ALLEYNODICTYON, A NEW ORDOVICIAN STROMATOPOROID FROM NEW SOUTH WALES

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ABSTRACT. A slender, cylindrical, branching labechiid *Alleynodictyon nicholsoni* gen. et sp. nov., is described from Ordovician limestones of central-western New South Wales. It is distinguished from other cylindrical labechiid stromatoporoids by having blade-like pillars. Its manner of growth and possible derivation are discussed.

DURING recent studies of the Bowan Park Limestone, V. Semeniuk discovered a number of unsilicified and partially silicified specimens of the same cylindrical stromatoporoid as had been described and assigned previously to *Cryptophragmus*? (Webby 1969). This latter, silicified material had been collected from the middle part of the Regan's Creek Limestone by R. A. McLean. The new unsilicified material comes from the lower part of the Bowan Park Limestone, from a somewhat lower horizon than the Regan's Creek specimens (for stratigraphical relationships, see Webby 1969). The blade-like pillars mentioned as occurring in the Regan's Creek material also prove to be present in the Bowan Park specimens, and they serve to distinguish the species from all other known cylindrical labechiids. Indeed, the species is considered to be sufficiently distinctive from other Ordovician cylindrical labechiids to warrant its designation as type species of the new genus, *Alleynodictyon*. It appears to be endemic to Australia, and seems to be restricted to horizons from Fauna I to the lower part of Fauna II of Webby (1969), viz., tentatively correlated with the Gisbornian (approximately Lower Caradocian).

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Order STROMATOPOROIDEA
Family LABECHIIDAE Nicholson 1885
Genus ALLEYNODICTYON gen. nov.

Type species. A. nicholsoni sp. nov.

Diagnosis. A slender, cylindrical, branching labechiid with blade-like pillars.

Discussion. According to Galloway and St. Jean (1961, p. 18), there is rarely continuity of tissue between axial column and 'sheath' in *Cryptophragmus*. Usually mud or calcite intervenes between axial column and 'sheath'. The 'sheath organism' has been regarded by Galloway and St. Jean as having the structure of *Labechia*, and growing 'downward from the top of the column after a cold season in which mud was deposited, making latilaminae'. If the 'sheath organism' proves to be an encrusting *Labechia* or alga, then the generic name must be restricted to the inner, axial column and adjoining narrow lateral zone. The type species, *Cryptophragmus antiquatus*, is unbranched, and is distinguished by Raymond (1931) from *Thamnobeatricea parallela*, which exhibits lateral branching, and *Cladophragmus bifurcatus*, which has bifurcating branches and lacks a lateral zone. According to Galloway and St. Jean (1961, p. 19), *C. antiquatus* has round pillars. The evidence for pillars in *Thamnobeatricea* is contradictory. In one place Raymond (1931, p. 181) mentioned 'distinct radial pillars' in the outer wall of dense cystose tissue, and in another (p. 184), 'no radial pillars' are so far known. *Thamnobeatricea* and *Cladophragmus* have been placed in synonomy with *Cryptophragmus* by Galloway and St. Jean (1961). *Alleynodictyon* is distinguished from these North American forms by exhibiting blade-like pillars and a wider lateral zone with tissue in continuity with that of the axial column. It differs from *C. antiquatus* in being a branching form and lacking the 'sheath organism', from *T. parallela* in exhibiting branching of a bifurcating kind, and from *C. bifurcatus* in having a lateral zone. Nevertheless *Alleynodictyon* seems to be more closely related to these slender North American Middle Ordovician forms than to the fasciculate-cylindrical Asian Middle? Ordovician forms, *Sinodictyon* Yabe and Sugiyama and *Ludictyon* Ozaki. *Sinodictyon* tends to be fasciculate and the pillars in the lateral zone seem to be round (Yabe and Sugiyama 1930, Ozaki 1938), and *Ludictyon* has only denticles and alternating zones of larger and smaller axial cysts along the length of the coenosteum (Ozaki 1938).

Aulacera (= *Beatricea*) from the Upper Ordovician of North America, China and Russia (Galloway and St. Jean 1961) also bears similarities but is unbranched, has a relatively larger lateral zone and lacks blade-like pillars.

Alleynodictyon nicholsoni sp. nov.

Plate 5, figs. 1–8; text-fig. 1

1969 *Cryptophragmus*? sp. Webby, p. 651, pl. 122, figs. 1–2.

Material. Two specimens (SUP 34170, 34173) from lower part of Bowan Park Limestone near The Ranch at Paling Yards Creek, and 4 specimens (SUP 34171–2, 34175–6) from a similar horizon near Quondong; 2 specimens (SUP 28169, 34174) from middle part of Regan's Creek Limestone. Numerous additional, unnumbered specimens have been collected from Bowan Park localities but fail to show internal structures.

Holotype. SUP 34170; other numbered specimens designated paratypes.

Description. Coenosteum cylindrical, more than 160 mm in length and from 6·5 to 20 mm in diameter; branches widely spaced, only observed where lengths of at least 80 mm preserved; may be encrusted by *Propora*, bryozoans, algae (Pl. 5, fig. 6) or other (problematical) organisms. Outer wall difficult to interpret owing to patchy external silicification; it varies in thickness from 0·3 to 1·5 mm, and in places seems to include areas of sparite fill and ?micrite. Fine vertical ridges seen on some silicified exteriors; occasionally small, irregular nodes occur on vertical ridges (SUP 34175–6).

Axial column exhibits large domed cysts and occupies from one-third to two-thirds of diameter; axial cysts of variable size, spaced from 0·5 to 2 mm apart (average of 1 mm); they have a slightly irregular, alternating (side-to-side), upward growth habit

(Pl. 5, fig. 2), and occasionally show denticle-like upgrowths on their upper surfaces. In outer parts of axial column, denticle-like structures becoming more continuous, forming blade-like pillars (Pl. 5, fig. 4). Axial cysts mainly completely span column, but in a few localized areas, smaller incomplete cysts occur; these latter may be related to pauses or slowing of rate of upward growth.

Between outer wall and axial column, there is a lateral zone exhibiting small, elongate cysts; these lateral cysts are from 0·1 to 0·3 mm apart, radially, and 2–5 times more widely spaced along length of coenosteum; they tend to be flat to concave outward between pillars, and convex outward in areas lacking pillars. Rows of lateral cysts traced along length of coenosteum seem to be aligned slightly obliquely to outer wall. Wall of axial and lateral cysts up to 200 μm thick, consisting of thin, dense median layer (only 20–40 μm thick) and thick, inner and outer flocculent layers. Sometimes thicker flocculent layers do not seem to be preserved.

Pillars chiefly occur in lateral zone and outer part of axial column; they are septa-like or bladed structures, and have been traced continuously for more than 6 mm along length of coenosteum (Pl. 5, figs. 3–4); they are spaced concentrically from 0·5 to 1·0 mm apart (rarely as close as 0·3 mm). Pillars vary from 100 to 200 μm in thickness; composed of two thick, flocculent? layers which are separated normally by a thin, dense, central layer, 30 μm thick; but sometimes dense, central layer is not apparently preserved. Few specimens (e.g. Pl. 5, fig. 6) exhibit rather narrow lateral zone relative to axial column, and pillars tend to be correspondingly less well developed. On outer

EXPLANATION OF PLATE 5

Figs. 1–8. *Alleynodictyon nicholsoni* gen. et sp. nov. 1–3, SUP 34170, holotype, lower part of Bowan Park Limestone at The Ranch. 1, Transverse section, $\times 4$, showing axial column with large axial cysts, lateral zone with pillars and small lateral cysts, and outer wall. Note irregular silicification of outer wall and peripheral part of lateral zone; also encrusting bryozoan and associated *Tetradium*. 2, Longitudinal section, $\times 3$, showing axial column with large updomed cysts and lateral zone with small, elongate cysts. Zones of smaller axial cysts may be caused by slowing of growth. Note denticle-like structures on upper surface of axial cysts and more continuous ends of blade-like pillars in outer part of axial column. Outer wall and peripheral part of lateral zone exhibit patchy silicification. 3, Tangential-longitudinal section, $\times 5$, showing outer part of axial column with axial cysts intersected by vertical, blade-like pillars (to left), and lateral zone with rows of small, elongate lateral cysts, the outer part of which is affected by a broad band of silicification (to right). Note problematical, tube-like organism encrusting ill-defined, silicified outer wall. 4, SUP 28169, paratype, $\times 4$, middle part of Regan's Creek Limestone; interior view of outer part of axial column showing inner concave surfaces of axial cysts and inner ends of vertical blade-like pillars. More solidly fused tissue of lateral zone is shown to top and right of illustration. 5, SUP 34174, paratype, $\times 4$, middle part of Regan's Creek Limestone; view of the top of a smaller silicified specimen showing axial column with up-arched cysts and, away from axis, short, blade-like pillars, and relatively narrow, solidly fused lateral zone and outer wall. 6, SUP 34171, paratype, $\times 4$, lower part of Bowan Park Limestone at The Ranch; transverse section showing algal encrusted specimen with axial column and relatively narrow lateral zone; the latter with discontinuous pillars and lateral cysts of variable size. Alga appears to be of blue-green type. 7, SUP 34173, paratype, $\times 0{\cdot}5$, lower part of Bowan Park Limestone near The Ranch; exterior view of branching, silicified specimen. Note lack of taper along length of coenosteum, even at offsets. Little internal structure preserved. 8, SUP 34172, paratype, $\times 0{\cdot}75$, lower part of Bowan Park Limestone near Quondong; exterior view of branching, silicified specimen. Smaller offset, which exhibits relatively large, arched axial cysts and very narrow lateral zone, appears to issue from larger branch. Internal structure of larger branch has been destroyed.

surface of coenosteum of some silicified specimens, pillars can be traced as longitudinal grooves for up to 10 mm in length (Webby 1969, pl. 122, fig. 2). Locally, blade-like pillars extend discontinuously inwards almost to axis of coenosteum (Pl. 5, fig. 2). Also, denticle-like upgrowths occur on upper surfaces of axial cysts. Pillars not well enough preserved to positively resolve microstructure.

Derivation of names. After H. Alleyne Nicholson, whose pioneer contributions on the Stromatoporoidea, commencing almost one hundred years ago (1873), laid the foundations for all subsequent work.

Remarks. An oblique section of a fragment of a cylindrical stromatoporoid (SUP 34177) from the Gordon Limestone of Tasmania shows closely similar structures, including what appear to be blade-like pillars. Unfortunately the locality details of this particular specimen have been lost. Some Gordon Limestone specimens previously referred to *Cryptophragmus* and *Thamnobeatricea* (Banks 1962, 1965) may belong to *Alleynodictyon.*

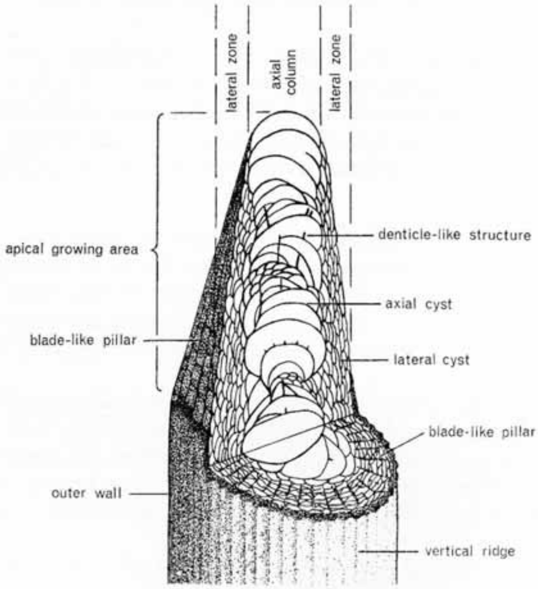
Orientation of living form. Schuchert (1919, pp. 294–5) found most specimens of the Upper Ordovician cylindrical labechiid *Aulacera* on Anticosti Island, Quebec, lying in the plane of bedding, and interpreted them as having broken away from their basal attachments. He noted that some of their basal attachments are 'quite large expansions, still stuck to the places where they grew', and interpreted the fossils as 'attached, vertical, colonial organisms'.

Galloway and St. Jean (1961, p. 24) also noted that specimens of *Aulacera* usually occur with their long axes parallel to bedding, but said that they must have stood upright in life because all sides are alike. According to them, no specimens show a base, or at least none has been described. The base should, they believe, have the structure of *Cystostroma*. Yavorsky (1955, p. 71) also favoured the idea that the living *Aulacera* stood erect.

Most specimens of *Alleynodictyon* are also preserved with their long axes in the plane of bedding, but they too must have assumed an upright living habit (text-fig. 1). Such a conclusion is supported by their symmetrical form about long axes, and presence, in at least one specimen (Pl. 5, fig. 6), of encrusting algae which completely surround them. Specimens usually seem to occur in clusters at the various localities and horizons, perhaps suggesting that they represent fragments broken and locally transported from colonial masses. They are typically preserved as empty shells with the entire interior structure removed and replaced by calcite.

Mode of growth and relationships. A common soft tissue (coenosarc) may have mantled the upper surface of the living form of laminar and hemispherical stromatoporoids, and may have been responsible for secreting the cysts (or laminae) and pillars. The exact manner of cyst and pillar formation is still largely unknown, though it may have been secreted from the undersurface of the coenosarc. Whether the mamelons and pillars (in part) occupied the sites of different kinds of zooids, and whether the astrorhizal canals contained entodermal extensions of the coenosarc or zooids remain a matter for speculation.

In cylindrical labechiids like *Aulacera* and *Alleynodictyon*, the soft tissue may have either mantled only the apical growing area (text-fig. 1) or extended over the entire cylinder (including the branches) or, if bases are eventually proven to exist, spread over the entire colony of erect cylinders and common base. Against the first and second alternatives is the lack of any attachment or anchoring structure which would be required to support erect cylinders situated freely on the sea floor. Yavorsky (1955, pl. 36, fig. 3; 1962, pl. 4, fig. 7) figured a specimen with an enlarged 'attachment' at the small end which, from the arrangement of cysts shown in his figure and drawing is



TEXT-FIG. 1. Diagram showing the morphological features and inferred nature and orientation of apical growing area in *Alleynodictyon nicholsoni* gen. et sp. nov. Approximately $\times 2 \cdot 5$.

orientated upside down. The small end is in fact at the top (the longitudinal section appears to be slightly oblique), and the 'attachment' may be part of an offset. The third interpretation seems the most appealing in view of the occurrences of clusters of broken cylinders, and inferred relationships with laminar-hemispherical labechiids. There is broad morphological similarity between a colony composed of erect cylinders attached to a base and a laminar-hemispherical labechiid with well-developed mamelons. The cylinders may be interpreted as attenuated mamelon structures from a laminar-hemispherical base.

In *Alleynodictyon*, axial and lateral cysts are essentially in continuity, and the rows of lateral cysts appear to lie at a slight angle to the outer wall, suggesting that active growth was restricted to the apical growing area of the coenosteum (text-fig. 1). The outer wall, though not well preserved, lacks growth lines or other structures suggestive of upwardly migrating soft tissue. The most common structures found on the exterior surfaces of cylindrical labechiids (especially *Aulacera*) are vertical to spiral ridges, nodes and papillae. Although admittedly negative evidence, this seems to support a view that during life the soft tissue completely mantled the exterior of the coenosteum and only after death did the coenosteum become exposed. The encrustation of one specimen by an alga (Pl. 5, fig. 6) seems to have taken place after death while it was still in an upright position. The fact that specimens of *Alleynodictyon* do not taper appreciably over lengths of many centimetres seems to indicate that after initial growth near the apex, the coenosteum remained ensheathed by soft tissue but did not increase markedly in size. In one specimen, a smaller offset seems to maintain a uniform diameter away from the main branch (Pl. 5, fig. 8). Such smaller branches typically exhibit a much narrower lateral zone relative to the axial column than larger branches.

The blade-like pillars of *Alleynodictyon* may have been derived from numerous small, round pillars, like those exhibited in the lateral zone of *Sinodictyon*, coalescing in vertical rows, or may have developed by extreme elongation in a vertical direction of a single radiating set of pillars. They are somewhat analogous to septa in rugose corals, and the denticle-like structures near the axis, which form on the upper surfaces of the cysts, resemble septal spines. However, this is probably no more than a homeomorphic relationship.

The cylindrical forms, *Cryptophragmus* (excluding the 'sheath'), *Thamnobeatricea*, *Cladophragmus*, *Ludictyon*, *Sinodictyon* and *Alleynodictyon*, may have evolved from laminar-hemispherical types with extended mamelon-like growths, possibly early in the Gisbornian (early Caradocian). Though no particular Middle Ordovician laminar or hemispherical labechiid closely matches, they could have been derived either from *Cystostroma*, *Stratodictyon*, *Pseudostylodictyon*, *Rosenella*, or from more than one of these genera.

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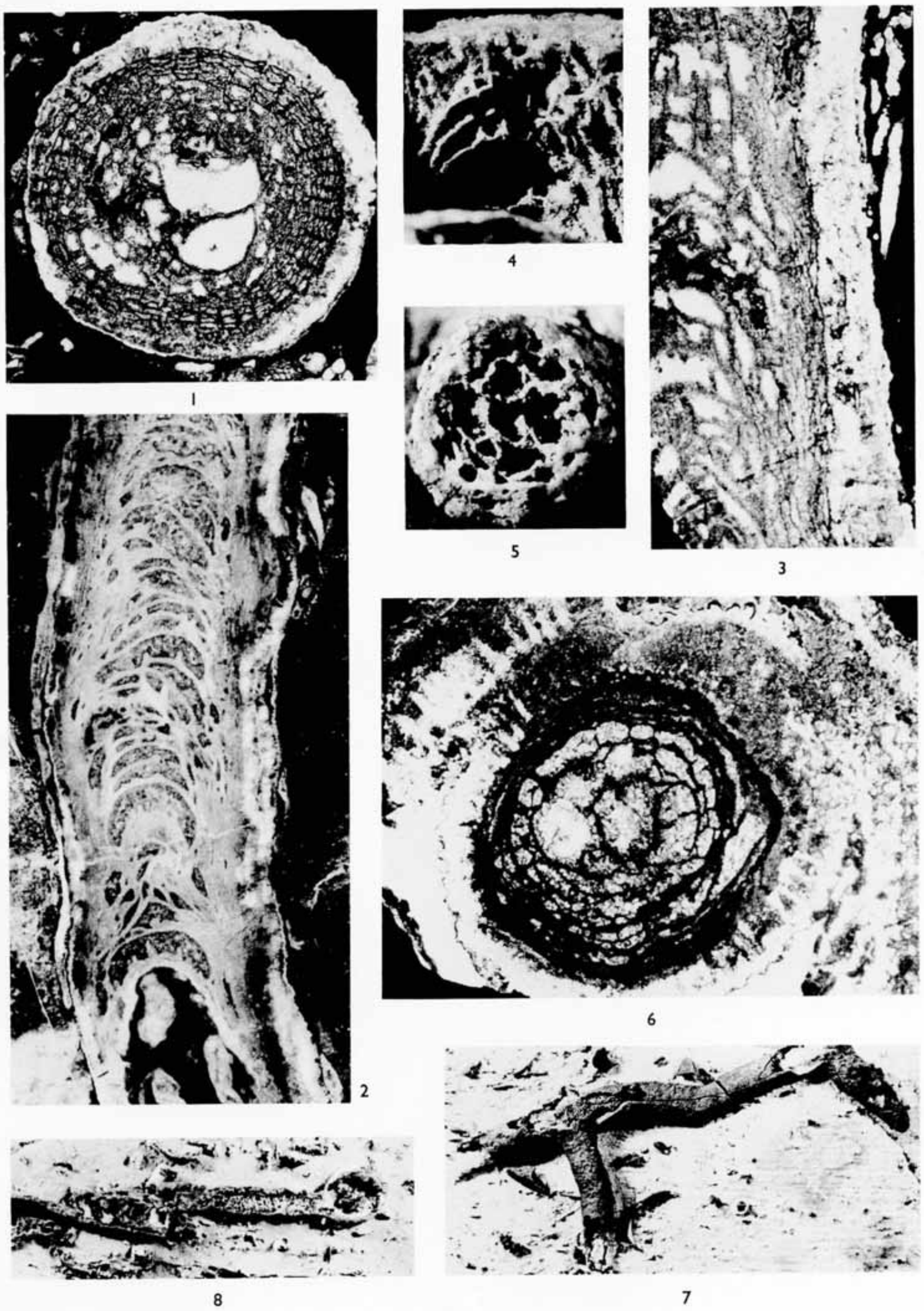

WEBBY, Ordovician stromatoporoid