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PART E, REVISED, VOLUME 4, CHAPTER 17: CLASS UNCERTAIN, ORDER PULCHRILAMINIDA, NEW ORDER

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Class UNCERTAIN Order PULCHRILAMINIDA new order

[Pulchrilaminida WEBBY, herein]

Large, laminar, domical to columnar skeleton represented by thin latilaminae of mainly calcite-spar-replaced skeletal elements that intercalate with mudrock layers; internally main skeletal elements preserved as erect, slender, upwardly tapering, spinose rods (walled but with spar-replaced centers); typically extending from tops of latilaminae into overlying mudrock layers; weakly developed meshworks also preserved in localized areas where rods combine with undulating rows of long, low cysts, or sometimes latilaminae exhibit intermingling wispy, threadlike elements; no astrorhizae known. *Lower Ordovician (upper Tremadocian)–Middle Ordovician (lower Dariwilian)*.

This small group of large, hypercalcified, frame-building organisms occupies an important place in the development of Lower Ordovician–Middle Ordovician reefs in North America, the Argentine Precordillera, and southern China (WEBBY, 2002; ADACHI, LIU, & EZAKI, 2011), but its affinities remain to be fully evaluated. The group has no apparent links with Cambrian hypercalcified sponges, but in exhibiting skeletons of large size, frayed lateral margins, and well-developed latilaminae, it shares certain resemblances with the nonspiculate Ordovician–Devonian labechiid stromatoporoids (and other stromatoporoids). The pulchrilaminids, however, differ morphologically in having a more loosely aggregated meshwork of skeletal elements, including slender, upwardly tapering, spinose rods that are spiculelike and may represent diage-

netically altered styles. They therefore seem best regarded as a separate, independent group of hypercalcified sponges. Relationships with known spiculate sponge groups remain uncertain. Previously the family Pulchrilaminidae WEBBY, 1993, was doubtfully incorporated in the order Labechiida (WEBBY, 1993, 1994, 2004; WEBBY in STEARN & others, 1999) but is excluded herein.

BOGOYAVLENSKAYA (2001, p. 46), adopted a different approach in introducing the order Protolabechiida to accommodate members of three families: the Lophiostromatidae NESTOR, 1966, Stratodictyidae BOGOYAVLENSKAYA, 1977, and Pulchrilaminidae WEBBY, 1993. But this is a heterogeneous grouping that bears little relation to the key morphological features of both pulchrilaminids and the other families. In this *Treatise* volume, the families Lophiostromatidae and Stratodictyidae are maintained as parts of the order Labechiida (see WEBBY's *Treatise Online*, Part E, Revised, vol. 4, Chapter 16B). BOGOYAVLENSKAYA's family Stratodictyidae is recognized as a part of the family Labechiidae NICHOLSON, 1879 (based on genus *Stratodictyon* WEBBY, 1969), and a part of the family Rosenellidae YAVORSKY in KHALFINA & YAVORSKY, 1973 (based on genus *Pseudostylodictyon* OZAKI, 1938, and its junior synonym *Parksodictyon* BOGOYAVLENSKAYA in BOGOYAVLENSKAYA & LOBANOV, 1990), of the Labechiida. None of the characters used by BOGOYAVLENSKAYA (2001) to define the order Protolabechiida is diagnostic specifically of that order [see English translation of BOGOYAVLENSKAYA's (2001) diagnosis of order Protolabechiida, in WEBBY's Introduction to Order Labechiida: General Relationships, *Treatise Online*, Part E, Revised, vol. 4, Chapter 16B]. All listed morphological

characters are present also in representatives of the order Labechiida. Consequently, the Protolabechiida is regarded in part as a junior synonym of the Labechiida. However, the family Pulchrilaminidae has fundamentally different diagnostic characters and must be separated from labechiids, including BOGOYAVLENSKAYA's two other protolabechiid families. The uniquely pulchrilaminid features are: (1) long, slender, spinose, spiculelike rods (usually erect but sometimes tilted) that characteristically protrude above tops of latilaminae into overlying mudrock, or more randomly spaced, oblique-to-erect threadlike elements; and (2) may, in localized areas (usually upper parts of latilaminae), combine in loosely aggregated meshworks with rows of finer, undulating cyst plates.

Family PULCHRILAMINIDAE

Webby, 1993

[Pulchrilaminidae WEBBY, 1993, p. 58]

Characters as for order. [The pulchrilaminid skeleton is distinguished by its large size (commonly up to 300 mm in width and 500 mm in height), thin latilaminae, and mainly erect (in a few places tilted), slender, upwardly tapering, spinose (spiculelike) rods. The latilaminae vary from 0.1 to 3.0 mm in thickness and are characteristically bounded by growth interruptions, probably mainly caused by regular, episodic sedimentation events, resulting in the intercalated mudrock layers. The latilaminae are commonly frayed at lateral margins to give a markedly ragged appearance to the skeleton. Even the thinnest latilaminae (0.1–0.2 mm thick) were able to support the bases of long, slender, tapering, spinose rods in upright orientations, and they extend into overlying layers of mudrock (maintaining their orientation in the mud to a height of at least 0.5 mm) without much evidence of visible support (apart from a few wispy films of broken or incomplete cyst plates). Cyst plates generally are not well preserved in the *Pulchrilamina* skeleton, mainly occurring in localized areas near tops of latilaminae

as rows of fine, closely spaced, undulating, platelike elements forming meshworks with the slender, upright, spinose rods. Only a few examples of rods tilted out of parallel alignments suggest that the overall structural meshwork of rods and cysts was rather weakly developed, with the cyst plates providing very limited support, unlike the larger, more compact and rigid skeletal frameworks of labechiid stromatoporoids. The intermingling, threadlike elements in some growth layers of *Zondarella* resemble the slender threads of a possible unnamed cyanobacterium (or possibly alga) that intergrew with the labechiid stromatoporeid *Cystostroma* in the Upper Ordovician Gordon Group, Tasmania (WEBBY, 1991, fig. 10a–c), which raises the possibility that *Zondarella* may have sometimes developed as an intergrowth of pulchrilaminid and cyanobacterial crusts. *Ianilamina* is another problematic genus that exhibits slender threadlike strands but differs in developing porous laminae]. *Lower Ordovician (upper Tremadocian)–Middle Ordovician (lower Darriwilian)*.

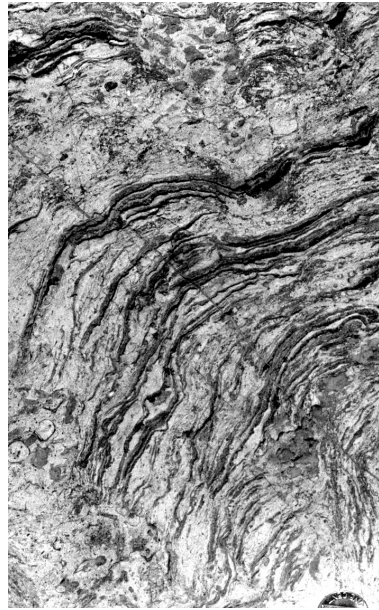
Pulchrilamina TOOMEY & HAM, 1967, p. 983 [**P. spinosa* TOOMEY & HAM, 1967, p. 983, pl. 128, 1–4; M; holotype, thin section, U.S. National Museum, Washington, no. USNM 155300, remains unfigured; three paratypes, USNM no. 155303, 155304, 155315, all longitudinal sections, have been figured (TOOMEY & HAM, 1967, pl. 128, 1–4)]. Large, strongly latilaminar, laminar, domical-to-columnar skeleton; latilaminae commonly ragged or frayed toward lateral margins, bounded top and bottom by growth interruptions, and alternating between wedges of mudrock; internally exhibit upwardly tapering long, slender, spinose (spiculelike) rods, characteristically protruding beyond tops of latilaminae into overlying mudrock; a few may be tilted out of an orderly, subparallel alignment; also, more localized rows of long, thin, low, undulating cyst plates may be preserved, forming meshworks in combination with the rodlike elements, but these appear, in a few places, to be rather loosely aggregated with some cyst plates not entirely fused to rods; in most areas, latilaminae are mainly replaced by spar, including crystalline calcite mosaics; no astrophorites have been confirmed. *Lower Ordovician (upper Tremadocian–Floian)*: Canada (Newfoundland), United States (Texas, Oklahoma), southern China (Guizhou, Hubei, Anhui).—FIG. 1a–c. **P. spinosa*; El Paso Group, McKelligon Canyon Formation, southern Franklin Mountains, western



a



b



c

Pulchrilamina

FIG. 1. Pulchrilaminidae (p. 2–5).

Texas, and Arbuckle Group, Kindblade Formation, Oklahoma; field photographs of outcrops showing growth form of skeletons; *a*, photograph of part of a reef mound, Kindblade Formation, dipping at 45° N, with exposure of individually large *Pulchrilamina* skeletal mounds that exhibit a columnar shape and lateral margins that sometimes

have a ragged appearance, but in other places have apparently been cut by narrow erosion channels and infilled by calcarenite deposits; structures exposed along Interstate Highway 35, southern Arbuckle Mountains, Oklahoma, $\times 0.24$ (Webby, new); *b*, more detailed characteristics of domical *Pulchrilamina* skeleton showing distinctive, slightly

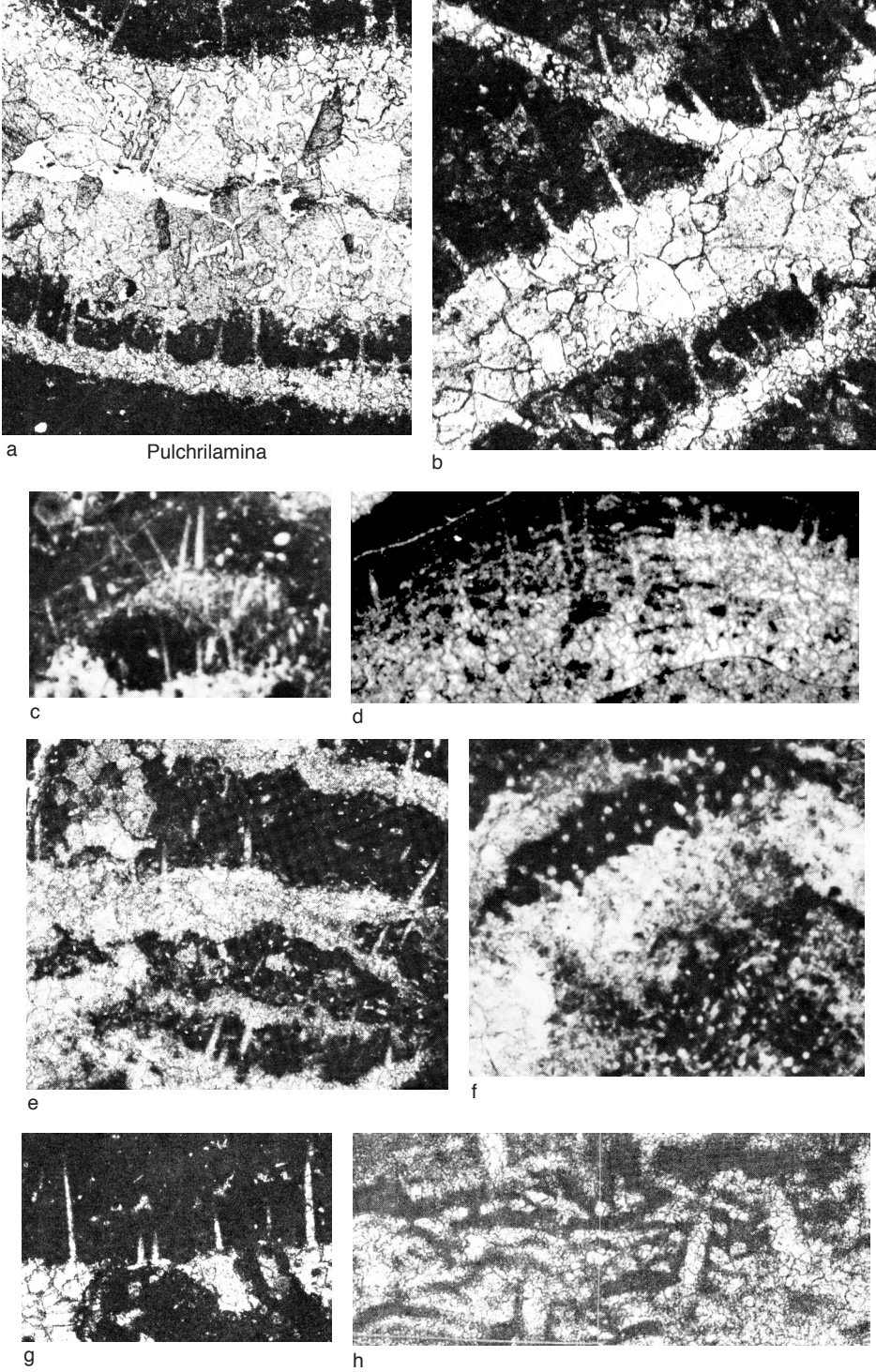


FIG. 2. Pulchrilaminidae (p. 2-5).

undulating laminae that appear to individually taper toward lateral margins of specimen (see area at lower left); exposed in reef mound, main biohermal interval, McKelligon Canyon Formation, southern Franklin Mountains, $\times 0.46$ (Webby, new); *c*, part of domical *Pulchrilamina* skeleton, laminae (see area at lower left) on lateral margin appearing to be sharply truncated by an erosion channel; main biohermal interval, McKelligon Canyon Formation, southern Franklin Mountains, $\times 0.33$ (for additional locality details, see TOOMEY & BABCOCK, 1983, p. 51–91, Stop 2) (Webby, new).—FIG. 2a–b. **P. spinosa*, thin sections of type and other specimens; *a*, paratype, USNM 155315, ~137 m above base of Kindblade Formation, Mill Creek section, Arbuckle Mountains, Murray County, Oklahoma, thin, lowermost, spar-filled latilamina and vertical spinose rods, continuous through a dark, mudrock inclusion into much thicker, overlying latilamina (completely replaced by mosaic calcite), $\times 20$ (Toomey & Ham, 1967, pl. 128, 4); *b*, paratype, USNM 155304, main mound section, lower part, McKelligon Canyon Formation, southern Franklin Mountains, western Texas, completely recrystallized main latilamina, and irregularly distributed, vertical, slightly tapering-upward, spinose rods that protrude upward into overlying mudrocks from its top, $\times 30$ (Toomey & Ham, 1967, pl. 128, 3); *c*, longitudinal section of specimen, MC-38-MB, D. V. LeMone collection, University of Texas, El Paso, McKelligon Canyon Formation, southern Franklin Mountains, divergent spinose rods, suggesting they formed in a loosely aggregated skeleton of weakly developed, very fine horizontal elements, unlike labechiid structures, $\times 20$ (Webby, 1986, fig. 4B; reproduced with the permission of Oxford University Press: “Problematic Fossil Taxa,” 1986, edited by A. Hoffman & M. H. Nitecki, p. 153, fig. 4B); *d*, longitudinal section, thin section no. PP22967, Toomey’s collection, Field Museum of Natural History, Chicago, same horizon in Mill Creek section as view *a*, finely preserved meshwork of long, slender, spinose rods and undulating rows of long-low cyst plates in upper part of latilamina, $\times 40$ (Webby, 1986, fig. 3E; reproduced with the permission of Oxford University Press: “Problematic Fossil Taxa,” 1986, edited by A. Hoffman & M. H. Nitecki, p. 153, fig. 3E); *e*, longitudinal section of unnumbered specimen, mound horizon, lower portion of McKelligon Canyon Formation, southern Franklin Mountains, part of latilamina forking into two (right center of photo), and a markedly spinose rod that projects up into dark mudrock above upper splay of that latilamina (right center), $\times 20$ (Toomey & Nitecki, 1979, fig. 12a; reproduced with permission of the Managing Editor of *Fieldiana*, Harold Voris, Field Museum of Natural History, Chicago); *f*, tangential section, thin section no. PP22845, Toomey’s collection, Field Museum of Natural History, Chicago, mound horizon in lower part of McKelligon Canyon Formation, southern Franklin Mountains, showing round shapes of intersected

spinose rods, $\times 20$ (Webby, 1986, fig. 3C; reproduced with the permission of Oxford University Press: “Problematic Fossil Taxa,” 1986, edited by A. Hoffman & M. H. Nitecki, p. 153, fig. 3C); *g*, longitudinal section of portion of paratype, USNM no. 155304, same horizon and locality as view *b*; very long, slender, upwardly tapering spinose rods from section of underlying latilamina that is only partially differentiated by spar-replacement structures (Toomey & Ham, 1967, pl. 128, 1); *h*, enlarged longitudinal section of unnumbered specimen from same locality and horizon as view *e*, showing greater detail of meshwork of vertical rods (spar-replaced but not wall-less vertical structures) and undulating horizontal rows of variably sized cyst plates, from tiny vesicles to more moderately sized, elongate, low-convexity structures, $\times 80$ (Toomey & Nitecki, 1979, fig. 13a; reproduced with permission of the Managing Editor of *Fieldiana*, Harold Voris, Field Museum of Natural History, Chicago).

?*Ianilamina* PICKETT & ZHEN in ZHEN & PICKETT, 2008, p. 63 [*I. kirkupensis* PICKETT & ZHEN in ZHEN & PICKETT, 2008, p. 64, fig. 5A–H,J; M; Londonderry Geoscience Centre, Geological Survey of New South Wales, Australia, holotype, thin sections no. MMF29887a–b and five paratypes, MMF44870a–b, MMF35560a–b, MMF44875a–b, MMF44876, and MMF 44879; eight thin sections]. Skeleton laminar to broadly domical in shape, and composed of successive, comparatively thin latilaminae (incremental units) that are discontinuous laterally and subdivided into a lower part of thicker, poorly differentiated, vaguely meshwork-like areas of threadlike strands, flocculent structures and calcite spar replacement textures, and an upper part defined by a very thin, darker, densely porous lamina. In addition, succession of latilaminae may be interrupted by darker mudrock layers, lighter-colored spar-filled cavities and encrustations of organisms like cyanobacteria, sponges, and bryozoans. [The presence of porous laminae is not characteristic of other pulchrilaminid genera; therefore, the genus is only doubtfully referred to the group. Other features of *Ianilamina* are similar to *Zondarella*; however, *Zondarella* shows a few traces of very fine, rounded, dotlike shapes suggestive of spinose rods, but these still require to be positively confirmed; see further discussion of *Ianilamina* in PICKETT & ZHEN (in ZHEN & PICKETT, 2008, p. 64, 66)]. *Middle Ordovician (lower Darriwilian)*: Australia (New South Wales).—FIG. 3a–f. **I. kirkupensis*; limestone lens from base of Goonumbla Volcanics, Kirkup property, near Gunningbland, central New South Wales; *a–c*, paratype MMF 44875a, longitudinal section showing different enlargements of the same thin section; *a*, general view of domical skeleton with extensive, thin latilaminae that encrusts an anthaspidellid sponge (lower right), $\times 1.2$ (Zhen & Pickett, 2008, fig. 5B); *b*, enlarged view of upper right part of view *a* showing successive latilaminae with a mainly dark flocculent appearance, except where capped by

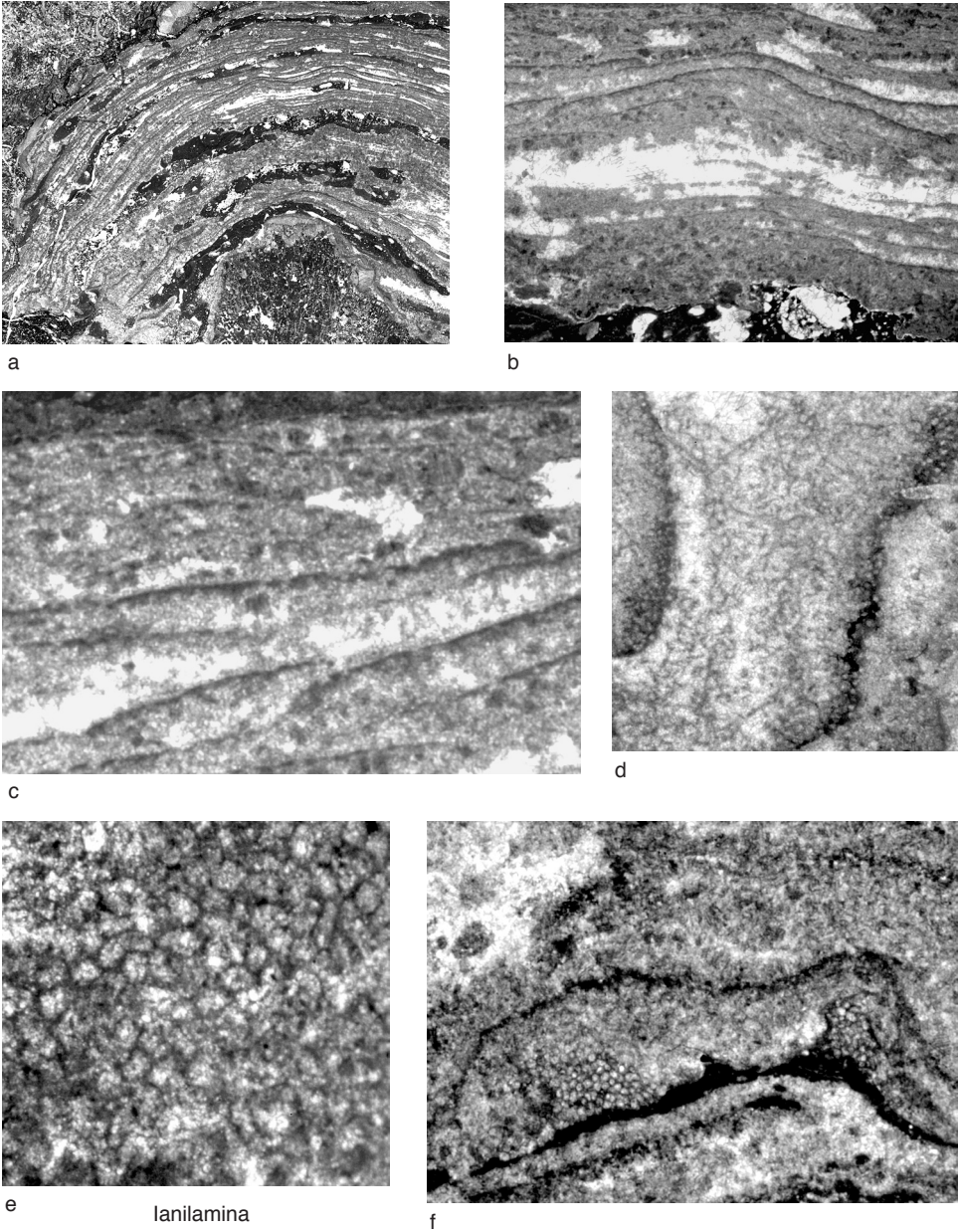


FIG. 3. Pulchrilaminidae (p. 5–7).

even darker, crustlike laminae and in an area near the middle where latilaminae have been largely replaced by lighter sparry calcite infills, $\times 6.8$ (Zhen & Pickett, 2008, fig. 5E); *c*, detailed view of small area in upper left part of view *b* showing regular latilaminar elements but may have only limited lateral continuity, as shown by a number of terminations where an upper lamina curves downward to

a meet an underlying lamina abruptly; each crustlike lamina commonly exhibits a row of very small disruptions that represent pores; vaguely threadlike strands are only shown in a few small areas within latilaminae, whereas irregular, elongated areas with sparry calcite replacements are more common, $\times 16.7$ (new); *d*, oblique-tangential section of paratype MMF 44875b through a latilamina showing

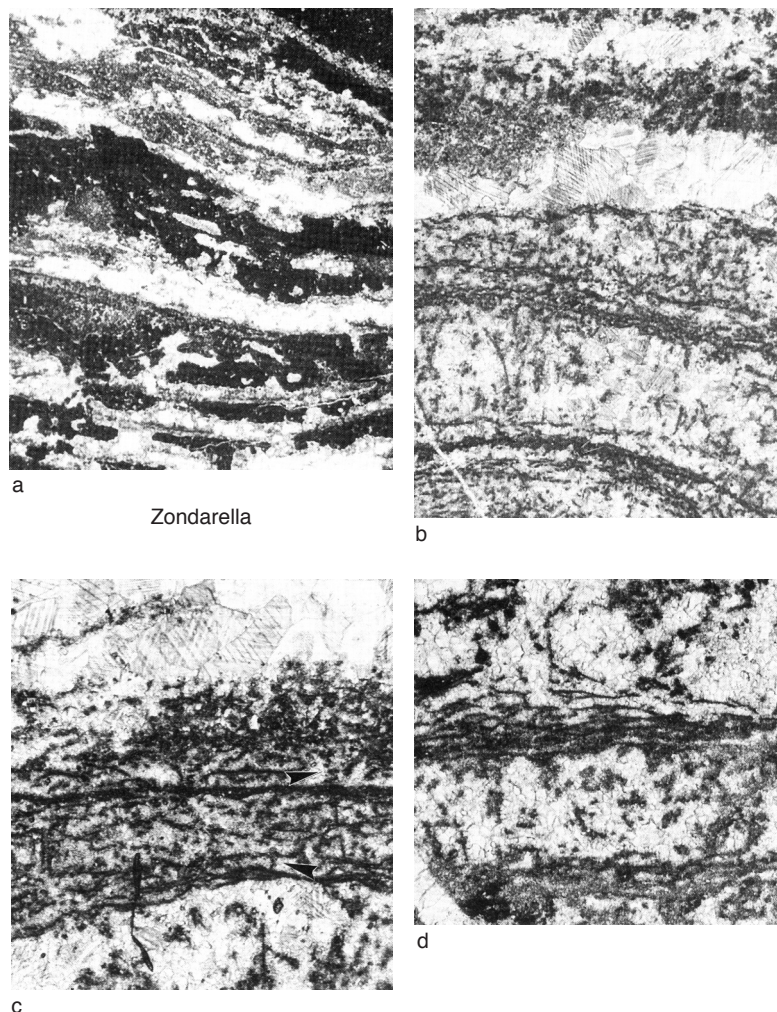


FIG. 4. Pulchrilaminidae (p. 7–8).

porous laminae along latilaminae boundaries and threadlike to vaguely cellular elements within the body of central latilaminar unit, $\times 8$ (Zhen & Pickett, 2008, fig. 5F); *e*, tangential section of holotype MMF 29887b, illustrating details of the pores within a single lamina, $\times 40$ (Zhen & Pickett, 2008, fig. 5J); *f*, longitudinal view of paratype MMF 44876 showing two small encrusting, rounded to irregular possible bryozoan colonies that grew above a dark mudrock sliver between underlying and overlying latilaminae of *Ianilamina*, $\times 10$ (Zhen & Pickett, 2008, fig. 5G).

Zondarella KELLER & FLÜGEL, 1996, p. 188 [**Z. communis* KELLER & FLÜGEL, 1996, p. 188, pl. 47, 1, 7, 9; pl. 48, 1–3; M; Institute of Paleontology, University of Erlangen, Germany, no. RA 641; no illustrations of types or other material have

yet been illustrated in tangential section]. Large, mainly domical to laminar skeleton characteristically composed of stacked, sheetlike growth layers, in places simulating latilaminae; both irregularly undulating, horizontal dark laminae, sometimes recognizable as less continuous discrete, elongated low convexity cyst plates or less continuous horizontal, spaced-out rows of colliculi-like rods, and more localized, randomly spaced, intermingling, oblique-to-vertical, threadlike elements (possibly rods) may occur and may alternate with bands filled with calcite spar and/or darker mudrock matrix. [Photos of tangential sections of specimens of *Z. communis* from the type locality (kindly provided courtesy of Marcelo Carrera, Córdoba, Argentina in 1999, 2008) show a pattern of very fine, rounded, dotlike shapes representing

probable rods. Compared with the dotlike appearance of spinose rods in *Pulchrilamina spinosa* (see tangential section: Fig. 2*f*), these are much finer (about half the diameter), and they are more closely spaced]. *Middle Ordovician (Dapingian)*: Argentina (Precordillera), Canada (?Newfoundland).—FIG. 4*a–d*. **Z. communis*; upper San Juan Formation, Las Lajas section, 24 km southwest of San Juan, Argentine Precordillera; *a*, holotype, longitudinal section, showing nature of latilaminar growth layers and a number of intercalations of dark layers composed of sedimentary matrix, $\times 3.5$ (Keller & Flügel, 1996, pl. 47,7); *b*, holotype, longitudinal section, contrasting zones of horizontal laminar and intermingling, oblique-to-vertical skeletal features in lower to middle parts, and zones of largely coarse, recrystallized sparite and fine matrix in the upper part, $\times 8.5$ (Keller & Flügel, 1996, pl. 47,9); *c*, holotype, longitudinal section, showing more continuous dark lines bounding latilaminae, and incomplete, slightly undulating laminae that are interrupted by a few short vertical elements (*arrows*) within the latilaminae, $\times 16$ (Keller & Flügel, 1996, pl. 48,1); *d*, longitudinal section, specimen no. RA 542, *Z. communis*, Los Berros section, San Juan Formation; darker bands showing well-defined, elongated, low-convexity cyst plates, $\times 16$ (Keller & Flügel, 1996, pl. 47,2).

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