Ordovician stromatoporoids from the Mjøsa district, Norway

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Five species of stromatoporoids are described and illustrated from the Middle Ordovician Mjøsa Limestone of Norway. They include the new genus *Radiostroma* (type species *R. tenue*) and three other new species, *Labechia bergevikense*, *Pachystylostroma surculum*, and *P. mammillatum*. *Radiostroma* with its long, slender, flange-like composite pillars, is interpreted as having been derived from a *Pachystylostroma*-like ancestor. The stromatoporoid assemblage is part of the earliest known stromatoporoid-dominated reef community preserved in European successions.

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Previous work on the Ordovician stromatoporoids of Norway includes the identification of Ashgill faunal elements in the Ringerike district by Kaljo, Klaamann & Nestor (1963) – *Clathrodictyon microundulatum* Nestor 1964 from stage 5a at Stavnestangen and *Pachystylostroma* sp. nov. ex gr. *fragosa* Nestor 1964 from stage 5b at Ullerntangen – and the recognition of stromatoporoids in reefs of the Mjøsa Limestone (late Caradoc) at Bergevika (formerly spelt Bergvika), on the island of Helgøya (in the lake Mjøsa) by Størmer (1953) and Skjeseth (1963).

The present contribution is based on a small collection of stromatoporoids from the 'reef-like' masses of the Mjøsa Limestone exposed in both north and south limbs of the syncline at Bergevika. The stromatoporoids form the major faunal constituent of the Bergevika reefs and include individual specimens ranging in size up to 1.3 m across and 0.4 m in height. The stromatoporoids are important for two main reasons: first for their role in forming the earliest known stromatoporoid-dominated carbonate build-ups in Europe; and secondly because this represents only the third known occurrence of European Middle Ordovician stromatoporoids – the others being a *Labechia* from the Stinchar Limestone of the Girvan district of Scotland (Webby 1977) and species of *Stromatocerium* from the Saku Member of the Oandu Stage of Estonia (Nestor 1964).

The Mjøsa Limestone has been correlated by Størmer (1953) and Henningsmoen (*in* Holtedahl 1960) with the Upper Chasmops Limestone (4 bδ) of the Oslo-Asker district. It may be referred to a level in the late Caradoc, approximately equivalent to the zone of *Dicranograptus clingani*. Størmer (1967) has visualized the Mjøsa Limestone to the north and the Encrinite Limestone to the south as part of an arcuate western belt of relatively pure carbonates with a biota of algae, stromatoporoids, and corals. The deposits are thought to have been laid down in the well-ventilated coastal waters. The contemporaneous beds to the east are more shaly and have a fauna of cystids, brachiopods, and trilobites. These beds are interpreted by Størmer as having formed in less well-ventilated offshore conditions.

Preservation of the Bergevika stromatoporoids is relatively poor; some specimens are recrystallized and some show evidence of destruction of original structures, with replacement by calcite spar or diagenetic silt. Similar trends to those outlined by Kapp & Stearn (1975) for the Chazy Group stromatoporoids are shown with diagenetic alteration from solid to hollow pillars and from hollow pillars to wall-less rods, but these trends of alteration are not confined to the vertical elements. The cysts may occur in regular rows with the individual upwardly convex cyst plates of a row in contact with cysts of the underlying row, but in less well preserved material each individual cyst in a row becomes erupted at its periphery, thus ceasing to make contact with the underlying cyst row. Sparry calcite comes to fill the space between the rows of cysts and gives rise to a type of diagenetically formed laminae (see Figs. 1C and E, 3A–B; also Webby 1977, pl. 1b). In some cases, drawing a

distinction between original laminae and diagenetically produced laminae is difficult if not impossible.

Systematic description

Type specimens are housed in Paleontologisk museum, Oslo, Norway, and have numbers prefixed by the letters PMO.

Family LABECHIIDAE Nicholson 1879

Genus *Labechia* Milne-Edwards & Haime 1851

Type species. – *Monticularia conferta* Lonsdale 1839

Discussion. – The type species, *Labechia conferta* from the Middle Silurian of England, has been shown by Nicholson & Murie (1878) and Nicholson (1879) to be composed of a large number of stout, vertically continuous, round pillars with a series of lenticular,upwardly convex vesicles (cysts) filling the interspaces. *L. conferta* and its close allies (*L. venusta* Yavorsky 1955 and *L. bajagirica* Nestor 1976, for instance) have a morphology dominated by thick, vertically persistent pillars with the horizontally aligned vesicular cyst plates much less conspicuous. In contrast a number of Ordovician species including *Labechia prima* Kapp & Stearn 1975, *L. eatoni* (Seely 1904), *L. aldonensis* Webby 1977, and *L. bergevikensis* sp. nov. show more prominent and regular horizontal elements (rows of broad, low, arcuate cysts). The pillars of these forms are relatively inconspicuous and lack vertical continuity through the coenosteum. These Ordovician forms are grouped in a separate species group here named the *Labechia prima* group.

Labechia bergevikensis sp. nov.

Fig. 1, A-E.

Material. – Holotype (PMO 97117) collected from disused quarry above cliff overlooking Mjøsa, south of Bergevika; paratypes (PMO 97115-16) from foreshore of Mjøsa north of Bergevika. Mjøsa Limestone.

Derivation of name. – After Bergevika.

Description. – Coenosteum laminar, undulating and with conspicuous latilaminae spaced from 2 to 11 mm high, frequently with interspersed sediment fill. Individual specimens fragmentary, up to 70 mm across and 70 mm high.

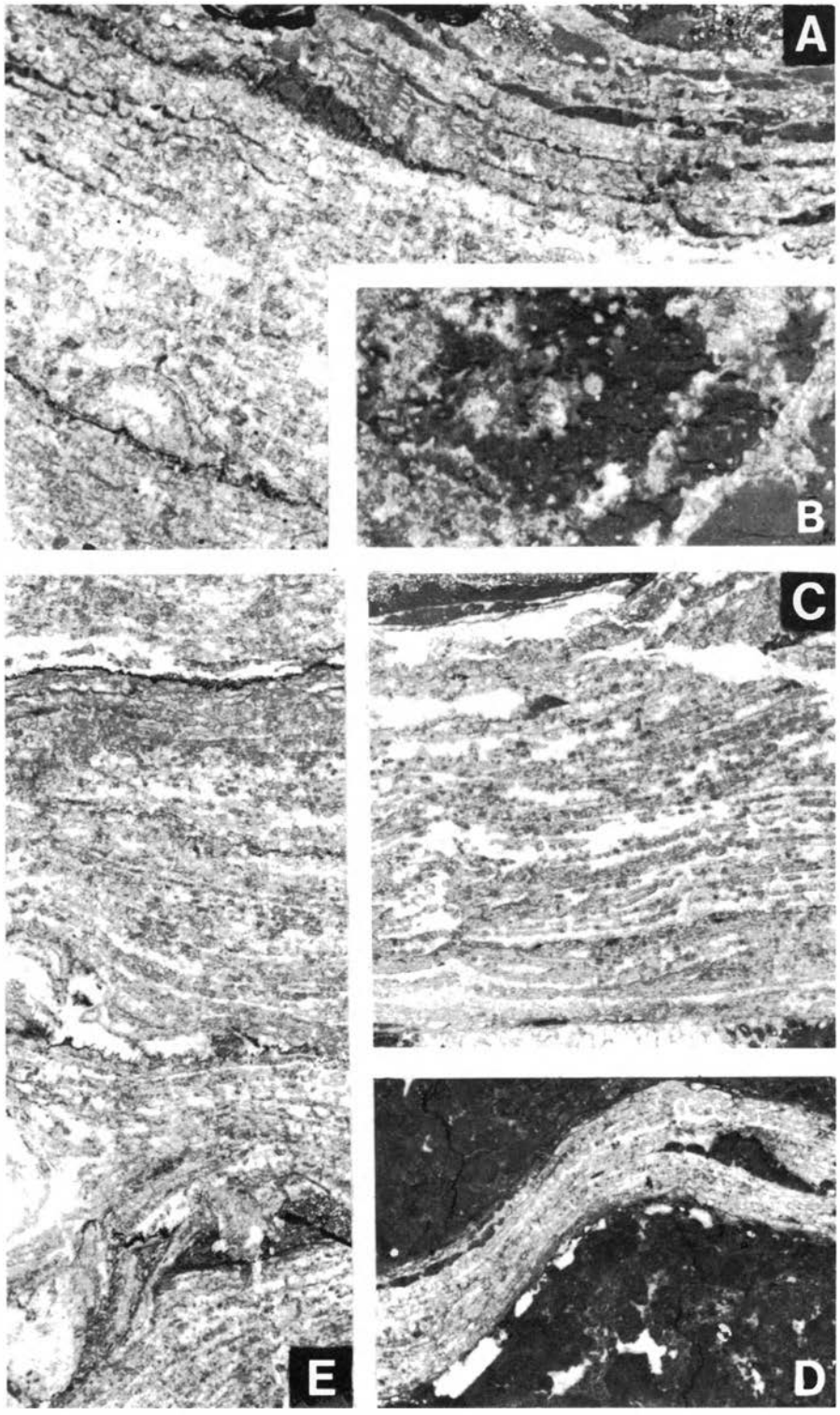
Vertical sections show rows of long, low cysts, frequently alternating with thin bands of sparry calcite which appear to have formed by partial or complete replacement of an individual cyst row, and represent regular but secondarily formed laminae. Cysts (and secondary laminae) usually spaced from 10 to 13 rows per 2 mm vertically; individual cysts from 0.1 to 0.3 mm high except in rare instances at base of latilaminae where they may attain a height of 1 mm or more (Fig. 1A). Cyst wall where still preserved is composed of compact tissue from 0.02 to 0.04 mm thick. Mamelons only prominent in one paratype (Fig. 1E); approximately 6 to 10 mm across and 3 to 7 mm high. Denticles characteristically long (0.1–0.2 mm high) and conical (about 0.1 mm in diameter); some virtually span intercyst spaces, and others have become superposed as discrete pillars (sometimes replaced by calcite spar, see Fig. 1C); pillars may be vertically continuous for up to 0.8 mm (Fig. 1A).

In tangential section, denticles and pillars rounded to slightly angular, 0.05 to 0.15 mm in diameter, and spaced from 0.2 to 0.4 mm apart.

Remarks. – This species resembles *Labechia eatoni* (Seely) from the Chazy Group of eastern North America (Kapp & Stearn 1975) but differs in exhibiting more widely spaced pillars, and less conspicuous mamelons. *L. aldonensis* Webby from the Stinchar Limestone of the Girvan district, Scotland, is also similar but has a wider spacing of cyst rows (3 to 10 in 2 mm vertically) and relatively larger denticles and pillars (Webby 1977).

L. bergevikensis exhibits features which suggests close relationships with other Ordovician genera, notably *Pseudostylodicyon* Ozaki 1938 and *Stratodictyon* Webby 1969. However, if we follow the criteria advocated by Kapp & Stearn

Fig. 1. Labechia bergevikensis sp. nov. A, vertical section of holotype, X10, PMO 97117a; B, tangential section of holotype, X10, PMO 97117b; C, vertical section of holotype, X5, PMO 97117c; D, vertical section of holotype, X5, PMO 97117d, from Mjøsa Limestone south of Bergevika; E, vertical section of paratype A, X5, PMO 97115a. from Mjøsa Limestone north of Bergevika.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(1975), it should be excluded from *Pseudostylodictyon* on the grounds that it exhibits pillars and lacks original laminae. It has a coarser textured form than the representatives of *Stratodictyon*, *S. ozakii* Webby 1969 and *S. columnare* Webby 1969, which have a spacing of 15 to 19 cyst rows per 2 mm vertically.

Genus *Pachystylostroma* Nestor 1964

Type species. – *Stromatopora ungerni* Rosen 1867

Discussion. – In their diagnoses of *Pachystylostroma* both Nestor (1964) and Kapp & Stearn (1975) stressed the presence of pillars in addition to denticles. The selection of the type species of *Pachystylostroma, P. ungerni* (Rosen) from the early Silurian of Estonia seems to have been an unfortunate choice, because it lacks indubitable pillars (see Nestor 1962, 1964). Indeed, at the generic level, it appears to be indistinguishable from a *Pseudostylodictyon* and even bears a certain resemblance to the type species of that genus, *Pseudostylodictyon poshanense* Ozaki 1938. *Pachystylostroma fragosum* Nestor 1964 also lacks pillars, and is the only Estonian Ordovician form referred to the genus; it too may be more properly allied to *Pseudostylodictyon,* or perhaps to *Rosenella.* Kapp & Stearn (1975), however, have recognized three species of *Pachystylostroma* from the Chazy Group of eastern North America. The genus also occurs in the Ordovician Gordon Limestone of Tasmania, and is conspicuously represented in the Middle Ordovician Mjøsa Limestone of Norway.

Nestor's (1976) tentative assignment of *Rosenella woyuensis* Ozaki 1938 to *Pachystylostroma* seems unjustified in view of its large and small cysts (but no laminae) and denticles (but no true pillars) exhibited in both the type specimens from China and the material from New South Wales (Webby 1969). Also, the division of the thick cyst wall into two – a 'basic plate' and a 'covering plate' (see Nestor 1976, fig. 5) – as exhibited by the Moiero specimens and the New South Wales material, is not a diagnostic feature of *Pachystylostroma,* and is not an acceptable basis for transferring *R. woyuensis* from *Rosenella* to *Pachystylostroma. Rosenella amzassensis* Khalfina 1960 from the late Ordovician of Gornaya Shoriya and the material from the Moiero River of northern Siberia (Nestor 1976) both exhibit occasional pillars and should be excluded from synonomy with *R. woyuensis*. However, despite the lack of well-defined laminae, they may be tentatively included in *Pachystylostroma*.

The specimens from the Moiero River assigned by Nestor (1976) to *Stromatocerium* cf. *sakuense* Nestor 1964 and *S. australe* Parks 1910 because they have 'hollow', sparry calcite-filled pillars should also be assigned to *Pachystylostroma*. Nestor (1964, 1976) and Kaźmierczak (1971) regarded the pillars of *Stromatocerium* as being originally hollow. I agree with Kapp & Stearn (1975) that the sparfilled pillars of *Stromatocerium* have been produced by diagnetic alteration of solid pillars, and are not of primary, but of secondary origin.

In summary, the genus *Pachystylostroma* differs from *Pseudostylodictyon* in exhibiting pillars, from *Labechia* in having laminae and better differentiated mamelons, from *Labechiella* Yabe & Sugiyama 1930 in exhibiting both denticles and cysts, from *Rosenella* Nicholson 1886 in showing both pillars and laminae, and from *Stromatocerium* Hall 1847 in having denticles and round pillars.

Pachystylostroma surculum sp. nov.

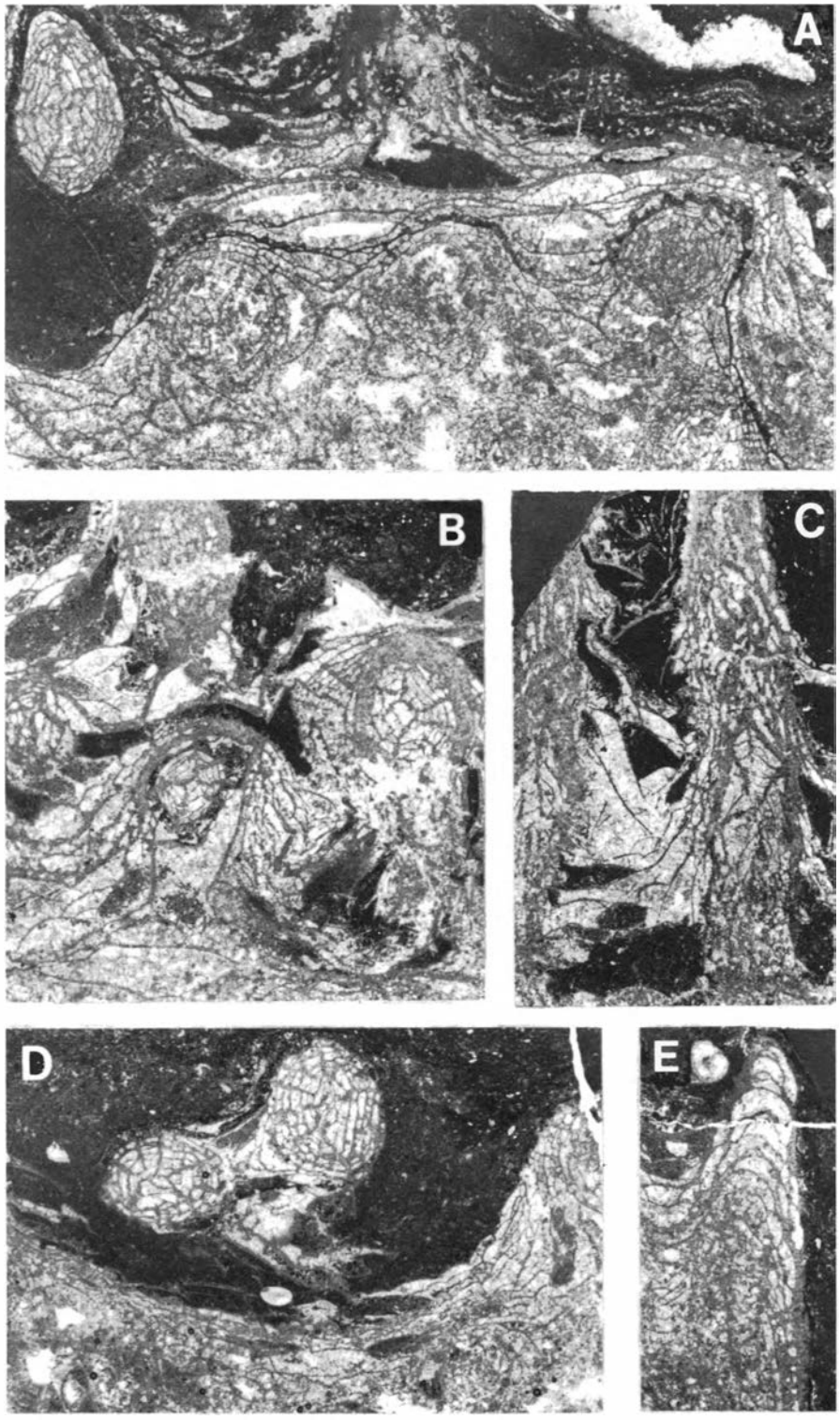
Fig. 2, A-E.

Material. – Holotype (PMO 97112) from the Mjøsa Limestone on the foreshore of Mjøsa north of Bergevika.

Derivation of name. – Alluding to sprout-like appearance of mamelons in surrounding sediment.

Description. – Coenosteum hemispherical and strongly mammillate; holotype measured 70 mm across and 90 mm in height before thin sectioning. Preservation variable; best in surface areas of coenosteum in association with carbonate mud. Latilaminae usually indistinct, but one

Fig. 2. Pachystylostroma surculum sp. nov., X5.A, vertical-tangential section of holotype, PMO 97112a; B, tangential section of holotype PMO 97112b; C, vertical section of holotype, PMO 97112c; D, vertical-tangential section of holotype, PMO 97112a; E, vertical section of holotype, PMO 97112d, from Mjøsa Limestone north of Bergevika.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occurs at periphery, from 2 to 9.5 mm thick, and separated from main body of coenosteum by sediment. Mamelons long and cylindrical, usually from 1.5 to 3.0 mm wide, spaced from 4 to 8 mm apart; rounded tips of mamelons elevated between ca. 7 and 16 mm above their adjacent contemporaneously formed intermamelon troughs.

Cysts are of variable size and convexity; somewhat sharply inflected into mamelon columns; typically from 0.7 to 3.0 mm long, and 0.2 to 1.0 mm high; smaller and more closely spaced (9 to 13 per 2 mm vertically) within and immediately adjacent to mamelons, and larger in troughs between mamelons (2 to 5 per 2 mm vertically); in extremes, cysts up to 9 mm long and 1.8 mm high; lamina-like horizontal elements rarely seen. Cyst walls usually from 0.02 to 0.05 mm thick, although occasionally up to 0.25 mm thick; typically composed of single dark compact layer.

Denticles irregularly distributed on upper surfaces of cysts; more prominent towards periphery of coenosteum; from 0.1 to 0.15 mm in diameter; rounded to pointed tips from 0.1 to 0.2 mm high; frequently superposed to form pillars of similar dimensions and spacing in vicinity of mamelons. Mamelons cut in tangential section usually show an incipient stellate pattern of outwardly radiating pillars (Fig. 2A-B and D); individually up to 1.4 mm long and spaced from 0.2 to 1.0 mm apart; pillars not always vertically and outwardly continuous in mamelons (Fig. 2E).

Remarks. – *P. surculum* bears little close resemblance to other previously described Ordovician species of the genus. It comes nearest to *P. champlainense* Kapp & Stearn 1975 and *P. vallum* Kapp & Stearn 1975 from the Middle Ordovician Chazy Group of eastern North America. However, *P. champlainense* lacks the erect mamelons and has a much less conspicuous development of radiating pillars in mamelons, and *P. vallum* exhibits broader, less erect mamelons, 'palisade bands' with close spaced denticles and laminae. Of the late Ordovician to early Silurian representatives of the genus from Estonia (Nestor 1964), *P. estoniense* Nestor 1964 from the early Silurian Tamsalu and Raikküla stages is the closest, but it has a coarser structure with more widely spaced horizontal and vertical elements, and has more conspicuous denticles.

Pachystylostroma mammillatum sp. nov.

Figs. 3, C-F; 4F; 5A.

Material. – Holotype (PMO 97114) and seven paratypes (PMO 97119-25) from the Mjøsa Limestone near Bergevika, of Helgøya. Holotype and five paratypes (PMO 97119-22, 97125) from foreshore of Mjøsa, north of Bergevika; one paratype (PMO 97123) from disused quarry north of Bergevika; one paratype (PMO 97124) from old quarry above cliff overlooking Mjøsa, south of Bergevika.

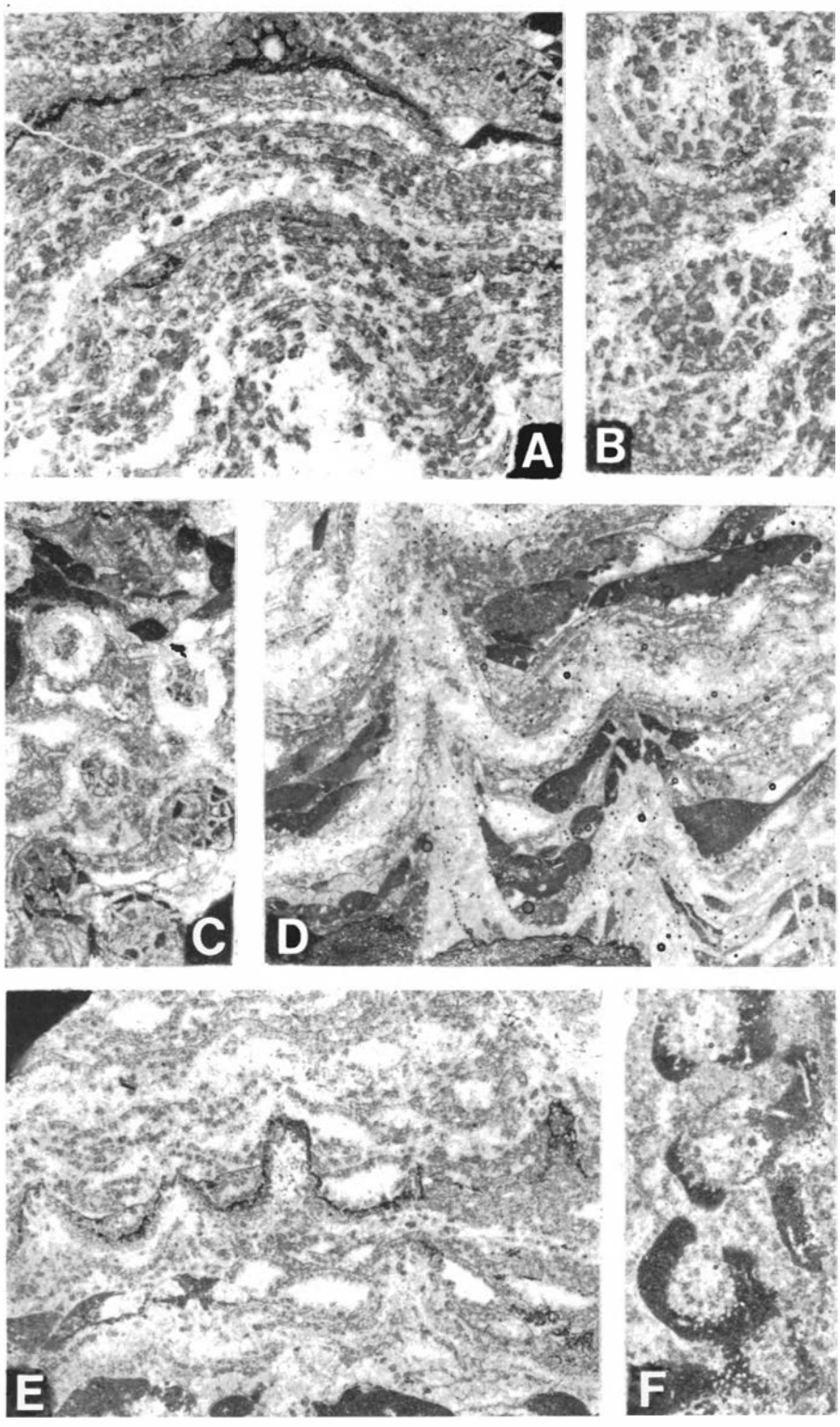
Derivation of name. – Referring to the prominent mamelons.

Description. – Coenosteum hemispherical to irregularly conical; in specimens under study, largest dimensions up to 120 mm across and 90 mm in height (PMO 97120). Latilaminae exhibited in some parts of coenosteum, usually from about 3 to 10 mm thick; sediment may sometimes fill space between successive latilaminae, especially near outer edge of coenosteum; some contacts between latilaminae modified by pressure solution with growth of stylolites or infill of diagenetic silt. Most specimens exhibit some degree of alteration, and infill or replacement with calcite spar or diagenetic silt.

Mamelons tall, slender vertical columns; sometimes persistent through successive latilaminae; may be elevated up to 8 mm above adjacent cyst-filled troughs; typically range from 1.2 to 2.0 mm in diameter and spaced from 3 to 7 mm apart. Intermamelon troughs usually filled with moderately large, irregularly sized, convex blisters, commonly 0.5 to 3.0 mm long and 0.2 to 0.7 mm high; occasionally arranged in more closely spaced, regular rows of smaller, long, low cysts, from 0.2 to 0.4 mm high. Cyst walls confirmed of dark compact layer, from 0.01 to 0.025 mm thick.

Denticles locally prominent on upper surfaces of cysts especially in areas of close-spaced, long, low cysts and in mamelons (Fig. 4F); they are

Fig. 3. A-B. *Pachystylostroma* cf. *P. mammillatum* sp. nov., X5. A, vertical section, PMO 97126a; B, tangential section, PMO 97126b, from Mjøsa Limestone north of Bergevika. C-F, *Pachystylostroma mammillatum* sp. nov., X5. C, tangential section of holotype, PMO 97114b, from Mjøsa Limestone north of Bergevika; E, vertical section of paratype, PMO 97124a; F, tangential section of paratype, PMO 97124b, from Mjøsa Limestone south of Bergevika.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usually from 0.1 to 0.15 mm across and spaced from 0.2 to 0.4 mm apart. Pillars develop from superposition of denticles, confined to mamelons and frequently form continuous upwardly and outwardly radiating elements, for vertical distances of up to 8 mm (Figs. 3D and 5A); may be fused axially into a composite flanged structure which in tangential section has stellate appearance of outwardly radiating pillars (Fig. 3C). Occasionally mamelons do not exhibit either denticles or pillars – only a vertical series of overlapping convex systs. Sometimes internal structure of mamelon centre replaced by sparry calcite infill (Fig. 4F) or less commonly diagenetic silt or sediment.

Remarks. – *Pachystylostroma mammillatum* resembles *P. surculum* but differs in exhibiting more slender and more narrowly spaced mamelons, in having pillars confined to mamelon columns, and in showing thinner cyst walls. The absence of pillars in the intermamelon spaces recalls the genus *Stylostroma* Gorsky 1938. However, *Stylostroma* has not hitherto been recorded from the Ordovician. It includes forms previously assigned to *Pseudolabechia* Yabe & Sugiyama 1930, and now excluded because the type species of *Pseudolabechia* proves to be an actinostromatid not a labechiid (see Mori 1969, 1970).

Another specimen (PMO 97126) from the Mjøsa Limestone on the foreshore of Mjøsa north of Bergevika seems to be allied to *P. mammillatum* but not identical with it. The form exhibits a greater regularity and closer spacing of cyst rows, from 7 to 11 in 2 mm vertically, it has more widely spaced, lower and broader mamelons (about 6 to 8 mm apart), and pillars (mainly preserved as spar-filled wall-less rods) also occur outside mamelon columns (Fig. 3A-B). Rows of long, low cysts show conspicuous disruption and sparry calcite replacement from the secondary, lamina-like banding. In tangential section (Fig. 3B), mamelons exhibit a stellate pattern of outwardly radiating pillars.

Although tentatively assigned to *P. mammillatum* this undulating, laminar, latilaminate specimen also shows some resemblance to *Labechia bergevikensis,* and it may be viewed as an intermediate form. However it differs from *L. bergevikensis* in having a slightly wider spacing of cyst rows and a stellate pattern of radiating pillars in mamelons.

P. mammillatum is by far the most common species in the 'reefal' deposits of the Mjøsa Limestone at Bergevika. Specimens are typically large, hemispherical, boulder-like, and from 150 to 300 mm in overall dimensions; the majority of these specimens are recrystallized or otherwise poorly preserved.

Pachystylostroma sp.

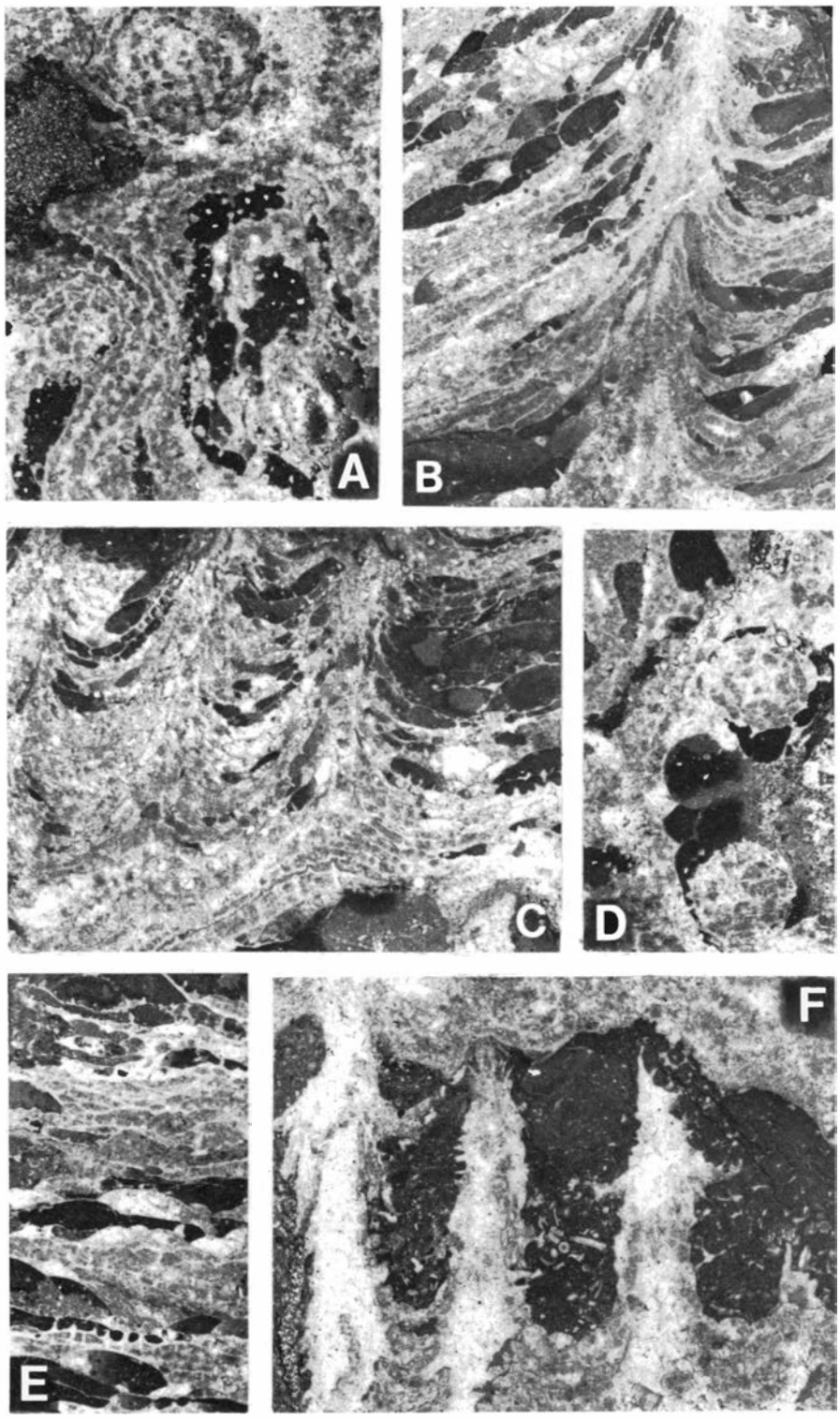
Fig. 4, A-E.

Material. – One specimen (PMO 97118) from disused quarry north of Bergevika. Mjøsa Limestone.

Description. – Coenosteum hemispherical; specimen incomplete, measuring 90 mm across and 60 mm high. Indistinct latilaminae, from about 15 to 35 mm thick. Mamelons inclined at up to 45° away from vertical seemingly because vertical sections aligned through outer margin of coenosteum (Fig. 4 B-C); vertical section at right angles does not show such marked inclination of mamelons from vertical orientation; Mamelons narrow, high, from 1.5 to 3.0 mm wide, and spaced from 5 to 10 mm apart. Both cysts and denticled laminae are exhibited; laminae spaced from 8 to 10 in 2 mm vertically, and cysts of larger, more variable size, usually from 3 to 7 in 2 mm. Cyst wall of varying thickness, typically from 0.01 to 0.05 mm thick. Denticles common throughout coenosteum; usually long and with pointed tips, from 0.1 to 0.2 mm wide and from 0.2 to 0.7 mm apart; often seen to be superimposed through one or more cysts or laminae to form short pillars, 0.7 mm long away from mamelons; pillars in mamelons seen to extend beyond 5 mm vertically, not always clearly differentiated owing to poor preservation; faint stellate pattern of radiating pillars seen in tangential section.

Remarks.–*Pachystylostroma* sp. is unfortunately based on too small a specimen to be adequately characterized. However, it is clearly distinct from *P. surculum* and *P. mammillatum* in ex-

Fig. 4, A-E. *Pachystylostroma* sp., X5. A, tangential section, PMO 97118a; B, vertical section, PMO 97118b; C, vertical section, PMO 97118c; D, tangential section, PMO 97118d; E, vertical section, PMO 97118e, from Mjøsa Limestone north of Bergevika. F, *Pachystylostroma mammillatum* sp. nov., vertical section of paratype X5, PMO 97119a, from Mjøsa Limestone north of Bergevika.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hibiting well marked, apparently original laminae, inclined mamelon columns, and abundant denticles through the coenosteum.

Genus *Radiostroma* gen. nov.

Derivation of generic name. – Alluding to the ray-like form of the 'composite' pillars of this 'Stromatopore'.

Type species. – *R. tenue* sp. nov.

Diagnosis. – Labechiid with hemispherical coenosteum composed of long, slender, vertical, flange-like composite pillars, and denticled cysts in the interspaces.

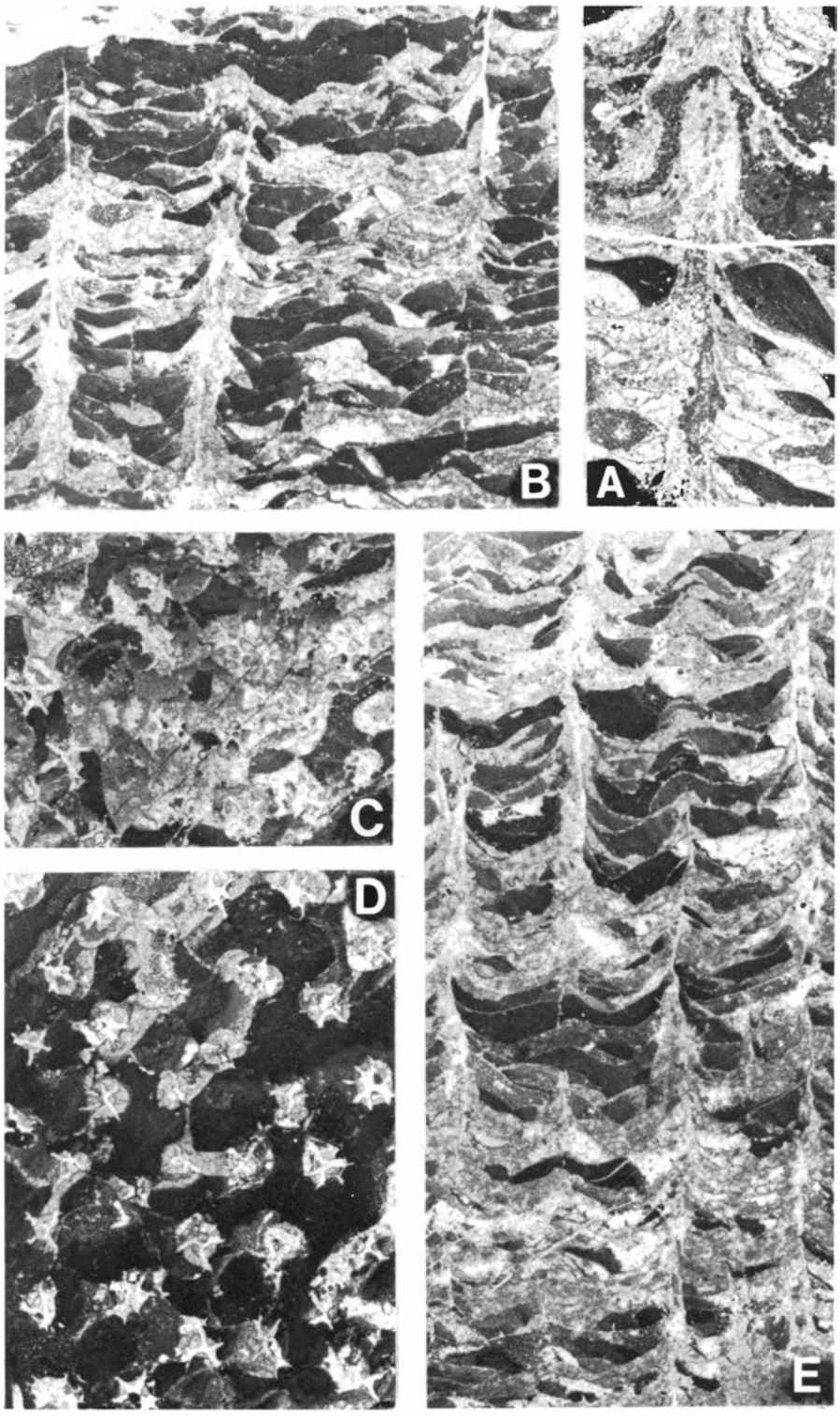
Discussion. – Etheridge (1895) originally introduced *Cystistroma* as a subgenus of *Labechia*, and based it on the type species *C. donnellii* from the Cliefden Caves Limestone (mid-late Caradoc) of central New South Wales. It has since been raised to generic rank by Webby (1969) and Pickett (1970) on the grounds of having large pillars with a rounded to irregular or serrated outline as seen in tangential section, and denticles on the upper surfaces of cyst plates and in places on outer surfaces of the larger pillars. The possibility of a derivation of the large pillars of *Cystistroma* from mamelon columns of a form like *Pseudostylodictyon poshanense* Ozaki has been suggested previously (Webby 1969: 654). The large pillars of *Cystistroma* could not have been derived by superposition of denticles as in a *Labechia* or a *Pachystylostroma* (Kapp & Stearn 1975: 169).

An allied form is *Stromatocerium canadense* Nicholson & Murie 1878 from the Middle Ordovician of eastern North America. It has denticles on the upper surface of cyst plates and 'short, spine like flanges' on the pillars (Parks 1910, Galloway & St. Jean 1961: 60). *S. canadense* and *S. sakuense* Nestor 1964 from horizons within the Estonian Ordovician succession have similar features ('small monticles' on the upper surfaces of cysts and 'hollow pillars' – see Nestor 1964), and should perhaps also be assigned to *Cystistroma*.

It is notable that the interiors of upwarding protruding tips of pillars on the upper surface of the coenosteum in an undescribed Tasmanian species of *Stromatocerium* have been selectively replaced and infilled with calcite spar. If they had been hollow originally, they could not have been preserved as upwardly protruding tubercles in the sediment. The evidence is strongly in favour of the view held by Kapp & Stearn (1975: 168) that the 'hollow pillars' formed by subsequent diagenetic leaching processes from solid pillars, rather than, as Nestor (1964, 1976) and Kaźmierczak (1971) have agreed, that the hollow pillars of *Stromatocerium* have a primary origin. According to Nestor (1976), representatives of *Stromatocerium* should include forms such as the type species, *S. rugosum* Hall 1847, which has 'hollow' wall-like pillars usually radiating from centres. They lack denticles.

Kapp & Stearn (1975) have pointed to a course of evolutionary development from *Pseudostylodictyon* to *Pachystylostroma* in the Chazy Group stromatoporoids. Denticles and pillars (by superposition of denticles) are developed in areas of the coenosteum of *Pachystylostroma* (not including the type species which lacks pillars – see earlier discussion). Numerous small upwardly and outwardly radiating pillars tend to be concentrated in the mamelons of both *Pachystylostroma* and the related genus, *Stylostroma* Gorsky. In vertical section the pillars may coalesce to form a vertically continuous, outwardly radiating, vane-like composite structure – see, for example, *Stylostroma gracile* (Yavorsky 1957, pl. 19, figs. 1-3) – while in tangential section there is a stellate pattern of outwardly radiating elements centred on the axis of the mamelon. In the Mjøsa Limestone at Bergevika, a series of forms is depicted with morphologies ranging from *Pachystylostroma mammillatum* with radiating pillars in mamelon columns to *Radiostroma tenue* gen. et sp. nov. with its pattern of long, slender, 'composite' radiating, vane-like pillars – no longer associated with individual mamelons. There would seem little doubt from this Bergevika series that *Radiostroma* was derived from a *Pachystylostroma*-like ancestor.

Fig. 5, A. *Pachystylostroma mammillatum* sp. nov., vertical section of paratype, X5, PMO 97125a from Mjøsa Limestone north of Bergevika. B-E, *Radiostroma tenue* gen. et sp. nov., X5. B, vertical section of holotype, PMO 97113a; C, tangential section of holotype, PMO 97113b; D, tangential section of holotype, PMO 97113c; E, vertical section of holotype, PMO 97113d, from Mjøsa Limestone south of Bergevika.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Radiostroma tenue sp. nov.

Fig. 5, B-E.

Material. – Holotype (PMO 97113) from the Mjøsa Limestone of main quarry situated above cliff south of Bergevika.

Derivation of specific name – Bearing on the slender form of the flange-like 'composite' pillars.

Description. – Coenesteum hemispherical; latilaminae not shown, but growth banding weakly exhibited; sediment infilling of a greater proportion of cyst chambers at certain levels of coenosteum than in others; gradation at intervals of about 8 to 10 mm vertically from levels of larger cysts with predominant sediment fill to slightly smaller cysts, almost sediment free. Parts of coenosteum affected by diagenetic alteration, with some patches of infill with calcite spar and others of diagenetic silt. Holotype measures 80 mm by 70 mm across, and 110 mm in height.

Cysts large, usually sagging (rarely horizontal) in troughs between adjacent pillars, but in areas of coenostem exhibiting lesser concentrations of pillars; show updomed or undulating cyst form, with shapes varying from small highly convex blisters to long, low, almost laminar elements; vertical spacing varies from 3 to 8 in 2 mm; individually, cysts are from 0.3 to 1.0 mm high, but some larger elements may be up to 1.5 mm in height; cysts also variable in length, from 0.6 to 4.0 mm, with larger cysts up to 9 mm long. Cyst wall, where apparently not diagenetically altered, from 0.02 to 0.03 mm thick, and composed of compact tissue. Pillars long, slender vertical elements (Fig. 5B and E), each composed of a series (usually 40 to 8) outwardly radiating, vane-like plates; usually linked at or near axis giving a stellate appearance in tangential section (Fig. 5D); but sometimes additional vane-like plates develop to enclose polygonal spaces and give a meshwork appearance to pillar (Fig. 5C). Characteristically, pillars from 1.2 to 1.8 mm in diameter, and from 1.5 to 3.0 mm apart. Vane-like plates of pillars only 0.1 to 0.15 mm thick, and frequently show serrations suggestive of denticles on free, outer edges (Fig. 5B). Denticles occur randomly throughout coenosteum, but always on upper surfaces of cysts; mainly from 0.1 to 0.2 mm high and about 0.1 mm in diameter.

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