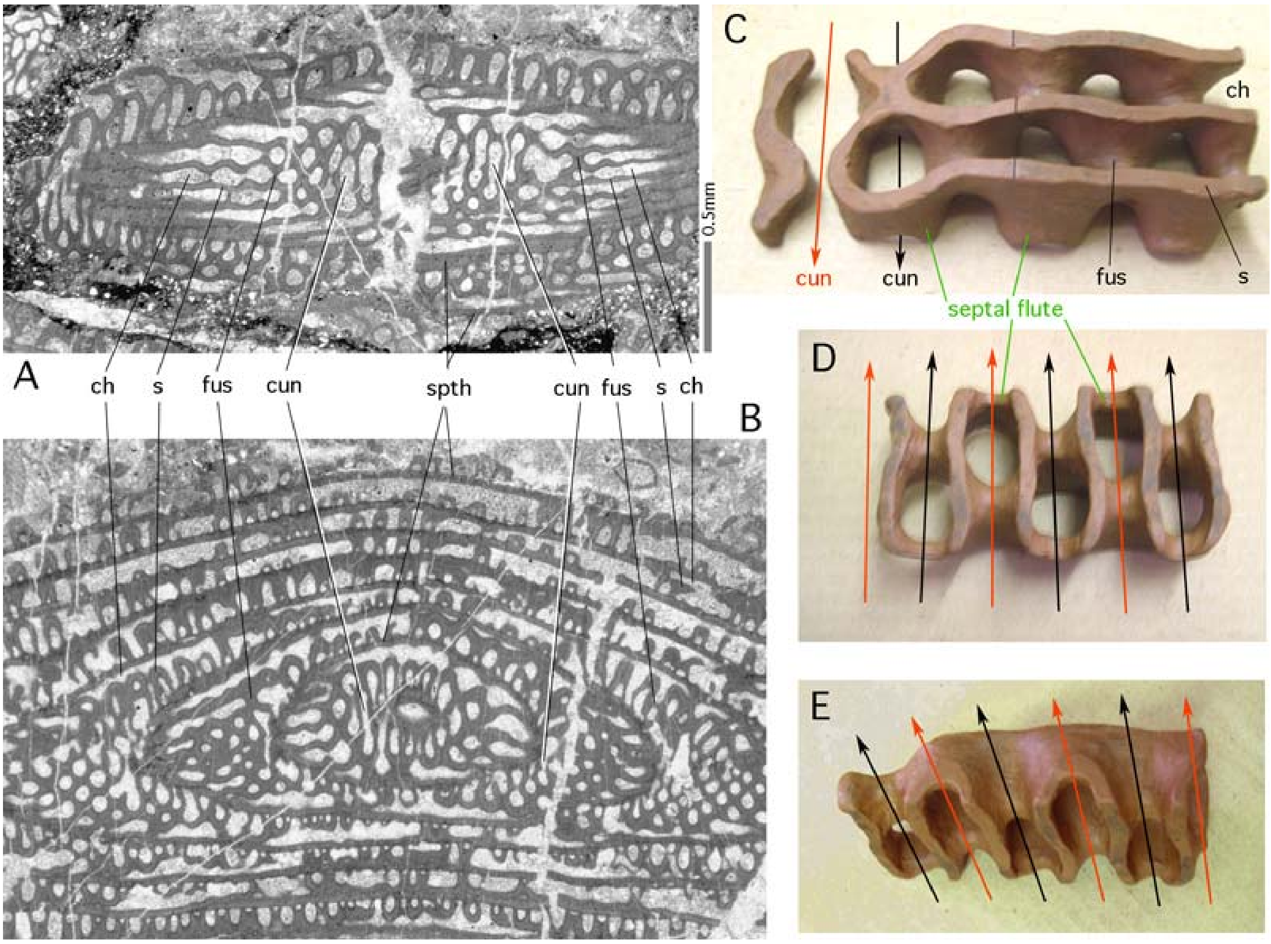


Figure 35: Cuniculi and septal fluting in *Eopolydiexodina* sp. Transmitted light micrographs. ALLEMANN collection, Permian, Iran.
A: shallow tangential section parallel to coiling axis. **B:** Deep transverse section parallel to coiling axis. **C-E:** plasticine model sculptured about 1945 by M. REICHEL (* 1896 - † 1984). **C:** Oblique peripheral view showing undivided peripheral parts of two successive chambers. Arrows point in the direction of growth. **B:** Proximal view showing cuniculi (arrows). **C:** oblique proximal view showing fluted septal face and cuniculi.
ch: chamber lumen; **cun:** cuniculus; **fus:** point of fusion of subsequent septal flutes in opposing positions; **s:** septum; **spth:** spirotheca carrying a keriotheca.

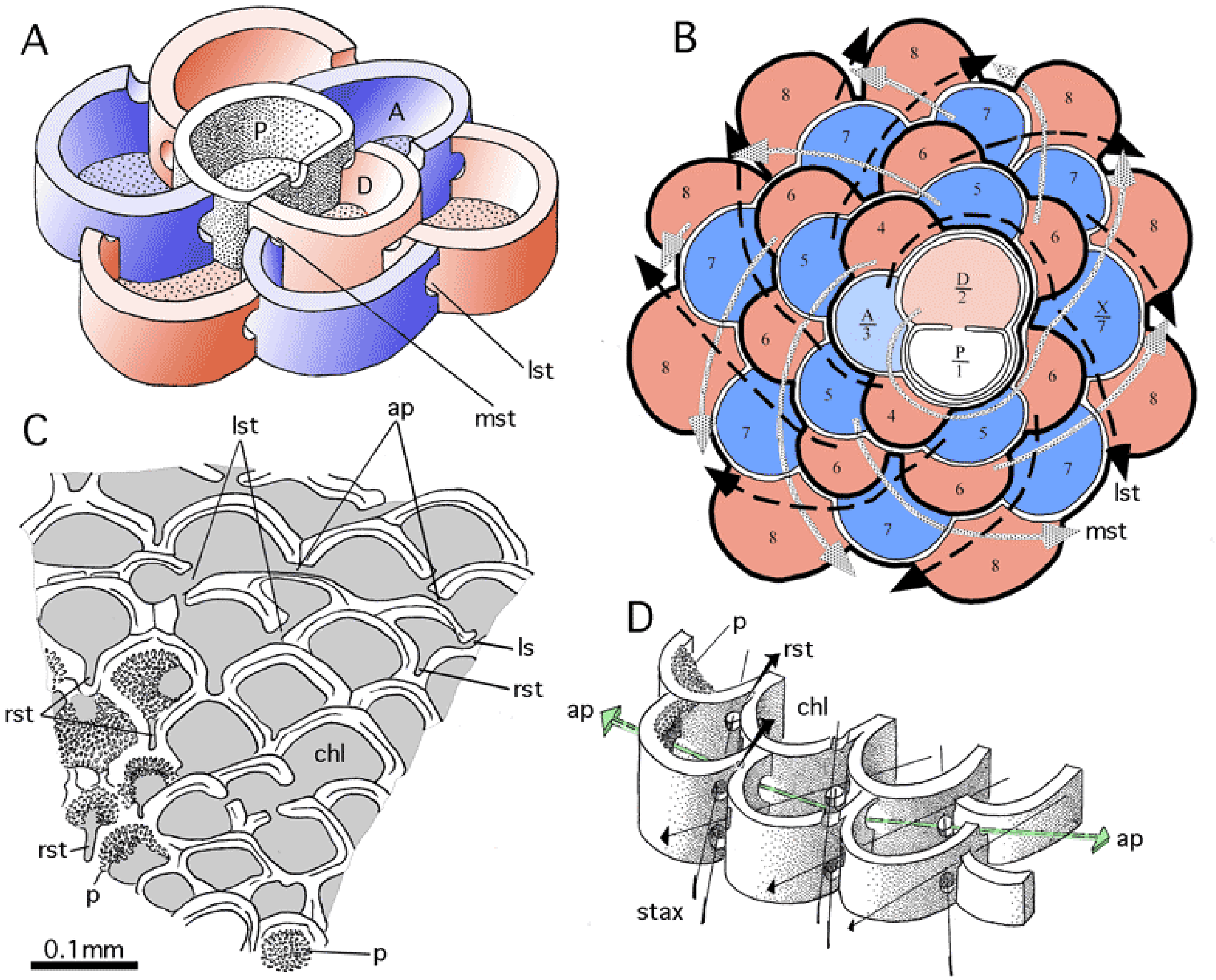
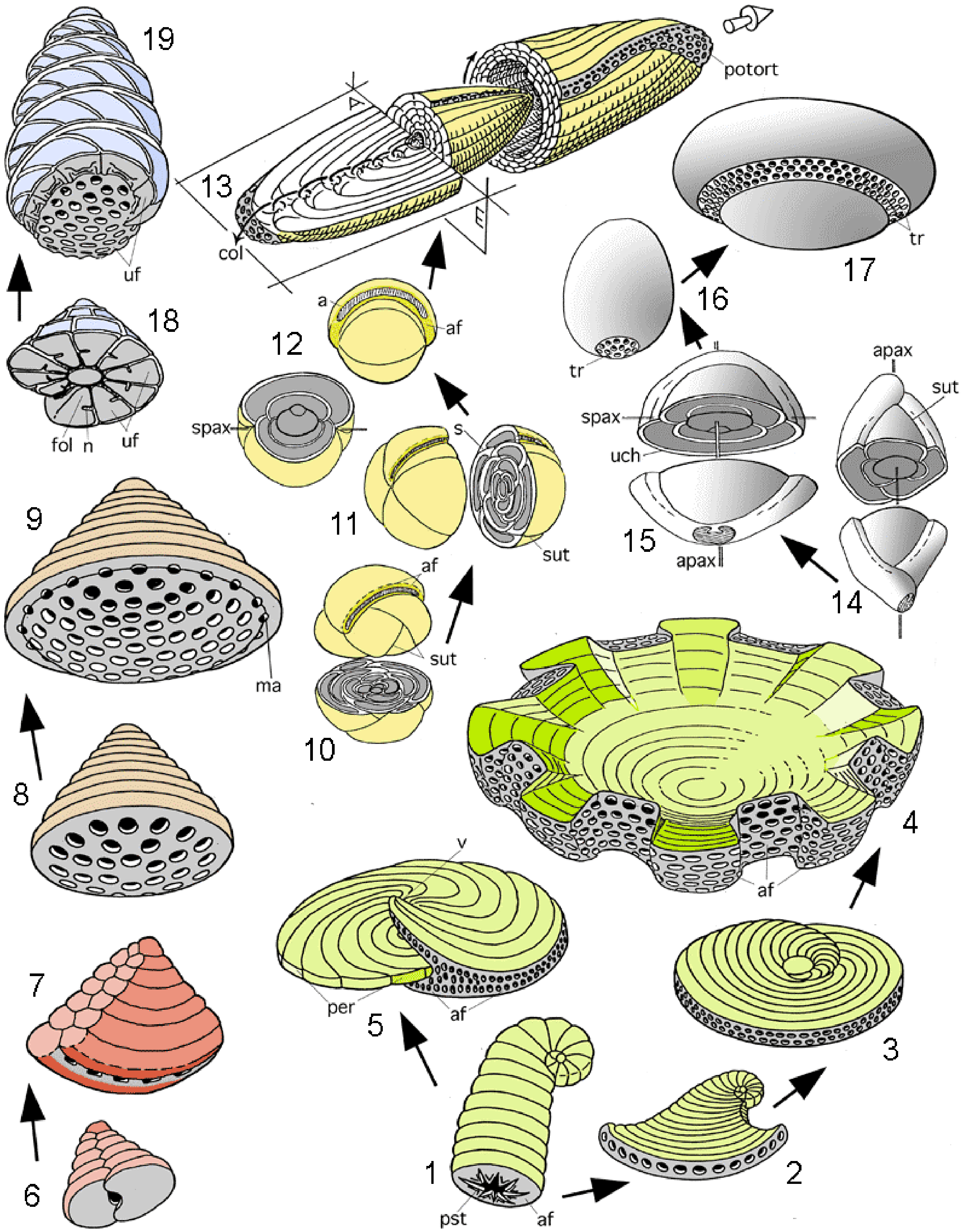


Figure 36: Development of chamberlet cycles from an auxiliary chamber in an early orbitoid, the Campanian *Lepidorbitoides minima* H. DOUVILLÉ from Mexico, after AGUILAR *et alii*, 2002.
A: stereograph of a megalospheric embryo consisting of a biconch (protoconch and deuteroconch) supplemented by a third chamber (auxiliary chamber) with a median and two lateral stolons. Successive growth stages coloured alternately in red and blue. Lamellation omitted. Schematic, not to scale. **B:** development of chamberlet cycles. Schema, not to scale. Inner lamella omitted, outer lamella alternating in white or plain black in successive growth stages. Axes of successive stolons form overcrossing spirals (arrows). Median stolons indicated by dotted arrows, lateral stolons by black arrows. **C:** Camera lucida drawing of a slightly oblique section of the equatorial main chamberlet layer of adult growth stage showing retrovert apertures and annular passages. **D:** stereograph of adult chamberlets of two successive cycles with their crosswise-oblique stolon axes, the annular passage and their retrovert stolons. Schematic, not to scale.
A: auxiliary chamber; **D:** deuteroconch; **P:** protoconch; **X:** closing chamberlet filling up the first chamberlet annulus; **ap:** annular passage; **chl:** chamberlet lumen; **lst:** lateral stolon; **mst:** median stolon; **p:** pores; **rst:** retrovert stolons; **stax:** crosswise-oblique stolon axes.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◀ **Figure 37:** Chamber arrangement and apertural face. Schematic, not to scale. In part after HOTTINGER, 2000.
1: planispiral-spiroliniform. **2:** planispiral-evolute and flaring, peneropliform. **3:** planispiral-evolute, approaching reniform, **4:** annular-concentric, with thickened and folded margins, as in *Marginopora vertebralis*. **5:** planispiral-involute, as in *Archaias*. **6:** biserial – textulariid. **7:** biserial-cuneiform. **8:** uniserial-conical. **9:** uniserial-conical with marginal apertures. **10:** streptospiral-involute as in *Pseudonummuloculina*. Coiling axis rotating with each chamber. **11:** streptospiral with planispiral-involute adult stage, as in *Helenalveolina*. **12:** planispiral involute. Coiling axis fixed throughout ontogeny. **13:** planispiral-fusiform: A: axial section, E: equatorial section. Black arrow: direction of growth; white arrow: direction of movement. **14:** miliolid (-quinquelocular, -trilocular), with fixed apertural axis and with coiling axis rotating in perpendicular position in respect to apertural axis. **15:** miliolid-bilocular with fixed apertural and coiling axes. **16:** unilocular-concentric, with discoidal trematophore, as in *Lacazina elongata*. **17:** unilocular-concentric with annular trematophore, as in *Lacazina compressa*. **18:** low-trochospiral, as in *Rotorbinella*. **19:** high-trochospiral, as in *Sakesaria*.
a: aperture; **af:** apertural face; **apax:** apertural axis; **col:** columella; **fol:** folium; **ma:** marginal aperture; **n:** notch; **per:** periphery; **potort:** polar totion; **pst:** peristome; **spax:** coiling axis.

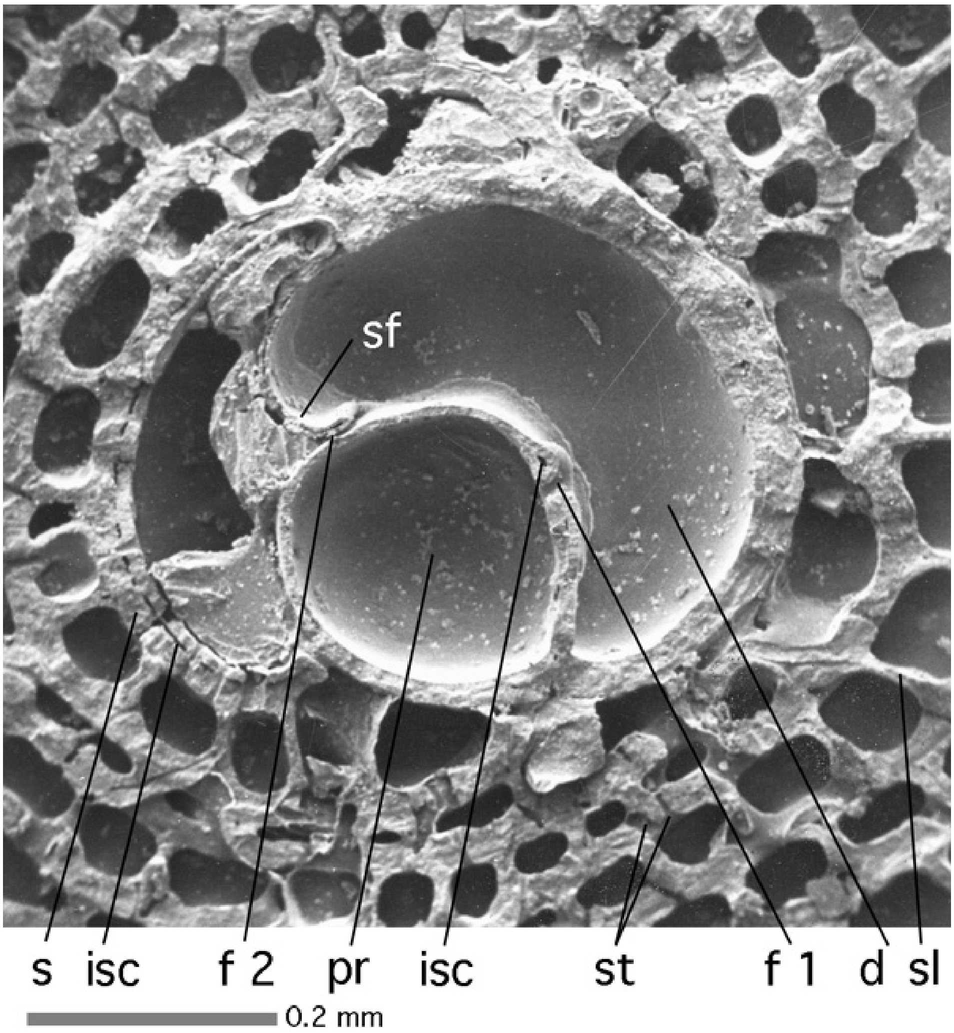


Figure 38: Deuteroconch in *Cycloclypeus carpenteri* (BRADY), Bikini, Pacific. Recent. SEM graph of shell split open in the equatorial plane.
d: deuteroconch; **f 1:** foramen of protoconch; **f 2:** foramen of deuteroconch; **isc:** intraseptal canal system; **pr:** proloculus; **s:** septum; **sl:** septulum; **st:** stolon (Y-shaped).

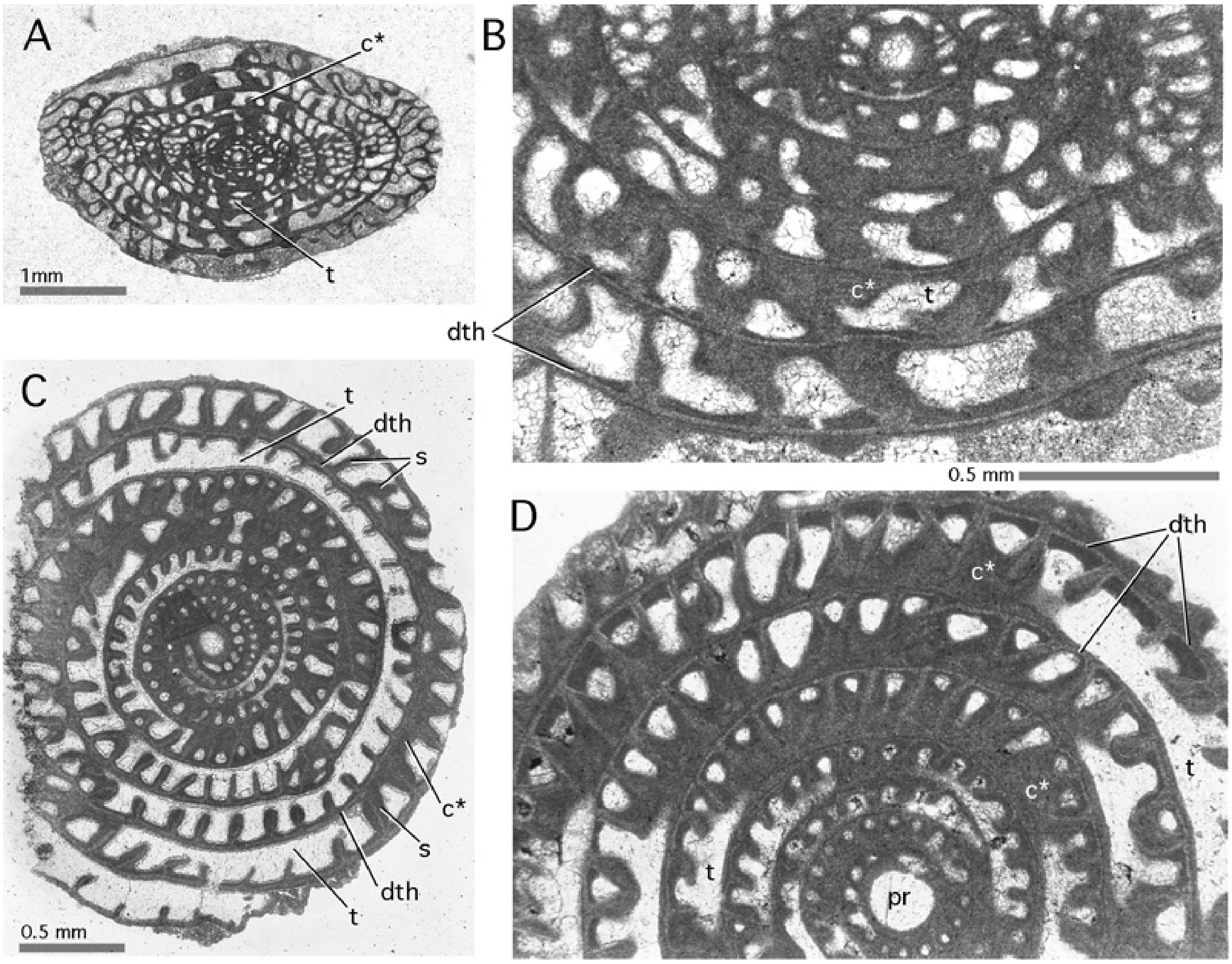


Figure 39: Diaphanotheca in *Fusulina distenta* ROTH et SKINNER, Hartville Fm., DesMoines series, Guernsay, Wyoming, Upper Carboniferous. Transmitted light micrographs.
A: slightly oblique, imperfectly centered axial section; **B:** detail of A showing diaphanotheca in axial section of adult whorls; **C:** equatorial section showing diaphanotheca extending over septal faces; **D:** detail of other specimen.
c*: choma; **dth:** diaphanotheca; **pr:** megalosphere. Note presence of some kind of flexostyle. **s:** septum; **t:** tunnel.

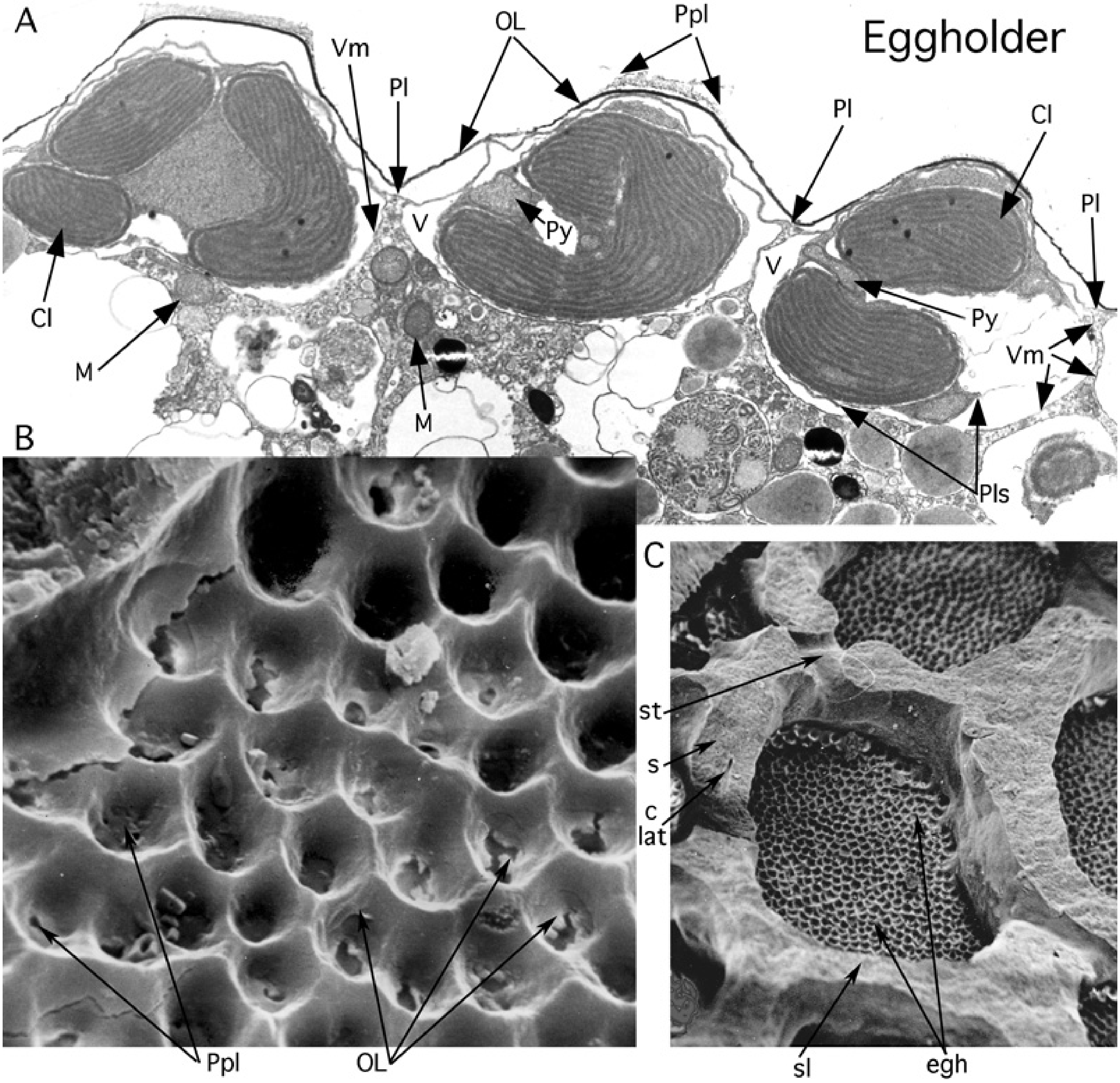
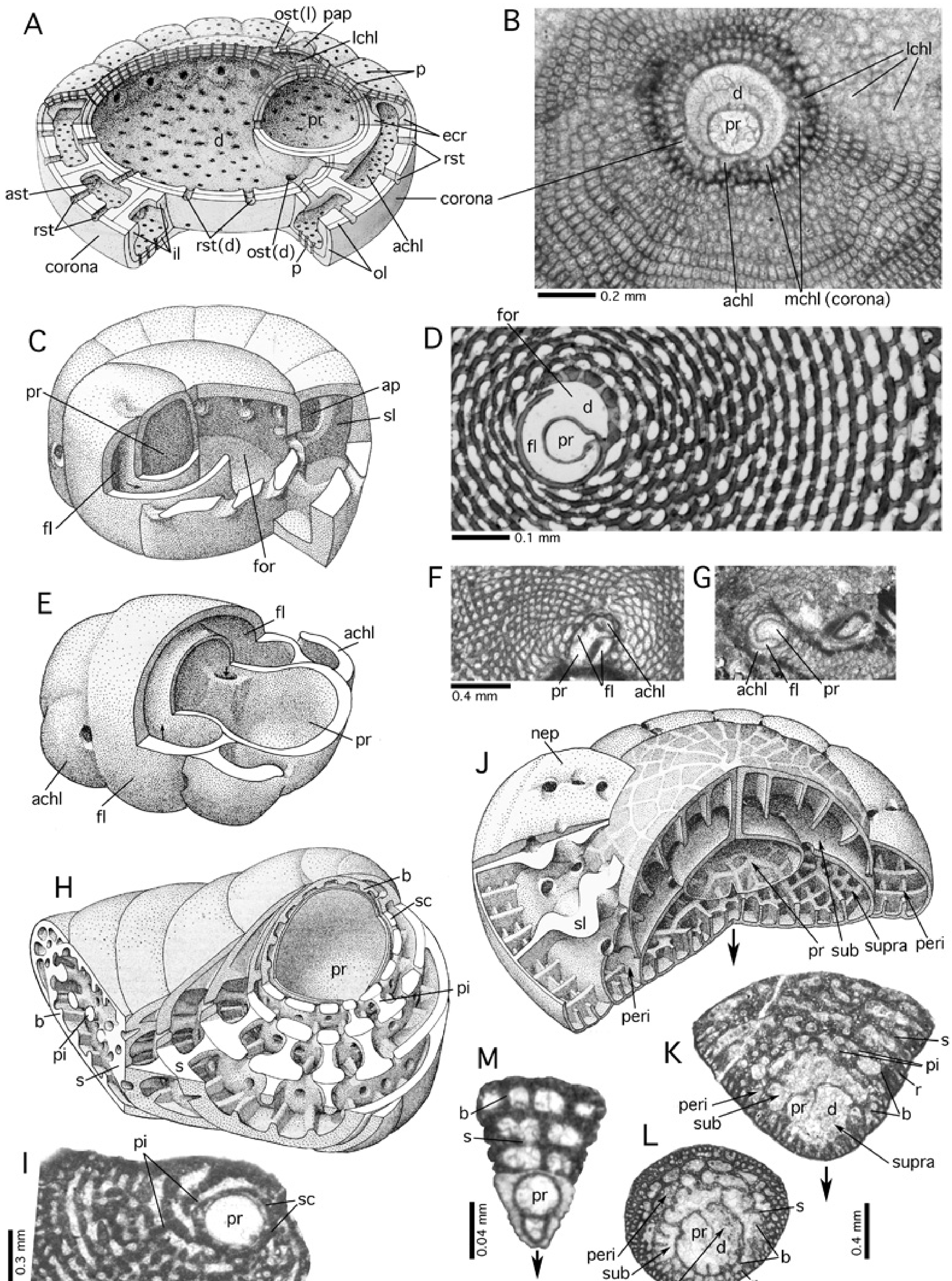


Figure 40: Eggholders harbouring the symbionts in *Heterostegina depressa* d'ORBIGNY. Gulf of Aqaba. Recent.
A: TEM micrograph of section perpendicular to lateral chamber wall; biomineralized wall dissolved, organic cell walls distinctly separated by the techniques of preparation. Courtesy S. REBER-LEUTENEGGER. x 9,800. **B-C:** dried shell, split open in the equatorial plane. The internal surface of the lateral chamber wall bears eggholders. SEM graphs, x 4,800 and x 480. Drying strechted the organic cell walls.
Cl: chloroplast of bacillariophycean symbiont; **clat:** lateral intraseptal canal; **egh:** eggholder; **M:** mitochondria; **OL:** organic lining of host; **Pl:** plasmalemma of host; **Plp:** pore plug (see pore); **Pls:** plasmalemma of symbiont; **Py:** pyrenoid; **s:** septum; **sl:** septulum; **st:** stolon (Y-shaped); **V:** Vacuole housing symbiont; **Vm:** vacuolar membrane.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◀ **Figure 41:** Embryonic apparatus.
A: *Discocyclina*, stereograph after FERRANDEZ (1999), modified. Schema, not to scale. **B:** *Discocyclina* sp., equatorial section, showing corona. Transmitted light micrograph. **C:** *Amphisorus* sp. Stereograph, schema, not to scale. **D:** *Amphisorus hemprichii* EHRENBERG from the Gulf of Aqaba, Red Sea. Recent. Equatorial section, transmitted light micrograph, showing flexostyle and forecourt. **E:** *Orbitolites* sp., stereograph after LEHMANN, 1961, redrawn. Note the shape like a dumb-bell of the proloculus. **F-G:** *Orbitolites* sp., Lower Eocene, Pakistan, ALLEMANN collection. Oblique-centered sections, in approximately equatorial and axial direction, showing flexostyle constricting the proloculus. Transmitted light micrographs. **H:** *Orbitopsella* sp., stereograph showing sphaeroconch with its exoskeleton. Schema, not to scale, after HOTTINGER, 1967. Note the appearance of endoskeletal pillars not before the third chamber. **I:** *Orbitopsella praecursor* (GÜMBEL), Middle Lias, Morocco, equatorial section showing the thin proloculus wall and the sphaeroconch with its simple exoskeleton consisting of beams only. Transmitted light micrograph. **J:** Advanced orbitoliniform embryo, schematic, not to scale. Note the apex that is directed downwards (arrows) to facilitate the comparison with HOFKER's drawings (1963). **K-L:** embryos of *Karsella hottingeri* SIREL, a Upper Paleocene form that exhibits an architecture strikingly similar to the one of Mid-Cretaceous orbitolinids. Pakistan, ALLEMANN collection. Transmitted light micrographs. **M:** *Sabaudia minuta* HOFKER Jr, embryo followed by three agglutinated chambers of the same series and presenting a simple exoskeleton. Lower Cretaceous. Note the hyaline embryo wall. The embryos are known to be formed within the mother shell and seem to have no access to grains in the environment to build their agglutinated walls.
achl: auxilliary chamberlet; **ap:** annular passage; **ast:** annular stolon; **b:** beam; **d:** deuteroconch; **ecr:** equatorial crest; **fl:** flexostyle; **il:** inner lamella; **lchl:** lateral chamberlet; **mchl:** main chamberlets; **ol:** outer lamella: **ost:** oblique stolon; **ost(d):** oblique stolon of deuteroconch; **p:** pore; **pap:** papilla; **peri:** periembryonal chamberlets; **pi:** pillar; **pr:** proloculus; **rst:** radial stolon; **rst(d):** radial stolon of deuteroconch; **s:** septum; **sc:** sphaeroconch; **sl:** septulum; **sub:** subembryonic chamber (= deuteroconch); **supra:** supraembryonic chamber.

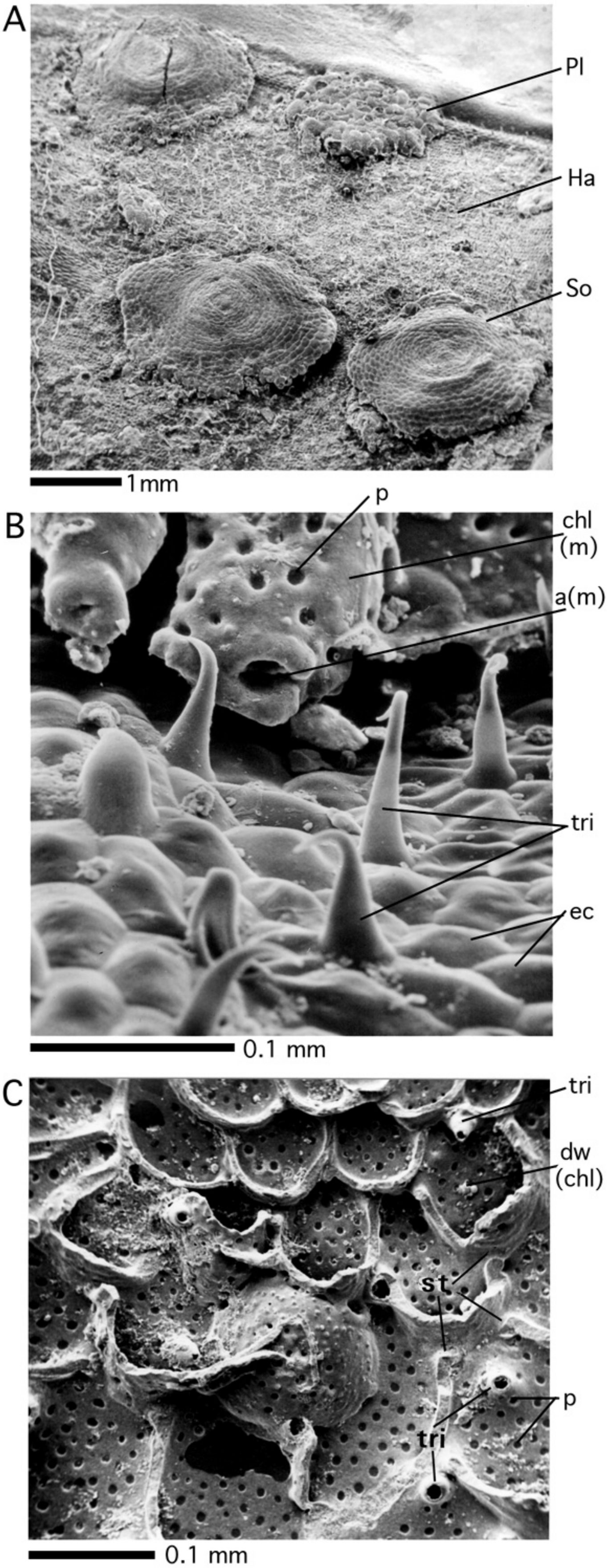


Figure 42: Epiphytic foraminifera and trichomes. Recent. Gulf of Aqaba, Red Sea. SEM graphs.

A: Epiphytes on *Halophila* leaf. **Pl:** *Planogypsina acervalis* (BRADY); **Ha:** surface of *Halophila* leaf with leaf hairs (trichomes); **So:** *Sorites orbiculus* (FORSKAL). **B:** Trichome on *Halophila* leaf and aperture in a radially-marginal position of the epiphytic *Planogypsina acervalis* (BRADY). **C:** Opened test of *Planogypsina acervalis* showing the inner side of the perforate, dorsal chamberlet walls, coating the overgrown trichomes of their substrate, and the dorsal part of the septal walls with stolons representing intercameral foramina.

a(m): aperture of a marginal, terminal chamberlet; **chl(m):** chamberlet of the ultimate marginal chamberlet cycle; **dw(chl):** dorsal wall of chamberlet; **ec:** epithelial cells of the *Halophila* substrate; **p:** pore; **st:** stolon; **tri:** trichome.

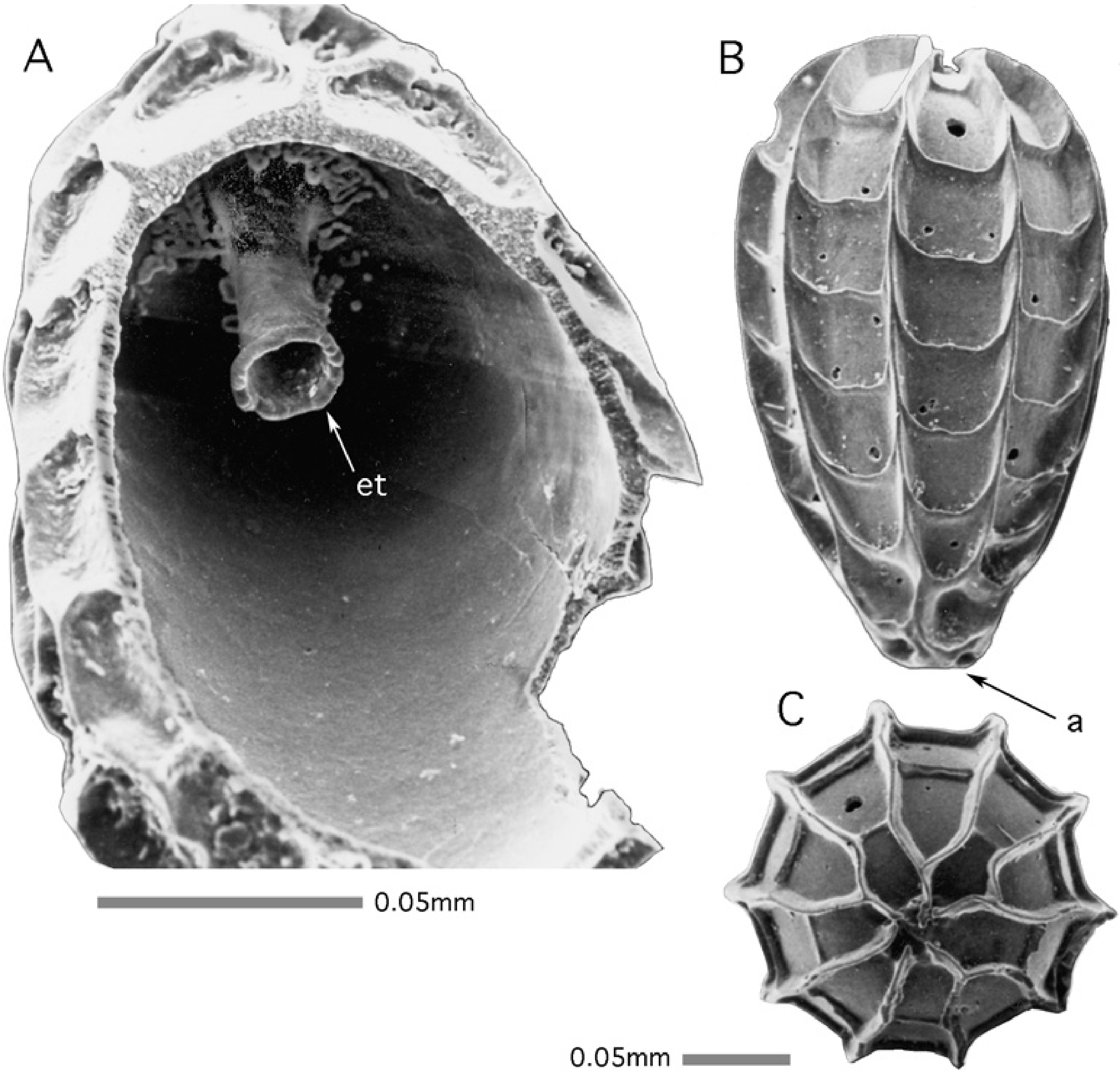
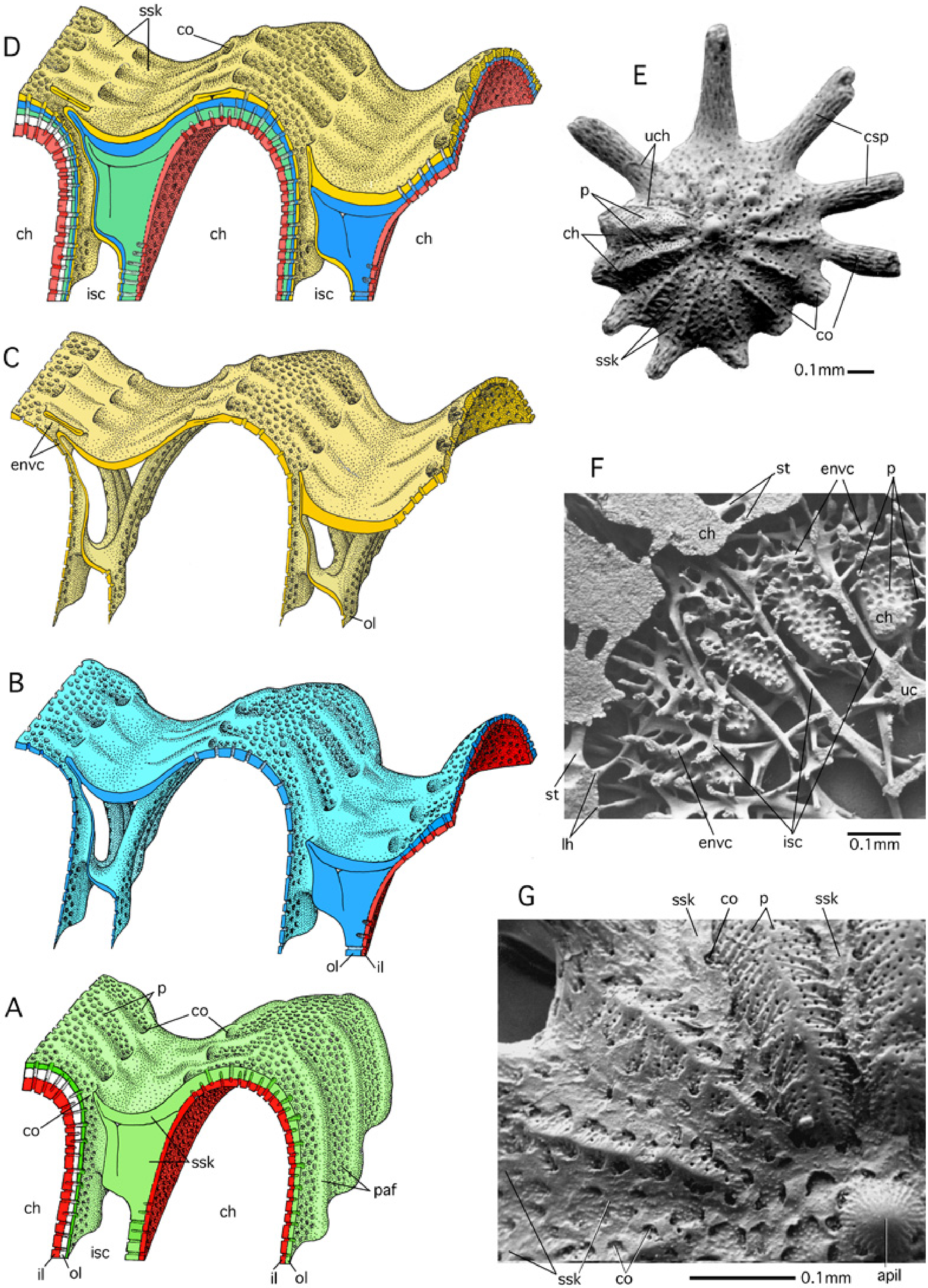


Figure 43: Endosolen in *Favulina melosquamosa* (McCulloch), Gulf of Aqaba. Recent. SEM graphs.
A: dissected specimen, oblique aboral view; **B:** lateral view; **C:** aboral view.
a: aperture; **et:** endosolenian tube.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◀ **Figure 44:** Enveloping canals produced by folded outer lamellas.
A-D: Lamellae in the peripheral portion of three successive chambers. Stereograph, schematic, not to scale. **A:** ultimate and penultimate chamber: **red:** inner lamella; **green:** outer lamella of ultimate chamber, **white:** outer lamella of penultimate chamber. **B:** addition of the next chamber with an inner lamella in **red** and an outer lamella in **blue**. **C:** addition of an other chamber with its outer lamella in **yellow**. **D:** superposition of lamellas B and C over the then final chamber A after two additional growth steps. **E:** SEM micrograph of the complete test of *Calcarina defrancii* d'ORBIGNY, ventral view, showing distribution of canal orifices over all the test including the canaliferous spines. **F:** SEM micrograph of an epoxy resin cast of the shell cavities in *Calcarina gaudichaudii* d'ORBIGNY cut in a direction perpendicular to the axis of the spiral shell, ventral view; **G:** detailed SEM micrograph of the ventral shell surface of *C. gaudichaudii*. Calcarinas from Keij Island, Indonesia. Recent. After HOTTINGER and LEUTENEGGER, 1980.
apil: axial pile of lamellae; **ch:** chamber and chamber lumen; **co:** canal orifice; **csp:** canaliferous spine; **envc:** enveloping canal; **isc:** intraseptal space or canal; **il:** inner lamella; **lh:** loop-hole; **ol:** outer lamella; **p:** pore; **paf:** perforate part of apertural face; **ssk:** supplemental skeleton; **st:** stolon; **uc:** umbilical canal network; **uch:** ultimate chamber suture, chamber walls broken off.

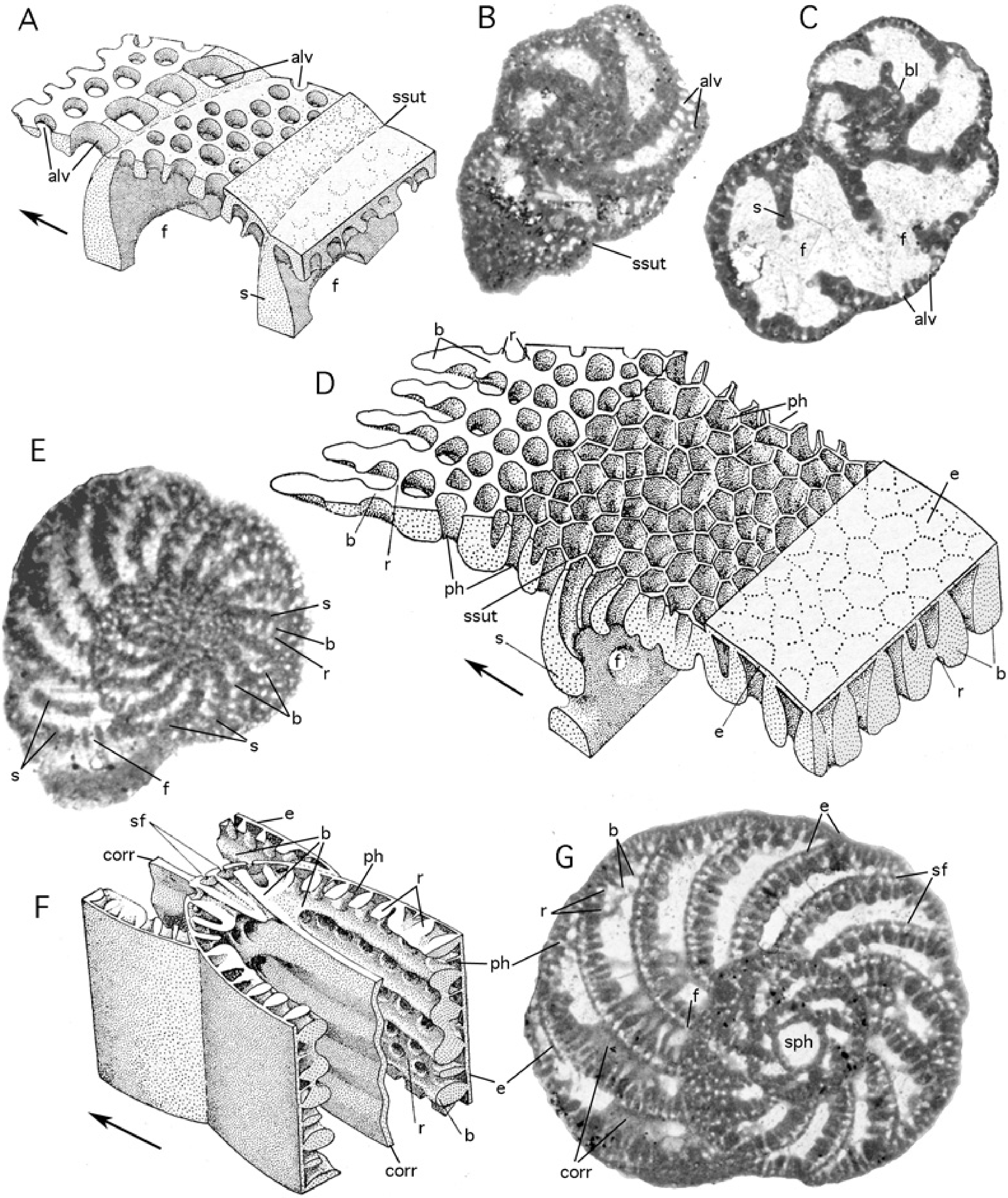

Figure 45: Alveolar exoskeleton and polygonal network.
A-C: simple alveolar layer in *Everticyclammina virguliana* (KOECHLIN), Mechra Klila, Northeastern Morocco, Uppermost Jurassic. **A:** stereograph, schematic, not to scale. **B:** tangential section. Note the large size of the alveoles in a postseptal position. **C:** para-equatorial, non-centered section showing septa and the basal coat at the bottom of the chamber, resembling a basal layer. **E-G:** polygonal network in Spirocyclinidae. **E:** *Choffatella tingitana* HOTTINGER, megalospheric generation, in tangential section near to the equatorial plane. Note the clear differentiation of beams and rafters. **D:** stereograph of spirocyclinid polygonal network. Note the curved pigeon holes in preseptal position which in axial section might be mistaken for foramina. **F-G:** extension of beams into a corrugated sheet that replaces endoskeletal pillars in Hottingertidae. **F:** stereograph representing a part of an axial section. Not to scale. **G:** *Alveosepta powersi* (REDMOND), Northeastern Morocco, Upper Jurassic. Equatorial section of megalospheric specimen.

alv: alveoles; **b:** beam; **bl:** basal layer; **corr:** corrugated median extension of beams; **f:** foramen; **ph:** pigeon holes; **s:** septum; **sf:** supplementary foramina; **sph:** sphaeroconch; **ssut:** septal suture. **Arrows:** direction of growth. After HOTTINGER, 1967.

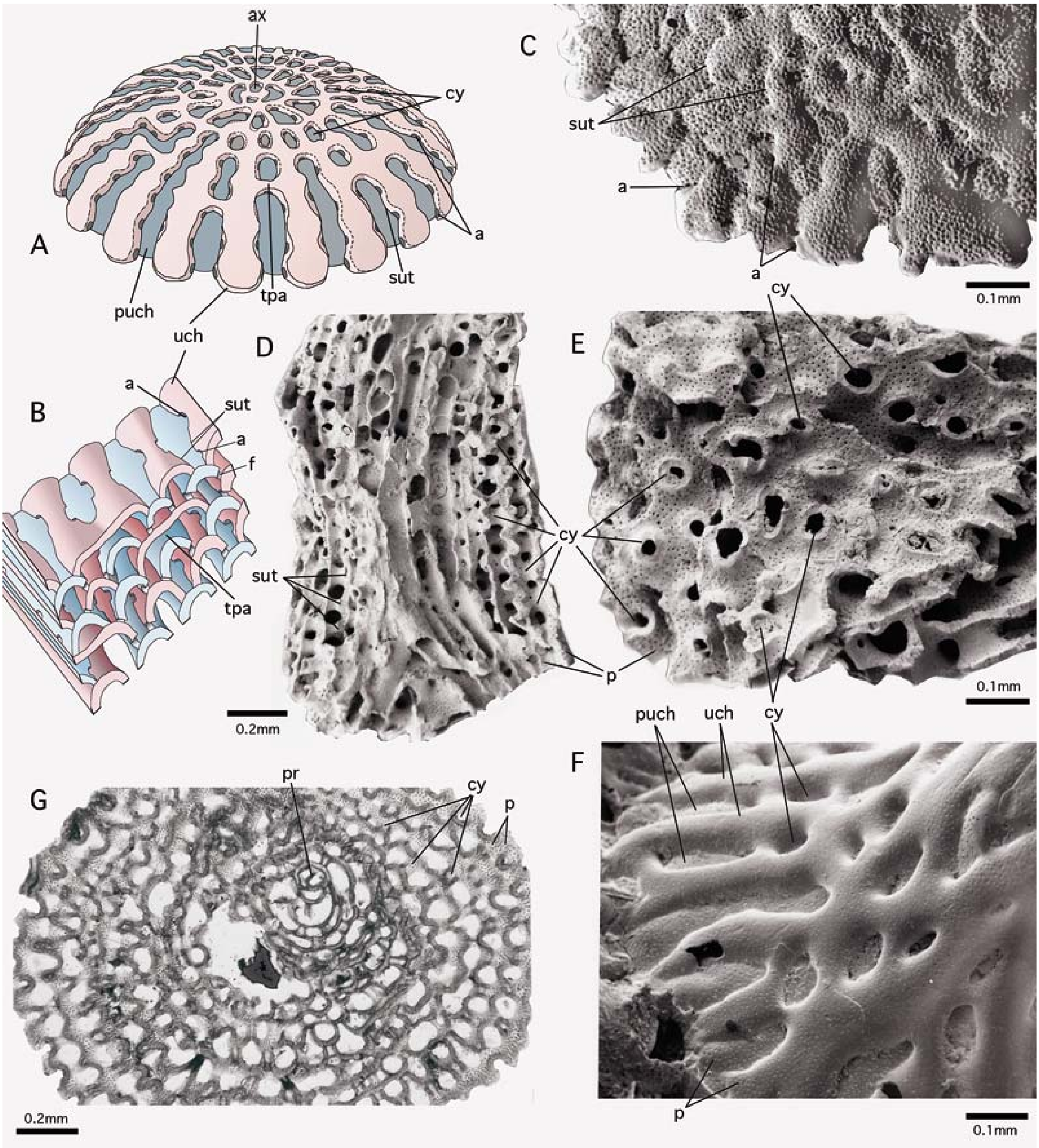

Figure 46: Expanse chambers and calyces.
A: Sketch of ultimate and penultimate expanse chambers, not to scale. **B:** A cut-out portion of five successive expanse chambers, cut in an oblique direction with respect to the shell axis, schematic, not to scale. Lamellation of walls omitted. **C:** Ultimate and penultimate expanse chambers in *Planogypsina squamiformis* (CHAPMAN). Gulf of Aqaba, Red Sea; Recent. SEM graph. **D-G:** Expanse chambers with calyces in *Miniacina miniacea* (PALLAS), Gulf of Aqaba, Red Sea; Recent. **D-F:** SEM graphs, **G:** thin section in transmitted light. **D:** broken surface perpendicular to the axis of a branch of the arborescent shell: the expanse chambers are grouped around tubular extensions of the peristomes of earlier chambers. **E:** a fragment of shell showing the inner surfaces of two successive expanse chambers. Note the alternating arrangement of the calyces. **F:** radial spreading of ultimate expanse chamber at the foot of an arborescent shell, thus enlarging the shell's surface of attachment. **G:** centered section near and parallel to the surface of attachment, so cutting the latest, outermost expanse chambers at diminishing angles.
a: aperture; **ax:** shell axis; **cy:** calyx; **p:** pore; **pr:** proloculus; **puch:** penultimate expanse chamber; **sut:** suture of expanse chamber; **tpa:** tubular passage connecting parts of expanse chamber; **uch:** ultimate expanse chamber.