GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

BULLETIN 92

CONTRIBUTIONS TO CANADIAN PALÆONTOLOGY

Stromatoporoid Fauna of the Waterways Formation (Devonian) of Northeastern Alberta

C. W. Stearn

Columnaria pax (Smith) and the Silurian *Columnaria columbia* n. sp. from British Columbia

B. S. Norford

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1962

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ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1962

Price $1.50 Cat. No. M42-92

Preface

Stromatoporoids and rugose corals were important reef-forming and rock-building organisms in Palæozoic times. Widely distributed and often well preserved, they are of considerable stratigraphic significance in the chronology of the rocks in which they occur.

Practical application of palæontological correlation is directly dependent upon systematic study of fossil faunas, and the two papers comprising this bulletin present the results of such systematic studies. The first deals with the stromatoporoids of the Devonian Waterways Formation of northern Alberta; the second paper describes a new coral species, and suggests a Silurian age for another coral hitherto assumed to be Devonian.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, August 9, 1961

Геологическая Служба Канады,
Бюллетень 92.

1. Строматопоровая фауна Ватервейской свиты (девон) северо-восточной Альберты.
   С. В. Стерн.
2. **Columnaria pax** (Smith) и силурийская **Columnaria columbia** n. sp. из Британской Колумбии.
   Б. С. Норфорд.

1. Die Stromatoporenfauna der Waterways Formation (Devon) im nordöstlichen Alberta
   von C. W. Stearn.
2. **Columnaria pax** (Smith) und die silurische **Columnaria columbia** n. sp. aus Britisch-Kolumbien von B. S. Norford.

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B. S. Norford

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STROMATOPOROID FAUNA OF THE WATERWAYS FORMATION (DEVONIAN) OF NORTHEASTERN ALBERTA

C. W. Stearn

Abstract

Stromatoporoids occur abundantly in the Devonian of Western Canada and have up to the present received little systematic study. The fauna described in this report was collected from the Waterways Formation, an Upper Devonian formation widespread in northern Alberta. Ten new species are described, and are assigned to the families Actinostromatidae, Idiostromatidae, and Stromatoporidae; six genera are represented.

Résumé

Les stromatoporoïdes abondent au sein des formations dévoniennes de l'Ouest canadien mais, jusqu'à présent, on n'en a pas fait une étude véritablement systématique. La faune décrite dans le présent rapport provient de la formation Waterways, qui date du Dévonien supérieur, et est très répandue dans le Nord albertain. Dix nouvelles espèces y sont décrites et rattachées aux familles des actinostromatidés, des idiostromatidés et des stromatoporidés. Six genres y sont représentés.

Introduction

Near the town of McMurray in northeastern Alberta, Devonian limestone outcrops along Athabasca and Clearwater Rivers beneath the unconformable cover of the Cretaceous McMurray oil sands. These argillaceous limestones, calcareous shales, and massive limestones were described by the early explorers of the region but fossils were not extensively collected from them until F. H. McLearn of the Geological Survey studied them in 1916 (McLearn, 1917). Warren described fossil collections from the limestone in 1933 and proposed that the beds be called the Waterways Formation. Recently the stratigraphy of these beds has been restudied and redescribed by Crickmay (1957), Carrigy (1959), and Norris (in press). The collections made by Norris and McLearn for the Geological Survey were the materials used in this study of the stromatoporoid fauna.

Stratigraphic Setting

The nomenclature of the stratigraphic succession used by Norris in the Clearwater-Athabasca area is given in the following table:

Epoch	Formation	Member
Lower Cretaceous	McMurray	
unconformity		
Upper Devonian	Waterways	Mildred
		Moberly
		Christina
		Calumet
		Firebag
unconformity ?		
Middle Devonian	Livock River	
	'First Salt'	
	Methy	
	McLean River	
	unconformity?	
	LaLoche	
unconformity		
Precambrian		

Limestone and shale of the Waterways Formation outcrop discontinuously in the banks of Clearwater River from just below Cascade Rapids to the junction with Athabasca River, a river distance of about 48 miles. The exposures on Athabasca River are scattered between Crooked Rapids and a point about 3 miles below Eymundson Creek, a river distance of about 90 miles.

The Waterways Formation unconformably (?) overlies a thin carbonate unit of Middle Devonian age referred to as the 'Slate Point Equivalent' by Crickmay (1957), which was named the Livock Formation by Norris (in press). In the outcrop area the Waterways Formation is unconformably overlain by the McMurray Formation of Lower Cretaceous age. Progressively younger Devonian beds appear below the unconformity in a southwestern direction because, in that direction, the regional dip of the Devonian strata is greater than that of the overlying Cretaceous beds. The Waterways Formation has been divided by Crickmay (op. cit.), mainly on the basis of subsurface data, into five members. Parts of each except the Mildred are represented in outcrops. The Mildred Member has been eroded away in the outcrop area but is present in the subsurface downdip a short distance west of Athabasca River.

The Waterways Formation can be traced through wells westward and southward for correlation with the standard Devonian section of the Alberta Plains (Belyea, 1953). It can be shown to be equivalent to the Beaverhill Lake Formation of the Edmonton region and to be a correlative in part of the Flume and Lower Cairn Formations of the Rocky Mountains. The exact correlation of the last-named formations with the Beaverhill Lake Formation has not as yet been demonstrated.

Some of the largest oil discoveries in recent years have been made in reefs within the Beaverhill Lake Formation in the region 120 miles northwest of Edmonton and 240 miles southwest of McMurray. These discoveries include the Swan Hills field, Judy Creek and the smaller Judy Creek West, Virginia Hills, and Kaybob fields. The reefal limestones from which the oil is produced in these fields is composed in large part of stromatoporoids. Little has been written on this stromatoporoid fauna to date (Fischbuch, 1960) but palæoecological studies have been made (Thomas and Rhodes, 1961).

Most palæontologists have dated the Waterways Formation as early Late Devonian (Early Frasnian), although some have maintained that it is partly or wholly of Middle Devonian age. The stromatoporoids described here throw little light on this problem for nearly all are new species. The palæontological zonation of the formation has been discussed by Crickmay (1957), Warren and Stelck (1956), and Norris (in press).

The Stromatoporoid Fauna

Stromatoporoids occur abundantly in the outcrops of the Waterways Formation mainly within the Moberly Member, which is best exposed along Athabasca River between McMurray and MacKay. Those collected by Norris are from a single, hard, massive limestone unit which ranges from 6 to 19 feet in thickness and occurs

about 40 feet above the base of the member. McLearn (1917, p. 147) has recorded three stromatoporoid-bearing units in the Moberly Member along Athabasca River between Moberly Rapids and MacKay. McLearn's lower 'Stromatopora bed' is undoubtedly the unit from which Norris collected stromatoporoids.

Although Devonian stromatoporoids of Western Canada occur in great abundance in the petroleum-bearing reefs, they have received little detailed study. Stearn (1961) has recently described a part of the stromatoporoid fauna of the Fairholme Group from the Rocky Mountains, and McCammon (1960) has described some stromatoporoids in her report on the fauna of the Dawson Bay Formation of Manitoba. Although McCammon places the upper part of the Dawson Bay Formation in correlation with the lower part of the Waterways, the stromatoporoid fauna of the Moberly Member described here and that of the Dawson Bay Formation are totally different. Galloway (1960b) has described some stromatoporoids from the region of Norman Wells in the Northwest Territories but these too seem to be totally different from the stromatoporoids in the Waterways Formation. Fischbuch has discussed the stromatoporoids of the Kaybob Reef (1960) and Thomas and Rhodes (1961) described some palæoecological aspects.

The stromatoporoid fauna is not a large one yet seems to be unusual in several ways. Three of the most common genera of Devonian stromatoporoids, *Actinostroma, Anostylostroma,* and *Stromatopora* are absent or rare. Poorly preserved individual specimens of the last two genera were found in the collections but are not worthy of description. *Amphipora* is absent in the collections although Norris reported a few poorly preserved specimens in his Christina Member on the lower part of Christina River. *Amphipora* is also abundant in the Beaverhill Lake Formation in the subsurface. Almost a third of the specimens are *Clathrocoilona inconstans* n. sp. These peculiarities are undoubtedly caused by environmental factors. The significance for the reconstruction of past environments of the form and structure of stromatoporoids has not been determined to the extent that the palæontologist can suggest certain environments for certain species or genera.

Systematic Palæontology

Family ACTINOSTROMATIDAE Nicholson

Genus *Trupetostroma* Parks

Type species: *Trupetostroma warreni* Parks 1936.

Laminae continuous, compact, composed of a fine primary dark or light microlamina clothed in light grey tissue. Pillars compact, of lighter tissue, the more conspicuous element of the structure, spool-shaped, well superposed, typically with small vacuoles.

Trupetostroma papulosum n. sp.

Plate I, figures 1-5

This species is represented in the collections by seven coenostea.

Description. The coenostea are plate-like, and form thin, extensive, probably encrusting structures less than 3 cm thick. The largest specimen is about 17 cm long, 9 cm wide, and 1½ cm thick. The surfaces of coenostea are minutely granular and covered with small, regular, low, rounded, mamelons spaced at intervals of 3 to 5 mm. Growth was latilaminate and the coenostea tend to break readily along these growth planes. The thickness of the latilaminae ranges from about 1 to 3 mm. Surface of latilaminae is covered with large sprawling astrorhizae which do not seem to be related to the mamelons. One specimen is intergrown with *Clathrocoilona inconstans*.

Vertical section: General appearance of vertical sections is of a regular network of persistent pillars and laminae with prominent mamelon columns.

Laminae thin (40 to 80 microns), composed of compact tissue that generally shows no fine structure. In well-preserved parts of most sections laminae with a central light line can be seen. Locally the laminae seem to be transversely porous. The laminae are persistent, gently undulant, to generally straight, but sharply inflected into mamelon columns, generally closely spaced, about 10 to 12 in 2 mm. Laminae locally pierced by foramina but these are not abundant. In places the laminae are replaced by dissepiments.

Pillars are thicker than the laminae, are superposed and appear to penetrate the laminae. They are 100 to 200 microns in diameter, spaced six to eight in 2 mm, are basically spool-shaped but are very little expanded at the laminae. Pillars are not conspicuously vacuolate.

Astrorhizal canals not prominent in vertical section but may be represented by some of the larger rounded galleries. Galleries are rounded, superposed, irregular in shape but generally much wider than high. They are crossed by abundant, flat or curved, fine tabulae. Although dissepiments are common throughout the structure, they are more abundant in some zones than in others. The mamelon columns are small but persistent through the structure. Pillars radiate away from the axis of the inflection of the laminae and dissepiments tend to be more abundant near these inflections.

Tangential section: Tangential sections show mamelon columns of concentric and radial structure. Laminae appear as compact, thin lines concentric with the mamelon centres. Pillars are compact and in a few places seem to be vacuolate. They are bar-like and irregular in form where they radiate from the columns. Between the columns they emerge as irregularly shaped bars and dots. Astrorhizal canals about 200 microns in diameter radiate away from the mamelon centres. The galleries are highly irregular, vermiform, and crossed by dissepiments. The columns do not have axial canals.

Discussion. This species is similar to several that have been described. It most closely resembles *Trupetostroma cimacensis* Lecompte in dimensions and form, but tangential sections of this European species do not show the conspicuous mamelon columns of *T. papulosum,* and the fibrous structure of the pillars described by Lecompte is not present. The new species is also similar to *T. porosum* Lecompte but does not show the line of pores marginal to the pillars which is the feature of this species. It also resembles *T. lecomptei* Stearn but has less regular laminae and many more dissepiments.

Material and occurrence. Holotype, GSC No. 15328, from GSC loc. 5840; paratype, GSC No. 15329, from GSC loc. 5869; paratype, GSC No. 15330, from GSC loc. 29100.

The species is common in the Moberly Member of the Waterways Formation and is easily identified by its laminar latilaminate coenostea covered with small mamelons. Specimens were collected from localities 5840, 5845, 5869, 29100 (two specimens), 29201 (*see* Locality Index, p. 22).

Trupetostroma pycnostylotum n. sp.

Plate II, figures 1-3; Plate III, figure 1

Description. Coenosteum variable, generally irregularly massive, cabbage-shaped, up to 10 cm in diameter; in some specimens irregularly laminate. Five specimens of this species are represented in the collection. The surface of none of these is well exposed but astrorhizae are apparently present on one coenosteum. One of the specimens is intergrown with *Pseudoactinodictyon norrisi.*

Vertical sections show thick pillars and thinner, well-defined laminae, which together form a rectilinear network. The laminae are formed of an axial line of fine, dark granules bordered on either side by light, compact, translucent tissue which is transversely fibrous. The fibres seem to extend outward from the axial granules at right angles to the surface of the galleries and resemble the trabecular structures of coral septa. The tissue bordering the axis of the laminae is similar in structure to the pillars and ranges in thickness from place to place in the same section from 10 to 200 microns. The laminae are persistent, gently undulant and inflected into small mamelons. They are spaced from eight to twelve in 2 mm. Foramina are common in the laminae and are generally closed by a thin dissepiment.

Pillars are thick (70 to 250 microns), about as thick as the galleries between them, and in places almost adjacent to one another. They are apparently transversely fibrous, composed of sprays of fibres curving outward from their axes like trabeculae. Pillars are conspicuously and regularly spool-shaped and very closely superposed from lamina to lamina. Near the mamelons they are thicker and more closely spaced so that locally they coalesce. Normally they are spaced about four to six in 2 mm. No traces of vacuoles in the tissue were seen.

Astrorhizal canals are not obvious in vertical sections but some of the larger galleries near upward inflections of laminae may represent these canals. Galleries are round and regularly superposed. Mamelon columns are not prominent but several

sharp upward inflections of the laminae can be seen in most sections. Short dissepiments are scattered in the structure. They are more common near the mamelons but nowhere abundant.

Tangential sections show prominent mamelon columns. Near the centres of these the laminae are thin, well defined, and concentric, farther away they cannot be readily distinguished. They are composed of a fine line of granules clothed in secondary tissue. Pillars radiate from the mamelon centres as slightly irregular bars of light, compact, in part fibrous tissue rarely showing small vacuoles. In the limited areas between the mamelons the pillars emerge as isolated dots and as dots coalesced into irregular bars. Galleries radiate from the centres of the mamelons. Astrorhizae are not obvious but some of the more sinuous radial galleries crossed by the occasional dissepiment may represent astrorhizae. Mamelons have a central canal or several smaller central canals. Dissepiments are not conspicuous in tangential sections.

Distinguishing features of this species are the thick pillars, paucity of dissepiments, the thin laminae, the spacing of the pillars, and the obscurity of the astrorhizae.

The trivial name refers to the thickness of the pillars.

Discussion. This species belongs in the *Trupetostroma raricystosum* Galloway and St. Jean group along with *T. arduennensis* Lecompte and *T. crassum* Lecompte. All have thick laminae with thin distinct microlaminae in the centre, generally few dissepiments, and very thick pillars. *T. pycnostylotum* is similar in structure also to *Gerronostroma* in the transversely fibrous nature of the pillars and laminae but species of this genus do not generally have a median microlaminae. The fibrous nature of the tissue is compared to trabecular structure in the description, but this does not imply a relationship with the corals for many writers on the stromatoporoids have denied that these fossils have this structure. *T. pycnostylotum* differs from its nearest relative, *T. raricystosum* Galloway and St. Jean, in its lack of flocculent tissue, its more closely spaced pillars (but not as close as *T. crassum* Lecompte), and in the prominence of mamelons in the structure.

Material and occurrence. Holotype, GSC No. 16434, from GSC loc. 5860; paratype, GSC No. 16435, from GSC loc. 5839.

The species is not common in the Moberly Member of the Waterways Formation. Specimens were collected from localities 5839, 5841, 5860 (two specimens), 29201 (two specimens).

Family IDIOSTROMATIDAE Nicholson

Genus *Idiostroma* Winchell

Type species: *Stromatopora caespitosa* Winchell 1866.

Coenosteum cylindrical dendroid or fasciculate. Stems with an axial tube that may be branched, composed of thick laminae with an axial dark microlamina and long thick superposed pillars. Tissue is compact.

Idiostroma mclearni n. sp.

Plate II, figures 4, 5; Plate III, figures 2-4

Description. The two coenostea in the collection are from the same locality and are possibly part of the same individual. The largest fragment is a cylinder 4 cm long and 1.2 cm in diameter, which is unbranched but seems to have been cracked before preservation at a point where it makes a gentle bend. Orifices open on the surface of the cylinder, which is covered with fine vermicular lines. The lines seem to lead away from the orifices like astrorhizae.

Transverse sections show a beautifully preserved network of superposed radial pillars and concentric laminae. The axial canal is well defined, about 0.5 mm across, bounded by an irregular thin wall, and crossed by curved tabulae. It is surrounded by a zone about 2 mm in diameter of tissue forming a delicate network in which neither radial nor concentric structures can be distinguished. This tissue is marked by a central dark line of coarse granules that look like maculae. Outside this zone is one in which radial pillars and concentric laminae are well defined and form a grid. The pillars are thick (about 100 microns). They are marked longitudinally by dusty streaks of fine inclusions which give them a fibrous appearance. The pillars thicken outwards until near the periphery they join to form a solid bank of tissue in which the laminae are reduced to dark lines of granules. Near the axial zone the laminae are about as thick as the pillars and consist of a central line of dark granules clothed on either side by translucent tissue which is transversely fibrous in favourably preserved parts of the coenosteum but not apparently vacuolate. Interspaces are rounded and equidimensional near the axial zone but become elongate radially where the pillars and laminae form a dense border zone. Here they look like pseudozooidal tubes and are crossed by thin dissepiments — the continuations of the primary laminae across the interspaces. Large tubes, 0.5 mm in diameter, branch from the central tube and emerge in low prominences on the exterior surface. In transverse sections this surface seems to have been rough and to have been formed by the ends of the emergent pillars for sediment has infiltrated between them.

Axial sections show a prominent axial canal of irregular diameter from which subsidiary canals of about the same diameter branch to low mounds at the surface. An axial zone surrounds the axial canal in the thicker and presumably more mature part of the coenosteum. It is composed of a fine network of tissue similar to that described in transverse section. A few vague lines of dark granules can be followed through the otherwise irregular network but no regular arch of laminae is formed. In thinner (and presumably less mature) parts of the coenosteum, the laminae form an arch in the axial zone which is interrupted by the axial canal.

Outside the axial zone is a zone in which pillars and laminae are well differentiated and have features similar to those described from transverse sections. In some places the two elements are fused together into solid tissue in which only the fine line of granules that marks the centre of the laminae and the streaky inclusions in the pillars can be distinguished. In other parts discrete pillars and laminae emerge. Large interspaces, radially and longitudinally elongate, are scattered throughout the structure. Near the axis they seem to be true galleries but in the peripheral areas the

galleries seem to have been eliminated by the fusion of the pillars and laminae and the interspaces represent canals.

In tangential sections the pillars form a regular network. Galleries are round, tend to be regularly spaced, and to take up about twenty per cent of the section. Branching astrorhizal canals are prominent.

The species is named for Dr. F. H. McLearn of the Geological Survey of Canada, who collected the type material in 1916.

Discussion. This species resembles some species of *Stachyodes* particularly in the peripheral zones. The problems of differentiating the two genera have recently been discussed by Lecompte (1952, p. 314) and Galloway (1960a). The divergence of opinion on the generic features of the Idiostromatidae can be appreciated by a consideration of Galloway's (op. cit.) wholesale redistribution of Yavorsky's and Lecompte's species among the genera *Idiostroma, Stachyodes,* and *Dendrostroma.* The characters which place this species in the genus *Idiostroma* are the well-developed laminae and pillars in the inside of the peripheral zone, the transversely fibrous laminae with axial dark lines, and the persistent central canal in the coenosteum. Whether the genera mentioned above can be differentiated on the basis of their tissue structure is a matter of debate for both show in some species the streaky structure of the pillars described above and the vacuolate peripheral zones which do not occur in this species.

The species is close to *Idiostroma roemeri* Nicholson, and *I. uralicum* Yavorsky, which Galloway (1960a) believes to be conspecific. It differs in that the axial zone is a delicate network not crossed by the thick laminae in the mature stages, and in the lack of vacuoles in the tissue.

Material and occurrence. The two specimens, probably of the same individual, are from locality 5849 and are holotype, GSC Nos. 16436 a, b.

Genus *Stachyodes* Bargatsky

Type species: *Stromatopora (Caunopora) verticillata* McCoy 1851.

Description. Coenosteum dendroid, with axial canal crossed by tabulae. Tissue finely streaked radially and traversed by irregular fine canals, not clearly differentiated into pillars and laminae specially in the central parts of coenostea. Laminae marked by fine dark lines particularly in the peripheral parts of coenostea but not separated by galleries. Pillars thick, defined by radial, tabulate galleries (or canals) in the peripheral parts of coenostea.

Unfortunately considerable confusion has arisen over the identity of the genera *Clavidictyon* Sugiyama, *Idiostroma* Winchell, *Stachyodes* Bargatsky, and *Dendrostroma* Lecompte. *Clavidictyon* has short pillars which are not superposed, flocculent tissue, and no axial canal according to Galloway (1960a). *Dendrostroma* was established by Lecompte (1952) for stromatoporoids with an axial tube, pillars not superposed, and compact tissue. *Idiostroma* has a much more regular system of pillars and compact laminae than the other three genera. *Stachyodes* has a much denser structure of laminae and pillars characterized by minute tubules in the tissue.

Stachyodes crebrum n. sp.

Plate IV, figures 1-3, 5, 6

Description. The coenostea are small, twig-like and dispersed through the limestone, generally not in great concentrations. All specimens are embedded in matrix and appear to have been slightly current sorted. The exterior surface was not observed. Most of the coenostea are single rods but some are subequally branched. Several of the specimens are completely encased in other stromatoporoids, notably *Pseudoactinodictyon* and *Clathrocoilona*. Specimens of this species are commonly associated with *Thamnopora* and in hand specimen are difficult to distinguish from them. This association may be due to current sorting or to convergent evolution of two distantly related stocks to the same form in adapting to a similar environment.

Transverse sections of the round stems are from 2 to 4 mm in diameter. The structure is dense and about seventy per cent of the section is occupied by tissue and about thirty per cent by canals and galleries. The axial region is rarely occupied by a single canal but generally by a group of three to five subequal canals. Around these canals is flocculent, dense, tissue pierced by astrorhizal canals which branch from the axial canals. Only in the peripheral zone do the radial pillars emerge as vague structures from the structureless axial zone. In most specimens they are ill-defined even in the peripheral zone and only two or three laminae can be recognized in the peripheral zone. In some they are well defined by a fine dark concentric line in the generally radially oriented tissue, in others they are defined by incipient galleries.

The pillars of the peripheral zone are thick, either fused to their neighbours or separated by fine radial galleries. The pillar tissue shows a suggestion of the fine radial tubules of this species but the microstructure is not well defined in most transverse sections. The exterior surface may be smooth as if formed by an epitheca or lamina, or the matrix may enter re-entrants between the pillars.

Axial sections are marked by a series of axial canals or a single canal crossed by fine tabulae. Around this axis a crude stratification identifies the start of laminar structure and this becomes more evident near the periphery where thick contiguous pillars can also be distinguished in the dense tissue. In places very fine branching tubules (40 microns in diameter) penetrate the tissue in all directions. These are much finer than the astrorhizal canals which are from 100 to 200 microns across. Oblique sections show a mass of flocculent tissue through which the tabulate astrorhizal tubes run in a generally longitudinal direction.

Discussion. This species is characterized by its small stems, multiple axial canals (in most specimens), lack of distinct laminae or pillars except near the periphery, and the general density of the structure.

Stachyodes crebrum with its tubules in the tissue, closely fused pillars, and few laminae clearly belongs in *Stachyodes* but its lack of a single axial canal gives it the appearance of *Clavidictyon*. It resembles *S. odinekensis* Yavorsky but does not have the axial tube consistently as this species seems to have. It also resembles *S. verticellata* McCoy but does not have the long distinct pillars in the peripheral zone and is much smaller generally. In many respects the species is similar also to *S. caespitosa* Lecompte but the stems are much more slender than those of that species.

Material and occurrence. Holotype, GSC No. 16438, from GSC loc. 5860; paratype, GSC No. 16439a, from GSC loc. 29100; paratype, GSC No. 16440, from GSC loc. 5853; paratype, GSC No. 16439b, from GSC loc. 29100; paratype, GSC No. 16441, from GSC loc. 29100; paratype, GSC No. 16439c, from GSC loc. 29100.

The species is not generally common in the Moberly Member of the Waterways Formation but is locally abundant in the few outcrops where it occurs. Specimens were collected from localities 29100, 5853, 5860.

Family STROMATOPORIDAE Winchell

Genus *Taleastroma* Galloway

Type species: *Stromatopora cummingsi* Galloway and St. Jean 1957.

Laminae thin, interlaminar spaces largely filled with maculate tissue leaving small round irregular galleries. Pillars long with light compact centres and borders of dark maculae. Pseudozooidal tubes short.

Taleastroma ? confertum n. sp.

Plate V, figures 1-3

Description. Of the five specimens representing this species in the collections, four are intergrown with other stromatoporoids, notably *Clathrocoilona inconstans*, and only one is free and forms its own coenosteum. This specimen is a vaguely hemispherical mass about 5 cm in diameter. The surface appears to have been smooth and without mamelons and this is generally confirmed by the evidence of the thin sections. The other specimens consist of one or more latilaminae within other stromatoporoids. In general, these can be distinguished in hand specimen by the much lighter and denser appearance of the bands which represent *T. confertum*. Growth was generally latilaminar and the latilaminae are about 2 mm thick.

Vertical sections consist almost entirely of tissue in which vertical elements predominate almost to the exclusion of horizontal ones and galleries. Microlaminae are difficult to distinguish in most parts of the sections but in places can be distinguished as a series of very closely spaced darker lines continuous through the pillars. In most places the laminae are fused with the pillars and their thickness cannot be measured, where small interspaces have developed near their boundaries the latilaminae can be measured at about 110 microns thick. In a few places where laminar structure is defined, the microlaminae are spaced about twenty to twenty-five in 2 mm.

Pillars are the dominant structures in vertical sections. They are thick, essentially in contact with their neighbours and composed of light, translucent tissue which even under 600 power appears to be finely granular and not maculate. Between the lighter pillars are areas of fibrous, dark tissue. The fibres in these vertical interpillar zones radiate outward and upward from the axes of the zones in spray-like patterns similar

to the barbs of a feather. Maculae arranged in such a pattern are said to be characteristic of the genus *Syringostroma* by Galloway (1957) but the fibrous areas seem to be interpillar structures rather than structures of the pillars themselves, and even with high magnification cannot be resolved into maculae. The 'feather structure' is interpreted as recrystallized marginal maculate zones of the pillars.

In places the boundaries of the pillars are indeterminate and they blend into a general mass of light translucent tissue. Where well defined, the pillars are about 150 to 200 microns across and spaced about seven in 2 mm.

Rounded astrorhizal canals about 70 microns in diameter are scattered irregularly in the structure. Near the top of latilaminae a clear space in the tissue formed by a concentration of astrorhizal canals may appear. No inflection of the laminae into mamelons was seen in vertical section. Galleries are absent except near the tops of latilaminae where they are small and their regular horizontal arrangement defines the microlaminae.

Tangential sections show latilaminae as darker bands, immediately below them astrorhizal canals branch out like veins but are not conspicuously developed throughout the structure. Pillars emerge as large, light, translucent dots 100 to 200 microns in diameter in places joined to their neighbours. They are isolated by more finely crystalline and darker calcite. Microlaminae cannot be distinguished.

Discussion. Interpretation of the 'spray' or 'feather' structure is uncertain and makes generic assignment of the species difficult. In its latilaminae, inconspicuous microlaminae, and thick pillars, this species resembles many species of *Syringostroma* but the lack of maculae in the pillars makes this assignment untenable. *Taleastroma* is defined as having compact, light pillars with maculate borders and most of the rest of the structure filled with maculae. In *Taleastroma* ? *confertum* the pillars occupy so much of the structure that little area is left to be occupied by maculae. The species differs from any described species of either *Taleastroma* or *Syringostroma* in the closeness with which the pillars are spaced so that galleries are eliminated. Among the syringostromas it most closely resembles *S. aurorella* Fritz and Waines but has much less gallery space. Among the taleastromas it resembles *T. conicolamellatum* Galloway and St. Jean but differs in the same way.

Material and occurrence. Holotype, GSC No. 16442, from GSC loc. 5869; paratype, GSC No. 16456, from GSC loc. 5869.

The species was found in the Moberly Member of the Waterways Formation at localities 5867, 5869, 29201.

Genus *Syringostroma* Nicholson

Type species: *Syringostroma densum* Nicholson 1875.

Growth latilaminate. Tissue maculate; laminae closely spaced, thick, continuous; pillars more prominent than laminae, continuous, thick; galleries generally restricted. Maculae not vertically aligned.

Syringostroma bifurcum n. sp.

Plate V, figures 4, 5; Plate VI, figures 1, 2

Description. The two coenostea representing this species come from the same sample of rock. Both are about 2.5 cm long and consist of a lower stem 8 to 10 mm in diameter that branches once subequally about halfway along its length. Both specimens appear to be fragments of larger stems for both are broken at the ends. One was cut longitudinally and the other transversely just above the point of branching.

Transverse section. The axial zone is relatively narrow compared with the rest of the section (about 2 mm across). It is formed by coarsely maculate tissue, which occupies about eighty per cent of the space, and is pierced by canals (?astrorhizal) about 80 mm in diameter, which occupy the remainder of the space. No main axial canal is present. The transition from axial to peripheral zone is rather abrupt and marked by the first lamina. The dominant structures of the peripheral zone are thick, apparently compact pillars. Under very high magnification the pillars appear to be dusky but do not appear to be maculate. Between them are a few small galleries which make up about ten per cent of the area of the section. The translucent pillars are defined by dark areas which have a fibrous feather-like structure. The dark fibres follow short, curved paths diverging from a central region between the pillars. The sprays of these fibres diverge in a direction towards the axis of the coenosteum. Each line or 'feather' of fibres is not persistent across the whole of the peripheral zone but dies out in the translucent tissue. The fibres are not granular and cannot be resolved into particles even under a magnification of 600.

Laminae are poorly defined but appear as fine dark lines crossing the pillars in the inner part of the peripheral zone. In places where they are bounded by slit-like galleries they are about 15 microns thick. They are very closely spaced at about twenty in 2 mm. They are also related to the 'feather structure' described above as the periodic expansion of the fibres takes place between the laminae.

Astrorhizal canals penetrate the peripheral zone and appear in section as rounded holes surrounded by radiating fibres. They are uncommon. The surface of the coenosteum in section appears to be smooth.

Axial section. The axial zone consists of a network of coarsely maculate tissue through which many canals (?astrorhizal) pass in a general axial direction. The canals are finely tabulate and about 150 microns in diameter. No prominent axial canal is present. Some galleries may be present in this zone but most of the open spaces in the structure seem to represent canals. Farther from the axis the maculae seem to be aligned into arches, and these arches merge into the laminar structure of the peripheral zone. This outer zone is almost identical in appearance in longitudinal and transverse sections. It shows light coloured, thick pillars separated by dark zones of feather-like structure and crossed by very closely spaced laminae. The pillars are spaced about seven in 2 mm and the laminae up to thirty-five in 2 mm. There is a suggestion on one side of the stem that an epitheca may have covered parts of the coenosteum.

Oblique or nearly tangential sections show the pillars emerging as circles in contact with their neighbours, and about 150 to 200 microns in diameter.

The species is characterized by the cylindrical, branching coenosteum, the persistent, almost contiguous pillars, and the closely spaced laminae.

Discussion. Superficially this species resembles some species of *Stachyodes* but differs in its lack of an axial canal, and in the microstructure of the tissue. Only one other species of *Syringostroma* has been described that has the cylindrical form, *S. cylindricum* Fagerstrom. From this species it differs in the greater prominence of the pillars, their greater width, the lesser size of the laminae and their closer spacing, and the greater restriction of the gallery space.

The nature of the feather structure is obscure. The possibility was considered that it is a result of a particular mode of preservation, of a recrystallization around the galleries. However, the specimens are not otherwise recrystallized and the structure occurs not only in this species but also in the several specimens of *Taleastroma* ? *confertum* described above. It might also be compared with the spray-like structure of the maculae described by Galloway (1957) as being characteristic of the pillars of *Syringostroma*. Even under high magnification, however, the fibres cannot be resolved into maculae. The direction in which the fibres diverge is also opposite to that described for the lines of maculae in the pillars of this genus. In a tissue as closely compressed as that of *S. bifurcum*, difficulty may be encountered in distinguishing between the pillars and the material that has filled the galleries between them. After careful study, the writer feels certain that the feather structure is not a part of the pillars themselves but occupies a position between the pillars.

Material and occurrence. Holotype, GSC No. 16443, from GSC loc. 5853; paratype, GSC No. 16437, from GSC loc. 5853.

These two specimens are the only ones in the collection from the Moberly Member of the Waterways Formation.

Syringostroma fenestratum n. sp.

Plate VI, figures 4-7

Description. Of the three coenostea in the collection one is independent and two are interlayered with *Clathrocoilona inconstans*. The independent coenosteum is a hemispherical mass with a maximum diameter of about 10 cm and thickness of 5 cm. The surface is not well preserved but appears from the evidence of sections to have been largely smooth and without mamelons. Astrorhizal canals were apparently present on the surface. Latilaminate growth is not conspicuous.

Vertical sections show a fine network of persistent fine laminae crossed by irregularly spaced, superposed pillars. Laminae are fine, compact, and consist of a single dark line of tissue without pores. In most parts they are highly persistent and only gently undulant. At widely spaced intervals they are sharply but shallowly inflected upward. The laminae are 10 to 20 microns in thickness and are spaced thirteen to twenty in 2 mm. Groups of two or three laminae are commonly more closely spaced than their neighbours so that the laminae appear to be twinned or tripled. Vague, maculate translucent tissue fills the interlaminar spaces in zones that

define vague latilaminae about 2 mm thick. The maculae show a tendency to line up horizontally. In places this maculate tissue is dense enough to obliterate both pillars and laminae.

Pillars are maculate, thicker than the laminae (70 to 125 microns), generally spool-shaped and well superposed. The maculae are of irregular size and distribution. The larger are about 15 microns in diameter. Superposition of pillars is especially good and the pillars are thicker where the laminae are inflected upward into small low mamelons. Pillars are spaced irregularly (seven to ten in 2 mm). Where they are closely spaced they merge with the maculate tissue in the interlaminar spaces. In places the pillars are vacuolate, but they are not conspicuously so throughout.

Astrorhizal canals represented by round holes or elongate galleries are common to abundant in vertical sections. They are crossed by fine tabulae. The inflection of the laminae seems to be associated with a concentration of astrorhizal canals. Galleries are largely rectangular to slightly rounded, superposed, in places highly elongate where pillars are widely spaced. The abundance of dissepiments varies from section to section and from place to place in the same section. In certain zones they are common and rarely may even replace the laminae as horizontal elements. In most places they form small cysts between the regular laminae.

Tangential sections show areas of well-defined pillars and other areas of dense, granular, vague structure. The laminae appear as dark, very finely granular lines. Pillars radiate outward as irregular bars from the centres of the astrorhizal systems and far from the centres emerge as dots of irregular shape. They are maculate with regular maculae about 15 microns in diameter. The astrorhizae are well developed, about 250 microns in diameter, crossed by straight tabulae and branch several times before dying out in the structure. Concentric mamelon structures are not evident.

Discussion. This species is characterized by the extremely close spacing of the laminae (fifteen to twenty in 2 mm), the irregular spacing and tendency for clumping of the pillars, and the abundance of astrorhizal canals. Described species of *Syringostroma* can be divided into two groups: those with prominent mamelon columns of dense pillar structure, and those without. *S. fenestratum* belongs to the second group, which might be typified by *S. sandsukyense* Galloway and St. Jean or by *S. perfectum* Lecompte. From all described members of this group the new species differs in the closeness of spacing of the laminae, their fineness, and the delicacy of the network in general.

Material and occurrence. Holotype, GSC No. 16444, from GSC loc. 5856; paratype, GSC No. 16445, from loc. 29124; paratype, GSC No. 16446, from loc. 29294.

The species is not common in the Moberly Member of the Waterways Formation.

Genus *Clathrocoilona* Yavorsky

Type species: *Clathrocoilona abeona* Yavorsky 1951.

Thick laminae composed of a central light or dark zone clothed in maculate tissue. Pillars maculate, spool-shaped, confined to an interlaminar space but may be superposed. Galleries round, restricted.

Clathrocoilona inconstans n. sp.

Plate VII, figures 1-5; Plate VIII, figures 6, 7

Description. This new species is represented in the collections by twenty-six large specimens. The coenosteum is generally subspherical to arch-like in form. Some seem to be thin sheets of low curvature and may have been encrusting but most were obviously free growing. The largest specimen is 18 by 12 cm, but an average size would be about 5 by 5 cm. The surface is generally smooth with no mamelons and only low, gentle prominences and depressions. No astrorhizae were seen on the surfaces of any of the specimens. The specimens appear to be laminate due to the wide spacing of the thick laminae, but no true latilaminae are evident.

Vertical sections show widely spaced very thick laminae of variable structure and inconspicuous, poorly defined pillars. The structure of the laminae and pillars varies so greatly from place to place in the same section and from section to section that it may be difficult to distinguish included stromatoporoids of different species from variations in structure within the species.

In more than half of most sections the structure is completely filled with tissue and no galleries or pillars can be distinguished. In favourably preserved parts, the laminae show a central light line (or more rarely a dark one) with denser tissue on either side. This tissue on top grades upward into lighter irregularly maculate tissue that fills the interlaminar space and grades upward to the base of the next lamina. These parts of the stromatoporoid look much like a sequence of varved clays in vertical section. In other places in the structure the upper part of the lamina breaks up into pillars formed of the maculate tissue and described below. In rare places the laminae seem to break into a number of strands of dark tissue not unlike the laminae of *Synthetostroma.* In form, the laminae are gently undulant and locally bent up into small rises. These, however, are not vertically persistent in the coenosteum and rarely involve more than two or three laminae. The spacing of the laminae is irregular ranging from as few as two to as many as eight in 2 mm but the average is about four.

The tissue from which the pillars arise occupies the whole of the interlaminar space in many parts of vertical sections but in other places is broken by galleries which define the pillars. The tissue is irregularly maculate but locally the maculae are arranged in horizontal rows to give a stranded appearance. The pillars are fundamentally short and spool-shaped, and are spread out along the lamina above and rarely are branched at the top. Many pillars are incomplete, some are inclined; most of them are so short that they occupy only a fraction of the space between the primary laminae. They are not superposed. The pillars are spaced more closely than the laminae (from four to nine in 2 mm) but are difficult to measure because of their irregularity. They are from 100 to 250 microns thick. In places they can be seen merely as shadows of darker, vertically oriented tissue in the lighter tissue that fills the interlaminar space.

In some zones of some sections pillars are well defined, in places incomplete, branching at the top, and about 2 mm high although confined to an interlaminar space (*see* Pl. VII, fig. 5; Pl. VIII, fig. 6). Commonly these larger pillars are granular

in appearance but are not obviously maculate. They may represent another stromatoporoid that has become enclosed in the species, but do not occur independently in the collection.

Astrorhizal canals are not obvious in vertical sections but some round holes of intermediate size in some sections may represent these canals. All the coenostea are traversed by coarse tubes filled with pellets and organic fragments apparently made by a burrowing worm that may have been parasitic on this particular species. Such tubes are very rare in other stromatoporoids in the collection. Other inclusions such as shells, sediment lenses, gastropod shells, and other stromatoporoids (*Syringostroma, Stachyodes, Taleastroma,* etc.) are common in nearly all the specimens. No dissepiments occur.

Tangential sections show a vague structure about eighty per cent occupied by tissue and twenty per cent by galleries. The laminae are difficult to distinguish but in places more darkly pigmented sinuous zones may represent them. Rarely they form a ring where a low dome has been cut. Pillars emerge as round, maculate, regular dots in rare parts of the sections and in most places cannot be distinguished for they merge with the structureless tissue between the laminae. In some sections the interlaminar space is marked by a reticulate network of more darkly pigmented tissue formed by branching of at least three orders from a centre (Pl. VIII, fig. 7). These are not astrorhizal canals but appear to be related to the pillars, and perhaps to the oversized pillars described above.

Astrorhizal canals are rare but nearly all sections show a few small canals radiating from a centre. The parasitic worm tubes seen in vertical section are obvious in tangential ones also and are much coarser than the astrorhizal canals.

The specific name refers to the great variety of form found in representatives of this species.

Discussion. Clathrocoilona inconstans is characterized by its widely spaced laminae, the maculate tissue which in most parts of the coenosteum fills the interlaminar space, the smallness and inconspicuousness of the galleries and pillars, and the great lateral variability in the structure. It has much less gallery space and a much less regular structure than the type species, *C. abeona* Yavorsky. The species shows some resemblance to *C. restricta* Galloway and St. Jean but has many fewer galleries, less regular pillars and more widely spaced laminae. Similar features distinguish it from such closely allied species as *C. subclathrata* Galloway and St. Jean, *C. saginata* (Lecompte), and *C. intcherpense* Yavorsky. Its closest relative seems to be *C. solida* Yavorsky but its structure in tangential section is rarely as clearly indicative of the emergent pillars and does not show the wealth of astrorhizal canals exhibited by the Russian species. A much greater proportion of the interlaminar space is filled with tissue in the new species also.

Material and occurrence. Holotype, GSC No. 16447, from GSC loc. 5867; paratype, GSC No. 16448, from GSC loc. 5867; paratype, GSC No. 16449, from GSC loc. 29172; paratype, GSC No. 16450, from GSC loc. 28148; paratype, GSC No. 16451, from GSC loc. 29312.

This species is the most abundant member of the stromatoporoid fauna in the Moberly Member of the Waterways Formation. Specimens other than the types indicated above were collected from localities 5838, 5856 (two specimens), 5855, 5867 (three specimens), 5869 (two specimens), 29103 (three specimens), 29172, 29294 (three specimens), 29352, 29361, 29397 (two specimens), 29402 (two specimens).

Genus *Pseudoactinodictyon* Flügel

Type species: *Pseudoactinodictyon juxi* Flügel 1958.

The following is a translation of Flügel's (1958, p. 137) diagnosis of the genus:

> Tissue maculate. The coenosteum is formed of nearly completely developed horizontal elements (locally genuine laminae) and of short irregularly developed pillars which emerge from the horizontal elements. This network, wholely or partly developed appears inconsequential compared with the convex bubble-like dissepiments which together with the development of the pillars are diagnostic of this genus. The coenosteum is laminar. It has on its upper side mamelons which are connected partly with the well developed astrorhizal system.

Pseudoactinodictyon norrisi n. sp.

Plate VIII, figures 1-5

Description. Seven specimens of this species are contained in the collection. Coenostea are concavo-convex plates of low curvature, or are laminar, up to 12 cm in largest dimension in the specimens on hand. The surface is generally covered with small low mamelons spaced about 8 mm apart, but some specimens seem to have smooth surfaces. Astrorhizae were not seen on the surfaces of any of the specimens but are shown to be common by the thin sections. All coenostea show latilaminar growth with latilaminae from 0.3 to 1 cm thick. Many of the specimens have been stained along the latilaminae with iron oxides. In general this species does not appear to be susceptible to intergrowth with other species but one specimen has overgrown two specimens of *Stachyodes*.

Vertical sections show an irregular network of impersistent laminae, prominent dissepiments, and impersistent pillars in which large astrorhizal canals are prominent. Laminae are thin (an average of 50 microns), composed of tissue with dusky inclusions which represent poorly developed maculae. In a few places they have been thickened by tissue derived from the pillars. Locally the laminae are reduced to a line of dark granules. In form the laminae are impersistent and gently undulant. They are entirely absent and replaced by dissepiments in some zones, in others they are well defined and closely spaced. Measurements of their spacing are difficult because the dissepiments are not easily distinguishable from the impersistent laminae. However, the laminae seem to average about twelve in 2 mm. In a few places the laminae are bent upward into small mamelons but these are not conspicuous and do not continue through the section. Foramina are common and are generally bridged by dissepiments.

Pillars are composed of vaguely maculate tissue similar to that of the laminae. They are short, oblique, crooked, and locally, especially near the top, vacuolate.

Superposition of the pillars is poor and does not generally extend through more than two or three interspaces. The spacing of the pillars is very irregular and ranges from seven to twelve in 2 mm. The regular structure of pillars and laminae breaks down locally to a tangle of fibres.

Astrorhizal canals are abundant throughout the sections and are about half a millimetre in diameter. They are concentrated where the laminae are inflected upward. Dissepiments are abundant and in places they, rather than the laminae, seem to be the dominant horizontal elements in the structure. The dissepiments may be large or small and may be more abundant in some zones than in others. The astrorhizal canals are crossed by particularly large, flexuous dissepiments or tabulae.

Tangential sections show prominent, well-developed astrorhizal systems in the fine network of emergent pillars. Laminae are not identifiable in these sections. Pillars emerge as small dots commonly joined to adjacent pillars to form an irregular network. Some pillars appear to be vacuolate. The maculate nature of the pillars is more evident in tangential sections than in vertical ones. Galleries are irregular and labyrinthine, merging with the astrorhizal canals. The canals branch in several orders throughout the structure and range in diameter from 0.3 to 0.4 mm. Rarely they are crossed by curved tabulae. No mamelon structures can be identified in tangential sections.

The species is named for A. W. Norris of the Geological Survey of Canada.

Discussion. The abundance of dissepiments, and the short, impersistent maculate pillars and laminae of this species indicate that it belongs in the genus *Pseudoactinodictyon*. It differs from the type species *P. juxi* Flügel in the much poorer development of the laminae. From *P. vagans* Parks it differs in the closer spacing of the skeletal elements and the abundance of astrorhizal canals. The great variability shown by various sections and within the same section of *P. norrisi* is reminiscent of the great variability illustrated by Parks in *P. vagans*. Flügel states that the genus is confined to Middle Devonian rocks.

Material and occurrence. Holotype, GSC No. 16452, from GSC loc. 5860; paratype, GSC No. 16453, from GSC loc. 5840.

In addition to the two types, three other specimens were collected from locality 5860 where the form is apparently abundant. Other specimens referred to this species come from localities 5840 and 5841.

Pseudoactinodictyon athabascense n. sp.

Plate IV, figures 4, 7, 8; Plate VI, figure 3

Description. This species is represented in the collections by two specimens: one a concavo-convex segment of a small hemispherical coenosteum about 7 cm in diameter, the other a saucer-shaped inclusion about 1 cm thick within the coenosteum of *Clathrocoilona inconstans*. The surface of the coenosteum was apparently smooth.

Vertical sections show impersistent, thin laminae in most parts of the sections, replaced in other parts by many fine, thin dissepiments and associated impersistent pillars. The impersistent laminae can be traced laterally to where they die out in

cystose tissue. One section is notable in this regard showing an almost totally different relationship between laminae and dissepiments on one side than on the other. The laminae typically are thin (about 25 microns), only slightly thicker than the dissepiments but composed of lighter tissue that appears flocculent or finely granular. These laminae are only gently undulant and on one side of the sections can be traced for considerable distances. In another vertical section (Pl. VI, fig. 3) they are less persistent and more irregular in their courses. In horizontal zones spaced about 2 mm apart the structure becomes more irregular and is marked by dark accumulations of organic matter. These zones define inconspicuous latilaminae. In one specimen the laminae are gently and shallowly inflected into mamelons but in the holotype these inflections are lacking.

Pillars are composed of the same slightly flocculent (? maculate) tissue as the laminae but are more diffuse and are not as prominent an element of the structure. In places they are thick (70 microns) and penetrate four or five of the horizontal elements (in most places represented by dissepiments). Typically they are oblique, short, highly irregular, and form with the dissepiments an irregular spongy structure. They do not cross the laminae and maintain their identity through them, but rather seem to merge with them and emerge at the other side. Some of the pillars branch or are incomplete.

Astrorhizal canals, represented by round or oval holes in vertical section, are common but not a conspicuous element of the structure. Galleries are highly irregular and only locally superposed. No mamelon columns are formed but the laminae are inflected slightly in the paratype as described above. The galleries between the more persistent pillars where crossed by fine dissepiments resemble the pseudozooidal tubes of the Stromatoporidae.

Dissepiments are abundant throughout vertical sections and are the dominant horizontal elements. They are dark, compact, 8 to 16 microns thick, generally sharply curved but in places almost flat so that they are difficult to distinguish from the laminae. The horizontal elements, both laminae and dissepiments, are spaced from eighteen to twenty in 2 mm. The individual interspaces have a wide range of heights.

Tangential sections show well-defined pillars. The pillars emerge as small dots about 70 microns in diameter which may be isolated between the laminae, or near the laminae are joined to their neighbours in a vermicular form to make a network. The laminae are marked by darker bands where the pillars are most densely joined and are porous. The pillar tissue is finely flecked and may be maculate. Astrorhizae are well developed, composed of canals about 200 microns in diameter which branch outward from well-defined centres, and are crossed by fine straight or oblique tabulae. Large tubes of a parasitic worm traverse the holotype.

Discussion. Pseudoactinodictyon athabascense is distinguishable from *P. norrisi* in the following characters:

1. Pillars locally attain a much greater length or persistency.
2. Dissepiments are much more abundant.
3. Laminae are less common but are more persistent where they occur.
4. Astrorhizal canals are less common.

The two species may be shown by further collecting to grade into one another but no intermediate specimens were found in the collections. In many ways *P. athabascense* is more like *P. juxi* Flügel but has a more irregular structure, and the dissepiments and laminae are not as readily distinguished.

As in *P. norrisi,* the maculate nature of the laminae and pillars is not marked but locally the pillars appear to contain dark granules. If on further investigation these species are shown to have compact tissue, then they must be removed to the Clathrodictyidae. However, in this family no genus at present described will accommodate species showing the combination of poorly superposed pillars, fine laminae, and an abundance of dissepiments.

Material and occurrence. Holotype, GSC No. 16454, from GSC loc. 5838; paratype, GSC No. 16455, from GSC loc. 29381.

This species is uncommon in the Moberly Member of the Waterways Formation. It was found only at the two localities listed above.

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Locality Index

A. The fossil localities listed in this section were established by F. H. McLearn in 1916 on the banks of Athabasca River below McMurray. Unfortunately his manuscript map has been lost and the position of some of the localities is not now determinable. The identity of the informally named Dogrib Island and Anne Creek is not known. However, the original description of the localities is included here for the purposes of record. Those localities which cannot be located are marked thus *. The stromatoporoids collected all came from the Moberly Member of the Waterways Formation.

5838* — Lowermost stromatoporoid bed, W. bank, below 'Dogrib' Island.

5839* — Middle stromatoporoid beds, E. bank, 1 mi. below 'Dogrib' Island.

5840* — Hard bryozoan limestone, Athabasca River.

5841 — Probably W. bank, ¼ mi. below mouth of Steepbank River.

5845* — Lowest part of 48-ft. section, E. bank, 1 mi. below bank of 'Anne' Creek.

5849 — Top of section, ½ mi. below Poplar Island, E. bank.

5853* — Hard bryozoan and lowermost stromatoporoid limestone, W. bank, ¾ mi. above 'Dogrib' Island.

5855* — Middle stromatoporoid bed, W. bank, below 'Dogrib' Island.

5856* — Upper stromatoporoid beds, E. bank, 1 mi. below 'Dogrib' Island.

5860* — Hard bryozoan limestone, E. bank, 1 mi. below 'Dogrib' Island.

5867 — Middle and upper stromatoporoid limestone, E. bank, opposite Tar Island.

5869 — W. bank, 1½ mi. below Tar Island.

B. The localities listed in this section were visited by A. W. Norris.

The position of localities on Athabasca River have been scaled from the Upper Government Wing Dam at Waterways as shown on the navigation charts of the Mackenzie River Water Route, McMurray to Fitzgerald, District Drawing S-371 with sheets 1 to 5, and District Drawing S-372. These charts are obtainable from Harbours and Rivers Engineering Branch, Department of Public Works, Edmonton, Alberta.

29100 — E. bank of Athabasca River 7.5 mi. downstream from N. end of Inglis Island, and 19 mi. downstream from Wing Dam at Waterways.

29103 — E. bank of Athabasca River at mouth of Wood Creek, and 15.9 mi. downstream from Wing Dam at Waterways.

29124 — SE. bank of Stony Island 13.2 mi. downstream from Wing Dam at Waterways.

29148 — E. bank of Athabasca River 1.3 mi. upstream from mouth of Clarke Creek, and 5.4 mi. downstream from Wing Dam at Waterways.

29172 — W. bank of Athabasca River 1.4 mi. downstream from N. end of Tar Island, and 24 mi. downstream from Wing Dam at Waterways.

29201 — W. bank of Athabasca River 0.7 mi. below Tar Island, and 23.3 mi. downstream from Wing Dam at Waterways.

29279 — W. bank of Athabasca River 0.5 mi. S. of mouth of Steepbank River, and 24.1 mi. downstream from Wing Dam at Waterways.

29294 — E. bank of Athabasca River, opposite N. half of Poplar Island, and 9 mi. downstream from Wing Dam at Waterways.

29312 — W. bank of Athabasca River, opposite N. end of Inglis Island, and 18.1 mi. downstream from Wing Dam at Waterways.

29348 — W. bank of Athabasca River 1.3 mi. upstream from mouth of Muskeg River, and 32.9 mi. downstream from Wing Dam at Waterways.

29352 — W. bank of Athabasca River, opposite the southern half of Stony Island, and 13.3 mi. downstream from Wing Dam at Waterways.

29361 — E. bank of Athabasca River 0.1 mi. downstream from mouth of Clarke Creek, and 6.8 mi. downstream from Wing Dam at Waterways.

29381 — E. bank of Athabasca River, ¼ mi. S. of S. tip of Poplar Island.

29397 — E. bank of Athabasca River 1.2 mi. downstream from N. end of Inglis Island, and 19.4 mi. downstream from Wing Dam at Waterways.

29402 — E. bank of Athabasca River 0.9 mi. downstream from mouth of Clarke Creek, and 7.6 mi. downstream from Wing Dam at Waterways.

Columnaria pax (Smith) AND THE SILURIAN *Columnaria columbia* n. sp. FROM BRITISH COLUMBIA

B. S. Norford

Abstract

Columnaria pax (Smith) was described from a river boulder and thought Devonian. The species is morphologically very similar to the Silurian *Columnaria columbia* n. sp., and a Silurian age is therefore suggested.

Résumé

L'espèce *Columnaria pax* (Smith) qui provient d'un bloc trouvé dans une rivière, fut décrite comme remontant au Dévonien. Du point de vue morphologique, cette espèce ressemble beaucoup à l'espèce silurienne *Columnaria columbia* n. sp., et, par conséquent, on la croit contemporaine du Silurien.

Introduction

In 1875 J. Macoun collected a silicified corallum from boulders along Peace River, northeast British Columbia. During the course of time Whiteaves, Lambe, and Smith each examined the specimen and respectively thought the coral Carboniferous or Permian, Devonian, and Middle or Upper Devonian. The species *Columnaria pax* (Smith) has yet to be identified from outcropping rocks, and D. J. McLaren (personal communication) has not found any related forms in the known Devonian faunas of British Columbia.

Recent field work in the Rocky Mountains near Peace River has resulted in the collection of specimens of a new coral species that is closely related to *C. pax*. This new species is Silurian, suggesting a similar age for *C. pax*.

Systematic Palæontology

Phylum COELENTERATA

Family STAURIIDAE Milne-Edwards and Haime 1850

Genus *Columnaria* Goldfuss 1826

Columnaria Goldfuss, 1826, p. 72.
Columnaria Goldfuss, Lang and Smith, 1935, pp. 426-430.

Type species: *Columnaria sulcata* Goldfuss 1826, by subsequent designation, M'Coy, 1849, p. 121.

Diagnosis, after Lang and Smith "Typically cerioid, but also phaceloid, rugose corals with small corallites; long or short thin septa, with expanded bases; tranverse tabulae, which are generally complete; and elongated dissepiments, usually uniserial, but not always present".

Discussion. Several genera with small, subparallel, phaceloid corallites are common in the Ordovician, Silurian, and Devonian of Western Canada. Genera that lack dissepiments include the Ordovician *Palaeophyllum* Billings, the Silurian *Synamplexoides* Stearn and *Fletcheria* Milne-Edwards and Haime (of which *Pycnostylus* Whiteaves is probably a junior synonym; Hill, 1957, p. F298), and the Devonian *Synaptophyllum* Simpson and *Dendrostella* Glinski. Similar genera with dissepiments include the Silurian *Diplophyllum* Hall that Smith and Lang (1931, p. 91) showed to be a genomorph of *Acervularia* Schweigger, the Siluro-Devonian *Spongophyllum* Milne-Edwards and Haime that has a lonsdaleoid dissepimentarium, and the Devonian *Fasciphyllum* Schlüter that has a peripheral stereozone. Devonian disphyllid corals commonly have carinate or dilated septa and include *Peneckiella* Soshkina, *Thamnophyllum* Penecke, and *Phacellophyllum* Gürich (all with horseshoe dissepiments),

Sudetia Rózkowska, *Acinophyllum* McLaren, and *Disphyllum* de Fromentel. Some species of *Disphyllum* lack carinae but most of these have several ranks of globular dissepiments rather than the solitary rank of elongate dissepiments that is characteristic of most *Columnarias*.

The redescription (Lang and Smith, 1935, pp. 428-430) of *Columnaria sulcata* Goldfuss, the Middle Devonian type species, shows it to be a cerioid form with a single peripheral rank of elongate dissepiments that is in places discontinuous or doubled. Species lacking dissepiments were removed to *Favistella* Dana. Most species of *Columnaria* are cerioid but Glinski (1955, pp. 87-88) has described *C. junkerbergiana* Glinski that is subcerioid in parts of the corallum, and Lang and Smith admitted phaceloid coralla in their generic diagnosis.

Crickmay (1960, p. 4) erected *Planetophyllum* with the Devonian type species, *P. planetum,* essentially a dendroid *Columnaria* with most irregular corallite growth directions unlike the regular parallelism of the corallites of the two present species. Internally the corallites are very similar.

Columnaria pax (Smith) 1945

Plate IX, figures 1-3; Plate X, figure 3

Diphyphyllum ————(?); compare *D. arundinaceum* and *D. stramineum* Billings, Whiteaves, 1877, p. 102
Diphyphyllum arundinaceum Billings, Lambe, 1901, pp. 162-163, in part, the Peace River specimen only.
Spongophyllum pax Smith, 1945, pp. 56-57, pl. 11, figs. 6a-6c.

Holotype GSC 3588, a loose boulder collected by J. Macoun, 1875, from Peace River between Fossil Point and the old Hudson's Bay Company post above Hudson Hope, British Columbia. No identifiable associated fauna.

Discussion. Smith's description is quite adequate but his figured longitudinal sections are unsatisfactory and a general view of the corallum is lacking. The septa are continuous lamellae, neither dilate nor carinate, but a few with expanded bases against the wall, with the major septa less than half the corallite radius in length. The tabulae are closely spaced and commonly one series of elongate dissepiments (height to width ratio, 2:1) is present, rarely two and very rarely lacking, about twelve dissepiments in 10 mm longitudinally.

Planetophyllum planetum Crickmay has corallites somewhat similar to those of *Columnaria pax,* but they are smaller (about 5 mm diameter compared to about 7 mm) and have fewer septa (twenty-eight to thirty compared to about forty-four), and their mode of growth is very irregularly dendroid.

Distribution. The species is known only from the holotype, a river boulder that allows no determination of stratigraphic position. The age is therefore uncertain but the morphologic similarity to *Columnaria columbia* n. sp. suggests Silurian.

Columnaria columbia n. sp.

Plate X, figures 1-2; Plate XI, figure 1; Plate XII, figure 1

Material studied. Three fragments of silicified coralla from different localities in the Rocky Mountains.

Description. Phaceloid corallum composed of erect, subparallel, cylindrical corallites, 5-9 mm (mostly 8 mm) in diameter, commonly spaced 2-5 mm apart, without connecting processes. The holotype measures 20 by 15 by 12 cm. Epitheca bearing interseptal ridges and a few faint growth wrinkles. Septa continuous, radially arranged, thin, without carinae or dilatations, with broadened bases against wall, but without a distinct stereozone. Twenty-six to twenty-eight major septa reaching up to halfway to axis, minor septa about half as long.

Tabulae complete or incomplete, flat, medianly sagging, or slightly convex, variably spaced, commonly ten to eighteen in 10 mm. Narrow regular dissepimentarium almost invariably present, but may be locally lacking in parts of some corallites, composed of a single or rarely double row of elongate dissepiments (height to width ratio, 2:1), about eight to ten in 10 mm. Mode of increase unknown, presumably occurring at widely spaced intervals.

Distribution. Holotype, GSC 16524, collected by J. E. Muller, 1960, from GSC locality 42165, unnamed formation, second ridge east of Selwyn Creek, 123°29′W, 55°59′N, Pine Pass map-area, British Columbia. Age Silurian; associated fauna, *Favosites* sp., *Cystihalysites* sp., *Coenites* sp., poorly preserved entelophyllid colonial coral.

Paratype GSC 16525, collected by E. J. W. Irish, 1960, from locality 42549, unnamed formation, talus at 6,500 feet on southwest slope of 7,190-foot peak near Needham Creek, 123°32′W, 56°31′N, Halfway River map-area, British Columbia. Age Silurian, Clinton; associated fauna, stromatoporoid, solitary corals, arachnophyllid coral, *Favosites* sp., *Cystihalysites* sp. cf. *C. magnitubus* (Buehler), *Cystihalysites* sp., *Syringopora verticillata* Goldfuss, straight cephalopod, pentamerid (?).

Paratype GSC 10788, collected by B. S. Norford, 1961, from locality 45567, unnamed formation, at 1,840 to 1,900 feet below the base of Devonian rocks, ridge southwest of Ducette Peak and west of Clearwater Creek; section lies to south of small lake and is located at 123°13′W, 55°48′N, Pine Pass map-area, British Columbia.

Name. For British Columbia.

Discussion. The species has slightly larger corallites (about 8 mm diameter compared to about 7 mm) than *Columnaria pax,* and more numerous septa (fifty-two to fifty-six in a mature corallite compared to about forty-four).

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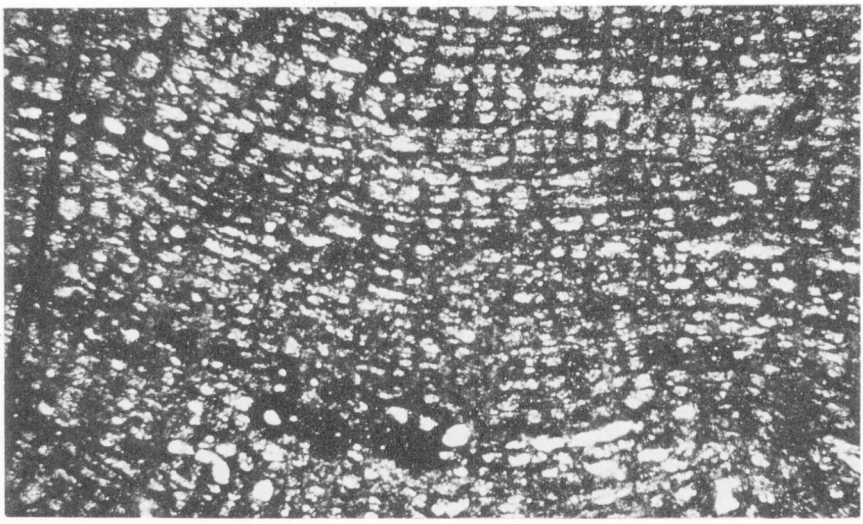
PLATES I to XII

PLATE I

Figures 1-5. *Trupetostroma papulosum* n. sp. 1, vertical section of holotype GSC No. 15328, x10, loc. 5840; 2, vertical section of another part of the holotype GSC No. 15328, x10, loc. 5840; 3, vertical section through a mamelon column of a paratype GSC No. 15330, x10, loc. 29100; 4, tangential section of a paratype GSC No. 15329, x10, loc. 5869; 5, detailed vertical section of holotype GSC No. 15328 showing pillars and laminar structure x30, loc. 5840. (Page 4)



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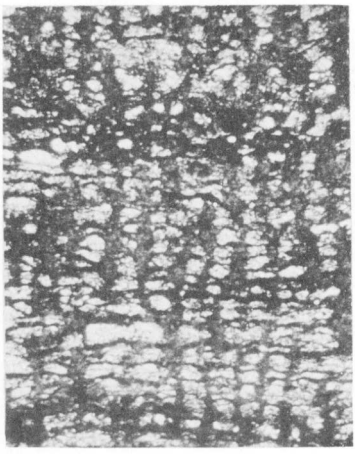

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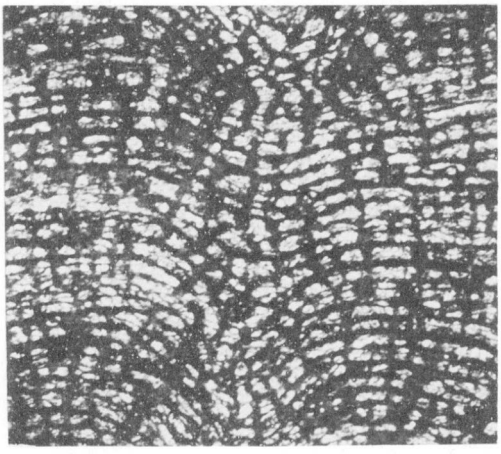

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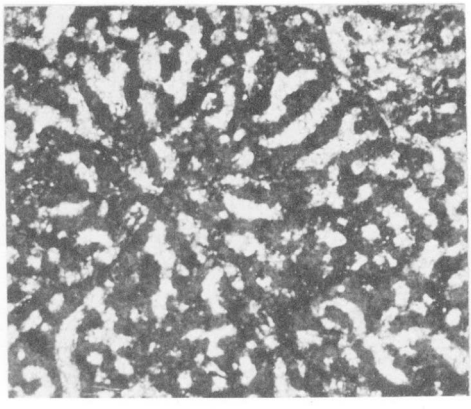

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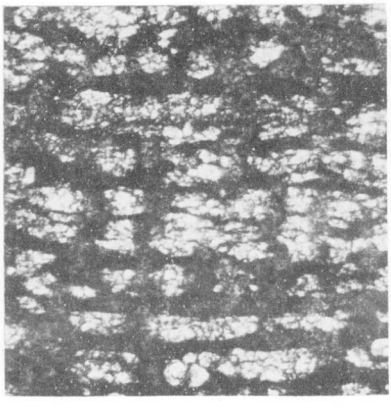

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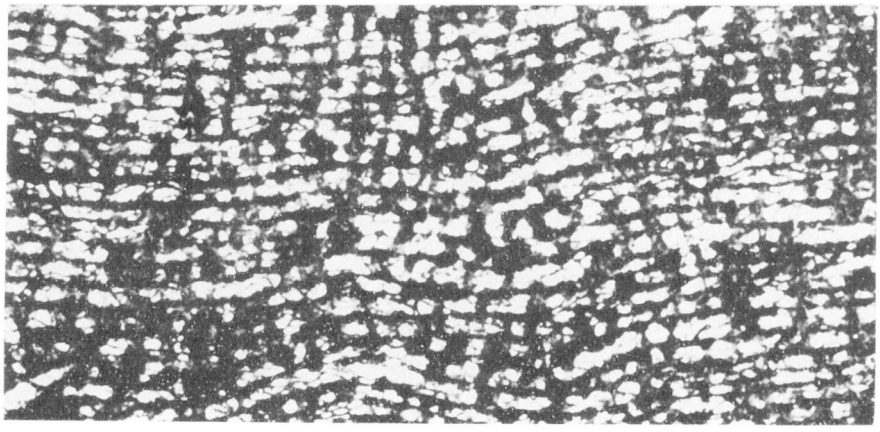
PLATE II

Figures 1-3. *Trupetostroma pycnostylotum* n. sp. 1, vertical section of holotype GSC No. 16434a, x10, loc. 5860; 2, tangential section of the holotype GSC No. 16434b, x10, loc. 5860; 3, vertical section of a paratype GSC No. 16435, x10, loc. 5839. (Page 5)

Figures 4, 5. *Idiostroma mclearni* n. sp. 4, cross-section of the holotype GSC No. 16436b, x5, loc. 5849; 5, a segment of another cross-section through the holotype GSC No. 16436a, x5, loc. 5849. (Page 7)



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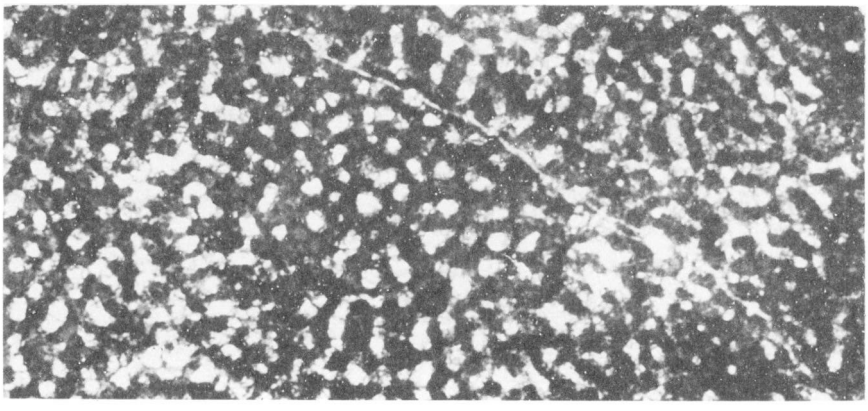

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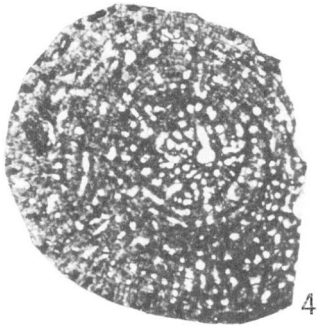

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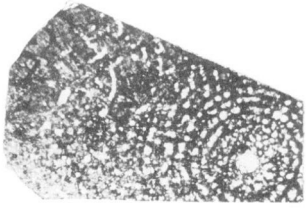

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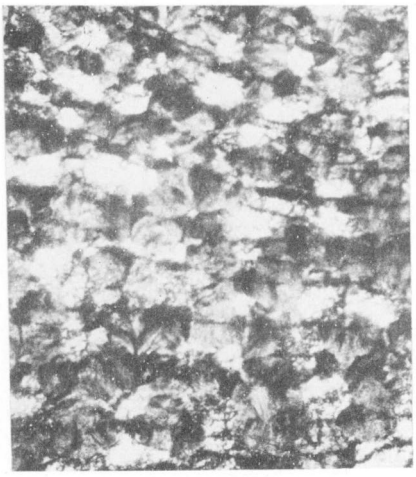
PLATE III

Figure 1. *Trupetostroma pycnostylotum* n. sp. 1, detailed vertical section of the holotype GSC No. 16434a, to show structure of pillars and laminae, x30, loc. 5860. (Page 5)

Figures 2-4. *Idiostroma mclearni* n. sp. 2, detailed cross-section of holotype from axial to inner peripheral zone GSC No. 16436a, x30, loc. 5849; 3, axial section of holotype GSC No. 16436c, x5, loc. 5849; 4, cross-section of the holotype GSC No. 16436a, x10, showing the central canal, a branching canal, axial and peripheral zones, loc. 5849. (Page 7)



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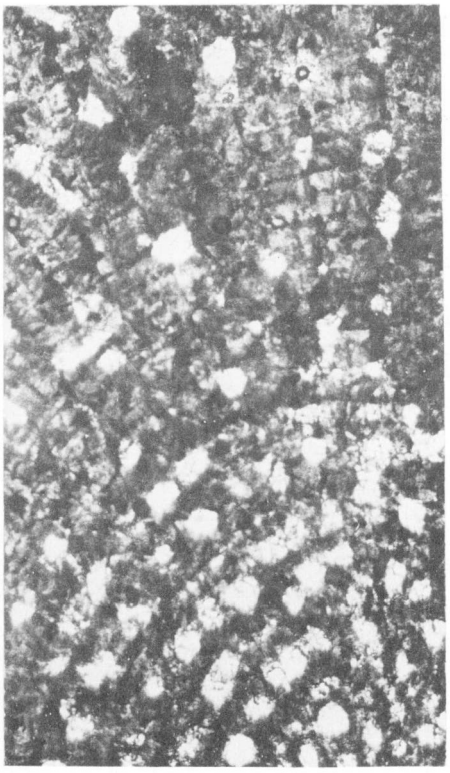

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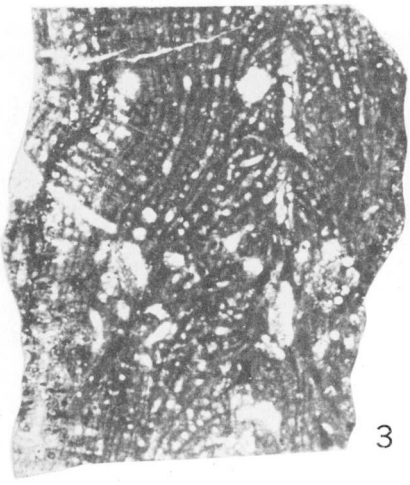

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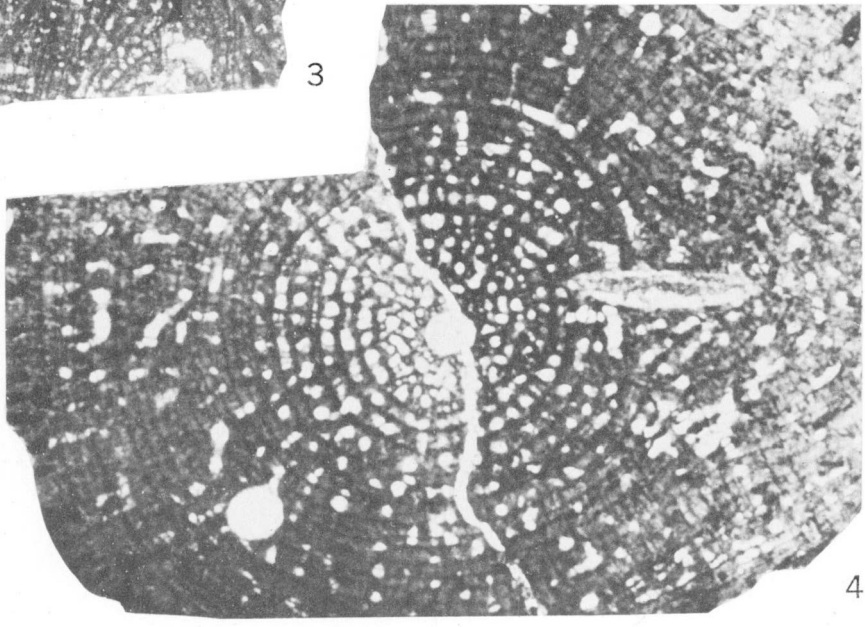

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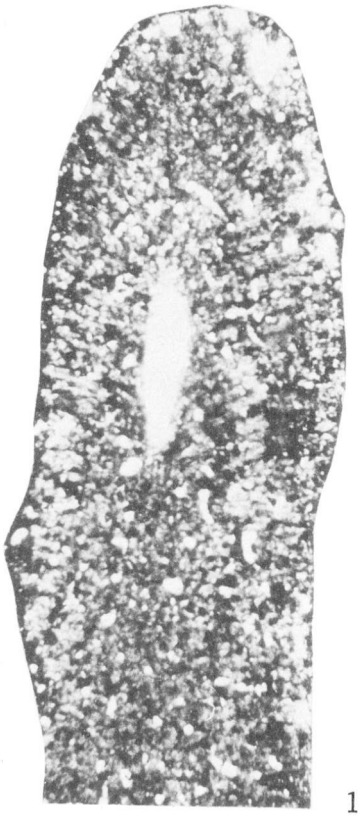
PLATE IV

Figures 1-3, 5, 6. *Stachyodes crebrum* n. sp. 1, axial section of a stem of a paratype GSC No. 16439a showing a single central canal, vague arching laminae, and subsidiary (?) astrorhizal canals, x10, loc. 29100; 2, cross-section of two paratypes GSC Nos. 16439b, c showing lack of a single central canal and poorly defined structure, x10, loc. 29100; 3, cross-section of the holotype GSC No. 16438, x10, loc. 5860; 5, axial section of a branched paratype GSC No. 16441 showing the central canal and much finer canals in the structure, x5, loc. 29100; 6, cross-section of a paratype GSC No. 16440 showing central canal and laminae at the periphery, x10, loc. 5853. (Page 9)

Figures 4, 7, 8. *Pseudoactinodictyon athabascense* n. sp. 4, vertical section of the holotype GSC No. 16454a, x10, showing the lateral impersistency of laminae, loc. 5838; 7, detailed vertical section of the holotype GSC No. 16454b, x30, showing abundant dissepiments and short pillars, loc. 5838; 8, tangential section of the holotype GSC No. 16454c, x10, loc. 5838. (Page 18)



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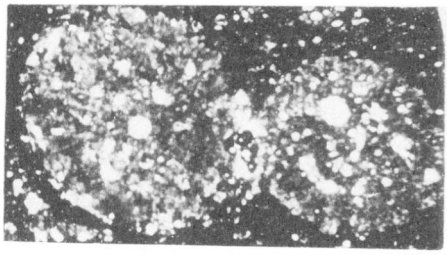

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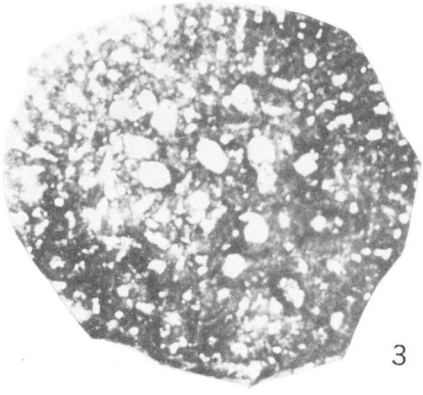

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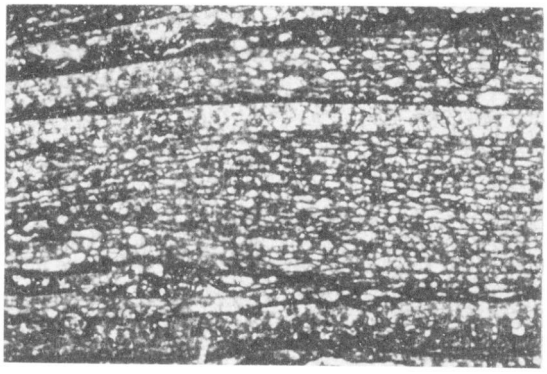

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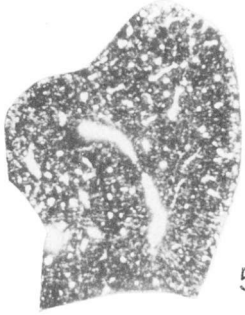

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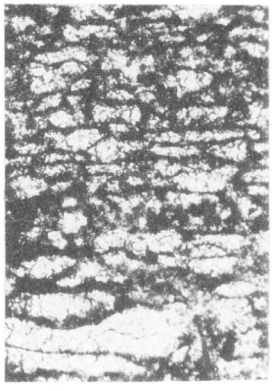

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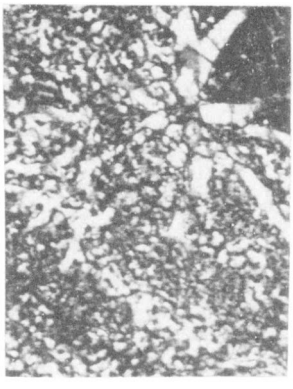

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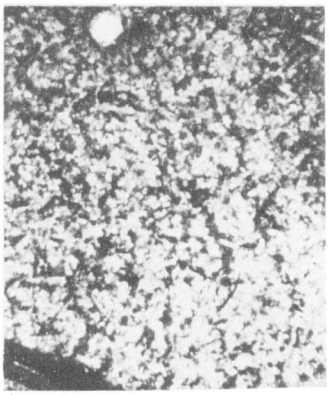
PLATE V

Figures 1-3. *Taleastroma*? *confertum* n. sp. 1, tangential section of the holotype GSC No. 16442a, x10, loc. 5869; 2, vertical section of the holotype GSC No. 16442b, x10, loc. 5869; 3, detailed vertical section of the holotype GSC No. 16442a, x30 showing the 'feather structure', loc. 5869. (Page 10)

Figures 4, 5. *Syringostroma bifurcum* n. sp. 4, axial section of the holotype GSC No. 16443, x5, loc. 5853; 5, cross-section of the paratype GSC No. 16437 just above its branching point, x10, loc. 5853. (Page 12)



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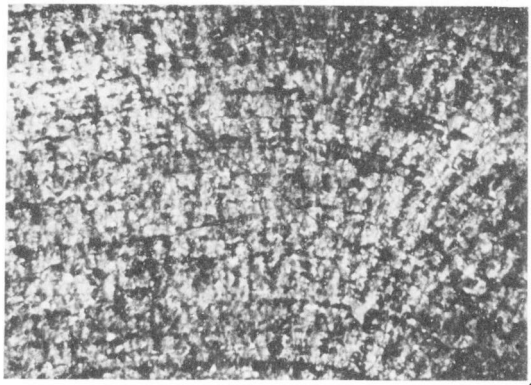

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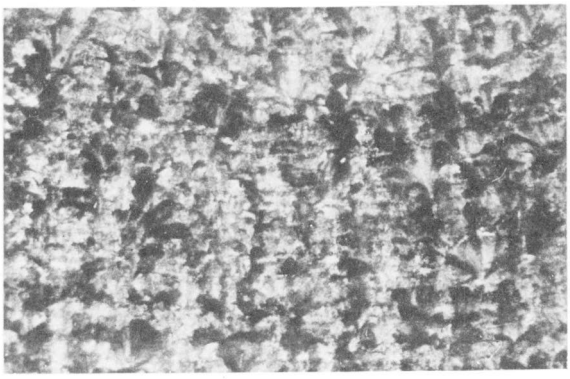

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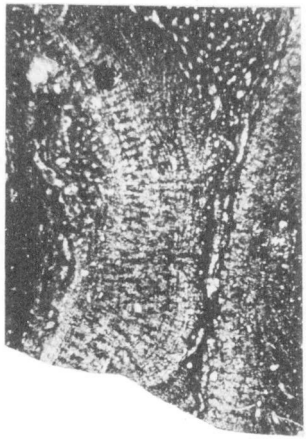

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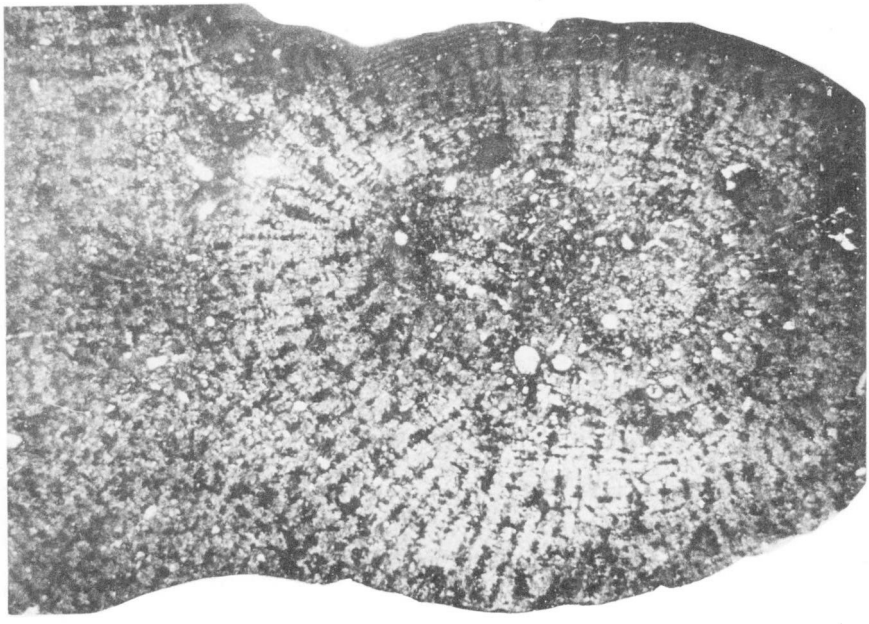

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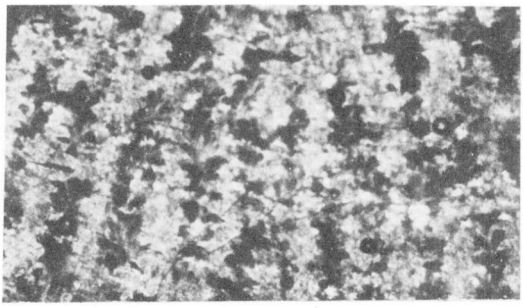
PLATE VI

Figures 1, 2. *Syringostroma bifurcum* n. sp. 1, detailed vertical section of the paratype GSC No. 16437, x30, showing pillars and fine laminae, loc. 5853; 2, detailed tangential section of the holotype GSC No. 16443, x30, showing the maculate tissue, loc. 5853. (Page 12)

Figure 3. *Pseudoactinodictyon athabascense* n. sp. 3, vertical section of the paratype GSC No. 16455a, x10, loc. 29381. (Page 18)

Figures 4-7. *Syringostroma fenestratum* n. sp. 4, tangential section of the holotype GSC No. 16444a, x10, loc. 5856; 5, detailed vertical section of the holotype GSC No. 16444b, showing maculate tissue between the laminae, x30, loc. 5856; 6, vertical section of a paratype GSC No. 16445, x10, loc. 29124; 7, vertical section of a paratype GSC No. 16446, loc. 29294. (Page 13)



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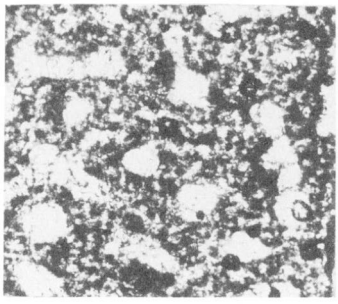

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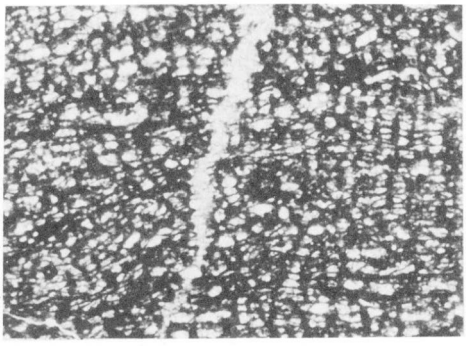

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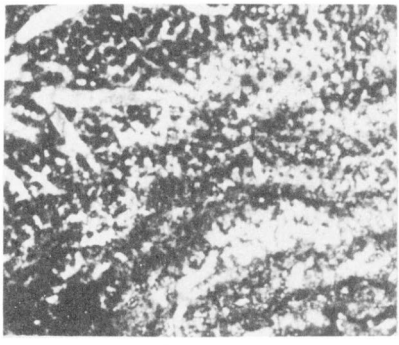

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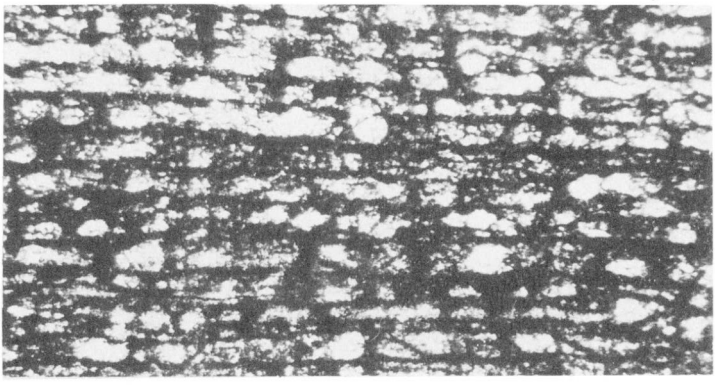

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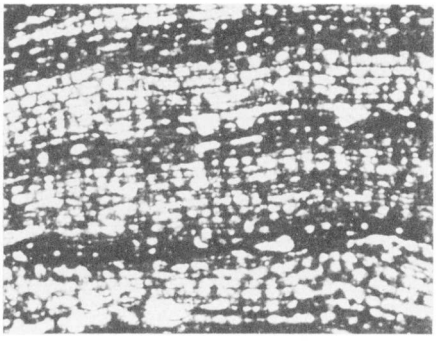

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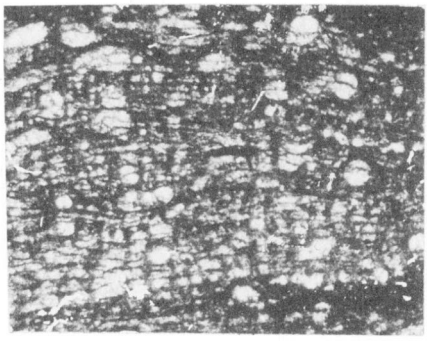

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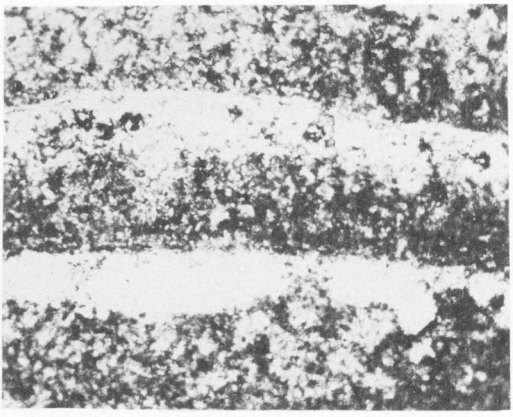
PLATE VII

Figures 1-5. *Clathrocoilona inconstans* n. sp. 1, detailed vertical section of a paratype GSC No. 16449, showing the nature of the laminae and irregularly maculate tissue, x30, loc. 29172; 2, tangential section of a paratype GSC No. 16450, x10, loc. 29148; 3, vertical section of a paratype GSC No. 16448a enclosing a brachiopod shell, x10, loc. 5867; 4, vertical section of the holotype GSC No. 16447, x10, loc. 5867; 5, vertical section of a paratype GSC No. 16451, showing a band of complex pillar structure, x10, loc. 29312. (Page 15)



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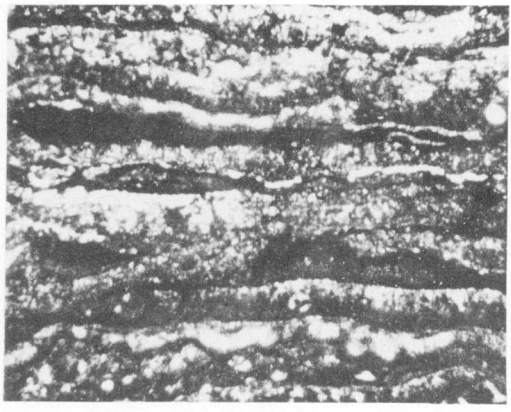

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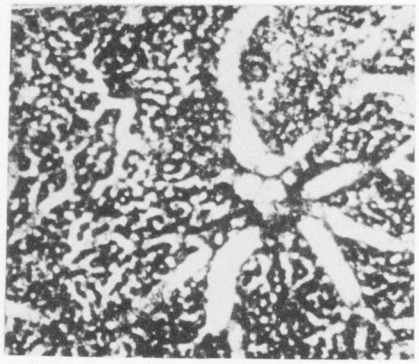
PLATE VIII

Figures 1-5. *Pseudoactinodictyon norrisi* n. sp. 1, tangential section of the holotype GSC No. 16452a, x10, loc. 5860; 2, detailed vertical section of the holotype GSC No. 16452, x30, loc. 5860; 3, vertical section of the holotype GSC No. 16542b, x10, loc. 5860; 4, vertical section of the paratype GSC No. 16453, x5, loc. 5860; 5, vertical section of the paratype GSC No. 16453, x10, loc. 5860. (Page 17)

Figures 6, 7. *Clathrocoilona inconstans* n. sp. 6, vertical section of a paratype GSC No. 16451, showing complex pillars (*see also* Pl. VII, fig. 5), x5, loc. 29312; 7, tangential section of a paratype GSC No. 16448b, showing a dark network, possibly astrorhizal, x10, loc. 5867. (Page 15)



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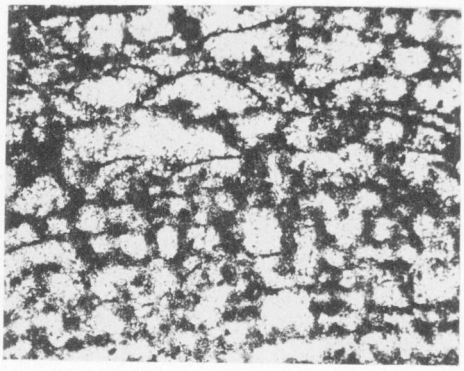

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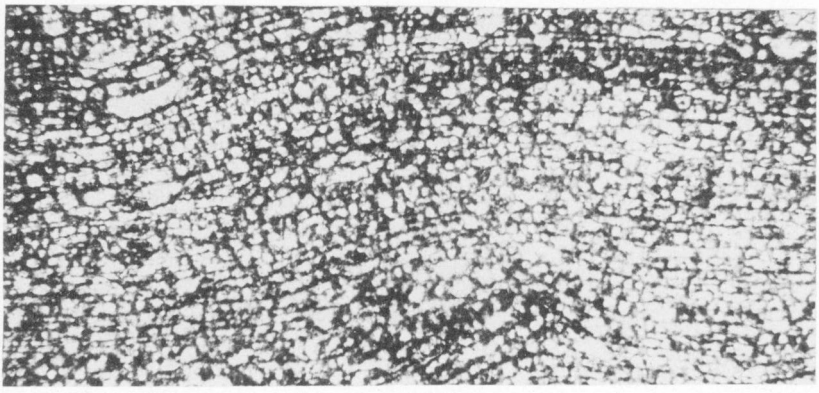

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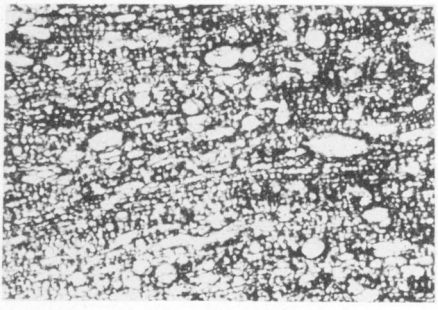

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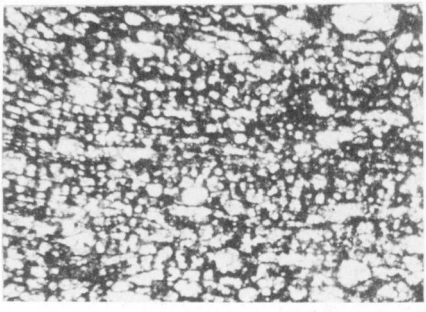

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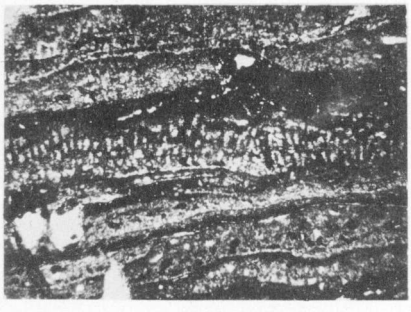

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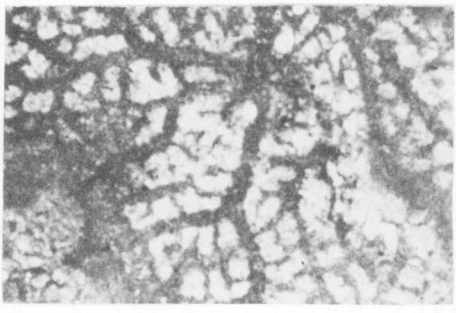

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PLATE IX

Figures 1-3. *Columnaria pax* (Smith). 1, longitudinal section GSC No. 3588c from the holotype enlarged, x2; 2, transverse section GSC No. 3588b from the holotype enlarged, x2; 3, side view of the holotype, GSC No. 3588, x1. (Page 28)

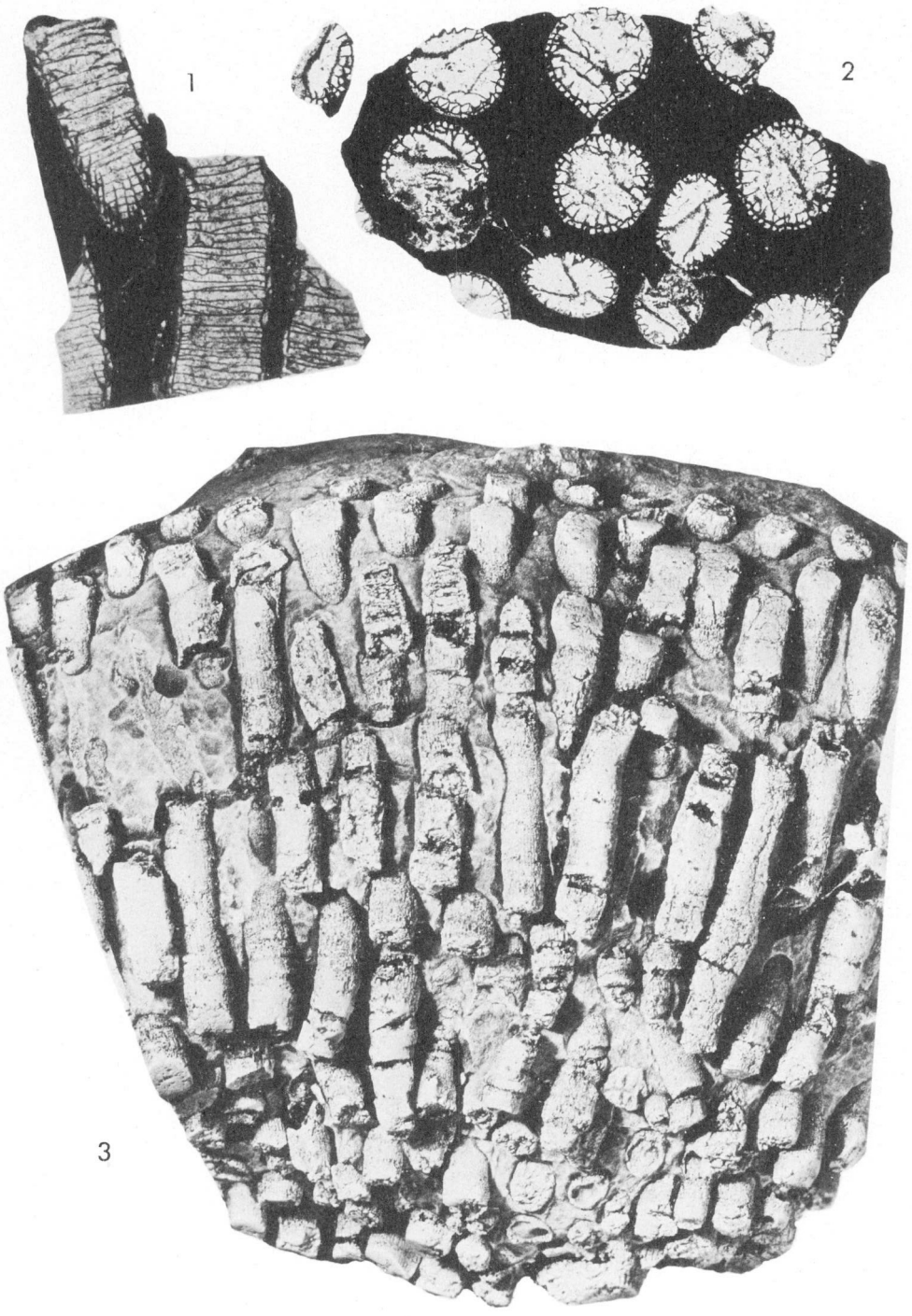
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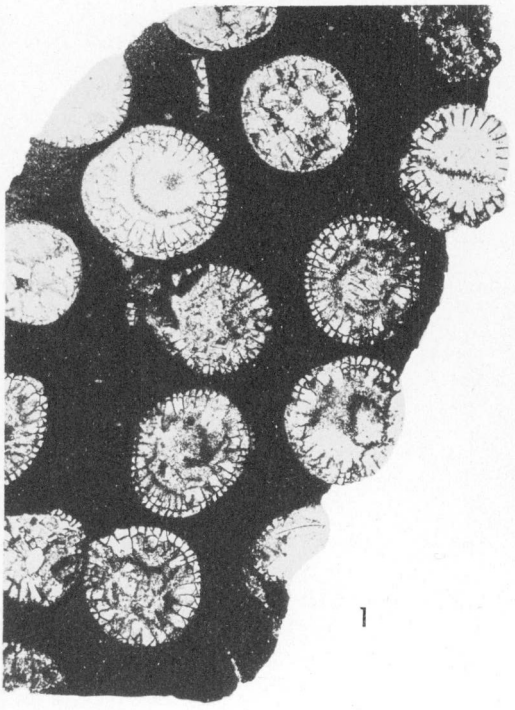
PLATE X

Figures 1, 2. *Columnaria columbia* n. sp. 1, transverse section GSC No. 16524a from the holotype, enlarged, x2; 2, longitudinal section GSC No. 16524b from the holotype, enlarged, x2. (Page 28)

Figure 3. *Columnaria pax* (Smith). 3, basal view of the holotype, GSC No. 3588, x1. (Page 28)



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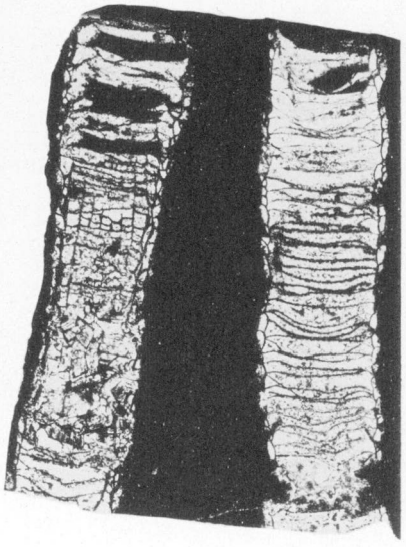

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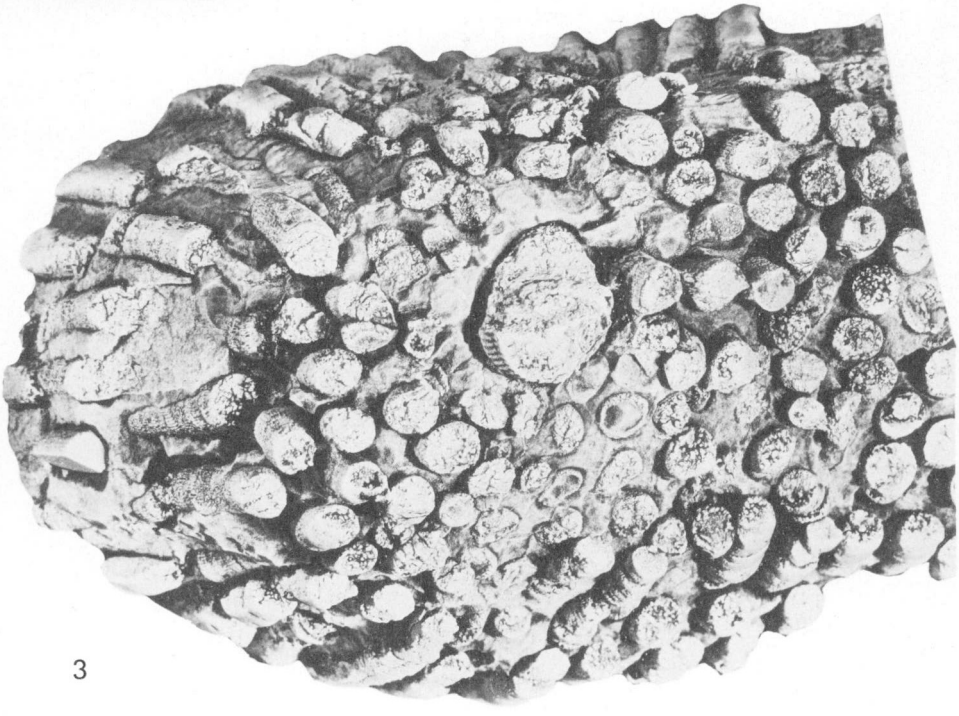

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PLATE XI

Figure 1. *Columnaria columbia* n. sp. 1, side view of the holotype, GSC No. 16524, x1. (Page 28)

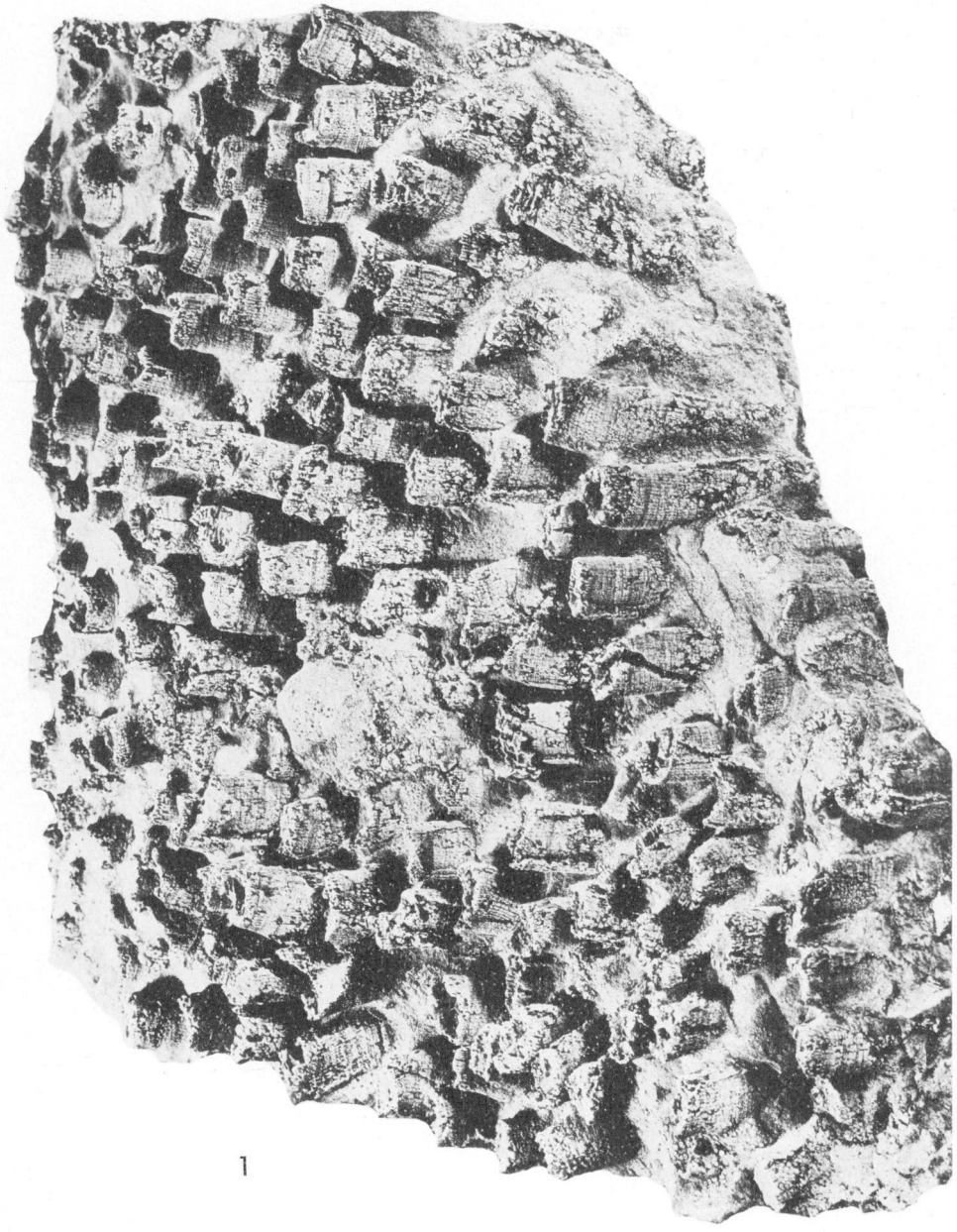

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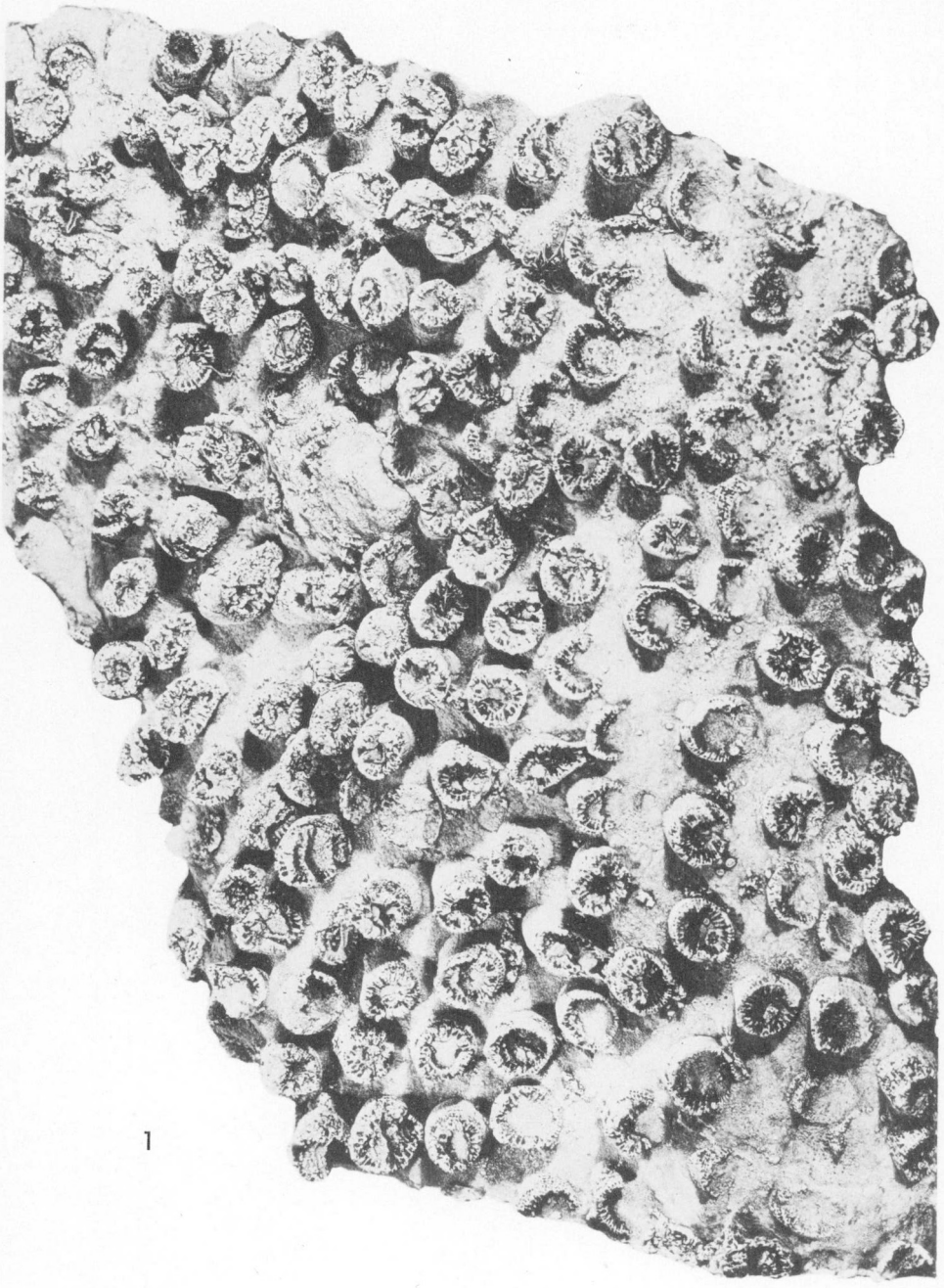
PLATE XII

Figure 1. *Columnaria columbia* n. sp. 1, top view of the holotype, GSC No. 16524, x1. (Page 28)



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