GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 201

ARCHAEOCYATHA FROM THE MACKENZIE AND CASSIAR MOUNTAINS, NORTHWEST TERRITORIES, YUKON TERRITORY AND BRITISH COLUMBIA

Robert C. Handfield

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Ottawa
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1971

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PREFACE

In 1965 a geological study and mapping program was begun in western Mackenzie and Selwyn Mountains in order to establish the stratigraphic sequence, determine the nature of abrupt facies changes that occur in the strata and to study the relationship and distribution of formations that are host to large base-metal deposits.

In the course of this work collections of Archaeocyatha were made from Lower Cambrian rocks. Archaeocyatha have been used to determine the age of many rock units in the Cordillera but it had not been possible to establish precise zones within the Lower Cambrian. However the stratigraphic framework established during the mapping program now makes this possible and the fossils described in this report now have a great potential for intercontinental correlation of Lower Cambrian strata.

Research in systematic paleontology is one of the means by which the Geological Survey of Canada provides data for the calibration of the geological time scale so necessary for the precise dating and correlation of the rocks that make up the geological framework of Canada.

Y. O. Fortier,
Director, Geological Survey of Canada

Ottawa, July 9, 1970

BULLETIN 201 — Archäocyathiden aus dem Mackenzie- und Cassiar-Gebirge in den Nordwestterritorien, im Yukonterritorium und in Britisch-Kolumbien

Von R. C. Handfield

Zwanzig Sammlungen von Archäocyathiden werden beschrieben. Eine neue Familie und acht neue Gattungen werden aufgestellt.

БЮЛЛЕТЕНЬ 201 — Археоциаты гор Макензи и Кассиар, Северо-Западные территории, территория Юкон и Британская Колумбия

Р. Ч. Хэндфилд

Описываются двадцать коллекций археоциатид; установлено одно семейство и восемь новых родов.

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Illustrations

ARCHAEOCYATHA FROM THE MACKENZIE AND CASSIAR MOUNTAINS, NORTHWEST TERRITORIES, YUKON TERRITORY AND BRITISH COLUMBIA

ABSTRACT

Twenty collections of well-preserved and/or stratigraphically important archaeocyathids are described from Lower Cambrian carbonate rocks of northern British Columbia, southern Yukon Territory and western District of Mackenzie.

Theories about the nature of exothecal outgrowths are reviewed and although the evidence is inconclusive it appears that there is no single cause of these growths. Parasitic growths, dimorphism and holdfasts are considered among the possible causes or uses of the outgrowths. Although the evidence is again inconclusive, there is, apparently, a relationship between exothecal growths and dissepiments.

For the first time in the northern Cordillera, archaeocyathids have been collected within a stratigraphic framework which allows for their evaluation as potential stratigraphic tools. Their usefulness for regional correlation is demonstrated but their greatest potential contribution seems to be for intercontinental correlation.

The archaeocyathids from the northern Cordillera have their greatest affinities with Siberian Archaeocyatha, three genera and two species being known only from these two areas.

These collections are assigned a Sanashtykgol age (medial Early Cambrian) on the basis of correlation with the Sayan-Altai Fold Belt of Siberia. Possibly one or two collections are somewhat older than this.

A single new family and eight new genera are recognized. The Acanthopyrgidae, n. fam. is erected for *Acanthopyrgus* Handfield. New Regularia are *Cordilleracyathus*, *Mackenziecyathus*, *Palmericyathus*, *Sekwicyathus* and *Yukonocyathus*. New Irregularia are *Clarucoscinus*, *Fenestrocyathus* and *Pseudosyringocnema*.

RÉSUMÉ

L'auteur décrit vingt collections d'archaeocyathidés bien conservés ou importants au point de vue stratigraphique, provenant de roches carbonatées du Cambrien inférieur du nord de la Colombie-Britannique, du sud du Yukon et de la partie occidentale du district de Mackenzie.

L'auteur passe en revue les théories sur la nature des apophyses exothèques et, bien que les preuves ne soient pas concluantes, il semble qu'il n'y ait pas de cause unique à ces croissances. L'auteur estime que les croissances parasitaires, le dimorphisme et les organes de fixation comptent parmi les causes ou utilisations possibles de apophyses. Bien que les preuves ne soient pas davantage concluantes, il existe apparemment une relation entre les croissances exothèques et les cloisons.

Pour la première fois dans la Cordillère du Nord, des archaeocyathidés ont été recueillis dans un cadre stratigraphique qui permet leur évaluation comme outils possibles en stratigraphie. Leur utilité pour la corrélation régionale est prouvée, mais leur plus grand potentiel semble résider dans la corrélation intercontinentale.

Les archaeocyathidés de la Cordillère du Nord ont leurs affinités les plus étroites avec les Archaeocyatha de Sibérie dont seulement trois genres et deux espèces sont connus dans ces deux régions.

On situe ces collections à l'âge de Sanashtykgol (milieu du Cambrien inférieur) en se fondant sur des corrélations avec la zone de plissement Sayan-Altai de Sibérie. Une ou deux collections sont peut-être un peu plus vieilles.

L'auteur reconnaît une seule nouvelle famille et huit nouveaux genres. La nouvelle famille des acanthopyrgidés est créée pour *Acanthopyrgus* Handfield. Les nouveaux genres réguliers sont: *Cordilleracyathus*, *Mackenziecyathus*, *Palmericyathus*, *Sekwicyathus* et *Yukonocyathus*. Les nouveaux genres irréguliers sont: *Clarucoscinus*, *Fenestrocyathus* et *Pseudosyringocnema*.

INTRODUCTION

This study is based on collections of Archaeocyatha from the Lower Cambrian of northern British Columbia, southeastern Yukon Territory and southwestern District of Mackenzie (Fig. 1). These collections were made by the author during the summers of 1965 and 1966 while employed by the Geological Survey of Canada.

Although Archaeocyatha have been studied by numerous students since their discovery in 1861 (Billings, 1861) recent documentation by several Russian workers of the stratigraphic and paleoecologic importance of Archaeocyatha (Zhuravleva, 1960; Rozanov and Missarzhevsky, 1966; Zhuravleva *et al.*, 1967) has given added impetus to their study elsewhere.

Debrenne (1964) has monographed the Archaeocyatha of northern Africa while Hill (1964a, b, 1965) has reported on the Archaeocyatha of Antarctica. Until now only the faunas of Australia and North America awaited study in the light of modern work done elsewhere. An excellent review by Hill (1965) summarized nearly everything known about Archaeocyatha to 1964 including a diagnosis of all recognized genera and their geographical distribution.

Archaeocyatha were first described from Labrador as *Archaeocyathus altanticus* Billings (1861). Other early North American discoveries were reported by Meek (1868), Ford (1873, 1878) and Walcott (1886). In this century Okulitch (1940, 1943, 1948, 1954, 1955a) was the prime student of North American Archaeocyatha. The first description of Archaeocyatha from the northern Cordillera was in 1955 (Okulitch, 1955a). A subsequent paper by Kawase and Okulitch (1957) described some Archaeocyatha from southern Yukon Territory. Greggs (1959) described the Archaeocyatha from Colville, Washington and Salmo, British Columbia. Okulitch and Greggs (1958) attempted to place the northern collections in a stratigraphic perspective relative to collections elsewhere in the Cordillera – a difficult task because very few collections of archaeocyathids in western Canada had been collected within a known stratigraphic framework.

Archaeocyathids have been instrumental in determining the age of many rock units in the Cordillera, but the establishment of precise zones within the Lower Cambrian has been impossible. Recently, a stratigraphic framework has been established (Gabrielse, 1963, 1967; Gabrielse *et al.*, 1965; Handfield, 1968) within which Archaeocyatha give promise of becoming useful stratigraphic tools. They give even greater promise for intercontinental correlation of Lower Cambrian strata.

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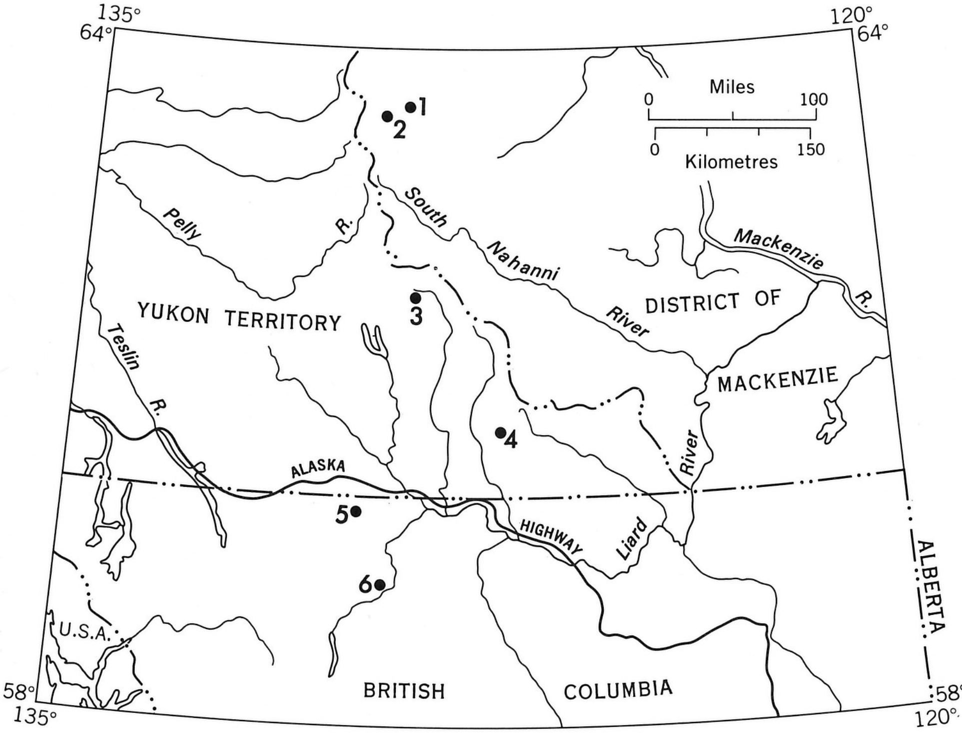

1. . . . . Caribou Pass section (73870-72)
2. . . . . Locality 73873
3. . . . . Locality 74845
4. . . . . Coal River section (68955-58, 73840)
5. . . . . One Ace Mountain section (73848-9)
6. . . . . Good Hope Lake section (75205-12)

GSC

Figure 1. Index map showing archaeocyathid localities.

Acknowledgments

The field work for this study, which was part of a doctoral dissertation at Princeton University, was done with the Geological Survey of Canada under the able guidance of H. Gabrielse and S. L. Blusson, to whom the writer is grateful.

I especially thank J. P. Lehman, Institut de Paleontologie, for space and equipment in his laboratory during an eight-month stay in Paris. The advice and guidance of Francoise Debrenne while I was in Paris, and since, is appreciatively acknowledged. A. Yu. Rozanov and I. T. Zhuravleva kindly showed me numerous examples of Siberian Archaeocyatha and offered many helpful suggestions during my visits to Moscow and Akademgorodok, respectively. Further guidance from A. G. Fischer, W. H. Fritz, A. R. Palmer and R. H. Hansman is gratefully acknowledged. I also thank J. St. Jean of the University of North Carolina (Chapel Hill) for the use of darkroom facilities and equipment. A. G. Fischer, E. Dorf, A. R. Palmer and Dorothy Hill critically read the manuscript, for which I thank them. My stay in Paris and visit to Russia was made possible by a Princeton University Travel Fellowship and Travel Grant. The Canadian Charles Caldwell Fellowship in 1968 at Princeton University and a Catawba College Summer Study Grant enabled me to complete this work.

MORPHOLOGICAL TERMINOLOGY

Alternating pore rows – Pores in adjacent longitudinal rows arranged so that the pores are alternate rather than opposite.

Apex – The smallest part of the cup; internal elements may be lacking.

Central cavity – That portion of a two-walled cup that is inside the inner wall.

Cup – The entire skeleton of an archaeocyathid.

Dissepiments – Thin, bubble-like, nonporous skeletal elements found in the intervallum or central cavity or absent.

Exothecal growths – Additional skeletal elements of varying shape and size attached to the outer wall or in the central cavity. Some have been given generic names, e. g. Tersia.

Inner wall – Found only in two-walled cups; porosity simple or complex.

Intervallum – The space between the inner and outer walls of two-walled cups.

Intervallum coefficient (IK) – The ratio of the width of the intervallum to the diameter of the central cavity.

$$IK = \frac{\text{intervallum}}{\text{central cavity}}$$

Linteaux – Skeletal elements between pores.

Outer wall – The external wall of the cup.

Pellis – A thin, nonporous sheath surrounding some cups.

Radial coefficient (RK) – The ratio of the number of septa (or taeniae) to the total diameter of the cup.

$$RK = \frac{\text{number of radial elements}}{\text{total diameter of cup}}$$

Septa – Radial, longitudinal plates extending from outer to inner wall; may be porous or imperforate.

Spitz – Same as apex.
Stirrup pores – Pores in outer or inner walls in line with a septal edge so that the hole in the wall is continuous with a pore in the septum.
Synapticulae – Small, cylindrical rods which may connect adjacent septa or taeniae.
Tabulae, pectinate – Horizontal projections, like the teeth of a comb, from the sides of the septa, the projections not meeting those on adjacent septa.
Tabulae, porous – Horizontal or arched porous plates which may occur in the intervallum.
Taeniae – Radial, longitudinal plates which occur only in the Irregularia; they are always porous; they are nearly always waved, zig-zagged or irregularly bent.

MORPHOLOGY

Hill (1965) gave an excellent review of all that is known about the skeletons of archaeocyathids. Since there would be little point in discussing much of this material I have restricted my comments to those areas where the material from the northern Cordillera can make some contribution to our understanding of archaeocyathan morphology.

Tabulae

There are two kinds of tabulae – porous and pectinate. Pectinate tabulae are definitely known from North America. Porous tabulae occur in both the Regularia (Coscinocyathina) and Irregularia (Archaeosyconia), but there are some differences in the tabulae of these two groups.

In the Regularia the tabulae may be flat or convex upwards with their centre of curvature in the intervallum. The pores are arranged in radial rows, two or more rows per intersept. They are generally round and uniform in size and arrangement.

In the Irregularia the tabulae are nearly always convex upwards and their centre of curvature is generally in the central cavity, but in some the centre of curvature is in the intervallum. Pores in the tabulae of Irregularia may be variable in size and arrangement on a single tabula.

So far as I know, the only species in which the tabulae appear to be convex downwards is Archaeosycon billingsi (Walcott), illustrated by Okulitch (1943, Pl. 14, fig. 2), and in this case the other structures in the intervallum suggest that the specimen has been oriented upside down.

The spacing of tabulae, both in the Coscinocyathina and Archaeosyconina, may be regular or irregular, close or distant. In a single individual the distance between tabulae may vary by as much as a factor of 3 although in most specimens the variation is less than by a factor of 2 and may be as low as 1.25.

My observations indicate that in those specimens in which no inter-tabular space exceeds 2 millimetres the variation is likely to be greater than in those specimens with widely spaced tabulae.

Graphs of distance between tabulae versus total height of specimen (Fig. 3) show a remarkable zig-zag line which reveals that the distance between tabulae neither increases nor decreases consistently with increased

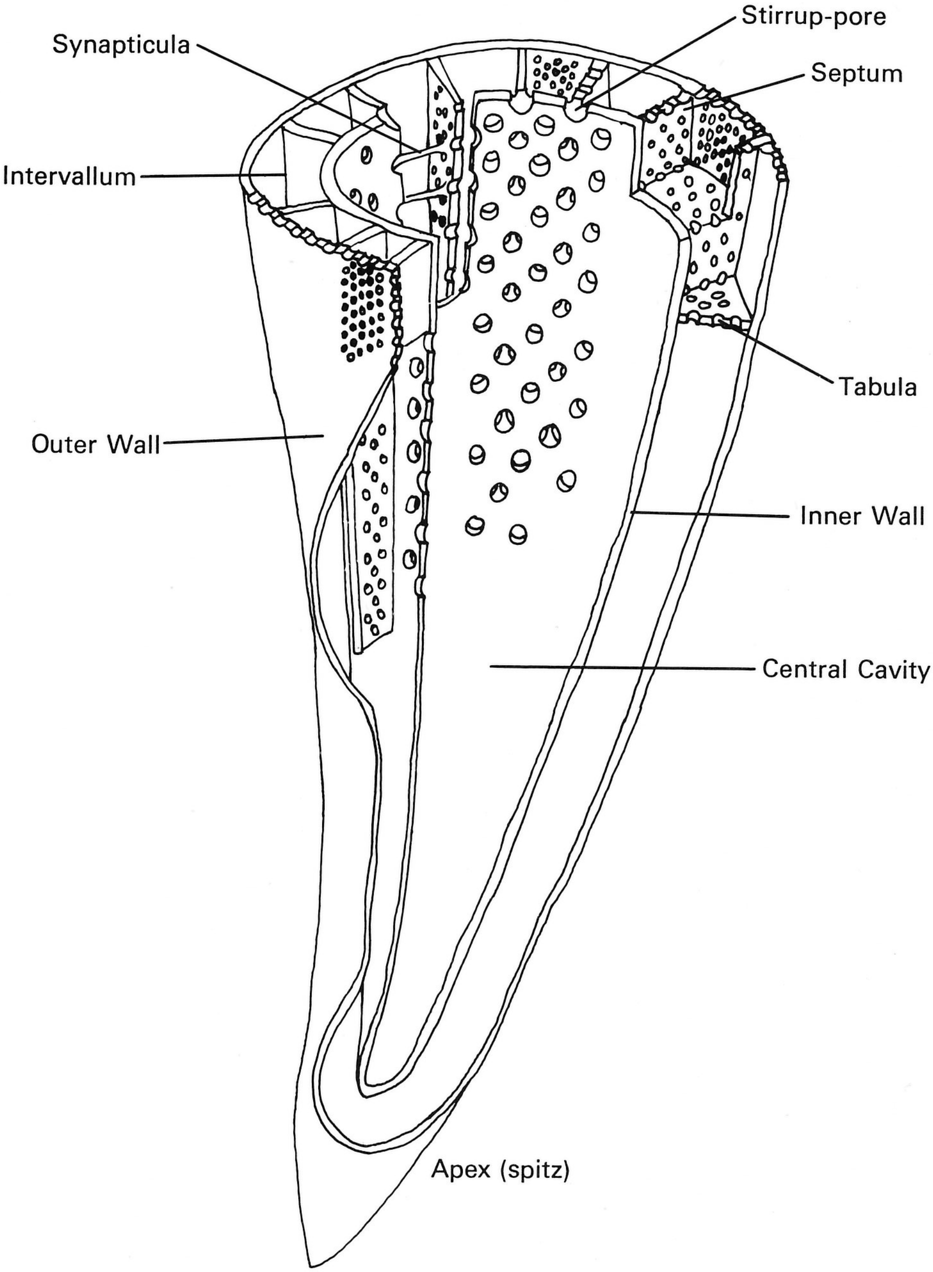

Figure 2. A generalized archaeocyathid (after Debrenne, 1964).

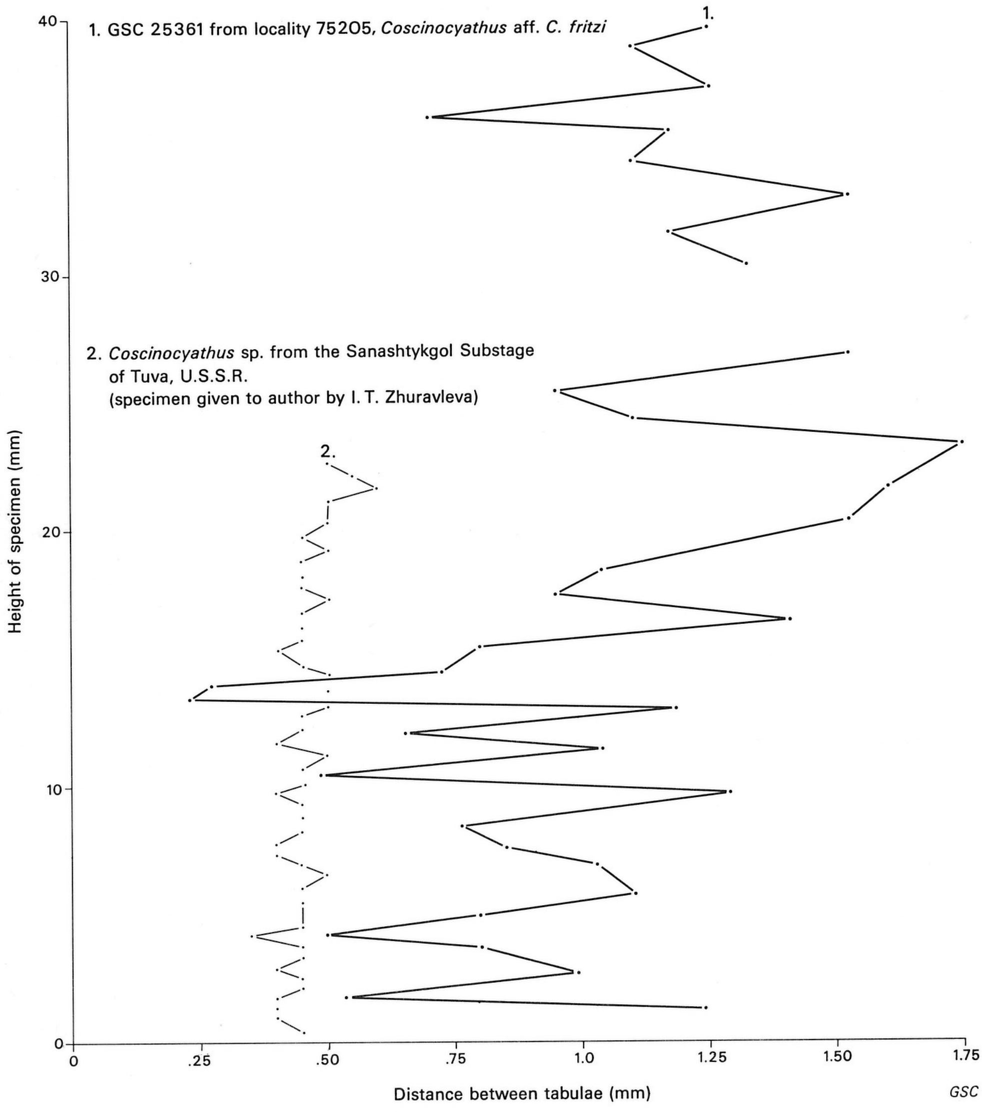

Figure 3. Graph of distance between tabulae versus height of specimen.

growth of the archaeocyathid. This conclusion may not hold true for the very youngest stages of archaeocyathids which were not available for examination.

The irregular spacing raises the possibility that the spacing of the tabulae represents some kind of cyclic growth - e.g. tidal, daily, seasonal, etc. Alternatively, the tabulae may record events that occurred at variable time intervals, with growth proceeding at a constant rate. Many more specimens than were available to me would be necessary to draw any solid conclusions regarding the periodic spacing of the tabulae.

At present it is not known whether the tabulae formed a floor for the living organism, or a roof, or whether they occurred within the tissues. Zhuravleva (1960b) argued that all tabulate Archaeocyatha ended their development with the formation of the top tabulae. This suggests that the other tabulae were also roofs and not floors but in that case we might expect the roofs to have been pushed aside when growth resumed. Zhuravleva (1960b) described specimens of <u>Ajacicyathus</u> <u>sunnaginicus</u> in which the intervallum had been closed by union of the outer and inner walls, both walls arching over the central cavity. In some individuals traces of these caps were found at various levels pushed aside as if by upward growth. In <u>Zonacyathus</u> <u>borealis</u> n. sp. three of four individuals have the intervallum closed by the outer wall arching over to the inner wall. No traces of these caps exist at lower levels in the cups.

Exothecal Growths and Dissepiments

One of the earliest workers to consider the problem of exothecal growths was Bornemann (1886). Since then a number of workers have offered as many interpretations. Vologdin (1931) was the first to apply generic names to these outgrowths and since then at least seven generic names have been applied to exothecal lamellae (Hill, 1965). Okulitch (1946) gave a very good summary of the views that had been expressed to that time and summarized the pertinent facts relating to these "organisms". Any theories concerning exothecal growths will have to account for the following: (1) exothecal growths are very abundant in some localities and rare to absent in other localities even though the numbers of Archaeocyatha are the same in the various localities; (2) some individuals of a species may have exothecal growths whereas others at the same locality do not; (3) any exothecal growth may encompass one, two or even more individuals, including individuals of different classes; (4) exothecal growths are most common on Irregularia but do occur on Regularia; (5) although this has not apparently been mentioned before, dissepiments appear to be more abundant in individuals having exothecal growths and, related to this; (6) in those individuals which have localized exothecal growths, dissepiments seem to be more abundant near the exothecal growth than elsewhere.

Bornemann (1886) regarded exothecal lamellae as a vegetative stage from within which the regular cups developed. Taylor (1910), Zhuravleva (1960b) and Hill (1965) believed they were outgrowths of attachment. Okulitch (1946) regarded them as outgrowths but not for any specific purpose. Bedford and Bedford (1937, 1939) and Maslov (1958) considered them to be parasitic organisms. Vologdin (1959, 1962) expressed the view that some are outgrowths while others are independent, encrusting Archaeocyatha.

In North America there is an especially striking difference between the abundance of exothecal lamellae at the Labrador localities and the paucity of these structures at the western Cordillera localities. Since the Labrador localities seem to be younger than other North American localities (W.H. Fritz, pers. comm., 1968) there may be some stratigraphic significance to exothecal lamellae. On the other hand, the Australian localities which have abundant exothecal growths are similar in age to the western North American localities. Thus it appears that the stratigraphic distribution of exothecal growths is probably worth further investigation. The usual reason given for differences in the abundance of exothecal growths is local environmental differences. As there are a large number of variables, many of which cannot be discerned from the rock record, this reason remains as a probable cause of geographical variations. In the western Cordillera, the examination of several localities ranging from southern British Columbia (50°N) to the District of Mackenzie (63°N) reveals about as wide a variety of lithologic types as Archaeocyatha have ever been found in. Presumably ecologic conditions were considerably varied also and yet nowhere are exothecal growths abundant or even common. Archaeocyatha localities in California and Nevada also have a dearth of exothecal growths.

The idea that all exothecal outgrowths are holdfasts seems untenable although certainly some are holdfasts. A small amount of evidence indicates that some outgrowths are parasitic (symbiotic?); furthermore it is nearly impossible to prove or disprove whether they might be pathological. For more detailed discussions of their functions as holdfasts see Okulitch (1946) and Zhuravleva (1960b).

Three specimens from the northern Cordillera show exothecal features that are worth discussing in detail. GSC 25372 has an exothecal growth attached to the outer wall by an area 10 millimetres long. Across half of this distance the intervallum contains abundant dissepiments whereas elsewhere in this cross-section no dissepiments are visible. All of the dissepiments at this point are convex inwards and form a wedge-shaped mass (Pl. XI, fig. 5). Two interpretations (but not the only ones) that can be made from this are: (1) the exothecal outgrowth was caused by a parasitic organism which had attacked the archaeocyathid and the dissepiments were formed by the parasite; (2) the exothecal outgrowth was caused by a parasite and the dissepiments were grown by the archaeocyathid in an attempt to prevent the entry of the parasitic growth. Specimen 25363 shows the same feature but with the dissepiments not so well developed.

The third specimen of interest is 25382 which contains one specimen of Protopharetra sp. and two specimens of Ladaecyathus joined by one large growth of exothecal lamellae (Fig. 4; Pl. XVI, fig. 3). The specimen of Protopharetra has exothecal growths on approximately 1/3 of its outer wall and filling in about 3/4 of the central cavity. Growths in the central cavity have been termed endothecal lamellae (Debrenne, 1964) but can seldom, if ever, be distinguished from growths attached to the outer wall. Dissepiments are found throughout the intervallum but are most abundant in that part nearest the exothecal growth. The exothecal growth itself exhibits several interesting features. The area adjacent to Protopharetra sp. 1 has abundant dissepiments whereas most of the area between the various individuals is devoid of dissepiments as are the two specimens of Ladaecyathus. At a maximum distance of 4.5 millimetres elements of the "growth" are thickened and the impression obtained is that growth stopped for some time before resuming.

This phenomenon is exhibited commonly in exothecal growths (Okulitch, 1946, Pl. 41, fig. 1) and Zhuravleva (pers. comm., 1968) also regards it as a sign of interrupted growth.

At an approximately equal distance from the three archaeocyathids and within the exothecal growth is a "central cavity" surrounded by dissepiments (Fig. 4; Pl. XVI, fig. 3). These dissepiments are continuous with the dissepiments near the specimen of Protopharetra sp. Zhuravleva (pers. comm., 1968) regards this secondary "central cavity" as an example of sexual dimorphism. As other specimens of exothecal growths (especially "Tersia") are known with "central cavities" this is a possibility although for the present I regard it as only a possibility and not a probability.

Although examples of exothecal growths encrusting more than one species have been reported (Okulitch, 1946) this is the first report of growths encrusting members of two classes. Again there are several possible explanations for this. Firstly, the exothecal outgrowth may be formed by a nonhost-specific parasite. Secondly, the growth may be parasitic but the two specimens of Ladaecyathus could have been dead before being encrusted. This is not likely since the dead archaeocyathids probably would have toppled over so their orientation in the matrix would be different from the "live" archaeocyathid. Thirdly, the "growths" may be true "outgrowths" of the Protopharetra sp. and have passively encrusted the other specimens. Lastly, the two species present may be dimorphs (sexual?) in which case the growth, if parasitic, could be host-specific.

The skeletal elements of many exothecal growths are very regular and suggest a close connection with the regular elements of the archaeocyathids. Generally there is not a one-to-one correspondence of elements, the outgrowth commonly (perhaps always) having additional elements. In other outgrowths the elements are very irregular and appear to have no relation at all to the skeletal elements of the archaeocyathid.

It seems safe to conclude that exothecal growths are not caused by any single factor and much more work is required on this problem.

As indicated above, dissepiments seem to be at least partly connected with exothecal growths. However, numerous examples of exothecal growths are devoid of dissepiments as are the associated archaeocyathids (Pl. IX, fig. 1a). Contrarily, many archaeocyathids contain abundant dissepiments without any sign of having exothecal growths. Needless to say, unless the complete cup can be examined, the absence of exothecal growths cannot be proven.

Dissepiments are thin, curved, imperforate plates, generally convex upward. They may be found in the intervallum, central cavity or exothecal growths. Their distribution within an individual is commonly erratic and their abundance may vary considerably in otherwise indentical specimens from the same locality.

Because water currents were essential to the proper functioning of Archaeocyatha (why else an elaborate system of porous skeletal plates?) the imperforate nature of dissepiments is their most striking feature. Surely an individual completely filled with imperforate dissepiments could not function in the same way as an identical individual with no dissepiments.

Dissepiments are always the first skeletal elements formed in the apical cavity of Irregularia but in a great many Irregularia they remain restricted to the embryonic stages. The exact systematic importance of dissepiments at levels below the family is still not agreed upon by most workers.

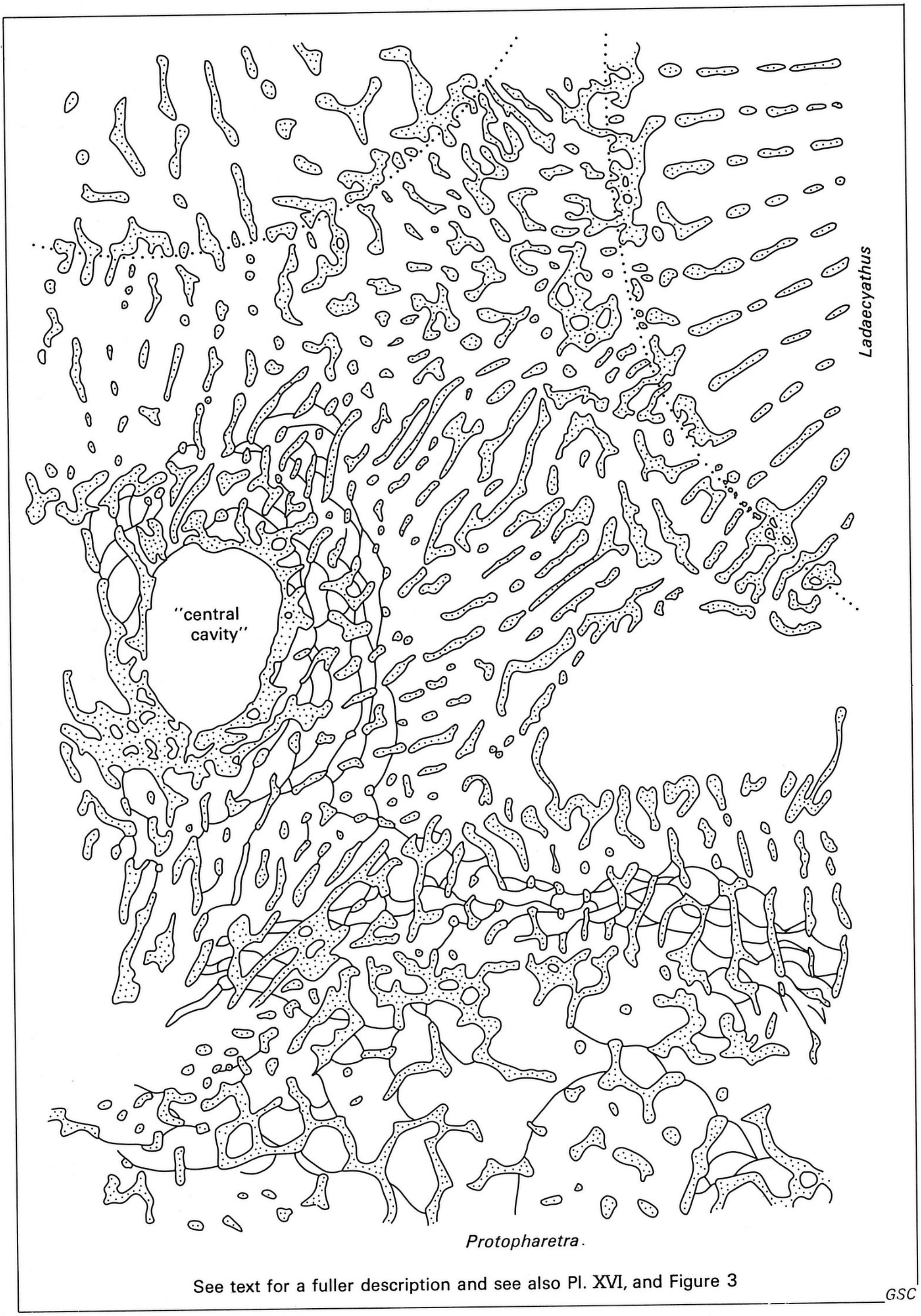

Figure 4. Exothecal growth joining a colonial specimen of Ladaecyathus and a specimen of Protopharetra .

Hill (1965, p. 46) states " ... dissepiments, which are always present in the youngest stages of Irregularia, may in the adult stages characterize some genera of Regularia or Irregularia, or merely some individuals of certain species". Zhuravleva (1960) and Debrenne (1964) regard dissepiments as being of generic value when they are always more or less abundant. Because the possibility exists of dissepiments being induced in a specimen by exothecal growths, considerable care should be used when basing a taxon on the presence or absence of dissepiments.

STRATIGRAPHY

Archaeocyatha were collected from the Sekwi Formation, the Atan Group (map-unit 5, Gabrielse and Blusson, 1969) in central Coal River map-area and map-unit 8 (Blusson, 1966) in Frances Lake map-area (Table 1).

The physical stratigraphy of the Sekwi Formation has been discussed by Handfield (1968) and Blusson (1968b).

Gabrielse (1967) regarded the Lower Cambrian in parts of the Mackenzie Mountains as divisible into three facies belts - an inner sandy belt, a central sandy-dolomite belt and an outer shale and limestone belt. The Sekwi Formation lies along the eastern margin of the Selwyn Basin (Gabrielse, 1967) in the central facies belt. Eastward (and shoreward) it changes facies to a predominantly orthoquartzite sequence while southwesterly it changes to a black argillaceous unit (of presumably deeper water origin). The extreme heterogeneity of the Sekwi Formation reflects this intermediate position where either a slight rise or fall in relative sea level could have a pronounced affect on both the sediment and depositional environment. The presence of both well-sorted orthoquartzites and thin-bedded, dark shales indicates that fluctuations indeed took place. Johnson and Belderson (1969), however, point out that many lithological changes that have in the past been attributed to changes in water depth could be as easily attributed to changes in tidal currents, which in turn are influenced by many other factors than solely the depth of water. Oolites, although of restricted occurrence, indicate very shallow agitated warm water during part of Sekwi time. The single most abundant rock type in the Sekwi Formation is sandy dolomite. This type ranges from strata in which the quartz grains are "floating" in carbonate through strata which are 50 per cent sand to strata which are almost 100 per cent sand. It is this rock type which renders so much of the Sekwi Formation barren of fossils. Archaeocyatha were collected in abundance at four localities in the Sekwi Formation and isolated specimens in a few other places. At Caribou Pass (section 1) they occur at three horizons in a silty, dolomitic limestone (insoluble residue 14 per cent) (Fig. 5). Here they are partially fragmented and longer pieces are parallel to bedding planes suggesting at least some transportation after death.

The archaeocyathids at locality 73873 occur in a light grey calcilutite in which they are very well preserved. It is likely that they grew in place here and no transportation has occurred. The presence of the blue-green? alga Renalcis (Pl. I, fig. 4) suggests a water depth of less than 50 metres (Zhuravleva, 1960b). The presence (in a single thin-section) of literally tens of small (0.5 x 0.05 mm) spicule-like cylinders shows bottom currents were weak to absent. Surprisingly, the insoluble residues (mostly clay) amount to 11 per cent by weight.

AREA	MACKENZIE MOUNTAINS		COAL RIVER MAP-AREA	NORTHERN BRITISH COLUMBIA	
	District of Mackenzie	Yukon Territory			
LOCALITIES FROM FIG. 1.	1,2	3	4	5,6	
OVERLYING BEDS	Middle Cambrian	Middle Cambrian	? Middle Cambrian	? Middle Cambrian	
LOWER CAMBRIAN	Sekwi Formation	(8)[1]	(5)[2]	ATAN GROUP	Limestone
					Shale
		?			Sandstone
		(3a)			

1. See Blusson, 1966
2. See Blusson, 1969

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Table 1. Stratigraphic units from which archaeocyathids were collected.

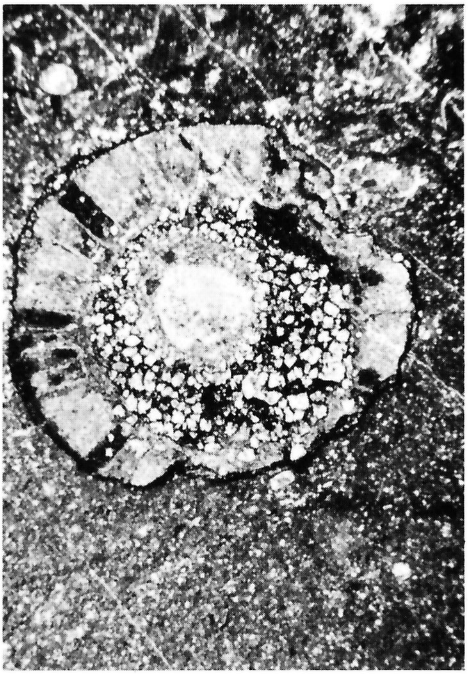

Figure 5.
Thin-section of unidentified archaeocyathid from Caribou Pass section. Note replacement by dolomite from centre out and corroded rim. Matrix is mixture of silt, calcite and dolomite. x9 (GSC Photo 201535)

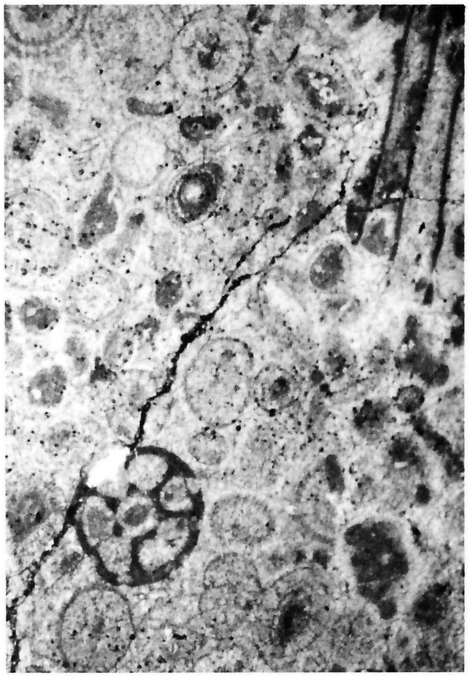

Figure 6.
Thin-section of Atan Group oolitic limestone from One Ace Mountain section. x15 (GSC Photo 201535-A)

Stromatactis-like structures are also present here. These strata certainly represent a bioherm although probably not a true wave-resistant reef.

Gabrielse (1963) gave a brief description of the Atan Group and informally divided it into three units - a lower sandstone unit, a thin intermediate shale and an upper limestone unit. All of the Archaeocyatha from this group were collected in the upper limestone unit. Two stratigraphic sections were measured, one at One Ace Mountain (section 5, Fig. 1), the other at Good Hope Lake (section 6, Fig. 1). In both places the Atan limestone represents a significant change in facies from the Sekwi Formation.

These pertinent features should be pointed out here: (1) quartz sand is very rare in, if not entirely absent from, the limestone unit, (2) dolomite is present but not common, (3) siltstones and shales are present but rare and (4) oolites and ?intraformational conglomerates are abundant. Some of these features, such as the first, are more a result of geography (i.e., relationship to a source area) than of the depositional environment.

In the oolitic limestone the archaeocyathids are all very small and greatly fragmented (Fig. 6).

In contrast a 50-foot interval near the base of the unit which is much siltier contains abundant archaeocyathids - many of which are very large and some of which are apparently in growth position. Many of the details there have been destroyed by later dolomitization. At Good Hope Lake, the limestones are, in general, finer grained and detrital features such as conglomerates are less obvious. The red alga Epiphyton (Pl. I, fig. 3) is abundant in many of these rock suggesting water depths in excess of 50 metres (Zhuravleva, 1960b).

If Zhuravleva's conclusions regarding the depth distribution of Renalcis and Epiphyton are correct, then collection 75208 from this section must have been deposited very near 50 metres in depth because it contains both algae.

Evidence of dolomitization is also more prevalent here than at One Ace Mountain with small rhombs of dolomite visible in many samples.

As Gabrielse (1963, 1967) has suggested, the Atan Group probably indicated relatively stable conditions on the Pelly-Cassiar Platform. The limestone unit possibly represents a large carbonate bank with water depths ranging from subtidal (oolite accumulations) to in excess of 50 metres.

The strata exposed in central Coal River map-area are unfortunately physically separated from both the Atan Group to the south and the Sekwi Formation to the northwest. Depositional conditions, as recorded by the lithotopes, were considerably different from the other two areas. Sandstone, siltstone and silty limestone are the most abundant rock types with only minor amounts of limestone present. In the upper half of the section a large bioherm is nearly 300 feet thick. Two rock types are prominent in this bioherm: (1) a bioclastic limestone in which trilobite fragments and archaeocyathids are dominant but with some oolites mixed in and (2) a calcilutite with archaeocyathids and algae in apparent growth position. Although lithology 1 apparently represents a turbulent environment the excellent preservation of abundant entire archaeocyathids (Pl. I, fig. 1) again suggests they underwent little, if any, transportation. Like the Sekwi Formation, these strata were deposited in the Selwyn Basin, in this case along the southern margin.

Archaeocyatha at locality 74845 in Frances Lake map-area have been found only in a single boulder of limestone in a limestone conglomerate. Within the boulder itself, abundant Epiphyton (Pl. I, fig. 2) appears in growth position and the archaeocyathids are generally not fragmented.

PALEOGEOGRAPHY

The available evidence strongly suggests a close connection between Siberia and northwestern North America during the Early Cambrian. Of the twenty-eight genera recorded in this study, eleven (41 per cent) are also known from Siberia and ten (37 per cent) from Australia. Only six (22 per cent) are known from North Africa. Three and possibly four (15 per cent) genera occur in North America and Siberia, with two (7 per cent) restricted to Australia and North America. At the species level the affinities to Siberia are even more pronounced with two and possibly four species found only in Siberia and North America but none restricted to North America and elsewhere. Zhuravleva (written comm., 1968) remarked on the similarity between the archaeocyathids of western Canada and those of eastern Siberia. Palmer (1968) concluded that his Early Cambrian-1 fauna (of Sanashtykgol age) had its greatest affinities with trilobites of Siberia.

The presence of Acanthopyrgus yukonensis Handfield and Tabulaconus kordeae Handfield (1969) in both eastern Alaska, and southern Yukon Territory and northern British Columbia suggests that a direct migration route existed between the two areas in medial Early Cambrian. The presence of Ethmophyllum whitneyi in the northern Cordillera and California suggests that the Early Cambrian western geosyncline was continuous from Alaska to California, at least during the middle Early Cambrian.

Palmer (1968) concluded that a trans-Arctic migration route existed between eastern and western North America during most of the Cambrian. If the specimens described from northern British Columbia as Cambrocyathus? sp. are congeneric with Cambrocyathus in Labrador, Palmer's conclusion is substantially strengthened.

ZONATION

It is obvious from the stratigraphic distribution of archaeocyathids in northwestern North America that they can be a useful, if not entirely satisfactory means of obtaining stratigraphic information - useful because they are restricted to the Lower Cambrian but not too satisfactory because of their short overall stratigraphic range (i.e. only a small part of the total Lower Cambrian can be subdivided on the basis of Archaeocyatha).

The longest continuous section containing archaeocyathids is at Good Hope Lake (section 6) where archaeocyathids extend over a stratigraphic distance of 750 feet within the lower 900 feet of the limestone unit of the Atan Group. On the basis of the identifications I made, every one of eight collections made could be distinguished from every other collection. Nevertheless it seems convenient to divide the section into only three zones; a lower zone "A" characterized by Ethmophyllum cf. E. whitneyi, Flindersicyathus mcdamensis n. sp., Zonacyathus princetonensis n. sp., Cambrocyathus sp., Protopharetra sp. and some others shown in Table 2; a middle zone "B"

75211	75210	75212	75205	75206	75207	75208	75209	Locality number
900	850	600	510	288	284	280	148	Feet above base of limestone unit
•	•							*Tabulaconus kordeae*
		•	•					*Coscinocyathus* cf. *C. multiporus*
			•					*Erismacoscinus ? uniporus* n. sp.
			•					*Coscinocyathus fritzi* n. sp.
			•					*Palmericyathus lineatus* n. gen.
			•					*Claruscoscinus billingsi* n. gen.
			•					*Cordilleracyathus blussoni* n. gen. et n. sp.
			•					*Ajacicyathus yukonensis*
				•				*Ladaecyathus* aff. *L. fischeri*
				•				*Protopharetra* sp.
				•				*Ajacicyathus* aff. *A. crassus*
				•				Genus A sp.
					•			*Flindersicyathus* cf. *F. aenigmatus*
					•			*Zonacyathus princetonensis* n. sp.
						•		*Robustocyathus* aff. *R. peludicus*
						•		*Flindersicyathus mcdamensis* n. sp.
		•				•		? *Cambrocyathus* sp.
		•			•		•	*Ethmophyllum* cf. *E. whitneyi*

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Table 2. Good Hope Lake section (Section 6).

characterized by Palmericyathus lineatus (Greggs), and abundant tabulate species shown in Table 2; and an upper zone "C" containing a few unidentified species and characterized by Tabulaconus kordeae Handfield. The trilobite Nevadella was found in the lower beds of "A" zone. A study of the archaeocyathids in the Atan limestone unit at One Ace Mountain (section 5) is only partially completed but the lowermost beds there are apparently correlative with the "A" zone at section 6. Nevadella is also present there.

The distribution of archaeocyathids in the Sekwi Formation is rather sporadic, the only successive stratigraphic collection being from Caribou Pass (section 1). There, three collections are spread over a stratigraphic distance of 240 feet. Again every collection can be distinguished from every other collection (Table 3). The middle collection (73871) is almost certainly correlative with collection 75205 of zone "B" of the Atan Group. The two collections have the following species in common: Palmericyathus lineatus, Claruscoscinus billingsi, Coscinocyathus fritzi, and Cordilleracyathus blussoni. The lowermost collection (73870) at section 1 may or may not be within the "B" zone of Good Hope Lake. It does contain the tabulate species C. billingsi as well as Cordilleracyathus blussoni but this last species is a rather long ranging form. The uppermost collection (73872) contains species from the "B" and "C" zones. Tabulaconus kordeae makes its appearance in addition to Cordilleracyathus blussoni and Coscinocyathus fritzi.

The Coal River section is in some ways the most useful section. Trilobites are much more abundant there, occurring even with the archaeocyathids through 455 feet of beds. All of the archaeocyathids here occur within the range zone of Nevadella, specifically within the upper two-thirds of its range zone. Holmia occurs through the middle third of the archaeocyathid biozone. The collections here seem to have more in common with each other than do collections at other sections. Nonetheless they can be distinguished (Table 4). Correlation with other sections is rather difficult but the presence of Ethmophyllum cf. E. whitneyi, Flindersicyathus cf. F. aenigmatus, Robustocyathus aff. R. peluduicus and Ladaecyathus fischeri suggest an age about the same as the "A" zone of the Atan Group. The absence of tabulate forms lends support to this correlation. The presence of Kaltatocyathus rozanovi and several other species not known from other collections suggests that collection 68955 may be older than the oldest collection from Good Hope Lake (see further discussion under correlation).

Locality 73873 (No. 2, Fig. 1) in the Sekwi Formation contained the following genera and species: Cordilleracyathus blussoni, Sekwicyathus nahanniensis, Gordonicyathus dorfi, Fenestrocyathus complexus, Tumuliolynthus (Propriolynthus) vologdini, Zonacyathus borealis, and Tabulaconus kordeae. Only three of these, C. blussoni, T. kordeae and Z. borealis, are known from other localities. The first two occur together at Caribou Pass locality 73872 while Z. borealis occurs in central Coal River area at locality 68955. An unidentified coscinocyathid also was found at locality 73873 suggesting that a correlation with locality 73872 is the more appropriate one.

Locality 74845 (=70774) (No. 3, Fig. 1) contained the following species: Acanthopyrgus yukonensis, Yukonocyathus francesi, Flindersicyathus cf. F. aenigmatus and Genus B sp. Y. francesi ranges through most of the Coal River section while F. cf. F. aenigmatus indicates a zone "A" correlation.

73872	73871	73870	Locality number
1793	1700	1558	Feet above base of Sekwi Formation
•			*Tabulaconus kordeae*
•	•		*Coscinocyathus fritzi* n. sp.
	•		*Palmericyathus lineatus* n. gen.
		•	*Metaldetes caribouensis* n. sp.
	•	•	*Claruscoscinus billingsi* n. gen.
•	•	•	*Pycnoidocyathus sekwiensis* n. sp.
•	•	•	*Cordilleracyathus blussoni* n. gen. et n. sp.

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Table 3. Caribou Pass section (Section 1).

73840	68958	68957	68956	68955	Locality number
1580	1450	1430	1410	1260	Feet above base of section
•					? *Porocyathus* sp.
	•				*Pycnoidocoscinus* sp.
		•			*Robustocyathus* aff. *R. peludicus*
•		•			*Ladaecyathus fischeri* n. sp.
		•			*Ethmophyllum* cf. *E. whitneyi*
		•			*Loculicyathus canadensis* n. sp.
			•		*Flindersicyathus* cf. *F. aenigmatus*
				•	*Mackenziecyathus bukryi* n. gen. et n. sp.
				•	*Zonacyathus borealis* n. sp.
		•		•	*Kaltatocyathus rozanovi* n. sp.
•			•	•	*Pseudosyringocnema uniporus* n. gen. et n. sp.
•		•		•	*Yukoncyathus francesi* n. gen. et n. sp.

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Table 4. Central Coal River Section (Section 4).

CORRELATION

The only other place in North America where the Lower Cambrian faunal succession is nearly as well known is in the White-Inyo Mountains of California where archaeocyathids occur throughout a stratigraphic interval of about 2,000 feet (McKee and Gangloff, 1969). There, three assemblages of archaeocyathids can be recognized. Since only lists (McKee and Gangloff, 1969) and not detailed descriptions of the faunas are available, correlations are only tentative. Five genera are common to zone A of the Good Hope Lake section and the two lower assemblages of the White-Inyo Mountains. Since Nevadella and Holmia occur in the strata immediately overlying the second assemblage, the most reasonable correlation would seem to be with the second assemblage. Tabulate Regularia make their first appearance in the upper Poleta limestone and this is probably correlative with zone B of the Atan Group.

McKee and Gangloff (1969) mentioned that in the White-Inyo Mountains Ethmophyllum (as Ethmophyllum whitneyi) occurs in beds older than Coscinocyathus in an apparent reversal of the sequence found elsewhere in the world. In the Atan limestone also, Ethmophyllum occurs before Coscinocyathus. A personal examination of specimens assigned to Ethmophyllum in Siberia leads me to believe that they are not congeneric with Ethmophyllum in the North American sense and there is thus no problem with regard to their time of appearance.

Tentative correlations between the northern Cordillera and California are summarized in Figure 7.

Although a revision of the archaeocyathids of British Columbia is planned, a discussion of their stratigraphic significance now may be useful. Okulitch and Greggs (1958), stressing the inadequacy of the data, undertook an analysis of the relative ages of the archaeocyathid zones of Washington, British Columbia and the Yukon (Fig. 8). Exact localities, faunal lists and lithologies can be obtained from their paper. At Colville, Washington, the complete lack of tabulate genera and the presence of Ethmophyllum whitneyi suggests a correlation with zone A of section 6. Nevadella addyensis in the underlying beds confirms a middle Early Cambrian age rather than an early Early Cambrian age as suggested by Okulitch and Greggs (1958). At Salmo, British Columbia, the presence of Palmericyathus lineatus together with Coscinocyathus and Pycnoidocyathus strongly favours a correlation with zone B of the Atan Group. In the Dogtooth Mountains, and at Sinclair Hills, British Columbia, Coscinocyathus and Pycnoidocyathus are evidence of a middle Early Cambrian age - zone B. At Aiken Lake, British Columbia, the Archaeocyatha are poorly preserved and not well known. At Wolf Lake, Yukon Territory, Lord's (1944) group C sediments and possibly his group B sediments are certainly correlative with zone B of the Atan Group. At Quiet Lake, Yukon Territory, Coscinocyathus and Pycnoidocyathus are evidence of a middle Early Cambrian age - zone B.

By far the best known sequences of Lower Cambrian strata and their contained fossils are in central and southern Siberia. There, the work of Vologdin (1932, 1940, 1957, and 1959), Zhuravleva (1959, 1960b), Zhuravleva et al. (1967), Rozanov and Missarzhevsky (1966) and Repina et al. (1964) has established a classic faunal sequence. As might be expected, the number of investigators has lead to the establishment of several stratigraphic schemes. The difficulties are further compounded because different facies were developed on the Siberian Platform and in the folded region and correlations

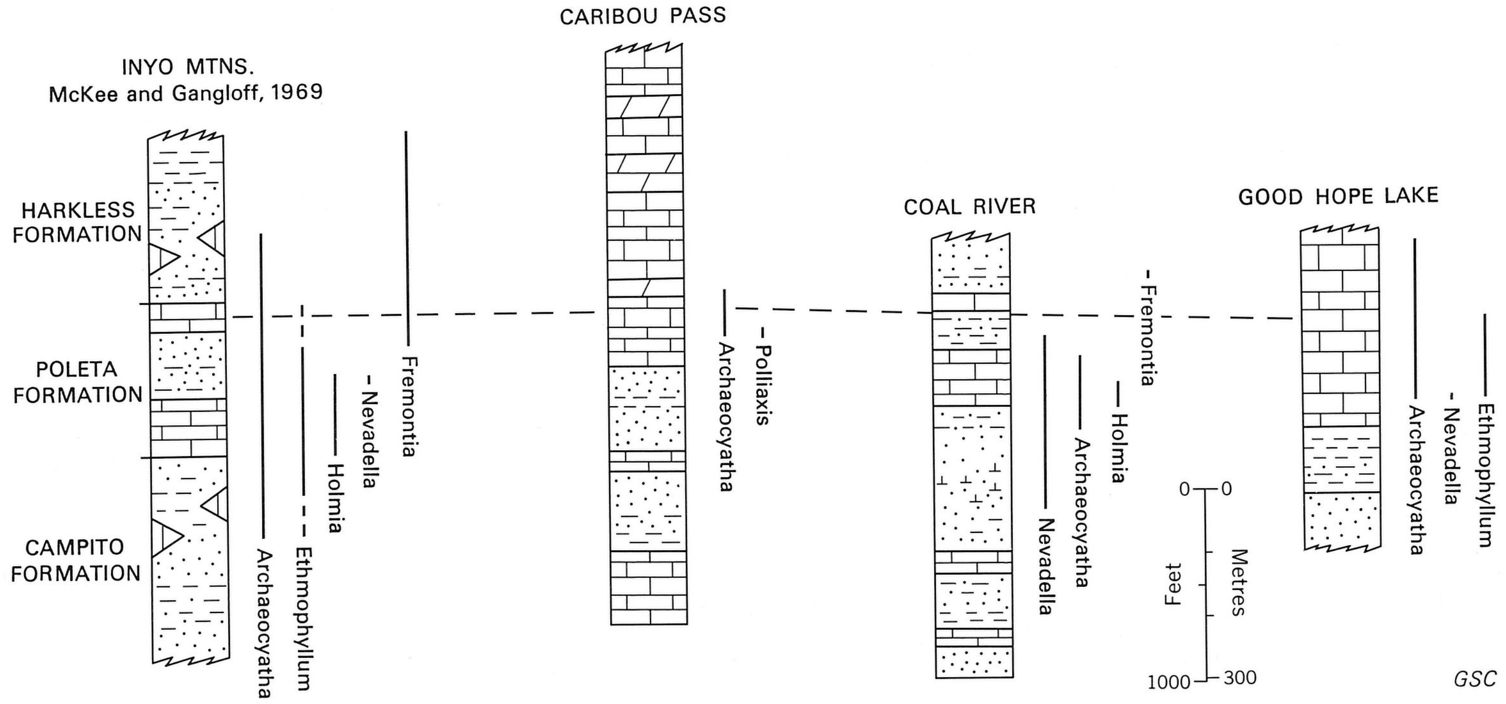

Figure 7. Chart showing tentative correlations between the northern Cordillera and Inyo Mountains, California.

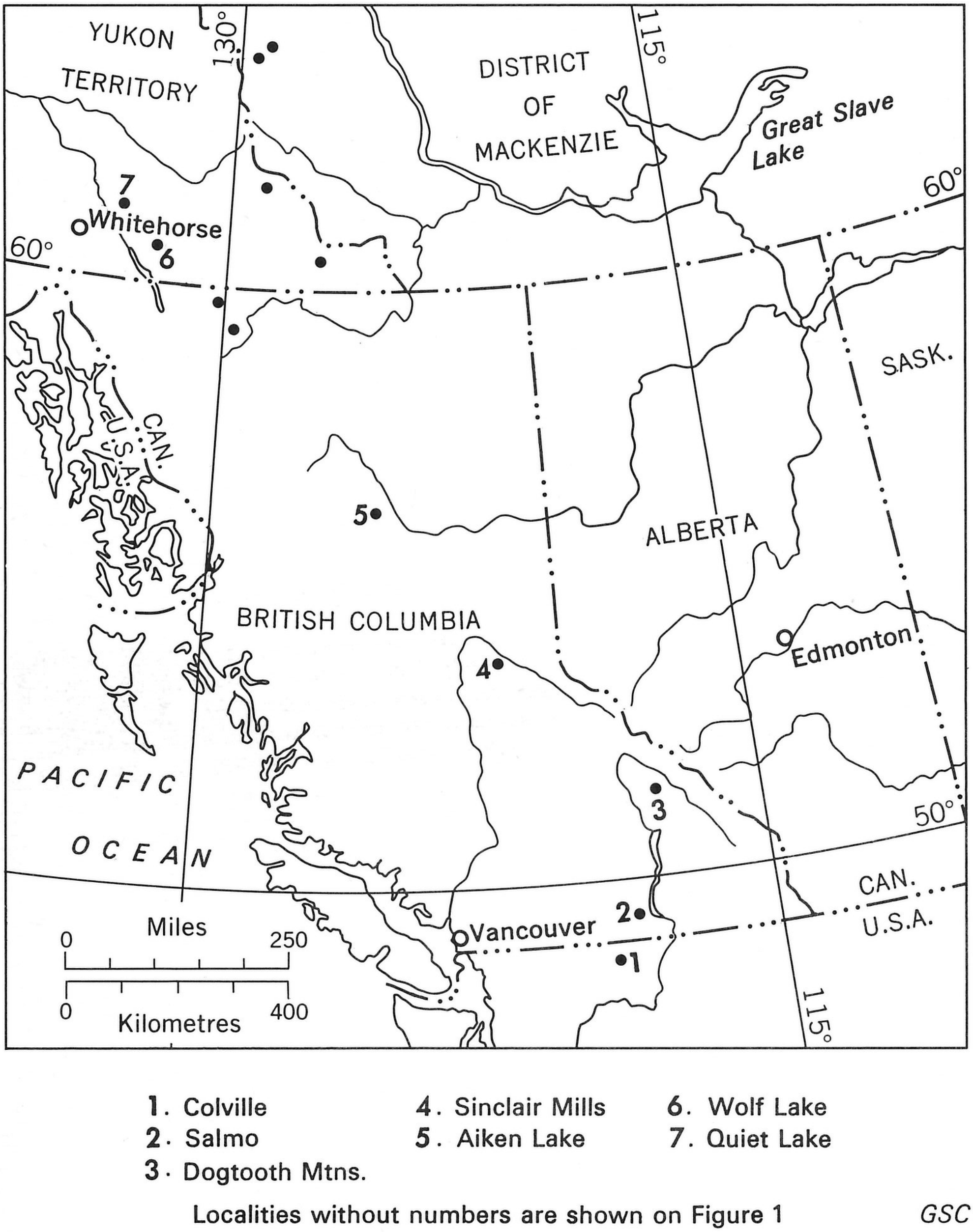

Figure 8. Archaeocyathid localities in the western Cordillera north of latitude 45°.

between the two regions and within the platform (from east to west) are still in a state of flux. One of the more recent schemes (Khomentovskiy and Repina, 1965) is shown in Table 5. This scheme is not accepted by everyone (Zhuravleva et al., 1967) and an alternate scheme is given in Table 6. Since there is considerably less dispute about the sequence (and the nomenclature) in the Sayan-Altai Fold Belt I have attempted my correlations with this area.

Since the archaeocyathid faunas of the northern Cordillera occur throughout such a small portion of the total Lower Cambrian there, it is probably reasonable in long-distance correlation to regard them as a single faunal horizon. Three species occur in both Siberia and Canada; Tumuliolynthus (Propriolynthus) vologdini, Claruscoscinus billingsi, and Flindersicyathus cf. F. aenigmatus. All of these are known only from the Sanashtykgol horizon in southern Siberia. A fourth species, Robustocyathus peludicus Zhuravleva, which may be present in Canada, is known only from the underlying Tolbachan (=Kameshki) horizon but since the identification of the Canadian material is doubtful, no serious problem arises at this moment. The genus Robustocyathus is a long ranging form known from nearly all horizons. Not counting questionable identifications or the genus Ethmophyllum, eleven genera occur in the northern Cordillera and Siberia. These are: Ajacicyathus, Coscinocyathus, Flindersicyathus, Gordonicyathus, Ladaecyathus, Loculicyathus, Kaltatocyathus, Protopharetra, Robustocyathus, Tumuliolynthus and Zonacyathus. Of these, only Kaltatocyathus has not been reported from the Sanashtykgol horizon. It is known from the underlying Kameshki and Bazaikha horizons. It was suggested earlier that the locality containing Kaltatocyathus was possibly older than the other archaeocyathid localities - perhaps the very top of the Kameshki horizon is present. Dorothy Hill (written comm., 1970) is of the opinion that a Kameshki or Bazaikha correlation would not be amiss for the earliest collections from this area. All of the other genera are rather long-ranging forms except Ladaecyathus which is known only from the Sanashtykgol horizon.

Handfield (1969) discussed further evidence for a Sanashtykgol age, especially the presence of the Gastroconidae and the trilobite Polliaxis. Serrodiscus, which according to A. Yu. Rozanov (pers. comm., 1968) is indicative of a Sanashtykgol age, was reported for locality 74845 by Handfield (1967a).

Three genera, Pycnoidocyathus, Metaldetes and Pycnoidocoscinus are known from Canada and Australia but not Siberia. Debrenne (1969) correlated the South Australian material containing these genera with the Upper Kameshki and/or Lower Sanashtykgol horizons. Walter (1967) correlated the upper part of the Hawker Group, southern Australia, containing Pycnoidocyathus, Flindersicyathus and Gordonicyathus with the Sanashtykgol horizon. Thus the evidence is overwhelmingly in favour of a Sanashtykgol age for the majority of the Archaeocyatha of western Canada.

Archaeocyatha from moraines in Antarctica have been assigned a Sanashtykgol age although the possibility remains that other horizons are also represented there (Hill, 1965). Seven genera are common to Antarctica and western Canada but nearly all of these are cosmopolitan genera. Ethmophyllum biseriale Hill appears to be a true Ethmophyllum in the North American sense rather than in the Russian sense. Ethmophyllum, as already indicated, appears to be restricted to strata correlated with the Sanashtykgol horizon.

Six genera, all long-ranging cosmopolitan forms, are found in both North Africa and western Canada. Since Debrenne (1964) considered most of

SERIES	STAGE	SIBERIAN PLATFORM		SAYAN-ALTAI FOLD BELT
		EAST	WEST	
LOWER CAMBRIAN	Lena	Elanka	Charska	Obruchev
		Ketema		Solontsov
	Botoma	Sinsko-Kutorgina	Olekma	Sanashtykgol
		Tarnska	Urishka	
	Aldan	Atdaban	Tolbachan	Kameshki
		Kenyada	Elganski	Bazaikha
			?	
		Sunnagin		Kundatska

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Table 5. Biostratigraphic horizons of the Lower Cambrian of the Siberian Platform and Sayan-Altai Fold Belt.

SERIES	STAGE	SUBSTAGE	SIBERIAN PLATFORM	SOUTH SIBERIAN FOLD BELT
LOWER CAMBRIAN	Lena	Angara	Elanka	Obruchev
			Ketema	Solontsov
		Botoma	Olekma	Sanashtykgol
			Tolbachan	Kameshki
			Sinyaya	Bazaikha
	Aldan	Zhura	Atdaban	
			Kenyada	
			Sunnagin	
		Tolba		

GSC

Table 6. Biostratigraphic horizons of the Lower Cambrian of the Siberian Platform and South Siberian Fold Belt.

the North African archaeocyathid-bearing horizons to be older than the Sanashtykgol horizon it is not surprising that there are so few genera in common between the two areas.

AGE OF THE ARCHAEOCYATHID-BEARING ROCKS

It has been tacitly assumed throughout this paper that the rocks in question were Lower Cambrian, but little independent evidence has been presented. The majority of Russian workers regard the boundary between Lower and Middle Cambrian as coming at the top of the Lena Stage, thus placing nearly all Archaeocyatha from Siberia within the Lower Cambrian. Vologdin (1956b, 1957) and Sivov and Tomashpolskaya (1958), on the other hand, regarded the Sanashtykgol and overlying horizons as Middle Cambrian. Opik (1961) regarded most of the Lena Stage (in the sense of Hill, 1965) as Middle Cambrian on the basis of trilobite correlation with Sweden and North America (see Hill, 1965, for a more complete discussion of this).

In North America, Archaeocyatha have long been regarded as of Early Cambrian age. Associated trilobites in the northern Cordillera substantiate this view. In North America the top of the olenellid biozone is generally regarded as the top of the Lower Cambrian whereas in Siberia the Olenellidae disappear at the top of the Aldan Stage (sense of Hill, 1965).

The Coal River section has the most abundant trilobites and will be discussed first. As indicated earlier, all of the Archaeocyatha there occur within the *Nevadella* range-zone. Within the Archaeocyatha range-zone, *Holmia* and unidentified olenellid trilobites are present. Approximately 390 feet above the highest archaeocyathan, a trilobite collection includes ? *Fremontia* and *Olenellus*. According to W.H. Fritz (pers. comm., 1968) *Nevadella* is regarded as being of middle Early Cambrian age whereas *Fremontia* and *Olenellus* are late Early Cambrian. Thus, there is no room for doubt as to the Early Cambrian age of the Coal River archaeocyathids.

At Good Hope Lake, the lowermost collection of archaeocyathids contains *Nevadella* sp. and other unidentified olenellid fragments. No trilobites were collected high in the section but in general the rock types are not the kind in which trilobites are abundant. At Caribou Pass olenellid fragments are abundant both within the archaeocyathid-bearing rocks and above them. *Polliaxis* sp. also was recorded there. This genus is recorded in an Early Cambrian fauna from Alaska (Palmer, 1968) and W.H. Fritz (written comm., 1969) regards it as being within the Lower Cambrian, somewhat above the top of the *Nevadella* range-zone.

There is, thus, no reason for regarding the Archaeocyatha of western North America as younger than Early Cambrian. This conclusion supports the majority opinion in Siberia that the Sanashtykgol horizon is Early Cambrian.

SAMPLING LOCALITIES

Exact localities are listed below for the measured sections and for the single localities not located in a section. The position of the localities within measured sections are given in Tables 2-4.

Section 1 – (Caribou Pass) – Sekwi Formation, 63°33'N, 129°15'W, Northwest Territories. The section was measured immediately to the northwest of the old Canol Road. Three collections (73870-72) are located here.

Section 2 – Sekwi Formation; locality 73873, 63°31'N, 129°34'W, Northwest Territories.

Section 3 – Map-unit 8 (Blusson, 1966); locality 74845 (=70774), 61°39'N, 128°11'W, Yukon Territory.

Section 4 – (Coal River map-area) – map-unit 5 (Gabrielse and Blusson, 1969). Five collections (68955-58, 73840) are located here; 60°37'N, 127°21'W, Yukon Territory.

Section 5 – (One Ace Mountain) – section measured in the limestone unit of the Atan Group. Only two collections are reported on in this paper – 73848 and 73849, respectively 40 and 45 feet above the base of the section; 59°51'N, 129°36'W, British Columbia.

Section 6 – (Good Hope Lake) – section measured in the limestone unit of the Atan Group. Eight separate collections (75205-12), 59°16'N, 129°11'W, British Columbia.

SYSTEMATIC PALEONTOLOGY

The classification used below is essentially that of Zhuravleva (1960b) and Hill (1965). A single new family has been erected for Acanthopyrgus Handfield. In the classification below, only the northern Cordillera material is included.

PHYLUM ARCHAEOCYATHA

CLASS REGULARIA

ORDER MONOCYATHIDA

Family Monocyathidae

Tumuliolynthus (*Propriolynthus*) *vologdini* (Yakovlev)

ORDER AJACICYATHIDA

SUBORDER DOKIDOCYATHIDA

Family Acanthopyrgidae n. fam.

Acanthopyrgus yukonensis Handfield

Family Kaltatocyathidae

Kaltatocyathus rozanovi n. sp.

Sekwicyathus nahanniensis n. gen. et n. sp.

SUBORDER AJACICYATHINA

SUPERFAMILY AJACICYATHACEA

Family Ajacicyathidae

Ajacicyathus aff. *A. crassus* Debrenne

A. yukonensis Kawase and Okulitch

A. yukonensis? Kawase and Okulitch

Loculicyathus canadensis n. sp.

Robustocyathus aff. *R. peluduicus* Zhuravleva

Family Cyclocyathellidae

Gordonicyathus dorfi n. sp.

Family Ethmophyllidae

Ethmophyllum cf. *E. whitneyi* Meek

?*Mackenziecyathus bukryi* n. gen. et n. sp.

?*Zonacyathus borealis* n. sp.

?*Zonacyathus princetonensis* n. sp.

?*Palmericyathus lineatus* (Greggs)

SUPERFAMILY ANNULOCYATHACEA

Family Porocyathidae

?*Porocyathus* sp.

Family ?

Cordilleracyathus blussoni n. gen. et n. sp.

Family ?

Yukonocyathus francesi n. gen. et n. sp.

SUPERFAMILY ERBOCYATHACEA

Family Erbocyathidae

Ladaecyathus fischeri n. sp.

Ladaecyathus aff. *L. fischeri* n. sp.

SUPERFAMILY ?

Family ?

Genus A sp.

SUBORDER COSCINOCYATHINA

SUPERFAMILY COSCINOCYATHACEA

Family Coscinocyathidae

Coscinocyathus fritzi n. sp.

Coscinocyathus aff. C. fritzi n. sp.

C. multiporus Kawase and Okulitch

C. cf. C. multiporus Kawase and Okulitch

Erismacoscinus cassierensis (Kawase and Okulitch)

Erismacoscinus cf. E. tubicornus (Kawase and Okulitch)

E. ?uniporus n. sp.

SUBORDER ?

SUPERFAMILY ?

Family ?

Genus B sp.

CLASS IRREGULARIA

ORDER ARCHAEOCYATHIDA

SUBORDER ARCHAEOCYATHINA

Family Metacyathidae

Metaldetes caribouensis n. sp.

?Cambrocyathus sp.

Family Archaeocyathidae

Flindersicyathus mcdamensis n. sp.

F. cf. F. aenigmatus Rodionova

F. sp.

Protopharetra aff. P. polymorpha Bornemann

P. sp.

Pycnoidocyathus sekwiensis n. sp.

Family Protocyclocyathidae

Fenestrocyathus complexus n. gen. et n. sp.

SUBORDER ARCHAEOSYCONINA

Family Metacoscinidae

Claruscoscinus billingsi (Vologdin)

Pycnoidocoscinus sp.

ORDER SYRINGOCNEMATIDA

Family Syringocnematidae

Pseudosyringocnema uniporus n. gen. et n. sp.

PHYLUM ARCHAEOCYATHA Vologdin, 1937

CLASS REGULARIA Vologdin, 1937

ORDER MONOCYATHIDA Okulitch, 1935

Family Monocyathidae Bedford and Bedford, 1934

Genus Tumuliolynthus Zhuravleva, 1963

Tumuliolynthus Zhuravleva, 1963, p. 101.

Tumuliolynthus, Okuneva, 1967, p. 133.

Diagnosis. Solitary, single-walled cups in which the wall pores are covered by tumuli.

Discussion. Okuneva (1967) divided the genus into the subgenera T. (Tumuliolynthus) in which the tumuli open upwards and T. (Propriolynthus) in which the tumuli open downwards.

Tumuliolynthus (Propriolynthus) vologdini (Yakovlev)

Plate II, figures 1, 2

Archaeolynthus vologdini Yakovlev, 1956, p. 855, Pl. 1, figs. 1-6.

Tumuliolynthus vologdini, Zhuravleva, 1963, p. 101, Pl. 7, figs. 4-6.

Tumuliolynthus (Propriolynthus) vologdini, Okuneva, 1967, p. 133, figs. 1,2.

Tumuliolynthus (Propriolynthus) vologdini, Zhuravleva et al., 1967, Pl. 3, figs. 1, 2.

Material. Hypotypes, GSC Nos. 25312, 25313.

Description. Solitary, cornuate, single-walled cups reaching an observed diameter of 3.4 millimetres. The outer surface of the cup is covered with downward opening tumuli. Thickness of the wall is 0.2 millimetre at a cup diameter of 3.4 millimetres. Pores are oval shaped, 0.08 millimetre in diameter and arranged in checkerboard pattern. Dissepiments are present in some specimens and absent in others.

Occurrence. Previously reported from Primor'ye, Khabarovsk Territory, Eastern Siberia and Tuva. In all cases this species is known only from the Sanashtykgol horizon. In North America, known only from locality 73873 (Northwest Territories).

Discussion. All the specimens observed in collection 73873 fall within the range of variability for T. (P.) vologdini as discussed by Okuneva (1967). She described her specimens as having empty central cavities whereas some dissepiments have been observed in my material. Since dissepiments are extremely variable in many species of Regularia they are not regarded here as being of specific importance.

Several different types of pelta were described in this species by Okuneva. Absence of pelta in my specimens may be attributable to their small size (presumably immaturity).

ORDER AJACICYATHIDA Bedford and Bedford, 1939

SUBORDER DOKIDOCYATHINA Vologdin, 1957

Family Acanthopyrgidae n. fam.

Diagnosis. Solitary cups divided into distinct segments by whorls of upward pointing, hollow spines. The spines are connected by a web. The intervallum is crossed by rods at each node (i.e. the point where the wall constricts and the spines join the wall). Outer wall with simple tumuli; inner wall with simple pores.

Occurrence. Middle Early Cambrian; southeastern Yukon Territory and eastern Alaska.

Discussion. The Family Acanthopyrgidae is similar in some respects to the Family Kaltatocyathidae Rozanov. Members of the latter family have simple tumuli on the outer wall and a simple inner wall. The intervallum contains only radial rods but their exact arrangement is not known - i.e. whether they are arranged in horizontal planes or "staggered" through the intervallum.

Examination of silicified specimens of Dokidocyathus simplicimus from Ajax, Australia, showed that the radial bars in this species at least are not arranged in horizontal planes although Hill (1965) stated in her description of the suborder Dokidocyathina that the radial links were "arranged in horizontal planes". Neither the Dokidocyathidae or the Kaltatocyathidae show "segmentation" or whorls of spines.

For the present, the Acanthopyrgidae are assigned to the suborder Dokidocyathina, but the possibility remains that a new suborder or order will have to be erected for this unique family.

Genus Acanthopyrgus Handfield, 1967

Type species. By monotypy, A. yukonensis Handfield.

Diagnosis. As for family.

Acanthopyrgus yukonensis Handfield, 1967

Plate II, figures 3, 4a-c

Acanthopyrgus yukonensis Handfield, 1967, p. 209, Fig. 1, Pl. 23, figs. 1-8.

Material. Topotypes, GSC Nos. 25314-25316.

Description. The solitary cups are straight and cylindrical except near the apex where they curve gently. The largest diameter of any specimen is 3.5 millimetres (GSC 25316).

The outer wall has a thickness of 0.03-0.04 millimetre. Large simple tumuli (0.15 mm diameter) occur in longitudinal rows spaced about 0.10 millimetre apart. Tumuli in adjacent rows more or less alternate. At each node the outer wall constricts sharply forming a shoulder from which the spines project. The shoulder area is nonporous. The amount of constriction varies considerably from individual to individual and even within an individual. Some observed values are: constriction of 0.4 millimetre when the total diameter before constriction is 2.0 millimetres; constriction of 0.7 millimetre when diameter before constriction is 2.1 millimetres. The outer wall of the next segment expands rapidly until it equals or exceeds the diameter of the preceding segments.

The only elements in the intervallum are radial rods which occur in a horizontal plane at each node. A single rod occurs between each row of pores in the inner wall. The rods are about 0.06 millimetre thick. The juncture of the outer wall and rods has not been observed in thin section.

The inner wall is about the same thickness as the outer wall. It has simple pores arranged in alternating longitudinal rows. The pores tend to be flattened vertically. The linteaux between rows are thinner (0.01-0.02 mm) than between pores in a row (0.03-0.04 mm). The size of the pores varies but are about 0.08 x 0.11 millimetre.

Spines occur in whorls of about 13 (3). The spines join each other just before abutting the shoulder formed by the outer wall and form a collar about the outer wall. The spines and collar are hollow but do not appear to communicate with the intervallum. A calcified membrane links the spines but does not extend to the tips of the spines. The collar and spines (and perhaps the web-membrane) are longitudinally striated.

Occurrence. GSC locality 74845 (=70774, Yukon Territory) and ?Alaska.

Discussion. The whorls of spines and apparent segmentation are the most striking features of this species. Zhuravleva (pers. comm., 1968) suggested that the spines could be a development of a "Tersia"-like outgrowth. A specimen of Parahacyathus from Siberia shows several "Tersias" arranged at different levels about the cup (Zhuravleva, 1959). Although this is a possibility, there is considerable difference between the spines of Acanthopyrgus and "Tersia".

The Alaskan material was shown me by Dr. A.R. Palmer and a cursory examination showed that in all probability it is conspecific with the Yukon material.

Family Kaltatocyathidae Rozanov, 1964

Diagnosis. The outer wall has simple tumuli or knobby structures. The intervallum has rods, not septa. The inner wall is simply porous.

Range. Bazaikha and Kameshki horizons, Siberia; Lower Cambrian, District of Mackenzie.

Discussion. The tumuli of the outer wall distinguish this family from all others of the Dokidocyathina,

Genus Kaltatocyathus Rozanov, 1964

Kaltatocyathus Rozanov, 1964, p. 92.

Diagnosis. The outer wall has simple tumuli. The intervallum contains rods. The inner wall is simply porous.

Kaltatocyathus rozanovi n. sp.

Plate II, figure 9

Material. Holotype, GSC No. 25321; paratype, GSC No. 25322.

Description. These are small, solitary cylindrical specimens with a maximum observed diameter 1.9 millimetre. At this diameter the intervallum is 0.5 millimetre wide giving an intervallum coefficient of 0.6.

The outer wall is moderately porous, each pore covered by a simple tumulus opening slightly upwards. The opening in the tumuli is 0.1 millimetre in diameter whereas the pore in the wall is 0.2 millimetre in diameter. The wall is 0.08 millimetre thick.

The intervallum is crossed only by sparse radial rods 0.1 millimetre thick. The arrangement of the rods is not visible in the material available.

The inner wall is simply porous, the pores being about the same size as in the outer wall, 0.2-0.25 millimetre in diameter. It is 0.1 millimetre thick.

Occurrence. The genus has been previously reported from eastern Sayan, U.S.S.R. This species is found only at localities 68955, 68957 (Yukon Territory) and ?73848 (British Columbia).

Discussion. This species differs from the two previously described species K. ?bazaichensis and K. kaschinae in intervallum coefficient, smaller size and much larger pores in the inner wall.

Three small specimens, diameter 0.2-0.8 millimetre, in collection 73848 are apparently young stages of this species. One of these in longitudinal section shows that the inner wall appears at a diameter of 0.28 millimetre.

Genus Sekwicyathus n. gen.

Type species. Sekwicyathus nahanniensis n. sp.

Description. The outer wall has spherical tumuli which protrude into the intervallum as well as protruding on the outside. The tumuli open ?upward on both sides of the wall. The intervallum has flattened rods. The inner wall is simply porous.

Occurrence. Lower Cambrian; locality 73873 (Northwest Territories).

Discussion. Kaltatocyathus has simple tumuli which bulge outward but do not protrude into the intervallum. Whether the pore structure of the outer wall of Sekwicyathus should be called tumuli is open to debate because the term was originally proposed for bubble-like coverings with one or more openings which covered pores of the outer wall and not for a sphere set into the wall. The only other genus in the family, Papillocyathus, has tumuli-like structures on the outer wall which may be nonporous.

Sekwicyathus nahanniensis n. sp.

Plate II, figures 5-8

Material. Holotype, GSC No. 25317; paratypes, GSC Nos. 25318-25320.

Description. Two thin sections remain of the holotype which was a cylindrical fragment 5 millimetres long before cutting. The diameter of the holotype is 1.9 millimetre with an intervallum 0.5 millimetre wide giving an intervallum coefficient of 0.6.

The outer wall is 0.07 millimetre thick between pores but the covering over the pores is about half this thickness. The somewhat sparse pores have a unique appearance. In transverse section they appear as partially to completely enclosed "bubbles" set in the wall so that they protrude on both sides of the outer wall (Fig. 9). In longitudinal section the pores are "V"-shaped, made up apparently of a tumulus on each side of the wall with the opening near the top and not in the centre of the tumulus. The size of the pore in the wall is 0.2 to 0.25 millimetre. A small spine projects down from the wall into the centre of the pore.

The intervallum contains sparse flattened rods apparently scattered at random throughout the intervallum so that sometimes one or even no rods are visible in a section.

The inner wall is 0.05 millimetre thick and is punctuated by simple pores 0.25 to 0.30 millimetre in diameter.

Occurrence. As for the genus.

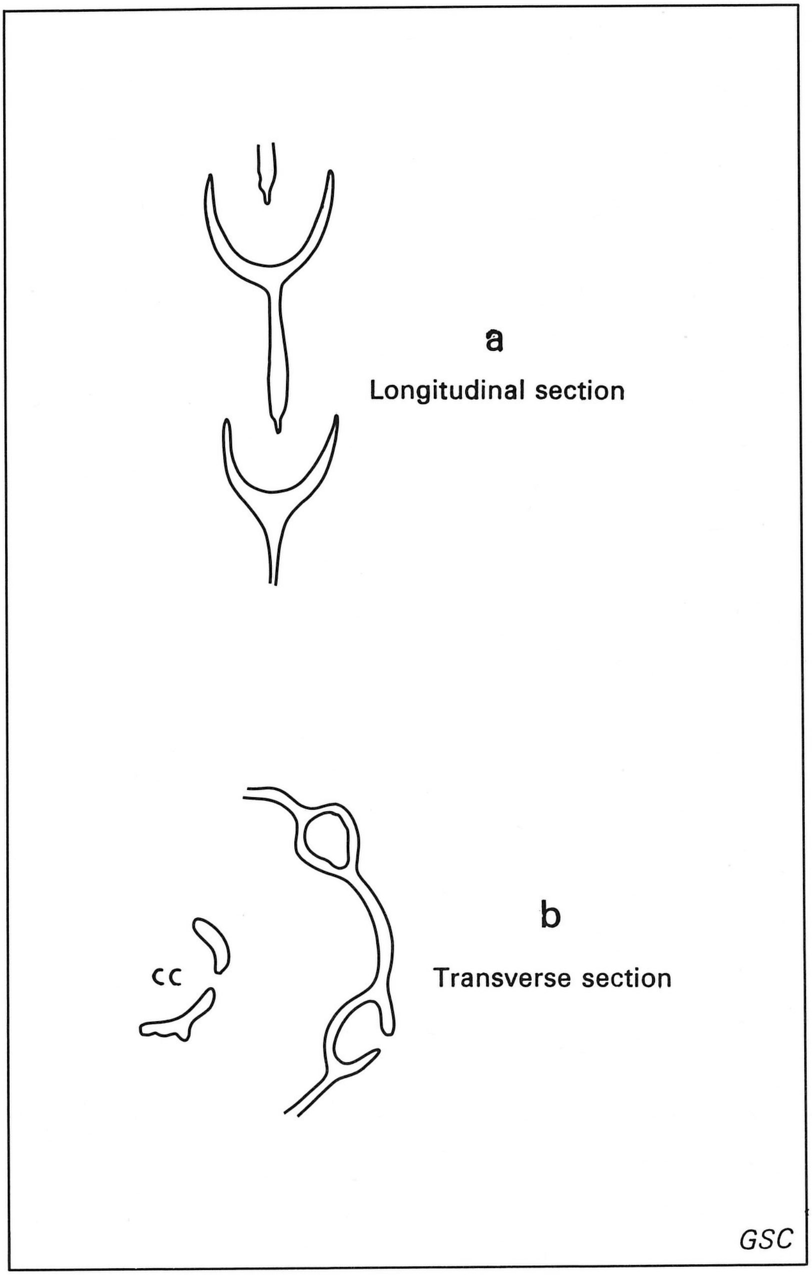


Figure 9. Outer wall of Sekwicyathus nahanniensis n. gen. et n. sp.

Discussion. The intervallum coefficient varies from 0.5 to 0.7 in the specimens from the type locality. The rods in the intervallum are flattened in the vertical plane so that they resemble rods in Dokidocyathus.

SUBORDER AJACICYATHINA Bedford and Bedford, 1939

SUPERFAMILY AJACICYATHACEA Bedford and Bedford, 1939

Family Ajacicyathidae Bedford and Bedford, 1939

Genus Ajacicyathus Bedford and Bedford, 1939

Ajacicyathus Bedford and Bedford, 1939, p. 73.

Ajacicyathus, Hill, 1965, p. 58.

Diagnosis. See Hill, 1965, p. 58.

Ajacicyathus aff. A. crassus Debrenne, 1961

Plate III, figures 1a-c

Material. Hypotype, GSC No. 25323.

Description. Only a fragment of the original cup is preserved. It is obviously from a large bowl-shaped specimen. The fragment before cutting exceeded 50 millimetres in length.

The outer wall has two to four pores per intersept, each pore being 0.20-0.25 millimetre in diameter. The wall is 0.2 millimetre thick.

The intervallum is crossed by porous septa only, each 0.1 millimetre thick and perforated by pores 0.2 millimetre in diameter. The septa are spaced 0.9-1.0 millimetre apart. The intervallum is 4.5 millimetres wide.

There are generally two pores per intersept in the inner wall but the presence of stirrup-pores in the septa occasionally increases this to 2 1/2. The pores are 0.3 millimetre in diameter in a wall 0.38 millimetre thick. The linteaux are 0.25 millimetre thick.

Occurrence. Lower Cambrian; locality 75206 (British Columbia). A. crassus is known from Morocco and Tuva, U.S.S.R.

Discussion. The genus Ajacicyathus has generally been regarded as having porous septa (Debrenne, 1964; Zhuravleva, 1960b; and others) whereas, in fact the type material (no holotype has been designated) has septa that are nonporous except for stirrup-pores at the inner wall (Hill, 1965). Since I do not propose to revise the Ajacicyathidae at this time I include this specimen in Ajacicyathus in the broad sense of the term.

This specimen differs from A. crassus in the shape of the cup, the latter being a conical form. In most other respects it agrees closely with A. crassus.

Ajacicyathus yukonensis Kawase and Okulitch, 1957

Plate III, figures 2a, b, 3

Ajacicyathus yukonensis Kawase and Okulitch, 1957, p. 915, Pl. 109, fig. 2.

Archaeocyathellus (Stapicyathus) yukonensis, Debrenne, 1969, p. 308.

Material. Hypotypes, GSC Nos. 25324, 25325.

Description. This relatively small form has a straight, conical cup reaching at least 10 millimetres in diameter. At this size the intervallum is 3.2 millimetres wide giving an intervallum coefficient of 0.8. There are twenty septa giving a radial coefficient of 2.0.

The outer wall has six to eight simple pores per intersept, each pore being 0.1 millimetre in diameter with the skeletal elements between pores also 0.1 millimetre thick. The wall is 0.18 millimetre thick. Stirrup-pores are present at the juncture of outer wall and septa.

The intervallum contains only septa, imperforate except for stirrup-pores at both ends. The septa are 0.15 millimetre thick and spaced 0.6-1.0 millimetre apart. The closer spacing occurs in specimen 25325 which is only 5.0 millimetres in diameter.

The inner wall has one row of stirrup-pores in front of each septum and may also have an additional pore-row per intersept. The wall is 0.1-0.2 millimetre thick with the pores being 0.2 millimetre in diameter.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia). This species was originally described from locality 24035, Wolf Lake area, Yukon Territory.

Discussion. The most striking feature of these specimens is the presence of stirrup-pores at both inner and outer walls. In this respect and in most others this material agrees closely with the type material, the only difference being a thicker inner wall in the holotype.

The type species of Ajacicyathus, A. ajax, has (Hill, 1965) only partial stirrup-pores at the outer wall and the inner wall has several pores per intersept. There is thus some room for doubt as to whether A. yukonensis really belongs in the genus Ajacicyathus.

Ajacicyathus yukonensis? Kawase and Okulitch

Plate III, figures 4a, b

Material. Hypotype, GSC No. 25326.

Description. This is a large cylindrical fragment 20.0 millimetres long and 18.8 millimetres in diameter. The intervallum width is 3.4 millimetres giving an intervallum coefficient of 0.3. The number of septa is estimated at thirty-one, giving a radial coefficient of 1.6.

The outer wall has four to six rows of pores per intersept. The pores are 0.1 millimetre in diameter in a wall 0.15 millimetre thick. The pores are arranged in alternating longitudinal rows.

Septa only are present in the intervallum and are imperforate except for stirrup-pores at each end. They are spaced 1.7 millimetre apart. The septa are 0.1-0.13 millimetre thick except near the inner wall where they thicken slightly.

The thick (0.27 mm) inner wall is penetrated by two to three pores per intersept, with a row of stirrup-pores in front of each septum. The pores are 0.3 millimetre in diameter with the skeletal elements between pores about 0.2 millimetre thick. The pores are arranged in adjacent longitudinal rows.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia).

Discussion. The intervallum and radial coefficients are considerably smaller in the type material than in the material described above, but this may be due, in part, to the considerably larger size of this specimen. As Kawase and Okulitch (1957) pointed out in the original description of *A. yukonensis*, the radial coefficient may not be of specific importance as Zhuravleva (1955) has shown that it varies with size, decreasing as the diameter increases. The outer wall of this specimen also has fewer pores per intersept and the discovery of more material might necessitate erection of a new species.

Archaeocyathellus Ford, 1873

Type species. *Archaeocyathellus rensselaericus* Ford.

Discussion. The original description and drawings of Ford are unsatisfactory, especially with regards to the inner wall. Subsequent to this the name *Archaeocyathellus* has been used for many specimens, apparently without regard for Ford's original description, poor as it was.

Okulitch (1943) repeated Ford's original descriptions and drawings and erected several new species of *Archaeocyathellus*. Since the monotype is lost (Okulitch, 1943), I have undertaken a re-examination of nearly all North American specimens assigned to *Archaeocyathellus*. The main features of the genus as pointed out by Ford are a longitudinally fluted outer wall with two rows of pores per intersept, and nonporous septa. Either dissepiments or synapticulae are present. Since the characters of the outer and inner wall are not known, no specimens can safely be assigned to this genus.

Of the three species described by Okulitch (1943), two (*A. uniporus* and *A. dwighti* (Walcott)) are very similar to *Ajacicyathus ajax*.

For unknown reasons Debrenne (1964) has used the genus for archaeocyathids having stirrup-pores in the septa at the outer wall. She also considered *Densocyathus* Vologdin and *Stapicyathus* Debrenne as subgenera of *Archaeocyathellus*.

Recently, some Russian authors have used the name *Archaeocyathellus* (Zhuravleva *et al.*, 1967).

Until the nature of *Archaeocyathellus* is clarified by study of topotype material the use of the name *Archaeocyathellus*, interpreted so differently by different authors, would seem to be inadvisable.

Genus *Loculicyathus* Vologdin, 1931

Loculicyathus Vologdin, 1931, p. 54.

Loculicyathus, Zhuravleva, 1960, p. 130.

Loculicyathus, Hill, 1965, p. 64.

Diagnosis. Cup cylindrical with simply porous outer and inner walls. Intervallum with simply porous septa and dissepiments. Dissepiments may also occur in the central cavity.

Occurrence. Lower Cambrian; Siberia, Mongolia, Morocco, Canada.

Loculicyathus canadensis n. sp.

Plate III, figures 5a-d

Material. Holotype, GSC No. 25327.

Description. The holotype is a gently waved planar fragment 24 millimetres long, presumably from a large bowl-shaped or saucer-shaped cup. The walls of this fragment are different but it is not clear which is the inner and which the outer one. I shall therefore refer to them as wall A and wall B.

Wall A is simple with one or rarely two rows of pores per intersept. Pores in adjacent intersepts alternate. The circular to slightly oval pores are 0.38-0.50 millimetre in diameter. The skeletal elements between pores in a row and between rows are about the same thickness, 0.2 millimetre. In transverse section the wall is 0.25 millimetre thick.

The intervallum is 2 millimetres wide and contains simply porous septa and dissepiments. The 0.12 millimetre-thick septa are regularly spaced at 0.75 millimetre intervals. Less than half of the septal area is pore-space, the pores being only 0.1 millimetre diameter and widely spaced. The dissepiments are the same as those typically found in Archaeocyatha - thin and nonporous. They are convex towards wall A. Each dissepiment is generally confined to a single loculus but one is seen to pass through a septal pore into the next chamber (Pl. III, fig. 5a).

Wall B is simple and has normally two pores per intersept, occasionally only one. The pores are mostly circular with a diameter of 0.2 millimetre. An interesting feature is the median division of the wall into a light-coloured inner half and a black outer half.

Occurrence. The genus is known elsewhere from Siberia, Australia and Morocco. This species occurs only at locality 68957 (Yukon Territory).

Discussion. Only one North American species of Loculicyathus has previously been described (Kawase and Okulitch, 1957). It differs from L. canadensis in its shape (cylindro-conical) and more abundant dissepiments. Kawase and Okulitch (op. cit.) do, however, point out that in one of their specimens the upper part is devoid of dissepiments. More specimens are required to investigate this matter. L. canadensis differs from all other species of Loculicyathus in shape, the others being conical or cylindrical.

Genus Robustocyathus Zhuravleva, 1960

Robustocyathus Zhuravleva, 1960b, p. 133.

Robustocyathus, Hill, 1965, p. 67.

Robustocyathus, Debrenne, 1969, p. 311.

Diagnosis. See Debrenne, 1969, p. 311.

Robustocyathus aff. R. peluduicus Zhuravleva

Plate IV, figures 1a-b, 2-4

Material. Hypotypes, GSC Nos. 25328-25331.

Description. The cup is solitary, conico-cylindrical and slightly curved. The diameter of the two largest specimens is 4.5 millimetres and 2.7 millimetres.

The outer wall is 0.04-0.05 millimetre thick with pores 0.7 millimetre in diameter, arranged in two to three longitudinal rows per intersept. Pores are arranged in alternating rows.

The intervallum is 1.1 millimetre wide and crossed only by sparsely porous septa. The septal pores are 0.08 millimetre in diameter. The septa are 0.04 millimetre thick except at the ends where they thicken slightly before joining the walls. They are spaced 0.2-0.3 millimetre apart.

The inner wall is pierced by a single row of pores per intersept, these being much larger than the pores of the outer wall (about 0.2 mm). Pores in adjacent intersepts alternate.

Occurrence. Lower Cambrian; GSC localities 75208 (British Columbia) and 68957 (Yukon Territory); in Siberia R. peluduicus is restricted to the Tolbachan horizon of the Lower Cambrian.

Discussion. The very high radial coefficient is similar to that of R. peluduicus which ranges from 6.5-8.0 in the type material. The small size is also characteristic, ranging from 3.6-4.0 millimetres according to Zhuravleva (1960). The major points of difference with the type material are the larger sizes of the outer and inner wall pores - being 0.07 as against 0.03 millimetre and 0.2 as against 0.1 millimetre respectively. Most other measurements are in good agreement.

Family Cyclocyathellidae Zhuravleva, 1959

Gordonicyathus Zhuravleva, 1959

Gordonicyathus Zhuravleva, 1959, p. 426.

Gordonicyathus, Hill, 1965, p. 71.

Diagnosis. Conical cups with simply porous outer wall, perforate septa and annulate inner wall. The inner wall has "V"-shaped annuli.

Occurrence. Lower Cambrian; Lower Lena Stage, U.S.S.R., Canada, and ?Australia.

Discussion. Zhuravleva established this genus to accommodate species of Thalamocyathus which lacked pectinate tabulae. Unless very large fragments of specimens are available it is difficult to say with certainty whether a specimen has or has not pectinate tabulae since they are generally very rare. Bedford and Bedford (1936, p. 75) stated that the pectinate tabulae are present in some specimens of Thalamocyathus trachealis but absent in others.

Debrenne (1964) regarded Gordonicyathus as a junior synonym of Thalamocyathus pointing out that Taylor's specimens of Thalamocyathus do not show pectinate tabulae. Hill (1965, p. 94) discusses this problem in some detail and rightfully points out that no definite conclusion can be reached until Taylor's type material is restudied.

Gordonicyathus dorfi n. sp.

Plate V, figures 2a-c

Material. Holotype, GSC No. 25335.

Description. Solitary, cylindrical cup, total diameter 12.0 millimetres. The diameter of the central cavity is 6.9 millimetres and the width of the intervallum 2.1 millimetres. The intervallum coefficient is 0.3.

The simple porous outer wall is 0.04 millimetre thick. The circular pores are 0.08 millimetre in diameter and arranged in alternating longitudinal rows, seven rows per intersept. The skeletal elements between pores are 0.02 millimetre thick.

The intervallum contains only straight, porous septa with no traces of pectinate tabulae. The septa are 0.07 millimetre thick and spaced about 0.65 millimetre apart midway across the intervallum. The septal pores are 0.17 millimetre in diameter. The exact arrangement of the septal pores is not known but they are abundant.

The inner wall consists of annular rings arranged so the pores slant up and into the central cavity. On the intervallum side of the annuli' there are two small shelves, one projecting up into the intervallum and the other projecting nearly horizontal into the central cavity. The resulting structure more nearly resembles a ship's anchor than anything else. The annuli are spaced 0.56-0.68 millimetre apart vertically and have a length of 1.0 millimetre.

Occurrence. Lower Cambrian; GSC locality 73873 (District of Mackenzie).

Discussion. Since this species lacks pectinate tabulae it belongs in the suborder Ajacicyathina, Family Cyclocyathellidae. The genera in this family to which it could possibly belong are Cyclocyathella. Gordonicyathus and Taylorcyathus. Cyclocyathella has downward pointing annuli and Taylorcyathus has "S"-shaped annuli leaving only Gordonicyathus. The annuli of Gordonicyathus have been described as "V"-shaped, leaving some doubt as to whether this species is really Gordonicyathus. The annuli of G. dorfi could be interpreted as non-symmetrically "V"-shaped with an added plate projecting into the central cavity.

Family Ethmophyllidae Okulitch, 1943

Genus Ethmophyllum Meek, 1868

Ethmophyllum Meek, 1868, p. 62.

Ethmophyllum, Okulitch, 1943, p. 64.

Ethmophyllum, Hill, 1965, p. 72.

Diagnosis. Solitary cups of cylindrical form with an outer wall of curved or geniculate pore-canals. Septa nonporous. Inner wall of complex, oblique pore-tubes formed by the ends of the septa.

Occurrence. Lower Cambrian; U.S.A., Canada, ?Antarctia, ?Australia, ?Siberia.

Discussion. Although many species in Siberia have been assigned to this genus, most of them appear not to be congeneric with Ethmophyllum. They have inner walls formed by pore-tubes but differ in the following respects: (1) they have a simple outer wall, (2) they have porous septa, (3) the inner wall is not made from the ends of the septa.

Ethmophyllum cf. E. whitneyi Meek

Plate IV, figures 5, 6a-d

Ethmophyllum whitneyi Meek, 1868, p. 62.

Ethmophyllum whitneyi, Okulitch, 1943, p. 65, Pl. 3, fig. 15; Pl. 4, figs. 1, 3, 4, 8.

Ethmophyllum whitneyi, McKee, 1963, p. 288, figs. 1-4.

Ethmophyllum whitneyi, Hill, 1965, p. 72, Pl. 4, fig. 1.

Material. Hypotypes, GSC Nos. 25332, 25333. The description and discussion below are based mainly on specimen 25333 which is the larger and better preserved.

Description. Specimen 25333 is a fragment of a large, solitary, cylindrical individual with a maximum diameter of 15 millimetres and length of 43 millimetres. If the rate of increase of the cup was relatively constant then the total length would have exceeded 145 millimetres. The central cavity is 9.1 millimetres wide giving an intervallum coefficient of 0.16. The radial coefficient is 4.2.

The outer wall has four or more commonly five pores per intersept, arranged in alternating longitudinal rows. The wall is 0.19 millimetre thick with the pores being 0.10 millimetre in diameter, so that they are actually canals. In transverse section the canals are straight and simple but in longitudinal section they are seen to be of inverted "V"-shape with the inner arm of the "V" longer than the outer arm. The skeletal elements of the outer wall are 0.03 millimetre thick.

The intervallum contains only nonporous, straight, radial septa. These are 0.04-0.06 millimetre thick.

The inner wall is formed by the joining of the ends of the septa, resulting in oblique pore-tubes, slanting up and into the intervallum. In a transverse section, this arrangement of pore-tubes gives the appearance of several concentric rows of pores. A second set of pores perpendicular to the main pore-tubes can be seen in the longitudinal section (Pl. IV, fig. 6d). The inner ends of the inclined tube elements have a small vertical lip so that the opening of the tube is smaller than the tube itself. The inner wall is 0.58 millimetre thick with pores 0.45 millimetre in diameter. The distance from the centre of pore to centre of pore vertically is 0.68 to 0.75 millimetre.

Occurrence. Lower Cambrian; Atan Group, British Columbia. In eastern California *E. whitneyi* occurs only in the upper Campito Formation and the lower Poleta Formation.

Discussion. The larger size (15 mm as against a maximum of 10 mm in the type) and lower intervallum coefficient (0.2 as against a minimum of 0.8 in material from the type area) suggests the northern Cordillera specimens may be a different species from the California specimens.

McKee (1963) in a study of the ontogeny of *E. whitneyi* showed that the intervallum coefficient varied considerably within individuals but unfortunately he did not tabulate the results for any specimen larger than 6 millimetres and the data presented are insufficient to make any valid conclusion about the dependency of intervallum coefficient on size of specimen.

The original description of *E. whitneyi* (Meek, 1868) indicated a simple outer wall. Hill (1965) after examining photographs of the holotype concluded that the outer wall had "simple, rounded and curved pore-canals arranged in quincunx". Examination of her photographs (1965, Pl. 4, fig. 1c) and especially of material from California suggests somewhat "V"-shaped canals, but the preservation of the material examined is not sufficiently good to be certain of this.

Family Ethmophyllidae ?

Genus *Mackenziecyathus* n. gen.

Type species. *Mackenziecyathus bukryi* n. sp.

Description. This genus is a solitary, cylindrical form with a smooth outer wall of simple pores. The intervallum contains only thin, radial, nonporous septa. The inner wall has two rows of oblique pore-tubes per intersept. These pore-tubes are intercommunicating.

Occurrence. Lower Cambrian; GSC locality 68955.

Discussion. The intercommunicating pore-tubes suggest this genus belongs to the Ethmophyllidae but the inner wall is not formed in the same way (by septal fluting) as in *Ethmophyllum*. The two rows of pore-tubes distinguish this genus from other members of the Ethmophyllidae.

Specimens described by Zhuravleva et al. (1967) as various species of Archaeocyathellus have some points of resemblance to this genus but it is impossible to say from the photographs whether there are two pores per intersept or not.

Mackenziecyathus bukryi n. sp.

Plate V, figures 1a-d

Material. Holotype, GSC No. 25334.

Description. The greatest observed height of this form is 22 millimetres. The holotype has a diameter of 10.0 millimetres, the central cavity occupying 8.0 millimetres. The intervallum coefficient is 0.1 and there are fifty-six septa giving a radial coefficient of 5.6.

The outer wall has four to eight simple pores per intersept. The pores have a diameter of 0.06 millimetre and occur in alternating longitudinal rows. The skeletal elements between pores are 0.03 millimetre thick. The thickness of the outer wall is 0.08 to 0.1 millimetre.

The intervallum has only simple, thin, nonporous septa. The septa vary in thickness from 0.03 millimetre to 0.5 millimetre. They are slightly thicker at the inner wall.

The inner wall consists of intercommunicating pore-tubes arranged in two alternating longitudinal rows per intersept (Fig. 10). The pore-tubes are oblique upwards into the central cavity. The pore-tubes are 0.17 millimetre in diameter with a length of 0.50 millimetre. The skeletal elements are 0.08 to 0.1 millimetre thick. Serial sections through the inner wall (Fig. 10) show that the two pores are larger than the width of the intersepts so that the septa bend around the pores. These sections also show that the wall between the two pores and between the pores above and below ceases to exist in the central part of the wall so there is free communication between all pores in an intersept. In transverse section the wall appears very complex with the septa bending towards or away from each other but seldom approaching the wall perpendicularly.

Discussion. In transverse section the inner wall is grossly similar to Cordilleracyathus but is much different in detail. Cordilleracyathus also differs in the construction of the outer wall, having pore-canals of inverted "V"-shape. Serial sections through the inner wall are almost a necessity for identifying this form.

Genus Palmericyathus n. gen.

Type species. Ethmophyllum lineatus Greggs.

Description. Solitary Archaeocyatha having a simple outer wall and nonporous septa. The inner wall has two rows of "V"-shaped pore-tubes per intersept.

Discussion. This genus is generally similar to Mackenziecyathus but differs from it in having "V"-shaped pore-tubes in the inner wall. In transverse section the two are not readily told apart.

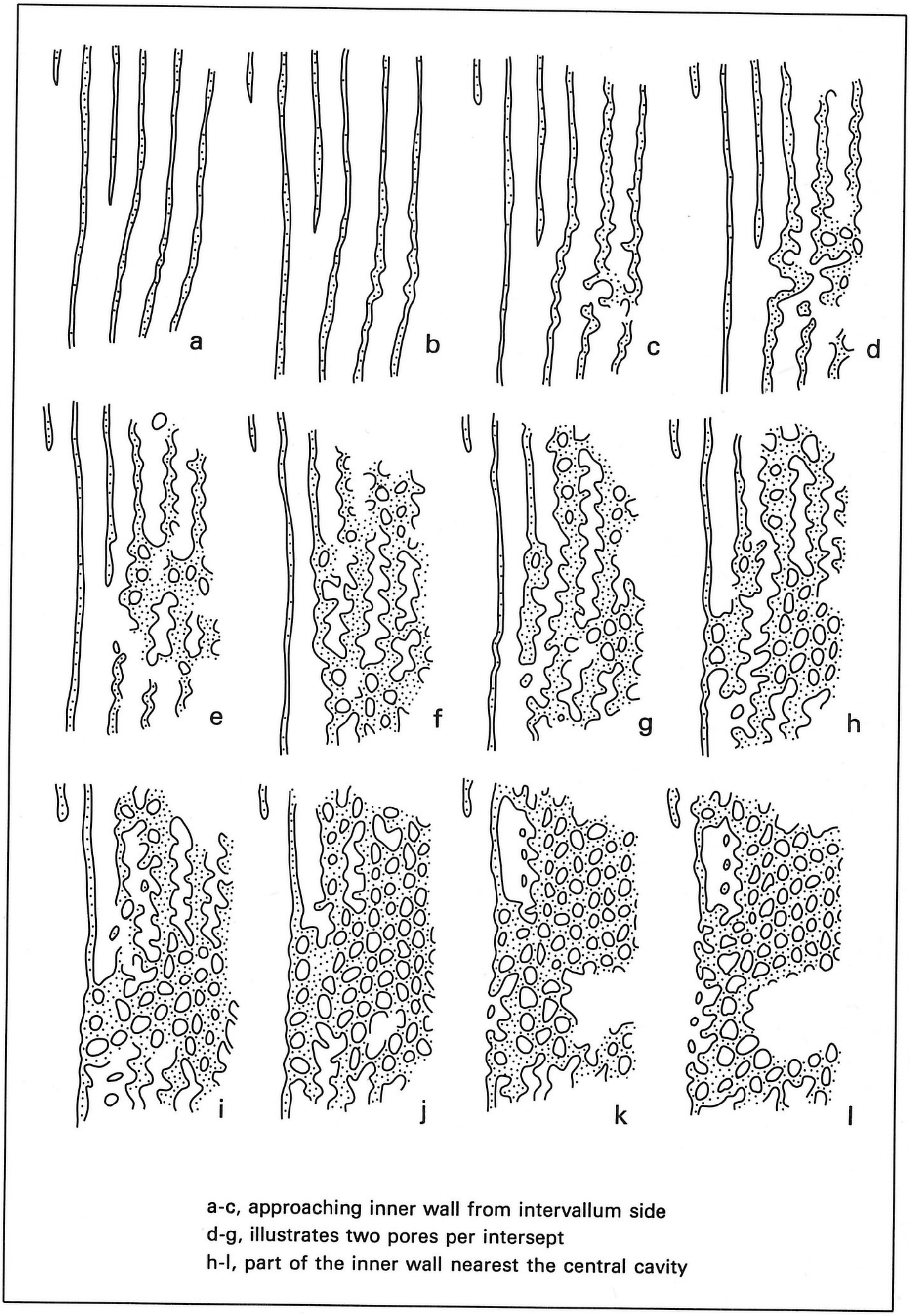


Figure 10. Serial sections through the inner wall of Mackenziecyathus bukryi n. gen. et n. sp.

The inner wall is not so complicated as in Ethmophyllum and the simple nature of the outer wall makes assignment to the Ethmophyllidae doubtful.

Palmericyathus lineatus (Greggs)

Plate V, figures 3a-c

Ethmophyllum lineatus Greggs, 1959, p. 66, Pl. 14, figs. 2-4.

Material. Holotype, GSC No. 14315, from Salmo River, southern British Columbia. Additional, better preserved material has been collected in the District of Mackenzie (GSC locality 73871) and the following emended description is based on this material (hypotype, GSC No. 25336 and unfigured material) as well as a re-examination of the holotype.

Description. Only fragments are known, but the skeleton is inferred to have been large and bowl-shaped. The fragments from the District of Mackenzie reach a maximum length of 28 millimetres. Neither the intervallum nor septal coefficients can be calculated because of the fragmentary nature of the cups.

The outer wall is perforated by three to six rows of simple canals per intersept. The pores are arranged in alternating longitudinal rows. The wall is 0.08 millimetre thick and the canals are 0.6 millimetre in diameter. The skeletal elements between pores are 0.03-0.04 millimetre thick.

The intervallum contains only simple, nonporous septa spaced about 0.4 millimetre apart. Each septum is approximately 0.04 millimetre thick but thickens slightly near the outer wall. The intervallum is 1.0-2.3 millimetres wide.

The inner wall is a complex structure which apparently has one and one-half to two rows of pores per intersept. The inner ends of the septa bend just before joining the inner wall. This gives the inner wall a complex appearance similar to Ethmophyllum and Cordilleracyathus.

In longitudinal section the wall consists essentially of "V"-shaped tubes with a small keel on the bottom of the "V".

Occurrence. Lower Cambrian; GSC localities 73871 (Northwest Territories) and 75205 (British Columbia).

Discussion. The exact construction of the inner wall is difficult to interpret; the bending of the septa near the inner wall is probably necessitated by the width of the two rows of pores per intersept, the two pores together actually being larger than the mean width of the intersept. This same situation occurs in Mackenziecyathus and the two are almost indistinguishable in transverse section.

The specimens from southern British Columbia generally have a narrower intervallum than do those from the Mackenzie Mountains (1.0-1.5 mm as against 2.2-2.3 mm). In other respects they agree closely.

Genus Zonacyathus Bedford and Bedford, 1937

Zonacyathus Bedford and Bedford, 1937, p. 36.

Zonacyathus, Debrenne, 1969, p. 314.

Diagnosis. See Debrenne, 1969, p. 314.

Zonacyathus borealis n. sp.

Plate VI, figures 1a-c, 2a, b

Material. Holotype, GSC No. 25337; paratypes, GSC Nos. 25338, 25339.

Description. Solitary, cornuate to cylindroconical cups. The holotype reaches a maximum diameter of 6.1 millimetres at a cup height of 15 millimetres.

The outer wall has four to six rows of simple pores per intersept. The thickness of the wall is 0.13 millimetre while the diameter of the pores is 0.10 millimetre. The skeletal elements between pores are 0.04 millimetre thick. The pores are arranged in a checkerboard pattern with close to equal spacing in all directions.

The intervallum is relatively wide (1.5 mm) giving an intervallum coefficient of 0.75 at a diameter of 6.1 millimetres. The septa are thin (0.03 mm), straight and nonporous. At the top of the cup the outer wall curves over to meet the inner wall so that the intervallum is closed off by a porous cap.

The inner wall is a complex zone of pore-tubes, irregular in arrangement; whereas one pore generally occurs per intersept, some pores occur directly in front of septa. The pores of the inner wall are much larger than those of the outer wall, the minimum size being 0.23 millimetre. The total thickness of the inner wall varies considerably but is about 0.5 millimetre.

Occurrence. The genus is known from Australia, Siberia and western Canada. The species is known from localities 68955 (Yukon Territory) and 73873 (Northwest Territories).

Discussion. In three out of the four specimens assigned to this species the cup ends with the intervallum being sealed off by the outer wall growing over to meet the inner wall. In all cases it arches over gently so that the cap is convex upwards. The cap does not project at all over the central cavity. Zhuravleva (1960b) described a cap in Ajacicyathus sunnaginicus formed by the outer and inner walls growing together but partially covering the central cavity. She did not know whether each intersept had its own cap or whether there was one for the whole organism. In the holotype of Z. borealis, it can be seen that only one cap covered all of the intervallum. Zhuravleva did not regard these caps as being of taxonomic value, but it seems to me to be remarkable and taxonomically significant that three out of four specimens of one species have such an intervallar cap and hundreds of other specimens of other species from the same area show absolutely no evidence thereof. Until evidence to the contrary is found I regard the intervallar cap as being of specific importance.

The type species of Zonacyathus, Z. retevallum (Bedford and Bedford), has only one to two pores per intersept in the outer wall whereas this species has four to six pores per intersept. A specimen in the Princeton University collections described by Bedford and Bedford (1937) as Z. retevallum has three to four pores per intersept in the outer wall but differs from the

Yukon species in having porous septa. Debrenne (1969) stated that the type material of *Z. retevallum* has, apparently, imperforate septa.

The two specimens from locality 73873 are doubtfully placed in this species. They have a greater total diameter (up to 10 mm) and a larger central cavity.

Zonacyathus princetonensis n. sp.

Plate VI, figures 3-6

Material. Holotype, GSC No. 25340; paratypes, GSC Nos. 25341-25343.

Description. Both specimens are fragments of large bowl-shaped organisms, the holotype being 55 millimetres high and 60 millimetres long. The diameter of the complete cups must have exceeded 100 millimetres (130 mm if completely circular).

The outer wall is pierced by four pores per intersept, each 0.1 millimetre in diameter. The skeletal elements between pores are 0.04 millimetre thick. The pores are arranged in alternating vertical rows.

The intervallum is 1.5 millimetre wide; it contains only imperforate septa which are spaced 0.6 millimetre apart. The septa are 0.08 millimetre thick.

The inner wall is somewhat thicker than the outer wall - 0.15 millimetre - and is pierced by pore-tubes 0.15 millimetre in diameter. The skeletal elements between pores are 0.1 millimetre thick. Pores occur in two alternating rows per intersept.

Occurrence. Lower Cambrian; locality 75207 (British Columbia).

Discussion. This species is distinguished from *Z. borealis* primarily on the shape of the cup, the latter species being cylindro-conical. In *Z. borealis* the intervallum is closed off at the upper edge by the outer wall growing over to the inner wall; it is not known if this occurs in *Z. princetonensis*. The inner wall of *Z. princetonensis* is also more regular in its pore arrangement than is *Z. borealis*.

The regular pore pattern of the outer wall in the holotype is occasionally disrupted when the pores occur in adjacent rows instead of alternating. Sometimes, in places, three pores occur where there should only be two. Such disruption probably occurs where new septa and new pore rows arise.

SUPERFAMILY ANNULOCYATHACEA Krasnopeeva, 1955

Family Porocyathidae Zhuravleva, 1960

Genus *Porocyathus* Zhuravleva, 1960

Porocyathus Zhuravleva, 1960, p. 180.

Porocyathus, Hill, 1965, p. 81.

Diagnosis. See Hill, 1965, p. 81.

? Porocyathus sp.

Plate VII, figures 1a, b

Material. Figured specimen, GSC No. 25344.

Description. A fragment 16 millimetres long of a conico-cylindrical cup with a maximum diameter of 6.5 millimetres. The intervallum is 1.1 millimetre wide giving an intervallum coefficient of 0.3. At this diameter there are fifty-five septa so that the radial coefficient is 8.4.

The outer wall is pierced by four or five rows of pores per intersept, adjacent rows alternating. The pores are of inverted "V"-shape when seen in longitudinal section. They are 0.04 millimetre in diameter and the wall is 0.07 millimetre thick.

The intervallum is crossed only by imperforate septa spaced about 0.25-0.3 millimetre apart. Each septum is about 0.04 millimetre thick except near the inner wall where it thickens slightly.

The inner wall consists of geniculate pore-tubes opening upwards. These are arranged in alternating longitudinal rows, a single row per intersept. The pores are 0.25 millimetre in diameter with the skeletal elements between them 0.05 millimetre thick. When viewed in tangential section the pores are polygonal to hexagonal and close packed, the septa waving slightly to pass between them.

Occurrence. Lower Cambrian; GSC locality 73840 (Yukon Territory).

Discussion. The major difference between this specimen and P. pinus (the type species) is the presence of uniformly porous septa in the latter. Zhuravleva (1960) regarded the difference between finely porous septa and sparsely porous septa as being of subgeneric importance but I have not erected a new subgenus here for lack of more material since I do not completely understand the construction of the inner wall of this specimen. In transverse section it is very close to that of Ethmophyllum besovae Vologdin but in longitudinal section it is almost identical to P. pinus.

Genus Cordilleracyathus n. gen.

Type species. Cordilleracyathus blussoni n. sp.

Description. Solitary, slender cups of straight, cylindrical or conical form. Outer wall with pore-canals of inverted "V"-shape. Intervallum with straight, radial nonporous septa. The inner wall has pore-tubes partitioned so that the central cavity has one pore per intersept and the intervallum side has two pores per intersept. The pore-tubes are of reversed "S"-shape with spines projecting into the central cavity.

Discussion. Assignment at the family level for this genus is fairly straight forward. Geniculate outer wall tubes are known only in the Annulocyathidae and Porocyathidae. The Annulocyathidae are characterized by an annulate inner wall while the Porocyathidae have a complex inner wall of geniculate pore-tubes. Cordilleracyathus is obviously closer to the porocyathids than the annulocyathids. The only feature which possibly casts some doubt on the familial assignment is the nature of the septa. In the Porocyathidae the septa are closely porous whereas Cordilleracyathus has completely nonporous septa. Many recent workers (Debrenne, 1964; Hill, 1965) have considered septal porosity to be of specific importance only.

The only other genera included in the Porocyathidae - Porocyathus Zhuravleva and Squamosocyathus Zhuravleva - differ from Cordilleracyathus in the possession of porous septa and undivided pore-tubes in the inner wall.

Cordilleracyathus blussoni n. sp.

Plate VII, figures 2, 3, 4a, b, 5, 6

Ethmophyllum americanum, Greggs, 1959, p. 66, Pl. 13, fig. 11; Pl. 14, figs. 5, 9, 12.

aff. Porocyathus sp., Handfield, 1968, p. 8.

Material. Holotype, GSC No. 25345; paratypes, GSC Nos. 25346-25350.

Description. The exact shape of the holotype is unknown but other specimens show that it is a generally cylindrical cup with a smooth outer wall. The holotype has a maximum diameter of 6.4 millimetres with the central cavity being 4.1 millimetres and the intervallum 0.7 millimetre. There are fifty-six septa giving a radial coefficient of 8.6. The intervallum coefficient is 0.2.

The outer wall has three or more commonly four longitudinal rows of pores per intersept, each pore being approximately 0.1 millimetre in diameter. The skeletal elements between pores are 0.03 to 0.04 millimetre thick. The pores of one longitudinal row alternate with those of neighbouring rows. The outer wall is 0.1 millimetre thick. The pores in longitudinal section are of inverted "V"-shape with a spine on the apex of the "V".

The intervallum is relatively narrow and contains nonporous septa only. These are 0.03 millimetre thick but thicken slightly near the outer wall although not near the inner wall.

The inner wall is a thick (0.25 mm) complex structure consisting of inclined geniculate pore-tubes, each with a vertical partition resulting in one pore per intersept on the central cavity side and two on the intervallum side. The former pores are elliptical (0.08 x 0.28 mm) with the long axis oriented transversely. Pores in each row alternate with those in adjacent rows. The skeletal elements between pores are 0.8 millimetre thick. The pores on the intervallum side of the inner wall are arranged side by side, two per intersept, those in neighbouring intersepts alternate. The pores are circular with a diameter of 0.01 millimetre. The skeletal elements between pores in the same row are thicker (0.1 mm) than between pores in adjacent intersepts. The two pores occupy slightly more than the full width of an intersept so that the septa bend around them. The pore-tubes have a spine of 0.2-0.3 millimetre projecting up and into the central cavity so that in longitudinal section the inner wall appears to have "V"-shaped tubes in contrast to the outer wall which has inverted "V" tubes.

Occurrence. Lower Cambrian; GSC localities 73870, 73872, 73873 and 75205.

Discussion. The specimens from localities 73870 and 73872 assigned to this species are all smaller than the majority of specimens from the type locality and may represent a different subspecies. The specimens identified by Greggs as Ethmophyllum americanum Okulitch appear to belong to this genus and species although I cannot be certain that the inner wall has a divided tube. The holotype of E. americanum is similar in cross-section to C. blussoni but as no longitudinal section is available and many genera with complex walls look the same in transverse section it is impossible to make a definitive identification. McKee (1963) suggested that E. americanum may be a synonym of E. whitneyi and this is a possibility. The complexity of ethmophyllids and porocyathids requires longitudinal sections for accurate identification.

Family ?

Genus Yukonocyathus n. gen.

Type species. Yukonocyathus francesi n. gen. et n. sp.

Description. A solitary, gently tapering cylindro-conical cup. Outer wall with small, moderately geniculate pore-tubes. Intervallum with only slightly porous septa, the pores occurring in a single row near the outer wall. Inner wall with one simple, large pore per intersept.

Occurrence. Lower Cambrian; southeastern Yukon Territory.

Discussion. There is no one character that distinguishes Yukonocyathus from other genera of the Suborder Ajacicyathina as all of its features occur in other genera. It is rather the combination of characters that make Yukonocyathus unique.

There are two ways to have geniculate pore-tubes in the outer wall (Fig. 11):

a. By having simple oblique pore-tubes with projections from the outer wall.
b. By having simple pore-tube which bend part way through the wall.

It appears that the outer wall of Yukonocyathus is formed in the first way, but with the pores opening down instead of up. Among the Suborder Ajacicyathina this type of wall is known only in the Superfamily Annulocyathacea.

Within the superfamily only one family (Tumulocyathidae) has a simple inner wall, but the outer wall has tumuli. The Family Porocyathidae has a geniculate outer wall but a complicated inner wall. For the present Yukonocyathus is left as incertae sedis within the Superfamily Annulocyathacea.

Yukonocyathus francesi n. sp.

Plate VIII, figures 1a-c, 2a, b

Material. Holotype, GSC No. 25351; paratypes, GSC Nos. 25352, 25353.

Description. The holotype is an incomplete, gently tapered cup 42 millimetres long and 9.5 millimetres in diameter at the large end. The small end is 3.0 millimetres in diameter. There are no indentations or ridges on the outer wall.

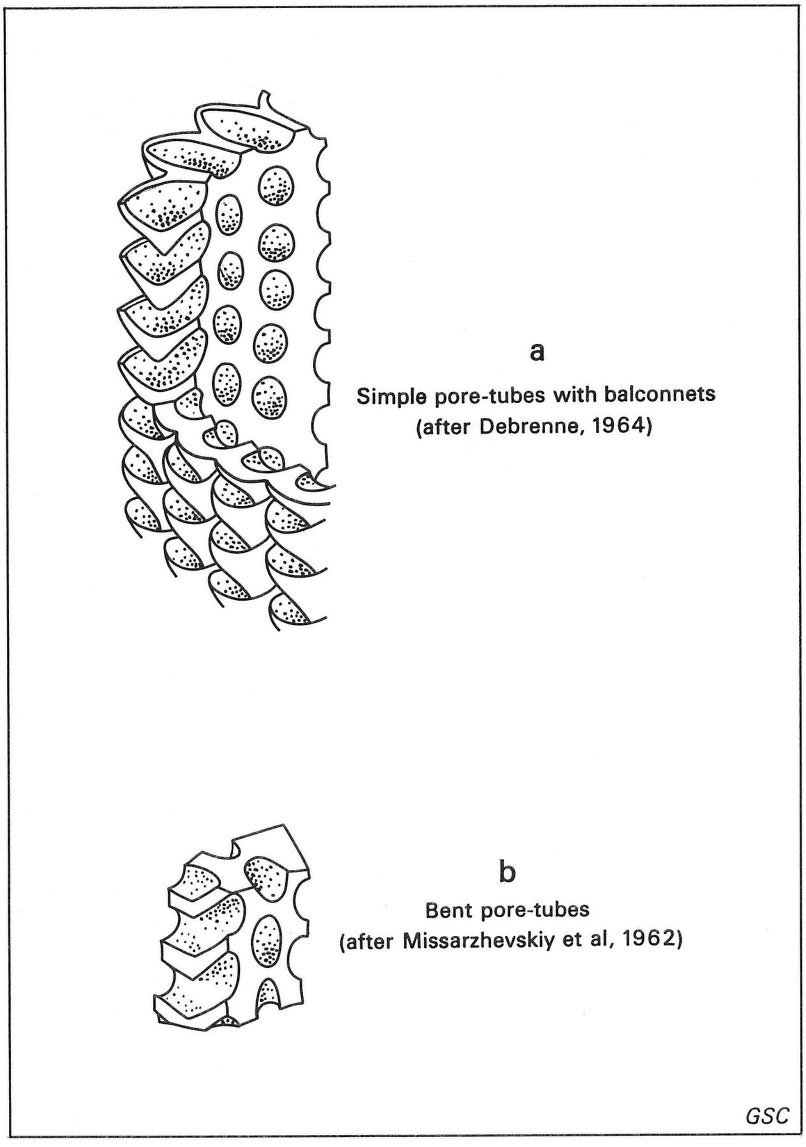


Figure 11. Two methods of constructing a wall with geniculate pore-tubes.

The thick (0.28 mm) outer wall has four to six rows of pore-tubes per intersept arranged in alternating longitudinal rows. The pore diameter is 0.12 millimetre while the linteaux are 0.05 millimetre thick. The pore-tubes are oblique down into the intervallum and protected by upside-down "balconnets" on the outer side. This gives the pore-tube a geniculate appearance in longitudinal section. The inner ends of the pore-tubes curve down slightly making the end of the tube smaller than the middle part. The "balconnet" projects up slightly into the pore-tube above.

The intervallum is 2.0 millimetres wide and contains straight, radial septa, each having only one row of pores located near the outer wall. The diameter of the pores is 0.2 millimetre. The septa thicken a little at the inner wall. The septa are 0.06-0.1 millimetre thick.

The inner wall is thick (0.28-0.34 mm) but very simple in construction. Pores occur in a single row per intersept, each pore occupying the full width of the intersept. Pores in each intersept alternate with those in neighbouring intersepts. The diameter of the pores varies from 0.40-0.55 millimetre while the skeletal elements range from 0.35-0.48 millimetre. Spines and other projections are completely lacking on the inner wall.

Occurrence. Lower Cambrian; GSC localities 68957, 73840 and 74845 (Yukon Territory).

SUPERFAMILY ERBOCYATHACEA Vologdin and Zhuravleva, 1956

Family Erbocyathidae Vologdin and Zhuravleva, 1956

Genus Ladaecyathus Zhuravleva, 1960

Ladaecyathus Zhuravleva, 1960a, p. 43.

Ladaecyathus, Hill, 1965, p. 84.

Diagnosis. Solitary, cylindrical cups with screened pore-canals; porous septa; bars and ribs between pores of walls with short hair-like outgrowths forming a screen across the mouth of each pore.

Occurrence. Lower Cambrian; Sanashtykgol horizon, U.S.S.R., Antarctica, Yukon Territory.

Discussion. The above diagnosis is after Hill (1965) who also states that there are no synapticulae. The new species, L. fischeri, named below has synapticulae. It is rather difficult to determine whether a character such as synapticulae should be considered as a specific or generic character. Hill (1965) considered synapticulae useful for distinguishing genera and Zhuravleva (written comm., 1968) treats synapticulae as generic characters. Debrenne (1964) assigned specific value to synapticulae when rare, and generic value when constantly present. For the present I am following Debrenne's usage. In the specimens under discussion, some transverse sections show synapticulae while others do not. This is the first report of Ladaecyathus in North America.

Ladaecyathus fischeri n. sp.

Plate VIII, figures 3a-e

Material. Holotype, GSC No. 25354; paratype, GSC No. 25355.

Description. The holotype is a very large rectangular fragment about 90 millimetres long and 85 millimetres wide. The central part of the cup is partly preserved near one edge showing that the original organism must have been large and saucer-shaped with a diameter exceeding 130 millimetres. Originally the apical portion was probably more typically cup-shaped which then expanded rapidly to form a saucer.

The outer wall in transverse section appears thin and simple with two or three pores per intersept. Tangential sections show that the pores form an irregular network which is divided into smaller and still more irregular pores by fine, irregularly shaped bars and rods which run in the plane of the wall but project slightly above it, forming a kind of secondary wall. There does not appear to be a distinct separation between primary and secondary walls.

The intervallum is 2.5-3.0 millimetres wide with straight septa. The septa are 0.15 millimetre thick and spaced 0.9-1.1 millimetre apart. The pores in the septa are up to 0.35 millimetre in diameter, the average being about 0.25-0.30 millimetre. They are circular or nearly so. Stirrup-pores are definitely present at the inner wall and appear to be present at the outer wall. Synapticulae are present but not abundant. They are most common near the apical part of the cup. Away from the apex they diminish so that in a cross-section 12 millimetres long only one synapticulae is present. In another transverse section distant from the centre no synapticulae are visible over a length of 22 millimetres.

The inner wall is very much like the outer wall but with a finer and more closely spaced secondary screen giving the wall a more complicated appearance in tangential section. This screen is on the central cavity side of the wall.

Occurrence. Lower Cambrian; GSC localities 68957 and 73840 (Yukon Territory).

Discussion. This species differs from the type species, L. limbatus, in shape and presence of synapticulae. The synapticulae make it unique amongst all known species of Ladaecyathus.

There has been some disagreement in the literature over the interpretation of the "screened" type of wall seen in Ladaecyathus and other genera of the Erbocyathidae. Zhuravleva (1960a) described the outer wall of Ladaecyathus as having branching pores and the inner wall as simple but with hair-like projections on the central cavity side. Debrenne (1964) described a type of outer wall consisting of two independent walls, the outermost being much thinner and with smaller pores than the inner part. She included Ladaecyathus in a list of genera having this type of outer wall. Her figure of the inner wall of Ladaecyathus shows simple pores with spines projecting into the central cavity. Hill (1965) describes the pores of both walls as having fine rod-like extensions, in the plane of the wall, across the pores and considers these as "differing in no way that I can discern from that illustrated by

Zhuravleva (1960a, Fig. IV) as an outer wall with branching pore canals". Unfortunately Zhuravleva did not illustrate tangential sections of the outer and inner walls, but after looking at photographs of the Yukon species she wrote that the inner and outer walls were the same as in Ladaecyathus. Hill's excellent photograph (1965, Pl. V, fig. 3e) shows that the fine rod-like extensions project away from the wall as well as in the plane of the wall so that the actual situation is a composite of the interpretations expressed above. The outer screen, however, does not form an independent wall as described by Debrenne.

Ladaecyathus aff. L. fischeri n. sp.

Plate IX, figures 1a, b; Plate XVI, figure 3

Material. Hypotypes, GSC Nos. 25356, 25382.

Description. This is a colonial, cylindro-conical form with screened outer and inner walls. When the two cups are within a single outer wall they have an individual diameter of about 15 millimetres. After branching the diameter of the more complete specimen is 20.2 millimetres with a central cavity 10.0 millimetres across and an intervallum 5.1 millimetres wide. There are an estimated forty-eight septa at this diameter. The intervallum coefficient is 0.5 and the radial coefficient is 2.3.

The outer wall has screened or "branching" pores similar to those described for L. fischeri. The pores in the fine outer screen are about 0.04 millimetre in diameter while those in the main wall are about 0.1 millimetre in diameter. There are six to eight fine pores and two to four larger ones per intersept.

The intervallum contains septa and synapticulae but no tabulae or dissepiments. The septa are 0.2 millimetre thick and spaced 0.7-0.8 millimetre apart. The pores in the septa are about 0.3 millimetre in diameter. The synapticulae are partly as thick as the septa, but thin midway between the septa so that the corners are rounded.

The inner wall has two pores per intersept but these are screened on the central cavity side similar to the inner wall of L. fischeri. The inner wall is 0.2 millimetre thick with pores 0.2 millimetre in diameter and linteaux 0.1 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75206 (British Columbia).

Discussion. The shape of the cups and their colonial habit throw considerable doubt on the specific and even generic identification of this specimen. L. fischeri has a large saucer-shaped cup and also has fewer synapticulae than does this specimen.

Debrenne (1969) did not regard the shape of the cup as having specific value whereas most other workers (Okulitch, 1943; Zhuravleva, 1960b) have done so.

Zhuravleva (1960b) regarded colonial habit amongst the Regularia as, at most, a specific character whereas Hill (1965) regarded it as a generic character.

Superfamily ?

Family ?

Genus A sp.

Plate X, figures 4a, b

Material. Figured specimen, GSC No. 25366.

Description. This specimen is a solitary cylindro-conical cup which at a diameter of 11.5 millimetres has a central cavity of 3.7 millimetres and an intervallum 3.1 millimetres wide. At this diameter there are twenty-eight septa giving a radial coefficient of 2.4. The intervallum coefficient is 0.8.

The outer wall is 0.15 millimetre thick and pierced by two to four rows of pores per intersept, each oval-shaped pore being about 0.15 by 0.22 millimetre. The pores are arranged in alternating longitudinal rows.

The intervallum is crossed by porous, radial septa, two of which bifurcate near the outer wall. The septa are 0.1-0.15 millimetre thick with pores 0.2-0.3 millimetre in diameter. The linteaux are 0.3 millimetre thick. The septa are spaced 0.7-0.8 millimetre apart. There are, apparently, stirrup-pores in the septa at the inner wall.

The inner wall is 1.1 millimetre thick and quite complex. There are one and one-half or two pores per intersept, the pores apparently being intercommunicating tubes. The pores are 0.25 millimetre in diameter, separated by skeletal elements 0.2 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75206 (British Columbia).

Discussion. The intervallum and both walls exhibit a rather unusual secondary thickening which covers nearly all skeletal elements and fills in the intersepts and much of the central cavity. The thickening occurs as light and dark layers, concentric within each intersept. Zhuravleva (1960b) described a similar secondary thickening in *Ajacicyathus* sp.

The inner wall of this specimen is very similar to the inner wall of *Tegerocyathus* but the outer wall is not screened or branching as in the type species *T. abakanesis* (Vologdin). *T. edelsteini* (Vologdin) figured in Zhuravleva (1960b, Pl. XV, figs. 4-7) is especially close to the British Columbia specimen.

SUBORDER COSCINOCYATHINA Zhuravleva, 1955

SUPERFAMILY COSCINOCYATHACEA Taylor, 1910

Family Coscinocyathidae Taylor, 1910

Genus *Coscinocyathus* Bornemann, 1884

Coscinocyathus Bornemann, 1884, p. 704.

Coscinocyathus, Debrenne, 1964, p. 162.

Diagnosis. This genus is a solitary, generally cylindrical form with thin porous septa and porous tabulae. The outer wall has slightly curved oblique pore-tubes whereas the inner wall has one row of pore-tubes per intersept.

Occurrence. Lower Cambrian; cosmopolitian.

Discussion. The above diagnosis is from Debrenne (1964) who re-examined the type material. Since Bornemann established the genus in 1884 it has become a catch-basin for nearly all Regularia with tabulae; over seventy-five species have been described, many of them based on poor material or superficial differences. Debrenne (1964) made a valiant first attempt to straighten out the Coscinocyathus complex with a re-examination of the type species and some suggestions about other species already described. The following genera were recognized by her: Coscinocyathus Bornemann - inner wall with one row of pore-tubes per intersept; Geniculicyathus Debrenne - inner wall with two or more "S"-shaped pore-tubes per intersept; Erismacoscinus Debrenne - inner wall with two or more simple pores per intersept; Retecoscinus Zhuravleva - inner wall with two or three short pore-tubes and tabulae with two rows of elongated pores per intersept; Coscinoteichus Debrenne - inner wall with two or three rows of straight, oblique pore-tubes.

The inner wall is the main distinguishing characteristic of these genera except for Retecoscinus which is distinguished by the unique pore-pattern of its tabulae. About the only possibility not covered by the above genera is an inner wall with one simple pore per intersept; this is described below as Erismacoscinus? uniporus n. sp.

All the described species of North American Coscinocyathidae are either listed or redescribed below under the appropriate genus.

Coscinocyathus fritzi n. sp.

Plate IX, figures 2a, b, 3-5

Material. Holotype, GSC No. 25357; paratypes, GSC Nos. 25358-25360.

Description. This straight cylindrical form reaches a diameter of 15 millimetres, the intervallum coefficient at this diameter being 0.3 and the radial coefficient 5.7. The intervallum and outer wall have pronounced transverse annulations which do not affect the inner wall.

The outer wall is poorly preserved on the holotype but paratype 25358 shows the outer wall to be simply porous with a thickness of 0.08 millimetre. On the upper side of many of the transverse expansions, the tabulae form the outer wall.

The septa are 0.05 millimetre thick with pores 0.2 millimetre in diameter.

The tabulae are 0.04 millimetre thick with pores 0.02 millimetre thick. The tabulae are strongly convex upwards with the centre of curvature generally in the intervallum but a few seem to have their centre of curvature in the central cavity. The tabulae are spaced 0.65 to 1.0 millimetre apart.

The inner wall is made up of one row of "S"-shaped pore-tubes per intersept. The inner end of each tube element flares slightly producing a small upper and lower lip. The pore-tubes have a length of 0.38 millimetre and a diameter of 0.40 millimetre. The tube elements are spaced 0.40 millimetre apart vertically.

Occurrence. Lower Cambrian; GSC localities 73871 and 73872 (Northwest Territories).

Discussion. The intervallum coefficient in this species has an observed range of 0.3 to 0.5 and the radial coefficient varies from 5.7 to 4.0. C. fritzi is similar to C. multiporus but the latter species lacks the pronounced expansions and contractions of the outer wall and intervallum.

Coscinocyathus aff. C. fritzi n. sp.

Plate X, figures 1a, b

Material. Hypotype, GSC No. 25361.

Description. This specimen is a long, cylindrical fragment 23.5 millimetres in diameter with an intervallum coefficient of 0.25 and a parietal coefficient of 4.4. The outer wall is not preserved.

The intervallum contains simply porous septa – 104 at a diameter of 23.5 millimetres – and upwardly convex tabulae. The septa are 0.04 millimetre thick with pores 0.15 millimetre in diameter. The tabulae are about twice as thick as the septa with pores 0.08 millimetre in diameter. There are three to four pore-rows per intersept on the tabulae. The spacing of the tabulae is quite variable, 0.23 millimetre to 1.75 millimetre.

The inner wall has one row of "S"-shaped pore-tubes per intersept. The pore-tubes are 0.23 millimetre in diameter and 0.33 millimetre in length. The end of each tube element curves up to partially block the opening of the pore-tube.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia).

Discussion. The intervallum and radial coefficients of this specimen are very close to those of C. fritzi as is the distance between tabulae. The pore-tubes of the inner wall however are more closely spaced in this specimen than in C. fritzi and the tube-elements do not have the small lip at the inner end. C. vardabassi Debrenne has an inner wall very much like the specimen under discussion but the tabulae of C. vardabassi are much more widely spaced.

Coscinocyathus multiporus Kawase and Okulitch, 1957

Coscinocyathus multiporus Kawase and Okulitch, 1957, p. 917, Pl. 109, figs. 7-9.

?Coscinocyathus inequivallus Kawase and Okulitch, 1957, p. 918, Pl. 110, figs. 1-6.

Material. Holotype, GSC No. 13329.

Description. This specimen is a large conical form 118 millimetres long and 38 millimetres in diameter. The intervallum coefficient is 0.6 and the radial coefficient 2.6.

The outer wall is 0.1 millimetre thick and perforated by four pores per intersept, each about 0.1 millimetre in diameter.

The intervallum is crossed by simply porous septa and tabulae. The septa are 0.08 millimetre to 0.1 millimetre thick with pores 0.1 millimetre in diameter. The tabulae are only slightly convex upwards; are 0.1 millimetre to 0.15 millimetre thick and spaced 1.5 to 2.2 millimetres apart. The pores in the tabulae are 0.1 millimetre in diameter and in regular rows about three to five per intersept.

The pores of the inner wall occur in one row per intersept, pores in adjacent rows alternating. The pores are polygonal to hexagonal with the short dimension vertical. The pores are 0.4 by 0.6 millimetre and are 0.5 millimetre long. They are slightly "S"-shaped.

Occurrence. Lower Cambrian; known only from the type locality, GSC 24035.

Discussion. C. inequivallus is similar to C. multiporus except for its radial coefficient which at 4.5 is considerably higher. This difference may be due to the large difference in size, the holotype of C. inequivallus being only 15 millimetres in diameter compared to 38 millimetres for C. multiporus. C. veronicus differs in both intervallum coefficient (0.3) and radial coefficient (4.4).

This species differs from C. serratus by the difference in spacing of the tabulae, being only 1.5 to 2.2 millimetres apart compared to 3.0 to 3.5 millimetres apart in the latter species.

Coscinocyathus cf. C. multiporus Kawase and Okulitch

Plate X, figures 6a, b

Material. Hypotype, GSC No. 25362.

Description. This specimen is an incomplete cylindrical fragment 33 millimetres long and 16 millimetres in diameter. The outer wall and intervallum are somewhat undulatory but the inner wall is not affected. The intervallum coefficient is 0.8 and the radial coefficient 2.5.

The outer wall is not well preserved and nothing is known of its porosity.

The intervallum contains simply porous septa 0.07 millimetre thick with pores 0.15 millimetre in diameter. The slightly convex tabulae are 0.07 millimetre thick and are spaced 0.75 to 1.45 millimetre apart. The pores in the tabulae are arranged in regular rows, about three per intersept, each pore being about 0.2 millimetre in diameter.

The inner wall has one row of slightly "S"-shaped pore tubes in each intersept. Each tube element has a slight flare at the end with small spines projecting into the central cavity. The pores are hexagonal to polygonal and occur in alternating rows. The pores are spaced 0.4 millimetre apart vertically, measured from centre to centre. The wall is 0.5 millimetre thick.

Occurrence. Lower Cambrian; known only from GSC locality 75205 (British Columbia).

Discussion. The only difference between the above specimen and C. multiporus are the presence of the small spines on the inner wall and a somewhat larger intervallum coefficient in the above. The poor preservation of the outer wall precludes a more positive identification.

Coscinocyathus serratus Kawase and Okulitch, 1957

?Coscinocyathus dentocanis, Okulitch, 1955, p. 51, Pl. III, figs. 5-7.

Coscinocyathus serratus Kawase and Okulitch, 1957, p. 920, Pl. 110, figs. 7, 9.

?Coscinocyathus dentocanis, Kawase and Okulitch, 1957, p. 916, Pl. 109, figs. 4-6.

?Carinacyathus perforatus, Kawase and Okulitch, 1957, p. 922, Pl. 111, figs. 1-5.

Material. Holotype, UBC AP-17.

Discussion. The holotype has not been examined, but the original description and illustrations are sufficient to confirm this species as a true coscinocyathid.

Coscinocyathus dentocanis Okulitch, 1943

Coscinocyathus dentocanis Okulitch, 1943, p. 67, Pl. 4, fig. 2.

Material. Holotype, GSC No. 9516 from Dogtooth Range, British Columbia.

Discussion. This specimen is too poorly preserved to warrant extension of the name to other specimens.

Coscinocyathus rhyacoensis Okulitch, 1948

Coscinocyathus rhyacoensis Okulitch, 1948, p. 343, Pl. 53, figs. 7, 8.

Material. Holotype, UBC 7 in V. J. Okulitch Collection, from Dogtooth Mountains, British Columbia.

Discussion. This specimen is too poorly known to warrant extension of the name to other specimens.

Erismacoscinus Debrenne, 1958

Erismacoscinus Debrenne, 1958, p. 65.

Erismacoscinus, Debrenne, 1964, p. 166.

Erismacoscinus, Hill, 1965, p. 108.

Erismacoscinus, Debrenne, 1969, p. 325.

Diagnosis. See Debrenne, 1969, p. 325.

Discussion. Debrenne (1964) erected the family Erismacoscinidae for this and several related genera but for the present I think the family Coscinocyathidae is sufficient for most of these genera. Hill (1965) through an apparent misunderstanding of the structure of the inner wall included Erismacoscinus in the Coscinocyathellidae.

Erismacoscinus cassiariensis (Kawase and Okulitch)

Coscinocyathus cassiariensis Kawase and Okulitch, 1957, p. 917, Pl. 109, figs. 10-13.

Material. Holotype, GSC No. 13330; paratype, GSC No. 13331.

Description. The material is fragmentary so that the general shape of the species is not known except that it is generally cylindrical. The holotype is an elliptical fragment 15 x 20.5 millimetres with an intervallum 4.0 millimetres wide. At this diameter there are seventy-five septa. The intervallum coefficient is 0.4 and the radial coefficient is 4.2.

Although the outer wall is not preserved in the holotype, it is seen in paratype 13331 to be simply porous with three to four pores per intersept. The wall is 0.07 millimetre thick with a pore diameter of 0.15 millimetre.

The intervallum contains simply porous septa and tabulae. The septa are 0.06 millimetre thick with pores 0.2 millimetre in diameter. The tabulae are considerably thicker (0.2 mm) but with pores of the same size as the septal pores. Only three tabulae are visible in the holotype and these are spaced 6 and 9 millimetres apart.

The inner wall is thin and simple with two pores per intersept, each of a diameter of 0.19 millimetre. The wall is 0.1 millimetre thick.

Occurrence. Lower Cambrian; known only from the type locality, GSC 24035.

Discussion. The above description is based on a re-examination of the type material. The simple inner wall with two pores per intersept places this species in Erismacoscinus. It is distinguished from other species by the wide spacing of the tabulae. The original description states that the tabulae are spaced 2 millimetres apart but this apparently resulted from confusion between the tabulae and almost tangential sections through several septa.

Erismacoscinus tubicornus (Kawase and Okulitch)

Coscinocyathus tubicornus Kawase and Okulitch, 1957, p. 921, Pl. 110, figs. 10, 11.

Material. Holotype, GSC No. 13334 from GSC locality 24036, Lower Cambrian, Wolf Lake area, Yukon Territory.

Discussion. The holotype was not re-examined. Kawase and Okulitch indicated that there may be two pores per intersept. If such is the case, this is a species of Erismacoscinus. The closer spacing of the tabulae (1.5-2 mm) distinguishes this species from E. cassiariensis.

Erismacoscinus cf. E. tubicornus (Kawase and Okulitch)

Plate X, figure 2

Material. Hypotype, GSC No. 25364.

Description. The specimen is a fragment 17 millimetres long of a cylindrical cup. The maximum diameter observed is 16.8 millimetres at which diameter the central cavity is 8.0 millimetres across and the intervallum is 4.4 millimetres wide. The intervallum coefficient is 0.6.

The outer wall has four simple pores per intersept with a diameter of 0.1 (?)millimetre. The wall is 0.2 (?)millimetre hick. The uncertainty is due to overgrowth of the wall by exothecal lamellae.

The intervallum is crossed by fifty-two straight, porous septa and domed, porous tabulae. The septa are copiously porous with up to fifteen pores visible in a septum in transverse section. The septa are 0.1 millimetre thick with pores 0.2 millimetre in diameter. The skeletal network between pores is 0.1 millimetre thick.

The distance between septa midway across the intervallum varies from 0.6-0.75 millimetre.

The tabulae are the same thickness as the septa but the pores are only half as large (0.1 mm). They are arranged in two to three rows per intersept and separated by skeletal bars 0.1 millimetre thick. The only tabulae visible are spaced 1.9 and 2.7 millimetres apart.

The inner wall is a simple, porous cylinder with two vertical rows of pores per intersept. It is 0.08 millimetre thick with pores 0.15 millimetre in diameter. The linteaux are 0.08 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia).

Discussion. This specimen is close to both E. tubicornus and E. cassiariensis. It differs from the latter in closer spacing of tabulae. On the other hand, the tabulae are slightly farther apart than in E. tubicornus.

Most interesting are the exothecal lamallae which are abundantly developed on the outer wall. Although dissepiments are normally associated with exothecal lamallae this specimen (at a diameter of 16 mm) has dissepiments only on one side and much of the exothecal tissue lacks dissepiments. A little lower down in the cup, dissepiments are abundant both in the intervallum and the central cavity. The exothecal growth also is filled with dissepiments at this level.

Erismacoscinus? uniporus n. sp.

Plate X, figures 3a, b

Material. Holotype, GSC No. 25363.

Description. The only specimen is an incomplete, gently tapering cone 23 millimetres long. The diameter 6 millimetres from the smaller end is 15.8 millimetres at which diameter the intervallum coefficient is 0.7 and the parietal coefficient is 2.5.

The outer wall is simply porous, with (?)three pores per intersept. The wall is 0.15 millimetre thick with pores 0.15 millimetre in diameter.

The straight radial septa are 0.08 millimetre thick with pores 0.23 millimetre in diameter. New septa grow in from the outer wall. The upward arching tabulae are about 2.5 millimetres apart. The tabulae are 0.15 millimetre thick with pores 0.23 millimetre in diameter.

The inner wall has one row of simple pores per intersept. The wall is 0.1 millimetre thick with oval-shaped pores 0.15 millimetre high and 0.4 millimetre wide. The pores in each longitudinal row alternate with those in adjacent rows. Skeletal elements between pores are 0.1 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia).

Discussion. *Erismacoscinus* was erected for tabulate genera with two or more simple pores per intersept in the inner wall. This species has only one and therefore should be placed in a new genus. I have not erected a new genus at this time in the hopes that more material will become available. This species is the tabulate equivalent of *Robustocyathus*.

SUBORDER ?

SUPERFAMILY ?

Family ?

Genus B sp.

Plate X, figure 5

Material. Figured specimen, GSC No. 25365.

Description. Only two oblique transverse sections are available so that the exact shape is unknown but they are generally cylindrical or cylindro-conical. GSC 25365 has a diameter of 8.2 millimetres with the central cavity being 3.6 millimetres across and the intervallum only 1.5 millimetre wide.

The outer wall is not well preserved, but where preserved in one or two places is apparently simple. There are several pores per intersept, each about 0.07 millimetre in diameter and separated by skeletal elements 0.09 millimetre thick. One undescribed specimen has a hint in one place of latticed walls.

The intervallum is crossed only by nonporous septa spaced about 0.2 millimetre apart. The septa are 0.03 millimetre thick but thicken very slightly at the inner wall. No tabulae (either porous or pectinate) or dissepiments were observed.

The inner wall is a thick complex structure of pore-tubes, possibly one and one-half or two per intersept. These pores are 0.2 millimetre in diameter and separated by skeletal elements 0.04-0.07 millimetre thick. The wall itself is 0.8 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 74845 (Yukon Territory).

Discussion. In Russia these specimens would almost certainly be classified as Ethmophyllum but the inner wall is considerably different from E. whitneyi and a revision of the Ethmophyllidae is badly needed. Formosocyathus is almost identical to this genus with the addition of pectinate tabulae. Since pectinate tabulae are often poorly or not at all preserved (Hill, 1965) these specimens may actually belong to Formosocyathus. In fact, Hill (1965) states "they [pectinate tabulae] may be absent in some, and rare in other individuals of the same species, while in yet others they abound."

If the hint of clathrate walls observed in the smaller of the two sections is true then this genus would be Tercyathus.

Both Tercyathus and Formosocyathus are regarded as having porous septa.

CLASS IRREGULARIA Vologdin, 1937

ORDER ARCHAEOCYATHIDA Okulitch, 1935

SUBORDER ARCHAEOCYATHINA Okulitch, 1935

Family Metacyathidae Bedford and Bedford, 1934

Genus Metaldetes Taylor, 1910

Metaldetes Taylor, 1910, p. 151.

Metaldetes, Hill, 1965, p. 119.

Metaldetes, Debrenne, 1969, p. 355.

Diagnosis. See Debrenne, 1969, p. 355.

Metaldetes? caribouensis n. sp.

Plate XI, figures 1, 2a-c, 3a, b

Material. Holotype, GSC No. 25367; paratypes, GSC Nos. 25368-25370.

Description. This is a rather small, solitary or more commonly colonial form. The holotype has a diameter of 8.3 millimetres with the intervallum being 3.0 millimetres giving an intervallum coefficient of 1.1. There are an estimated twenty-four taeniae at this diameter.

The outer wall is double. The taeniae become compact forming the inner part of the wall and a thin mesh covers this on the outside. The pores of this thin outer mesh are irregular in shape and distribution but are numerous, there being several per intertaenial space. The outer part of the wall is 0.03 millimetre thick while the inner part is 0.07 millimetre thick. The outer pores are 0.04 millimetre in diameter.

The very straight taeniae are 0.08-0.1 millimetre thick with pores up to 0.4 millimetre in diameter. Thin dissepiments are very abundant, both in the intervallum and the central cavity. The intervallum of some specimens also contains tabulae. This feature is further discussed below.

The inner wall is late developing in one specimen, appearing only at a diameter of 4.7 millimetres. When present it is a simple porous cylinder with two pores per intertaenial space. The pores occupy the full width of the intertaenial space and are arranged in alternating longitudinal rows.

Occurrence. Lower Cambrian; known only from GSC locality 73870 (Northwest Territories).

Discussion. The systematic value of dissepiments has been discussed elsewhere in this report. As they are so abundant in these specimens they are regarded as a specific character.

The outer wall is very similar to the outer wall of Bedfordcyathus Vologdin which Debrenne (1969) placed in synonomy with Metaldetes. The inner wall of these specimens is not so strongly developed as in other species of Metaldetes.

Genus Cambrocyathus Okulitch, 1937

Cambrocyathus Okulitch, 1937, p. 251.

Cambrocyathus, Okulitch, 1943, p. 72.

Cambrocyathus, Hill, 1965, p. 120.

Diagnosis. Conical cups with pronounced transverse annulations. The outer wall is simply porous. The intervallum has simply porous taeniae and abundant dissepiments. Synapticulae are present but not abundant. The inner wall is simple.

?Cambrocyathus sp.

Plate XI, figures 4, 5; Plate XII, figures 1a, b, 5

Material. Figured specimens, GSC Nos. 25371-25374.

Description. These are all rather large cylindrical forms, GSC 25372 having a diameter of 45 millimetres. At this diameter the intervallum is 6.5 millimetres wide and there are approximately 90 taeniae. Thus the intervallum coefficient is 0.2 and the radial coefficient 2.0.

The outer wall is thick (0.2 mm) and simply porous, the pores being about 0.2-0.3 millimetre in diameter. There are two to four pores per intertaenial space.

The intervallum is crossed by rather straight taeniae which are joined by synapticulae. These vary considerably in abundance from one specimen to the next. The straightness of the taeniae also shows considerable variation, many being so straight as to look like septa. The taeniae are 0.2 millimetre thick and are pierced by pores 0.3-0.4 millimetre in diameter. The synapticulae are about the same thickness as the taeniae except that they are thickened somewhat where they join the taeniae so that the corners are rounded. The taeniae are spaced 0.75-0.95 millimetre apart. Dissepiments are present in the intervallum of all specimens but vary from rare to abundant.

The inner wall is a simple, porous cylinder with two to three pores per intertaenial space. It is 0.2 millimetre thick. The pores are 0.15 millimetre in diameter. Exothecal lamallae are present in a few places on the central cavity side of the inner wall.

Occurrence. Lower Cambrian; GSC localities 75208 and 75212 (British Columbia).

Discussion. These specimens differ in several respects from Cambrocyathus profoundus (Billings), the type species. C. profoundus is a strongly conical form in which the intervallum and outer wall have strong transverse annulations, as in Pycnoidocyathus. Synapticulae are rare, but present, in C. profoundus except at smaller diameters where they are common. The taeniae in the type species are generally straight, suggesting septa. While dissepiments are abundant in the type species their systematic value is still debatable.

The network of taeniae and synapticulae, while too complex perhaps for Cambrocyathus, is not so complex as in Pycnoidocyathus or Protopharetra.

GSC 25372 shows an interesting relationship between an exothecal growth and dissepiments in the intervallum, the dissepiments occurring only adjacent to the exothecal growth.

Family Archaeocyathidae Hinde, 1889

Genus Flindersicyathus Bedford and Bedford, 1937

Flindersicyathus Bedford and Bedford, 1937, p. 28.

Flindersicyathus, Hill, 1965, p. 123.

Flindersicyathus, Zhuravleva et al., 1967, p. 93.

Flindersicyathus, Debrenne, 1969, p. 344.

Diagnosis. Solitary Archaeocyatha with a simply porous outer wall and an inner wall consisting of pore-tubes projecting obliquely up into the central cavity. There is a single row of pores per intertaenial space, each pore being bounded by the taeniae and the synapticulae joining them. The intervallum is crossed by more or less regularly waved taeniae joined by synapticulae. Dissepiments may be present but no tabulae are known.

Discussion. The above diagnosis is based on that given by Hill (1965) and confirmed by examination of the holotype of F. decipiens.

As Hill (1965) has pointed out, the combination of regularly-arranged synapticulae and waved, porous taeniae results in a curved, hexagonal mesh similar in appearance to Syringocnema.

The most striking difference between Flindersicyathus and Syringocnema is the number of pores on the hexagonal tube faces, the latter having two or three rows of small pores whereas the former has only one row of large pores.

Taylor (1910, p. 133) recognized the similarity between the construction of Pycnoidocyathus and Syringocnema, and Flindersicyathus is even more like Syringocnema.

See further discussion below under Pycnoidocyathus.

Flindersicyathus mcdamensis n. sp.

Plate XII, figures 2-4, 6a, b

Material. Holotype, GSC No. 25375; paratypes, GSC Nos. 25376-25379.

Description. Small, solitary or colonial cylindrical cups, the holotype having a maximum diameter of 6.0 millimetres. At this diameter the intervallum is 1.8 millimetre wide and there are thirty-two taeniae at the inner wall giving respectively an intervallum coefficient of 0.7 and a radial coefficient of 5.

The outer wall pores are irregular in size and distribution but apparently with two per intertaenial space. The wall is 0.08 millimetre thick with pores 0.1 to 0.2 millimetre in diameter.

The intervallum contains waved taeniae joined at the crests of the waves by synapticulae which are thinnest midway between the taeniae. The pore-rows in the taeniae curve up and out sharply from the inner wall. The arrangement of the synapticulae and taeniae forms a subhexagonal network of skeletal elements in the intervallum. The taeniae are 0.07 millimetre thick and pierced in a few specimens but only rarely.

The inner wall consists of upward slanting pore-tubes arranged in a single row per intertaenial space. The wedge-shaped louvres forming the tubes are 0.2 millimetre long with the average diameter of the tubes about 0.1 millimetre.

Occurrence. Lower Cambrian; GSC locality 75208 (British Columbia).

Discussion. Specimen 25378 is a massive colony with three central cavities surrounded by a single outer wall. Colonial habit amongst the Irregularia has usually not been regarded as being of systematic value, particularly at the generic level. Amongst the Regularia, however, it has been regarded as of generic value (Vologdin, 1937; Hill, 1965); subgeneric value (Debrenne, 1964) and of specific value (Zhuravleva, 1960). For the time being, at least in the Irregularia, I regard the colonial habit of no specific value.

Flindersicyathus cf. F. aenigmatus Rodionova, 1967

Plate XIII, figures 1a, b

Flindersicyathus aenigmatus Rodionova, 1967, p. 95, Pl. 45, figs. 1-5; Pl. 46, figs. 1-5.

Material. Hypotype, GSC No. 25380.

Description. The cup is a cylindro-conical fragment 35 millimetres long with a maximum diameter of 13.1 millimetres. At this diameter the intervallum is 4.2 millimetres wide giving an intervallum coefficient of 0.9. There are forty-five taeniae crossing the intervallum at the maximum diameter.

The outer wall is thin, 0.08 millimetre, and pierced by irregularly arranged pores 0.04 millimetre in diameter.

Synapticulae are abundant but dissepiments are lacking in the intervallum. The taeniae and synapticulae are of equal thickness – 0.04 millimetre.

The pores in the taeniae are about 0.3 millimetre in diameter. In the lower part of the specimen (diameter 11 mm) there are three closely spaced tabulae.

The inner wall, as seen in longitudinal section, consists of short oblique pore-tubes slanting in and up. There is one row of such tubes per intertaenial space. The tubes are 0.1 millimetre in diameter and 0.2 millimetre long. The sides of the tubes are 0.04 millimetre thick. Most of the tubes are slightly "S"-shaped.

Occurrence. Lower Cambrian; GSC locality 75207 (British Columbia); in Siberia, *F. aenigmatus* is known only from the Sanashtykgol horizon.

Discussion. The most unusual feature of this specimen is the presence of the three tabulae in the lower part of the cup and none elsewhere. Bedford and Bedford (1937) described a species of *Flindersicyathus*, *F. tabulatus*, characterized by what they called "growth tabulae" (see my earlier discussion of tabulae). The extremely limited occurrence of tabulae in the Canadian specimen makes them of dubious systematic value.

Lack of good longitudinal sections of the type material prohibits positive identification of my material.

Flindersicyathus sp.

Plate XIII, figure 2

Material. Figured specimen, GSC No. 25381.

Description. This is a cylindrical fragment 11.3 millimetres in diameter with a central cavity of 4.9 millimetres. The intervallum is 3.2 millimetres wide. The intervallum coefficient is 0.6.

The outer wall is thick (0.15 mm) and simply porous. The pores are 0.15 millimetre in diameter and separated by skeletal elements about 0.1 millimetre thick.

The intervallum contains an irregular network of taeniae and synapticulae, each of which is about 0.07 millimetre thick. The pore rows in the taeniae curve up and out from the inner wall. These pores are 0.38 millimetre in diameter. At a diameter of 11.3 millimetres there are approximately forty-five to fifty taeniae.

The inner wall has a single row of oblique pore-tubes per intertaenial space. The pores open upwards into the central cavity. They are 0.38 millimetre in diameter with each tube being about 0.6-0.7 millimetre long. The sides of the tubes are 0.07 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75205 (British Columbia).

Discussion. The taeniae and synapticulae are not so regularly arranged as in other species of *Flindersicyathus*. The inner wall is like that found in *Flindersicyathus* and *Pycnoidocyathus*, the only noteworthy feature being the large size of the pores. In this respect it is perhaps more like *Pycnoidocyathus*.

Genus Protopharetra Bornemann, 1884

Protopharetra Bornemann, 1884, p. 705.

Protopharetra, Debrenne, 1964, p. 213.

Protopharetra, Hill, 1965, p. 127.

Diagnosis. See Debrenne, 1964, p. 213.

Protopharetra sp.

Plate XIII, figures 3a, b

Material. Figured specimen, GSC No. 25382.

Description. This specimen is a conico-cylindrical form with a diameter of 26 millimetres. The intervallum coefficient ranges from 0.75 to 0.8 and the radial coefficient from 1.5 to 2 in the material studied.

The outer wall is relatively thick (0.1 mm) and only sparsely porous. The pores are irregularly arranged in the wall.

The intervallum contains abundant taeniae linked by synapticulae. Dissepiments are present but sporadically developed. The taeniae are waved and joined by synapticulae in a manner similar to that in Flindersicyathus. The taeniae are 0.13 millimetre thick and the pores in them are 0.4 millimetre in diameter. The taeniae and synapticulae thicken slightly when they join.

The inner wall is a simple, porous cylinder containing one row of pores in each intertaenial space. The pores occupy the full width of each space, being about 0.5-0.6 millimetre in diameter. The inner wall is 0.2 millimetre thick.

Occurrence. Lower Cambrian; GSC locality 75206 (British Columbia).

Discussion. Synapticulae are perhaps more abundant in these specimens than in most Protopharetra.

In 1964 Debrenne recognized fourteen species of Protopharetra. I am inclined to allow for more intraspecific variation and suspect the number of true species is smaller.

For this reason I have refrained from erecting a new species for this form. Protopharetra sp. has features in common with P. polymorpha Bornemann and P. bourgini Debrenne.

Protopharetra aff. P. polymorpha Bornemann, 1884

Plate XIII, figure 4

Material. Hypotype, GSC No. 25383 and some unfigured material.

Description. These specimens are colonial or solitary and all with abundant exothecal growths attached to the outer wall. GSC 25383 has a diameter of 4.4 millimetres, the central cavity being 1.0 millimetre in diameter. The intervallum coefficient is 1.7. In the other specimens the intervallum coefficient falls within the range 1.0-2.0.

The nature of the outer wall porosity is not known as it is mostly covered with exothecal lamellae or a nonporous pellis.

The intervallum is filled with an irregular network of taeniae and synapticulae. The taeniae are pierced by rather large pores (0.3 mm). Both the taeniae and synapticulae are 0.08 millimetre thick. Dissepiments are present in the intervallum but vary greatly in abundance from one specimen to the next.

The inner wall is 0.08 millimetre thick. It is simply porous with one or occasionally two pores per intertaenial space.

Occurrence. Lower Cambrian; GSC Locality 73849 (British Columbia). Elsewhere P. polymorpha is known from Sardinia and Antarctica.

Discussion. In the absence of tangential sections, positive identification of this material is impossible. The overall appearance is very similar to that of P. polymorpha from Sardinia.

Genus Pycnoidocyathus Taylor, 1910

Pycnoidocyathus Taylor, 1910, p. 132.

Pycnoidocyathus, Bedford and Bedford, 1939, p. 78.

Pycnoidocyathus, Hill, 1965, p. 128.

Type species. P. synapticulosus Taylor by subsequent designation of Bedford and Bedford (1939); specimens T 1589 A and B in the University of Adelaide collections.

Diagnosis. The outer wall and intervallum have strong periodic contractions and expansions so that the intervallum can vary in width by a factor of three. The intervallum contains abundant, rather straight taeniae that are waved slightly in the radial plane. Synapticulae are abundant and fairly regularly spaced but with no apparent definite pattern. No dissepiments are present. The inner wall consists of short oblique pore-tubes slanted ?upwards.

Occurrence. Lower Cambrian; Australia and Canada.

Discussion. The above diagnosis is based on a re-examination of the holotype of P. synapticulosus. Taylor's description and illustrations point out the salient features. The relatively poor preservation of the outer and inner walls prevents a more thorough analysis of their construction.

The slight waving of the taeniae combined with the abundant regular synapticulae produces an intervallum structure similar to, but not so pronounced as, that in Flindersicyathus. The resulting tube structure is rectangular whereas that in Flindersicyathus is more hexagonal. Taylor recognized the real significance of these prototubes in a statement made on page 133 (1910): "This seems to indicate the way in which the similar perforated horizontal tubes of Syringocnema may have originated." This point is discussed further elsewhere in this paper.

Debrenne (1969) regarded Pyncoidocyathus as a subgenus of Flindersicyathus, on the basis that the only real difference in them was the external shape, Pycnoidocyathus having strong expansions and contractions. As I indicated above the tube structure of the intervallum of Pycnoidocyathus is not so strongly developed as in Flindersicyathus. In any case, if the two are going to be considered as subgenera, then, according to the International Rules of Zoological Nomenclature, article 23c and article 24e, Pycnoidocyathus should be the genus and Flindersicyathus a subgenus, as Flindersicyathus dates only from 1937.

Pycnoidocyathus sekwiensis n. sp.

Plate XIII, figure 5; Plate XIV, figures 1, 2a-c

?Pycnoidocyathus columbianus, Okulitch, 1955, p. 58, Pl. 2, figs. 4-6.

?Pycnoidocyathus amourensis, Kawase and Okulitch, 1957, p. 923, Pl. 112, fig. 1.

?Pycnoidocyathus columbianus, Kawase and Okulitch, 1957, p. 924, Pl. 112, fig. 2.

Pycnoidocyathus spp., Handfield, 1968, p. 8.

Material. Holotype, GSC No. 25384; paratypes, GSC Nos. 25385-25387.

Description. The holotype is a fragment 141 millimetres long and is cylindro-conical in shape. The maximum diameter is 43 millimetres. At a diameter of 36 millimetres the diameter of the central cavity is 12 millimetres giving an intervallum coefficient of 0.75. At 43 millimetres diameter the intervallum coefficient is 0.8. The radial coefficient is 1.5 at a diameter of 36 millimetres.

The outer wall is 0.04 millimetre thick and perforated by simple pores somewhat irregular in size but about 0.08-0.1 millimetre in diameter. The pore arrangement is unknown.

The intervallum contains taeniae and synapticulae, both with a thickness of 0.08 millimetre. The pores of the taeniae are large and nearly square, the sides being close to 0.56 millimetre. The skeletal elements between pores are 0.15 millimetre thick. The pore rows in the taeniae curve up and out from the inner wall. The outer wall and intervallum have periodic expansions and contractions spaced about 8 to 10 millimetres apart.

The thick inner wall (0.76 mm) has one pore per intertaenial wall space. The wall consists of oblique pore-tubes slanted upwards and inwards. The vertical distance between pores is 2.3-3.0 millimetres and the pore diameter is 0.09-0.1 millimetre. The slant length of the pore-tube is variable but about 2.1-2.5 millimetres.

Occurrence. Lower Cambrian; GSC localities 73870, 73871 and 73872 (Northwest Territories).

Discussion. A certain amount of variation exists among the specimens examined, especially the intervallum coefficient, the radial coefficient and the abundance of synapticulae. Among the specimens from locality 73870 the intervallum coefficient varies from 0.6 to 0.9 and the radial coefficient varies from 1.5 to 1.9. Some of this variation is caused by the expansion and contraction of the intervallum and some by the differential growth of the width of the central cavity with respect to the width of the intervallum.

The major difference between P. synapticulosus and P. sekwiensis lies in the inner wall. The pore-tubes of P. sekwiensis are larger in diameter, and longer so that the inner wall is much more obvious than in P. synapticulosus. The taeniae in P. synapticulosus are also a little straighter and more regular than in P. sekwiensis.

There has been considerable confusion in the North American literature over the genera Pycnoidocyathus and Cambrocyathus Okulitch. The latter genus was established by Okulitch (1937) for Archaeocyathus profundus Billings. Subsequently, Okulitch erected several new species of Cambrocyathus, these being C. amourensis (1943), C. orthoconicus (1943), C. dissepimentalis (1943), C. columbianus (1943), C. donaldi (1948) and C. ? septimus (1948). Okulitch (1943) also included Ethmophyllum ceratodictyoides Raymond in the genus Cambrocyathus. Later, he (1950) placed Cambrocyathus in synonomy with Pycnoidocyathus. Zhuravleva (1955, p. 32) pointed out the error of equating Cambrocyathus with Pycnoidocyathus and stated that Cambrocyathus was a synonym of Loculicyathus Vologdin, but she later (1960b) regarded Cambrocyathus as not a synonym of Loculicyathus. Of Okulitch's species listed above, the following are probably true Cambrocyathus: C. loupensis, C. amourensis, C. orthoconicus, and C. dissepimentalis, as well as the type species C. profundus. The others probably belong to Pycnoidocyathus except for C. columbianus. I have made thin sections of the holotype of C. columbianus and find that it has tabulae but it is too poorly preserved to identify accurately.

Since 1950 numerous specimens from the Cordillera have been described as species of Pycnoidocyathus by Okulitch (1955), Kawase and Okulitch (1957) and Greggs (1959). Some of these (see synonomy above) appear to be conspecific with P. sekwiensis while others may be distinct species of either Pycnoidocyathus or Cambrocyathus.

Family Protocyclocyathidae

Genus Fenestrocyathus n. gen.

Type species. Fenestrocyathus complexus n. sp.

Description. This is a large cylindro-conical fossil with the outer wall consisting of a fine, irregular network of skeletal elements forming an irregular screen. The intervallum contains closely spaced, coarsely porous taeniae and abundant regularly spaced synapticulae. Dissepiments are present but not abundant. The inner wall is made up of somewhat "S"-shaped annular rings with a secondary screen on the central cavity side.

Occurrence. Lower Cambrian; GSC locality 73873 (Northwest Territories).

Discussion. The irregular taeniae and lack of tabulae place this genus in the Archaeocyathina in which only one genus with an annulate inner wall is known (Protocyclocyathus Vologdin). Fenestrocyathus differs from Protocyclocyathus by the presence of abundant synapticulae in the intervallum and more closely spaced taeniae. Protocyclocyathus also lacks the secondary screen on the inner wall. The intervallum of Fenestrocyathus is very similar in appearance and construction to the intervallum of Taeniaecyathellus Zhuravleva but this genus lacks annular rings in the inner wall.

Fenestrocyathus complexus n. sp.

Plate XIV, figures 3, 4a, b, 5; Plate XV, figures 1, 2

Material. Holotype, GSC No. 25388; paratypes, GSC Nos. 25389-25391.

Description. The holotype is a cylindrical fragment 18 millimetres long with a diameter of 10.2 millimetres. The intervallum is 3.6 millimetres wide and the central cavity is 3.0 millimetres in diameter. The intervallum coefficient is 1.2.

A thin pellicle envelopes the entire external surface of the specimen. Beneath this pellicle is a porous wall (0.03 mm thick) made up, in part, of the ends of the taeniae and, in part, of a separate skeletal layer. The pores are irregular in size, shape and distribution.

The intervallum, in transverse section, appears as an irregular network of taeniae and synapticulae. It actually consists of coarsely porous waved taeniae in which the pore-rows curve up and out from the inner wall. Regularly arranged synapticulae link the taeniae resulting in a proto-tube construction is much the same manner as in Flindersicyathus. The thickness of the elements in the intervallum is about 0.5 millimetre. The pores in the taeniae are square to rectangular, the maximum size being 0.23 by 0.18 millimetre with the long dimension vertical. The linteaux are 0.07 millimetre thick. A few dissepiments occur in the intervallum.

The inner wall consists of more or less "S"-shaped annular rings spaced about 0.4 millimetre apart vertically. The central cavity edge of the annuli has numerous, closely spaced hair-like projections screening the pore mouth. It is not known whether these projections reach from one ring to the next or are discontinuous. The annular rings are 0.06 millimetre thick and make pore-tubes 0.75-1.0 millimetre long. In the holotype and some of the other specimens (e.g. GSC 25390) some of the dissepiments continue into the central cavity where additional thickened skeletal material of irregular shape and size is attached to the dissepiments. This exothecal material does not occupy the entire central cavity.

Occurrence. Lower Cambrian; GSC locality 73873 (Northwest Territories).

Discussion. Some specimens show very few dissepiments so that the abundance of dissepiments in this genus does not appear to be of specific importance. The nature and categorical value of the material in the central cavity is not known.

It has been generally thought (Zhuravleva, 1960b; Hill, 1965) that an important difference between septa and taeniae is the arrangement of their pores - the pores in septa occurring in divergent rows spreading from the centre of the septa and the pores in taeniae occurring in rows curving up and out from the inner wall. In this species the general arrangement of the pores is in outward curving rows but several rows curve towards the inner wall. As this occurs in more than one specimen it is probably not accidental and may be of considerable significance.

SUBORDER ARCHAEOSYCONINA Zhuravleva, 1955

Family Metacoscinidae Bedford and Bedford, 1934

Genus Claruscoscinus n. gen.

Type species. Claruscyathus billingsi Vologdin.

Description. This is a large, solitary form with a simply porous outer wall. The intervallum has straight radial taeniae resembling septa. The tabulae are convex upward. The inner wall has a single row of oblique pore-tubes per intertaenial space. The pore-tubes extend obliquely up and into the central cavity.

Occurrence. Lower Cambrian; Canada, Siberia and Antarctica.

Discussion. Differs from the type species of Claruscyathus, C. cumfundus, by having much straighter, regular taeniae and pore-tubes.

Claruscoscinus billingsi (Vologdin)

Plate XV, figures 6a, b; Plate XVI, figures 1a-c

Claruscyathus billingsi Vologdin, 1940, p. 48, Pl. 6, figs. 2-4, 7.

Eucyathus obliquus Okulitch, 1948, p. 347, Pl. 55, figs. 4, 5.

Claruscyathus sp., Handfield, 1968, p. 8.

Material. Hypotypes, GSC Nos. 25397, 25398.

Description. These are solitary, cylindrical cups ranging in size to 12.5 millimetres in diameter and up to 50 millimetres or more in length. The width of the intervallum varies in relation to the diameter of the central cavity so that the intervallum coefficient ranges from 0.9 to 1.3. The radial coefficient varies from 3.0 to 4.7.

The outer wall is poorly preserved in most specimens but is seen to consist of several rows of simple pores per intertaenial space. The outer wall is thin (0.03 mm) with pores about 0.02-0.03 millimetre in diameter. Arrangement of the pores is not known.

The intervallum contains taeniae and upwardly convex tabulae. The taeniae are generally quite straight and regular, resembling septa. The thickness of the taeniae varies from 0.05 to 0.1 millimetre. The taenial pores occur in upward and outward curving rows. The pore diameter is 0.1-0.2 millimetre. Some taeniae start at the outer wall and extend only part way across the intervallum.

The tabulae generally have their axis of curvature in the central cavity, although some have it in the intervallum. The tabulae vary in thickness from 0.04-0.08 millimetre. The pores in the tabulae vary in shape, size and arrangement but are generally about 0.09-0.2 millimetre in diameter. The spacing of the tabulae is extremely variable, even within a single specimen.

The inner wall has one pore per intertaenial space consisting of an oblique pore-tube slanted up and in to the central cavity. The shape of the pore-tubes varies from straight to slightly "S"-shaped. The diameter of the pore-tubes is 0.25-0.3 millimetre while the length of the tubes is 0.35-0.5 millimetre. The tube elements are spaced 0.4-0.5 millimetre apart vertically resulting in one to three pores per intertabulum.

Occurrence. Lower Cambrian; GSC localities 73870, 73871 (Northwest Territories) and 75205 (British Columbia).

Discussion. The extreme variability of the spacing of the tabulae is one of the most interesting aspects of this species. The possibility of this irregular spacing representing rhythmic growth is discussed elsewhere in this paper.

A graph of total diameter plotted against intervallum coefficient shows the I_k to vary inversely with the diameter so care must be used to compare total diameter as well as the intervallum coefficient.

Eucyathus obliquus Okulitch from the Dogtooth Mountains of British Columbia appears to be conspecific with C. billingsi, although Okulitch stated that dissepiments and synapticulae are present in the Dogtooth specimen.

Genus Pycnoidocoscinus Bedford and Bedford, 1936

Pycnoidocoscinus Bedford and Bedford, 1936, p. 19.

Pycnoidocoscinus, Debrenne, 1969, p. 367.

Pycnoidocoscinus sp.

Plate XVI, figures 2a, b

Material. Figured specimen, GSC No. 25399.

Description. This specimen is a very large cylindro-conical cup with a length exceeding 100 millimetres and a maximum diameter of approximately 30 millimetres. At this diameter the central cavity is 15 millimetres in diameter.

The outer wall and intervallum have strong transverse corrugations like Pycnoidocyathus. This causes the total diameter to vary considerably but the diameter of the central cavity is not affected. The outer wall is not preserved.

The intervallum is a complex mesh of taeniae and synapticulae. Convex tabulae also are present in the intervallum. The taeniae are rather straight with only an occasional curve up and out near the outer wall but near the inner wall some run vertically or curve towards the inner wall. The pores are 0.3 millimetre in diameter and the linteaux are 0.15 millimetre thick.

The synapticulae are about the same thickness as the taeniae (0.10 mm) and very abundant. The synapticulae and taeniae thicken where they join so that the corners are rounded.

The convex tabulae have their centre of curvature in the intervallum. They are very irregularly spaced, intertabular distances ranging from 0.8 millimetre to 3.2 millimetres. The tabulae are thin (0.05 mm) and have irregularly distributed and irregularly shaped pores.

The inner wall is a simply porous screen formed by synapticulae and the ends of the taeniae. The pores are 0.30-0.4 millimetre in diameter but may be elongated longitudinally. No louvres are present to form pore-tubes as in *Pycnoidocyathus* and *Flindersicyathus*.

Occurrence. Lower Cambrian; GSC locality 68958 (Yukon Territory); elsewhere *Pycnoidocoscinus* is known only from Australia.

Discussion. The corrugated intervallum, tabulae and simple inner wall are characteristic of *Pycnoidocoscinus*. The irregular spacing of the tabulae suggests this specimen is not conspecific with *P. pycnoideum* which has more regularly spaced tabulae. The tabulae are also thicker in *P. pycnoideum*.

A small individual attached to this specimen apparently has arisen by budding.

ORDER SYRINGOCNEMATIDA TAYLOR, 1910

Family Syringocnematidae Taylor, 1910

Genus *Pseudosyringocnema* n. gen.

Type species. *Pseudosyringocnema uniporus* n. sp.

Description. The cups may be solitary or colonial with the intervallum containing hexagonal tubules. The tubule sides have only a single row of pores. The inner wall has oblique, "S"-shaped pore-tubes, two or three per tubule in vertical arrangement.

Occurrence. Lower Cambrian; Yukon Territory.

Discussion. This genus differs from *Flindersicyathus* in having true tubules in the intervallum and also in the construction of the inner wall. Both *Flindersicyathus* and *Syringocnema* have only a single pore-tube per tubule in longitudinal section. The sides of the tubules in *Syringocnema* have two or three rows of small pores rather than one. The construction of these tubules lends credence to the idea that *Syringocnema* and *Flindersicyathus* are rather more similar than has been indicated.

Pseudosyringocnema uniporus n. sp.

Plate XV, figures 3a-c, 4, 5

Material. Holotype, GSC No. 25392; paratypes, GSC Nos. 25393-25396.

Description. These specimens are all cylindrical; some solitary and some colonial. The largest specimen (GSC 25396) is 12.0 millimetres in diameter. The holotype is 9.7 millimetres in diameter with an intervallum of 2.0 millimetres wide. The intervallum coefficient is 0.7. Most of the other specimens are less than 7 millimetres diameter.

The outer wall is poorly understood but in places apparently very irregular. There is some suggestion that each tubule is covered by a single pore in a tumular-like structure similar to the outer wall of Syringocnema. This would account for its irregular appearance. The outer wall is generally poorly preserved.

The intervallum is crossed by hexagonal tubules which leave the inner wall at about a 45 degree angle upwards and then flatten out to nearly horizontal. The tubules, when viewed in a longitudinal tangential section are generally slightly elongated in a vertical direction, their longest dimension being 0.3-0.5 millimetre. Their shorter dimension is 0.3-0.4 millimetre. The tubules appear solid as in Syringocnema rather than retiform as in Flindersicyathus. Each side of a tubule is pierced by a single row of pores about 0.1-0.15 millimetre in diameter. The pores are separated by skeletal elements 0.15-0.2 millimetre thick.

The inner wall consists of upward slanting pore-tubes. There is a single row of pores per tubule when viewed in transverse section but two or three per tubule in vertical section. The pores are oval shaped, being 0.3 by 0.15 millimetre. The inner wall is 0.2-0.25 millimetre thick. The "S"-shaped tube elements are widge-shaped, being about twice as thick on the intervallum end.

Occurrence. Lower Cambrian; GSC localities 68955, 68956 and 73840 (Yukon Territory).

Plates I - XVI

Plate I

Figure 1. Archaeocyathids and a fragment of an olenellid trilobite from locality 68955, x1.

Epiphyton sp.

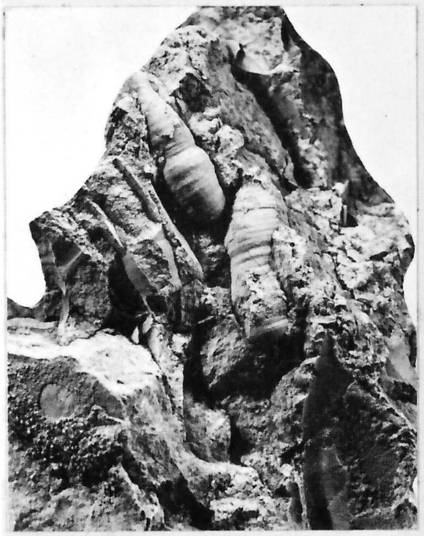
Figure 2. Longitudinal section of figured specimen 25400, from locality 74845, x14.

Figure 3. Transverse section of figured specimen 25401, from locality 75208, x9.

Renalcis sp.

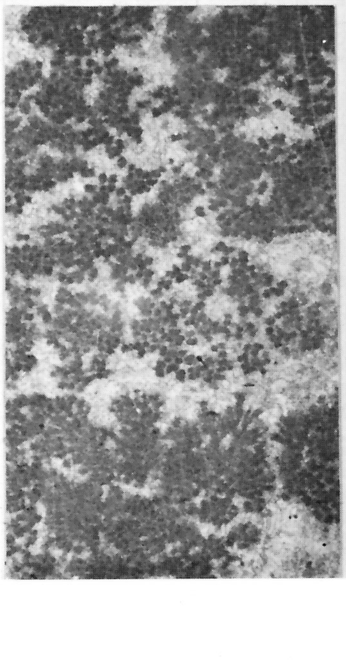
Figure 4. Figured specimen 25402, from locality 73873, x18.

PLATE I



1

2



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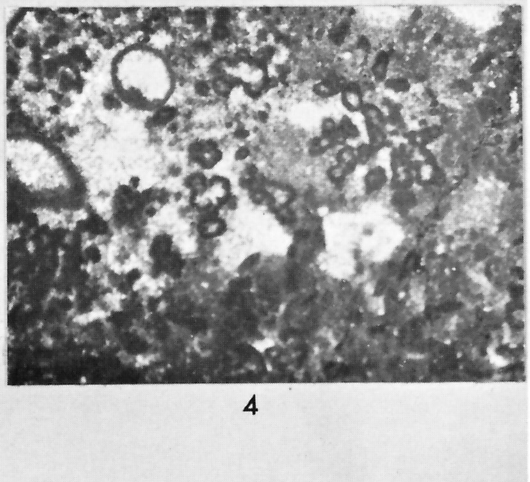


4

Plate II

Tumuliolynthus (Propriolynthus) vologdini (Yakovlev) (Page 30)

Figure 1. Longitudinal section of hypotype 25312 from locality 73873, x8.

Figure 2. Oblique transverse section of hypotype 25313 from locality 73873, x8.

Acanthopyrgus yukonensis Handfield (page 32)

Figure 3. Longitudinal section tangential to inner wall of topotype 25314 from locality 74845, x5.

Figures 4a-c. Topotype 25315 from locality 74845; 4a, transverse section, x6.5; 4b, enlarged detail of part of 4a, x16; 4c, enlarged detail of part of 4a, x14.

Kaltatocyathus rozanovi n. sp. (Page 33)

Figure 9. Transverse section of holotype 25321 from locality 68957, x10.

Sekwicyathus nahanniensis n. gen. et n. sp. (Page 34)
(all from locality 74873)

Figure 5. Oblique longitudinal section of holotype 25317, x14.4.

Figure 6. Transverse section of paratype 25318, x14.5.

Figure 7. Oblique longitudinal section of paratype 25319, x12.

Figure 8. Transverse section of paratype 25320, x11.5.

PLATE II

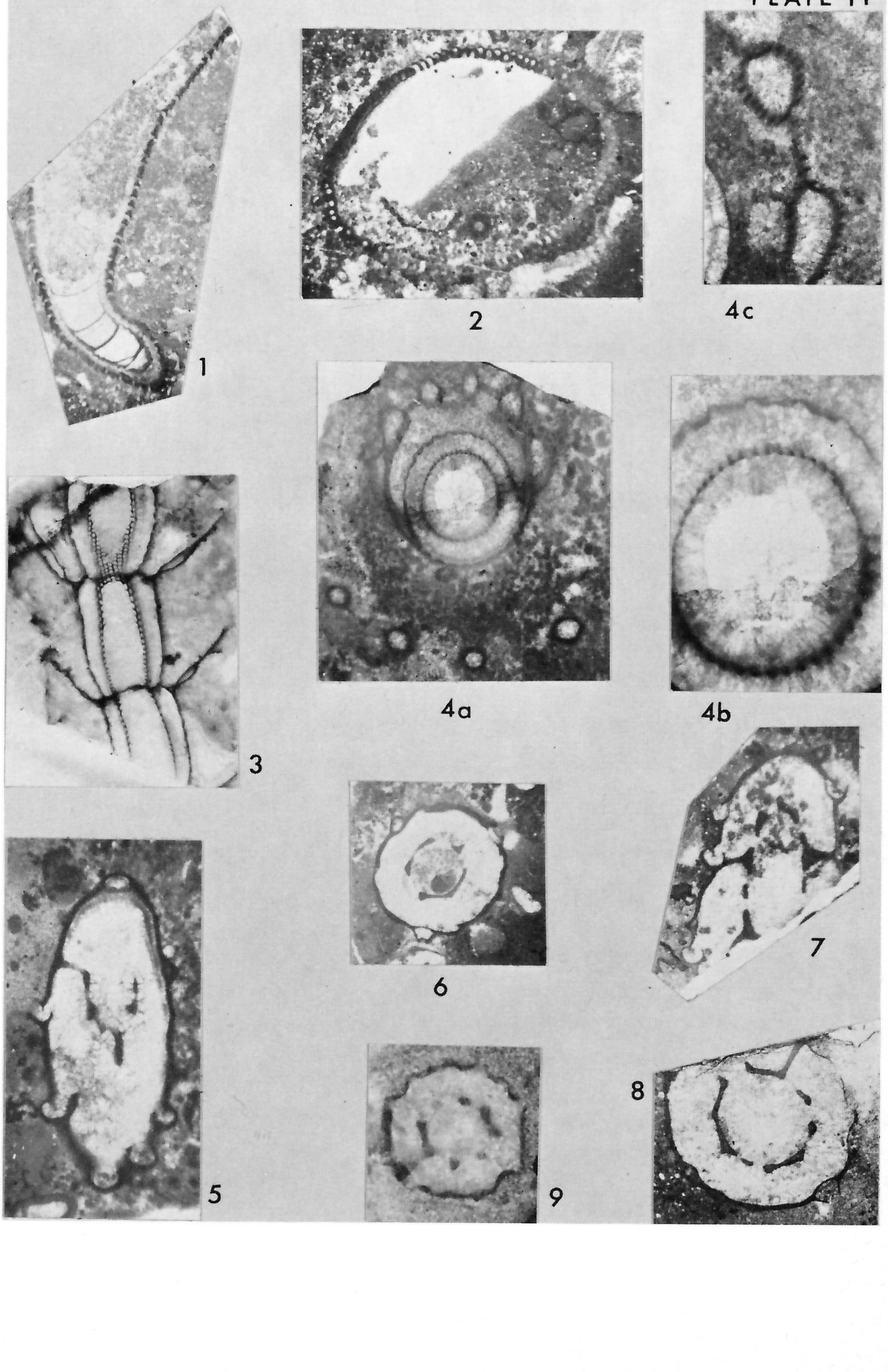


Plate III

Ajacicyathus aff. A. crassus Debrenne (Page 36)

Figures 1a-c. Hypotype 25323 from locality 75206; 1a, tangential section of outer wall, x4.2; 1b, longitudinal section, inner wall to left, x4.3; 1c, transverse section, outer wall at top, x4.7.

Ajacicyathus yukonensis Kawase and Okulitch (Page 37)

Figures 2a, b. Hypotype 25324 from locality 75205; 2a, transverse section, x3; 2b, oblique longitudinal section, x3.5.

Figure 3. Transverse section of hypotype 25325 from locality 75205, x6.

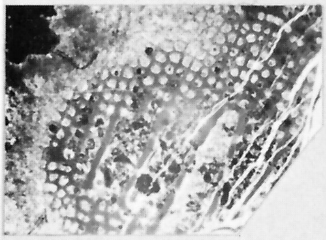
Ajacicyathus yukonensis? Kawase and Okulitch (Page 37)

Figures 4a, b. Hypotype 25326 from locality 75205; 4a, transverse section, x2.3; 4b, oblique longitudinal section, x3.

Loculicyathus canadensis n. sp. (Page 39)

Figures 5a-d. Holotype 25327 from locality 68957; 5a, transverse section, wall A at the top, x4; 5b, longitudinal section, wall A on the left, x3.5; 5c, tangential section of wall A, x4.5; 5d, tangential section of wall B, x4; note division of wall B into lighter and darker halves.

PLATE III



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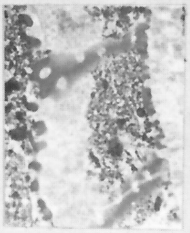

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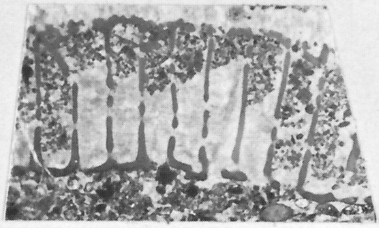

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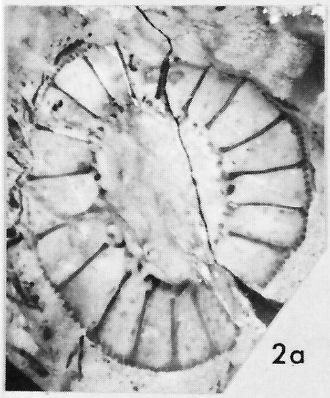
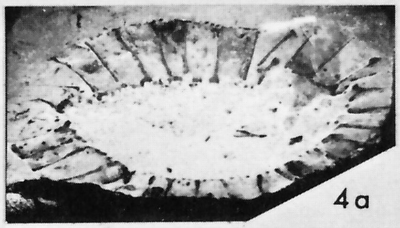


2a

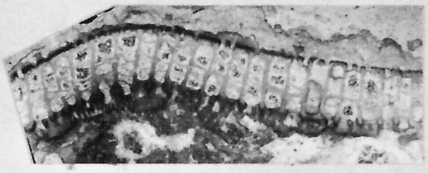
2b

4b

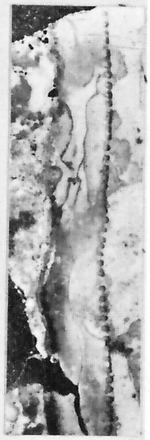


4a

3

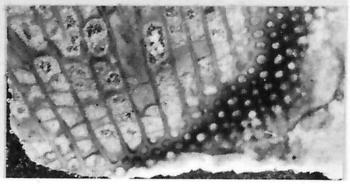


5a



5b

5c



5d

Plate IV

Robustocyathus aff. R. peluduicus Zhuravleva (Page 40)

Figures 1a, b. Hypotype 25328 from locality 75208; 1a, transverse section, x7.5; 1b, longitudinal section, x6.

Figure 2. Transverse section of hypotype 25329 from locality 75208, x12.

Figure 3. Transverse section of a spitz, hypotype 25330 from locality 75208, x32.

Figure 4. Transverse section of hypotype 25331 from locality 73848, x5.

Ethmophyllum cf. E. whitneyi Meek (Page 42)

Figure 5. Transverse section of hypotype 25332 from locality 75209, x5.

Figures 6a-d. Hypotype 25333 from locality 75207; 6a, transverse section, x3; 6b, longitudinal section, inner wall to left, x4; 6c, detail of outer wall from 6b, x13.4; 6d, detail of inner wall from 6b, x9.

PLATE IV

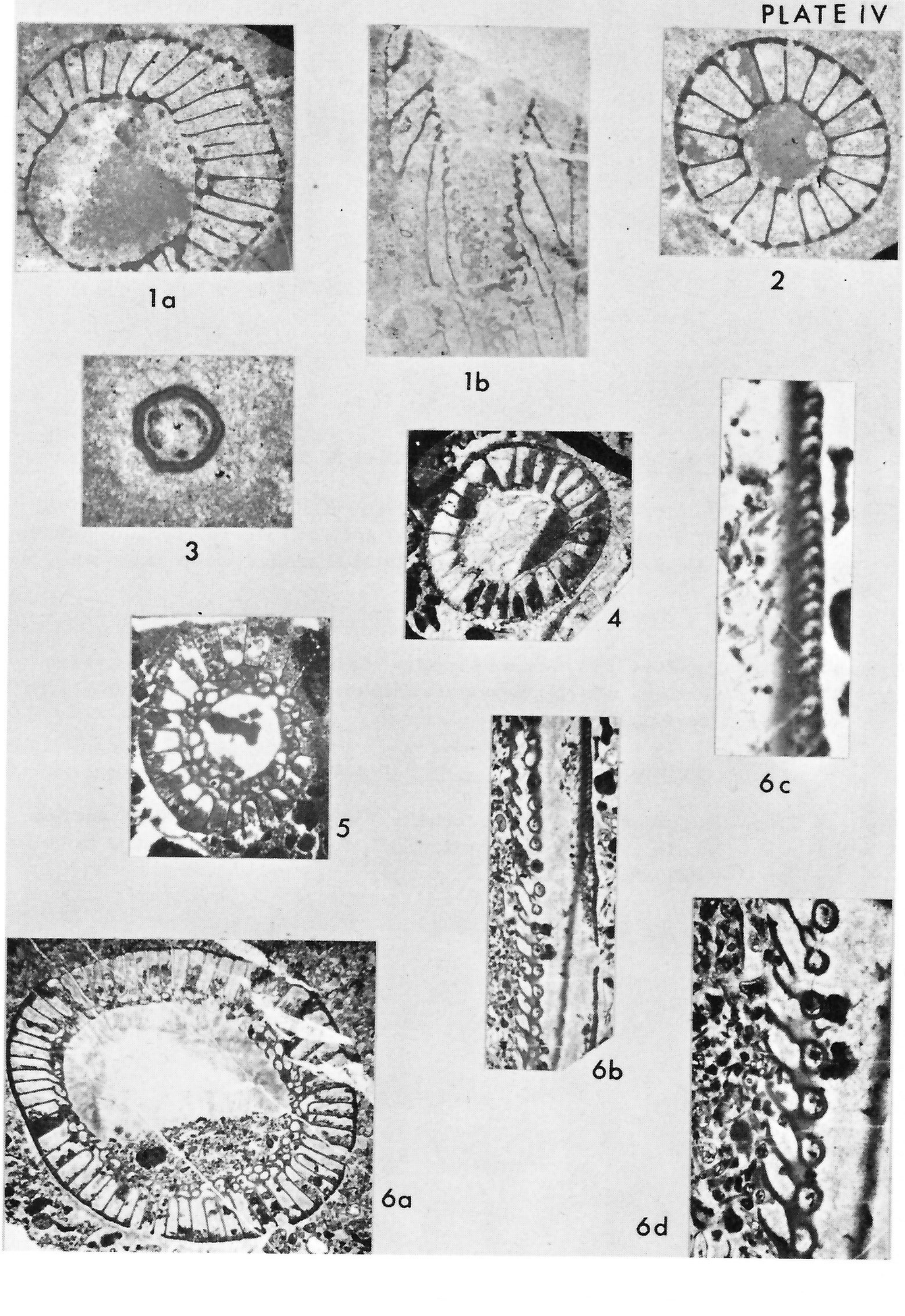


Plate V

Mackenziecyathus bukryi n. gen. et n. sp. (Page 44)

Figures 1a-d. Holotype 25334 from locality 68955; 1a, transverse section, x4.3; 1b, median longitudinal section, x4; 1c, section tangential to outer wall, x10; 1d, section tangential to inner wall, x3.

Gordonicyathus dorfi n. sp. (Page 41)

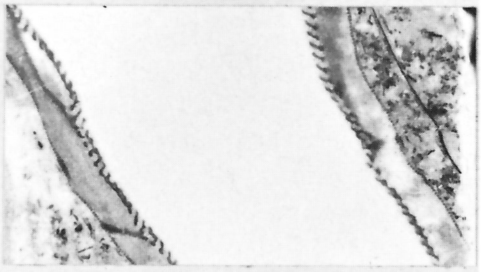
Figures 2a-c. Holotype 25335 from locality 73873; 2a, oblique transverse section, x4; 2b, retouched duplicate of 2a, x4; 2c, longitudinal section, x6.

Palmericyathus lineatus (Greggs) (Page 46)

Figures 3a-c. Hypotype 25336 from locality 73871; 3a, longitudinal section, x8; 3b, transverse section, x7; 3c, section tangential to outer wall, x10.

PLATE V

1a



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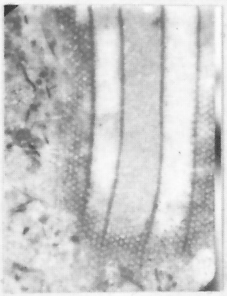

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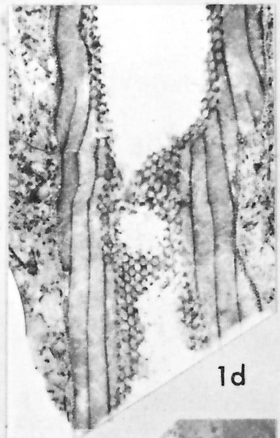
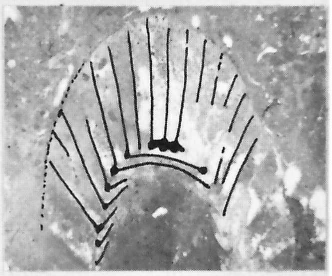


1d

2a



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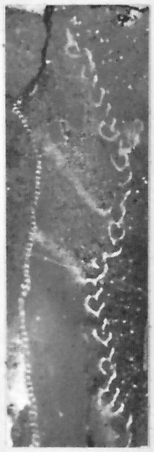
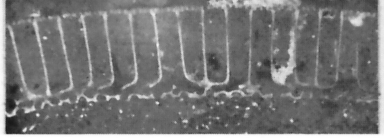


3a

2c



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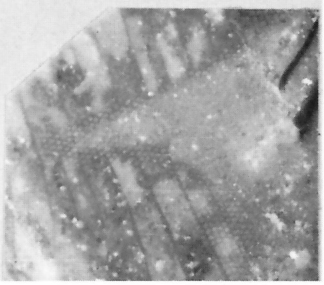


3c

Plate VI

Zonacyathus borealis n. sp. (Page 47)

Figures 1a-c. Holotype 25337 from locality 68955; 1a, longitudinal section, x3.5; 1b, transverse section, x7; 1c, top of cup showing outer wall covering the intervallum, x10.

Figures 2a,b. Paratype 25339 from locality 73873; 2a, longitudinal section, x2.3; 2b, detail of part of 2a, x6.4.

Zonacyathus princetonensis n. sp. (Page 48)
(all from locality 75207)

Figure 3. Section tangential to inner wall of paratype 25341, x8.

Figure 4. Oblique transverse section of paratype 25342, x3.5.

Figure 5. Transverse section of holotype 25340, x5.

Figure 6. Transverse section of paratype 25343, x6.

PLATE VI

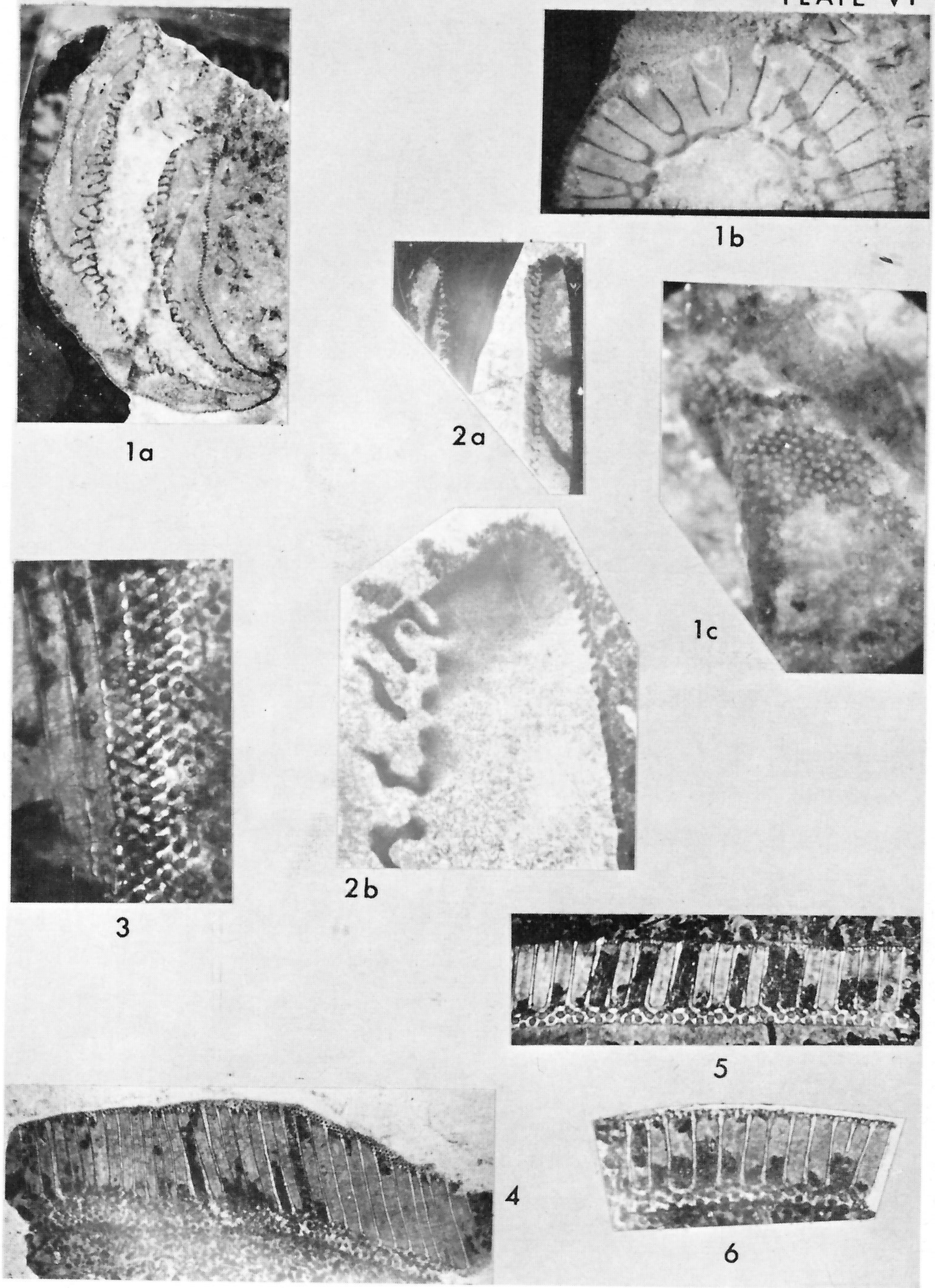


Plate VII

?Porocyathus sp. (Page 49)

Figures 1a, b. Figured specimen 25344 from locality 74840; 1a, transverse section, x5.4; 1b, longitudinal section tangential to inner wall, x6.

Cordilleracyathus blussoni n. gen. et n. sp. (Page 50)

Figure 2. Oblique section tangential to outer and inner walls of holotype 25345 from locality 74873, x13.3.

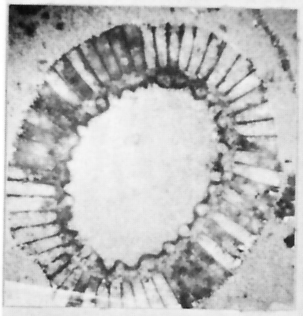
Figure 3. Oblique section of paratype 25346 from locality 73873, x2.4.

Figures 4a, b. Paratype 25347 from locality 73873; 4a, longitudinal section, inner wall on left, x7; 4b, enlargement of part of 4a, x20.

Figure 5. Section tangential to inner wall of paratype 25349 from locality 73870, x10.

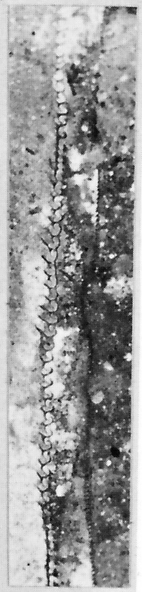
Figure 6. Transverse section of paratype 25348 from locality 73873, x7.6.

PLATE VII

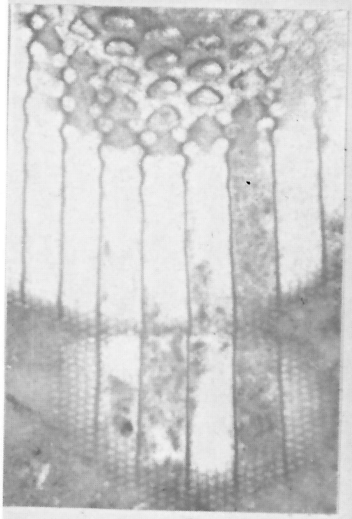


1a

1b



4a



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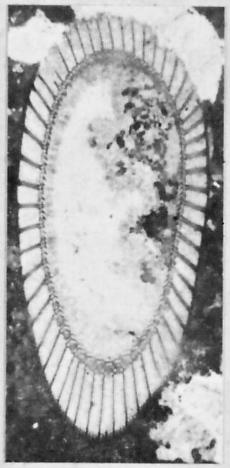

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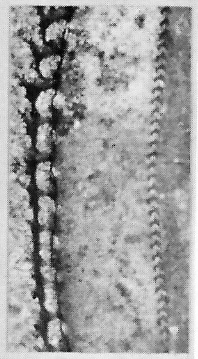


4b

5

6

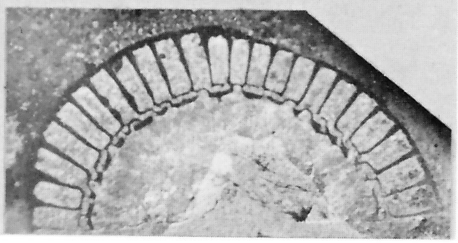


Plate VIII

Yukonocyathus francesi n. gen. et n. sp. (Page 51)

Figures 1a-c. Holotype 25351 from locality 74845; 1a, transverse section, x5; 1b, longitudinal section, outer wall to left, x6; 2c, transverse section at younger stage of same specimen, x8.

Figures 2a, b. Paratype 25352 from locality 68957; 2a, transverse section, x5; 2b, longitudinal section, x3.5.

Ladaecyathus fischeri n. sp. (Page 54)

Figures 3a-e. Holotype 25354 from locality 68957; 3a, section tangential to outer wall, x3; 3b, section tangential to inner wall, x3; 3c, transverse section near apex, x2; 3d, longitudinal section tangential to a septum, x3; 3e, transverse section distant from apex, x4.

PLATE VIII

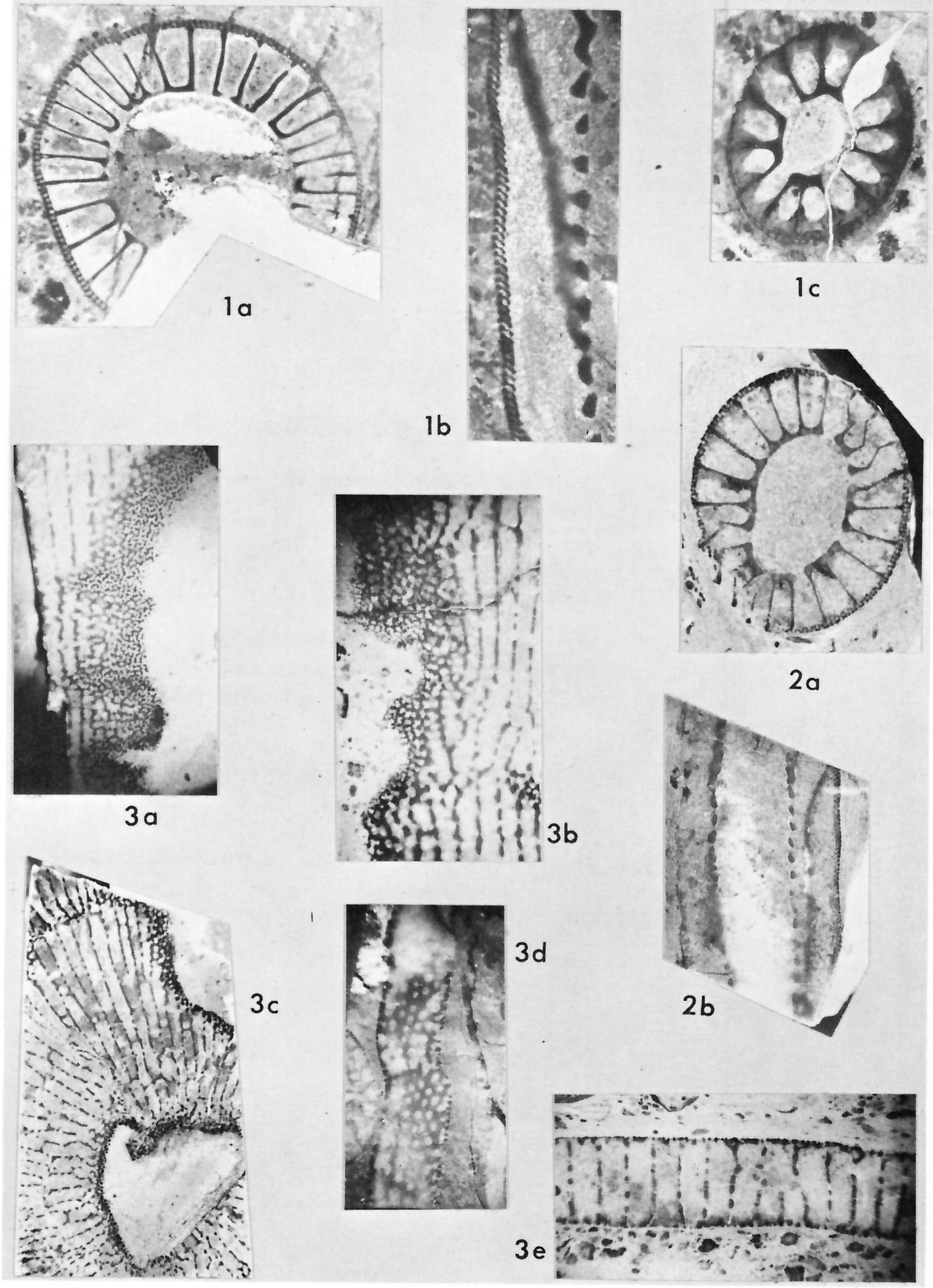


Plate IX

<u>Ladaecyathus</u> aff. <u>L.</u> <u>fischeri</u> n. sp. (Page 55)

Figures 1a, b. Hypotype 25356 from locality 75206; 1a, transverse section, x2; 1b, detail of outer wall, x18.

<u>Coscinocyathus</u> <u>fritzi</u> n. sp. (Page 57)
(all from locality 73872 except Fig. 4)

Figures 2a, b. Holotype 25357; 2a, longitudinal section, central cavity on left, approximate position of outer wall shown by dotted line, x6.5; 2b, detail of lower part of 2a, showing pores in septum, x20.

Figure 3. Detail of inner wall of paratype 25358, central cavity on right, x9.

Figure 4. Transverse section of paratype 25360, from locality 73871, x3.

Figure 5. Section tangential to inner wall of paratype 25359, x13.

PLATE IX

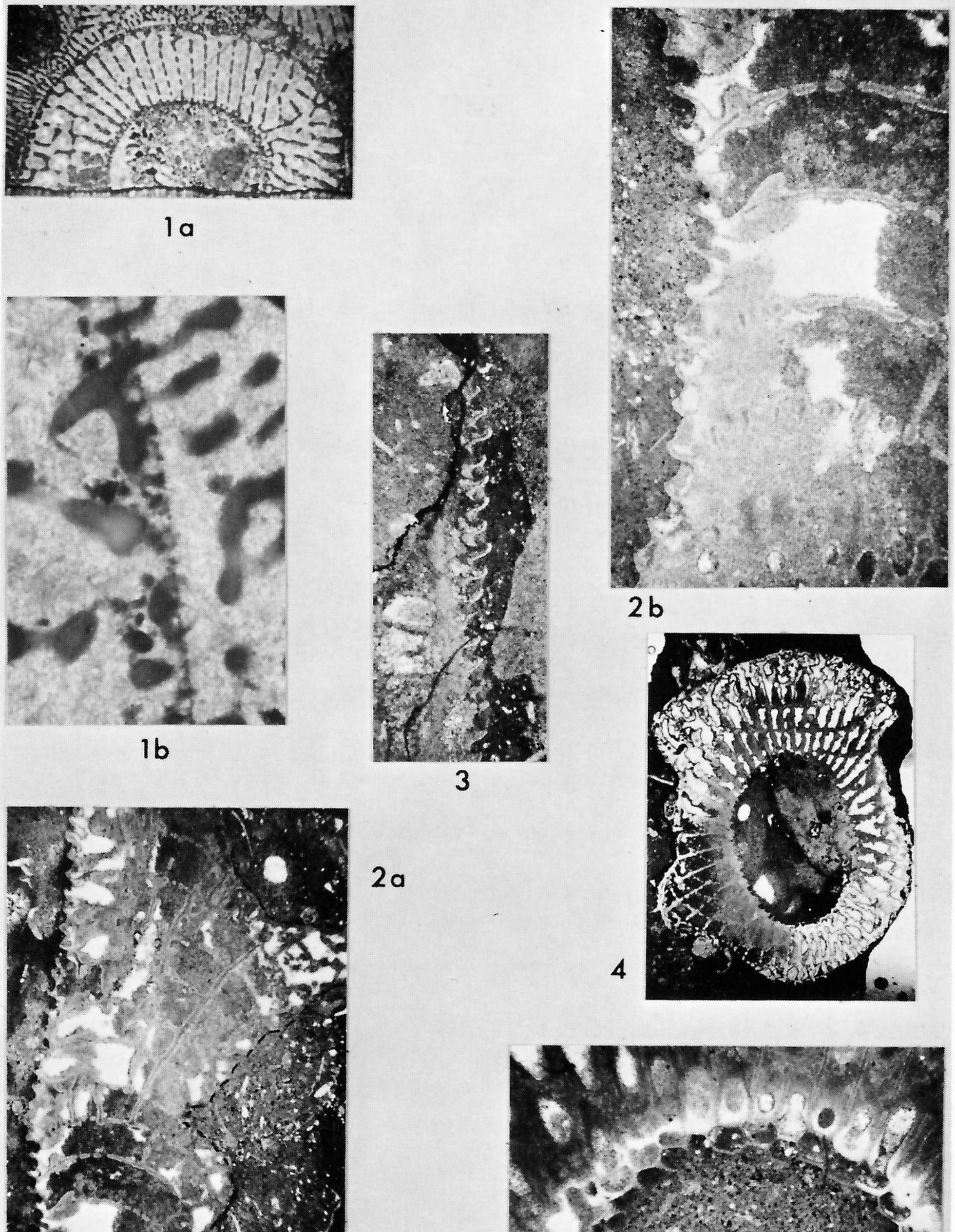


Plate X

Coscinocyathus aff. C. fritzi n. sp. (Page 58)

Figures 1a,b. Hypotype 25361 from locality 75205; 1a, longitudinal section, central cavity on right, x3.5; 1b, detail of part of 1a, x5.5.

Coscinocyathus cf. C. multiporus Kawase and Okulitch (Page 59)

Figures 6a,b. Hypotype 25362 from locality 75205; 6a, longitudinal section, x4.5; 6b, transverse section, x4.5.

Erismacoscinus cf. E. tubicornus (Kawase and Okulitch) (Page 62)

Figure 2. Transverse section of hypotype 25364 from locality 75205, x4.

Erismacoscinus? uniporus n. sp. (Page 62)

Figures 3a,b. Holotype 25363 from locality 75205; 3a, transverse section, x25; 3b, longitudinal section, central cavity to left, x3.

Genus A sp. (Page 56)

Figures 4a,b. Figured specimen 25366 from locality 75206; 4a, transverse section, x3; 4b, longitudinal section, x3.3.

Genus B sp. (Page 63)

Figure 5. Oblique longitudinal section of figured specimen 25365 from locality 74845, x3.4 (the dark lines running through the upper part of the specimen are fractures, not tabulae).

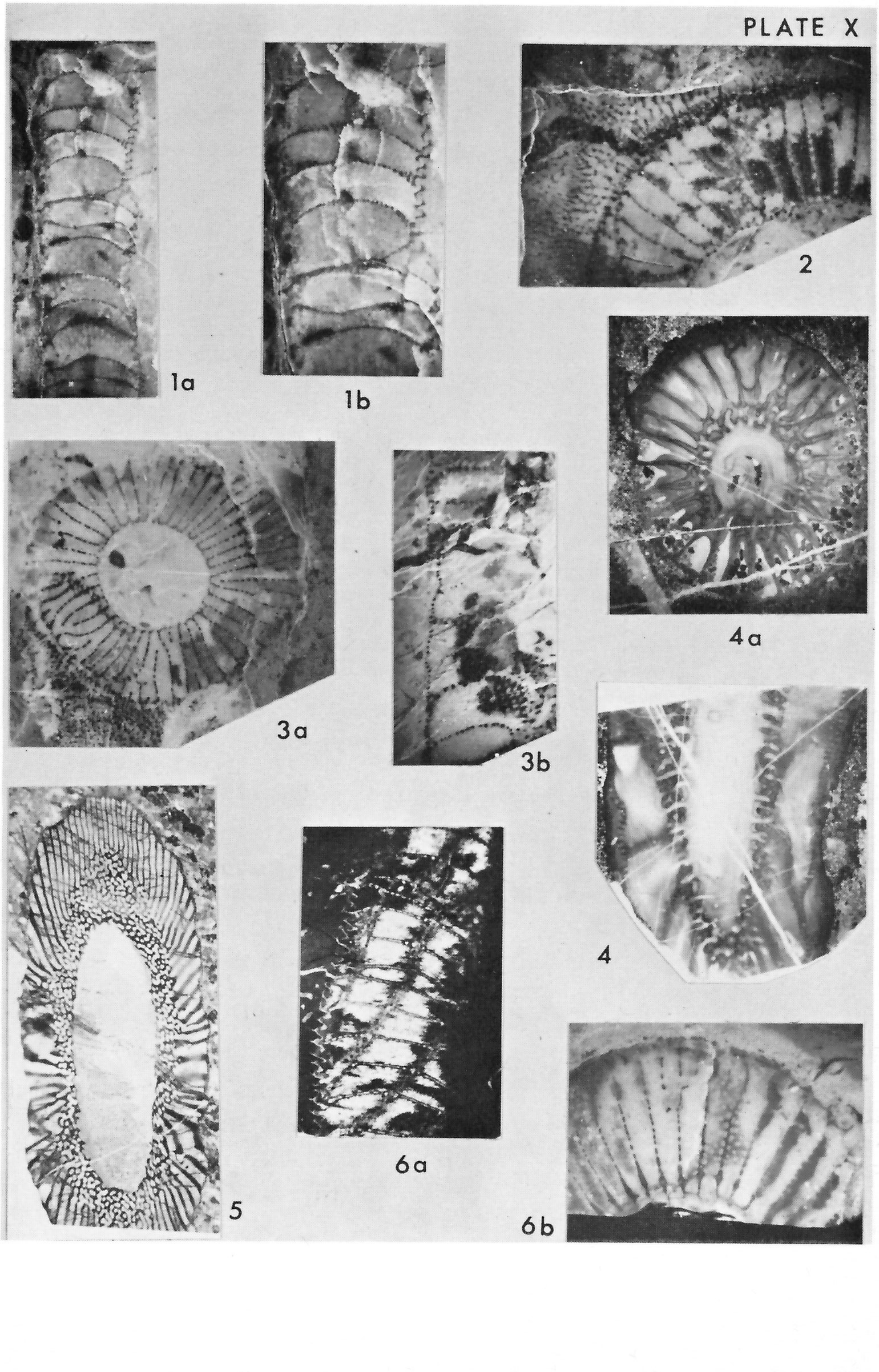


PLATE X
1a
1b
2
4a
3a
3b
4
5
6a
6b

Plate XI

<u>Metaldetes</u> ? <u>cariboensis</u> n. sp. (Page 64)
(all from locality 73870)

Figure 1. Oblique section of paratype 25368, x3.8.

Figures 2a-c. Holotype 25367; 2a, transverse section, x4; 2b, longitudinal section, x3.7; 2c, retouched duplicate of 2b, x3.7.

Figures 3a, b. Paratype 25369; 3a, longitudinal section showing irregular "growth tabulae", transmitted light, x2.5; 3b, the same in reflected light, x2.5.

? <u>Cambrocyathus</u> sp. (Page 65)

Figure 4. Transverse section of figured specimen 25371 from locality 75208, x2.5.

Figure 5. Transverse section of figured specimen 25372 from locality 75208, x3.3; note exothecal growth and dissepiments.

PLATE XI

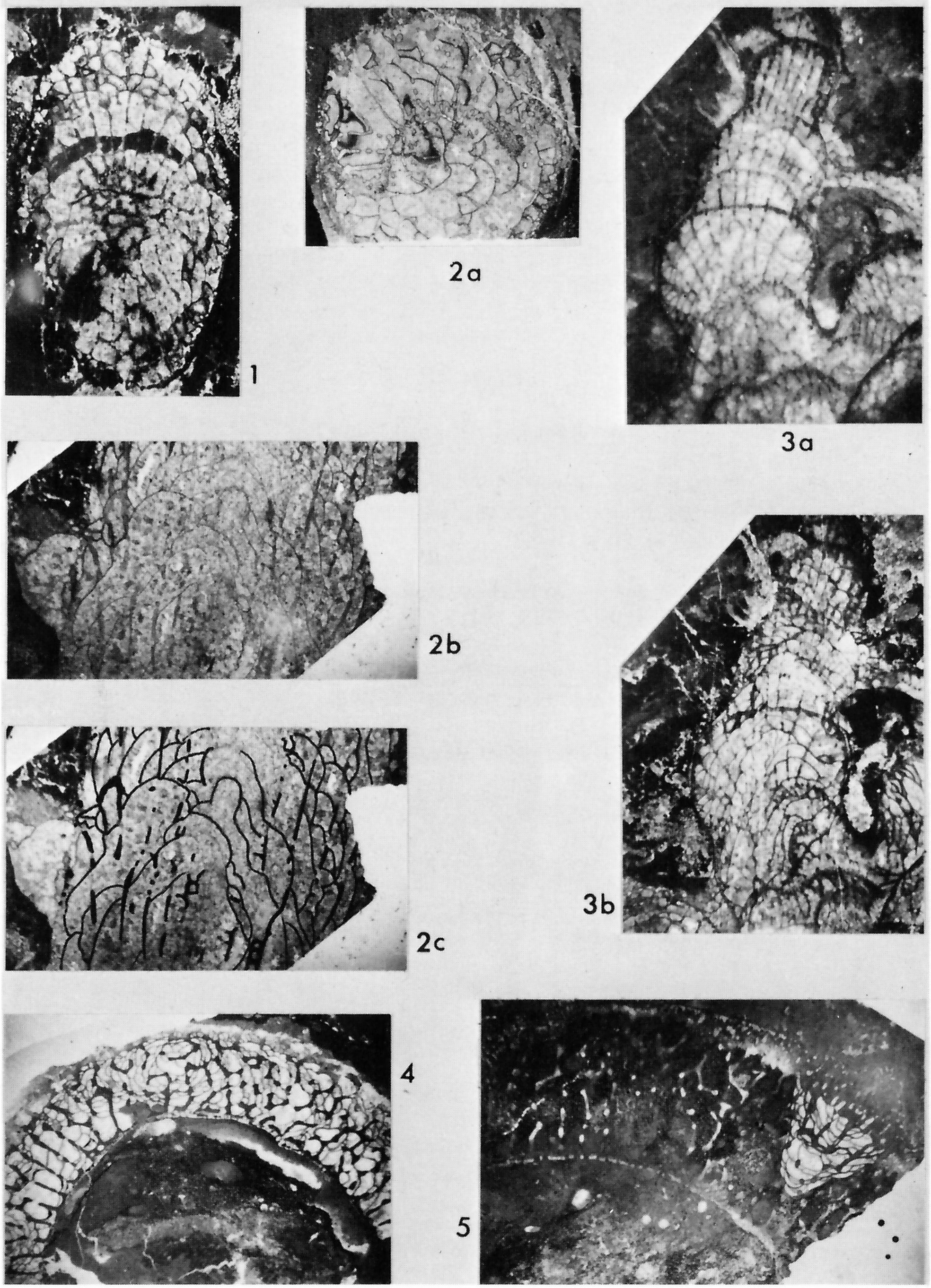


Plate XII

?*Cambrocyathus* sp. (Page 65)

Figures 1a, b. Figured specimen 25373 from locality 75208; 1a, transverse section (negative print), x2; 1b, longitudinal section, central cavity to right, x3.

Figure 5. Transverse section (negative print) of figured specimen 25374 from locality 75212, x1.8.

Flindersicyathus mcdamensis n. sp. (Page 67)
(all from locality 75208)

Figure 2. Longitudinal section of paratype 25376, x5.5.

Figure 3. Longitudinal section of paratype 25377, x5.

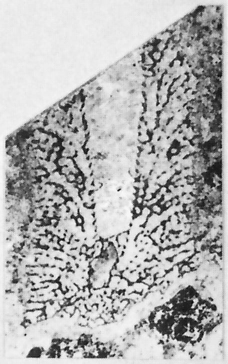
Figure 4. Transverse section of paratype 25378, x3.9.

Figures 6a, b. Holotype 25375; 6a, transverse section, x5.6; 6b, longitudinal section, x5.4.

PLATE XII

1a

1b



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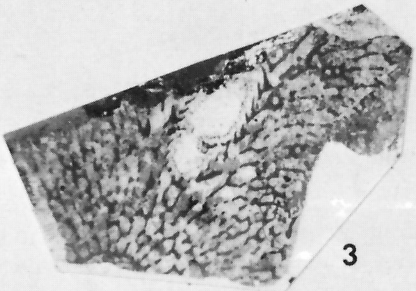

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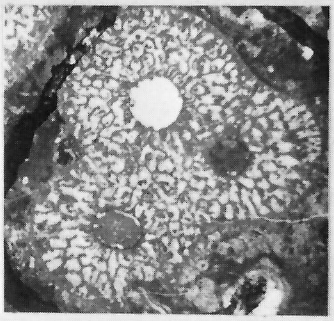

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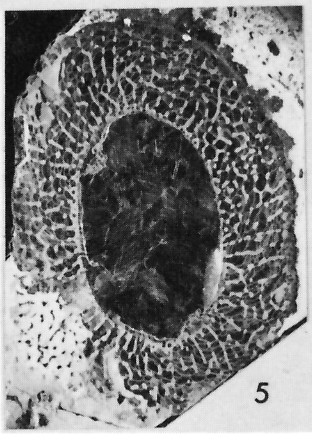

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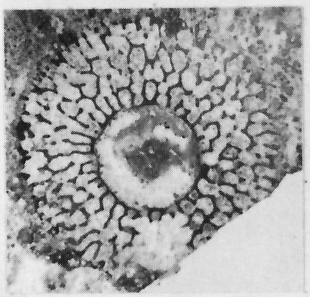
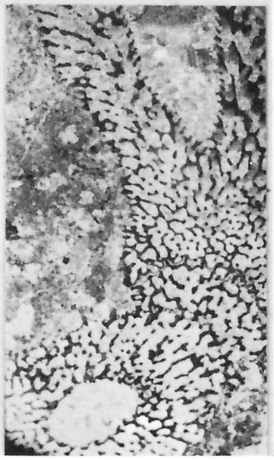


6a



6b

Plate XIII

Flindersicyathus cf. F. aenigmatus Rodionova (Page 67)

Figures 1a, b. Hypotype 25380 from locality 75207; 1a, transverse section, x3.4; 1b, longitudinal section, x2.6.

Flindersicyathus sp. (Page 68)

Figure 2. Longitudinal section of figured specimen 25381 from locality 75205, x2.2.

Protopharetra sp. (Page 69)

Figures 3a, b. Figured specimen 25382 from locality 75206; 3a, longitudinal section, central cavity to the right, x2.2; 3b, transverse section, x2.5.

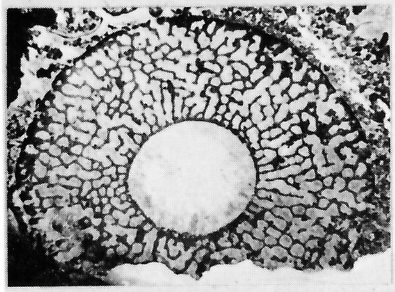
Protopharetra aff. P. polymorpha Bornemann (Page 69)

Figure 4. Longitudinal section of hypotype 25383 from locality 73849, x2.7.

Pycnoidocyathus sekwiensis n. sp. (Page 71)

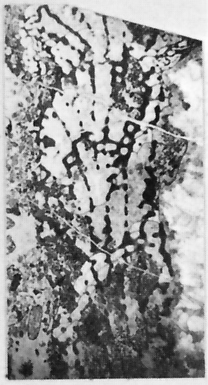
Figure 5. Transverse section of holotype 25384 from locality 73870, x1.8.

PLATE XIII



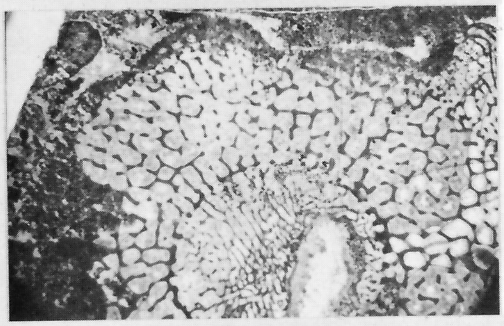
1a

2



3a

1b



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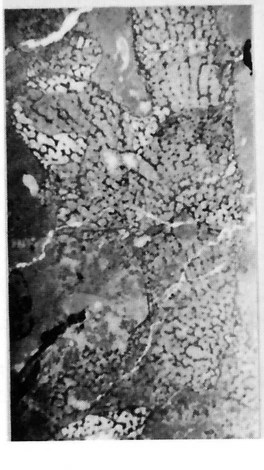

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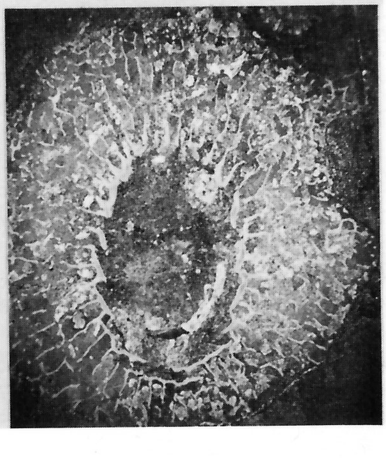

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Plate XIV

Pycnoidocyathus sekwiensis n. sp. (Page 71)

Figure 1. Transverse section of paratype 25385 from locality 73870, x1.4.

Figures 2a-c. Holotype 25384 from locality 73870; 2a, median longitudinal section, x1.3; 2b, detail of part of 2a, x3; 2c, longitudinal section tangential to inner wall, x1.3.

Fenestrocyathus complexus n. gen. et n. sp. (Page 73)

Figure 3. Longitudinal section tangential to inner wall of paratype 25389 from locality 73873, x6.5.

Figures 4a-b. Paratype 25390 from locality 73873; 4a, longitudinal section, x3; 4b, detail of lower part of 4a, x15.

Figure 5. Transverse section of holotype 25388 from locality 73873, x4.

PLATE XIV

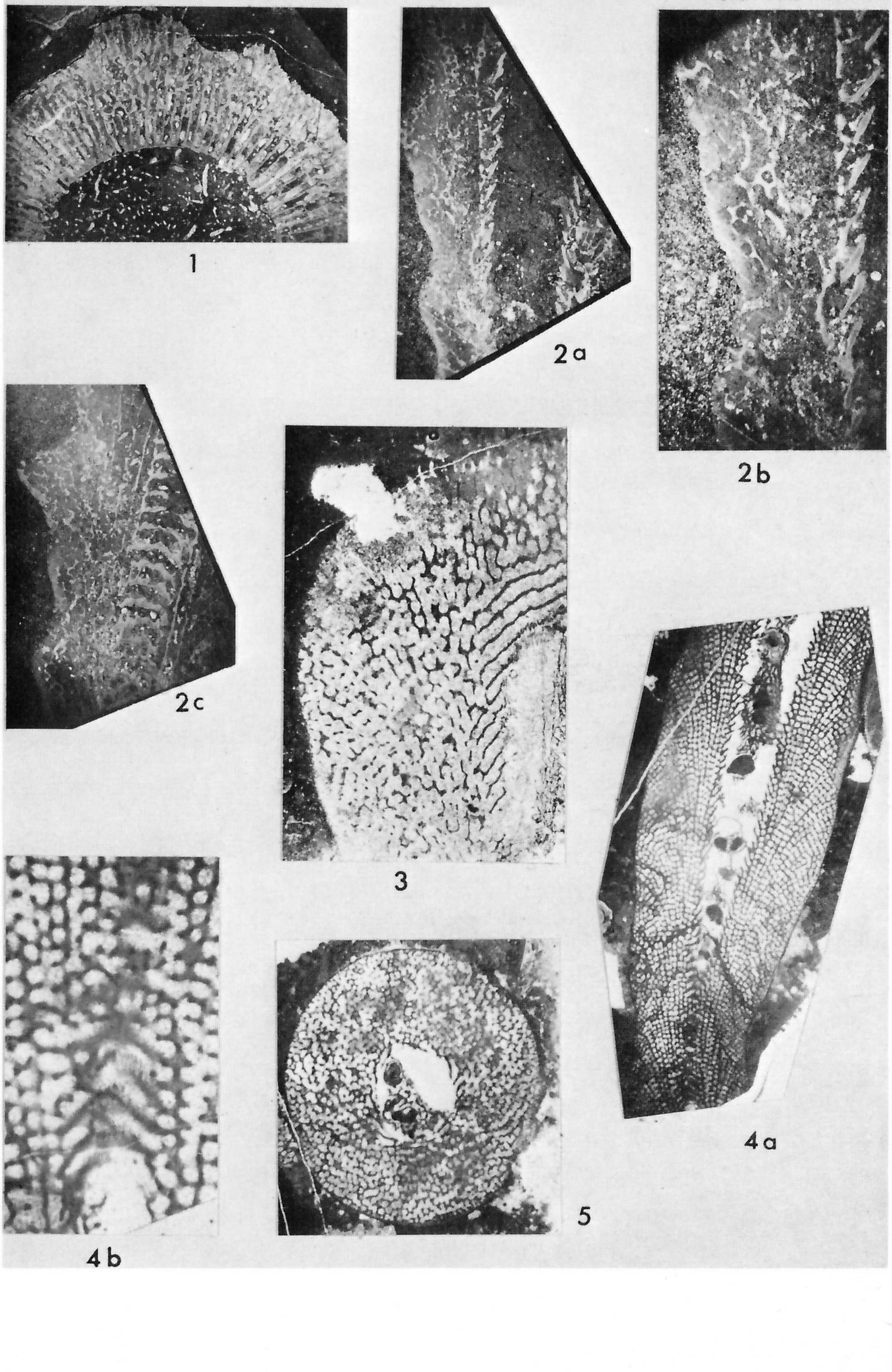


Plate XV

Fenestrocyathus complexus n. gen. et n. sp. (Page 73)

Figure 1. Median longitudinal section of holotype 25388 from locality 73873, x4.3.

Figure 2. Oblique section of paratype 25391 from locality 73873, x4.

Pseudosyringocnema uniporus n. gen. et n. sp. (Page 76)

Figures 3a-c. Holotype 25392 from locality 68956; 3a, oblique section tangential to inner wall, x4; 3b, median longitudinal section, x3; 3c, detail of part of 3b, x6.

Figure 4. Transverse section of paratype 25393 from locality 73840, x5.8.

Figure 5. Transverse section of paratype 25394 from locality 68955, x3.

Claruscoscinus billingsi (Vologdin) (Page 74)

Figures 6a, b. Hypotype 25397 from locality 73871; 5a, transverse section, x5; 5b, longitudinal section, x3.

PLATE XV

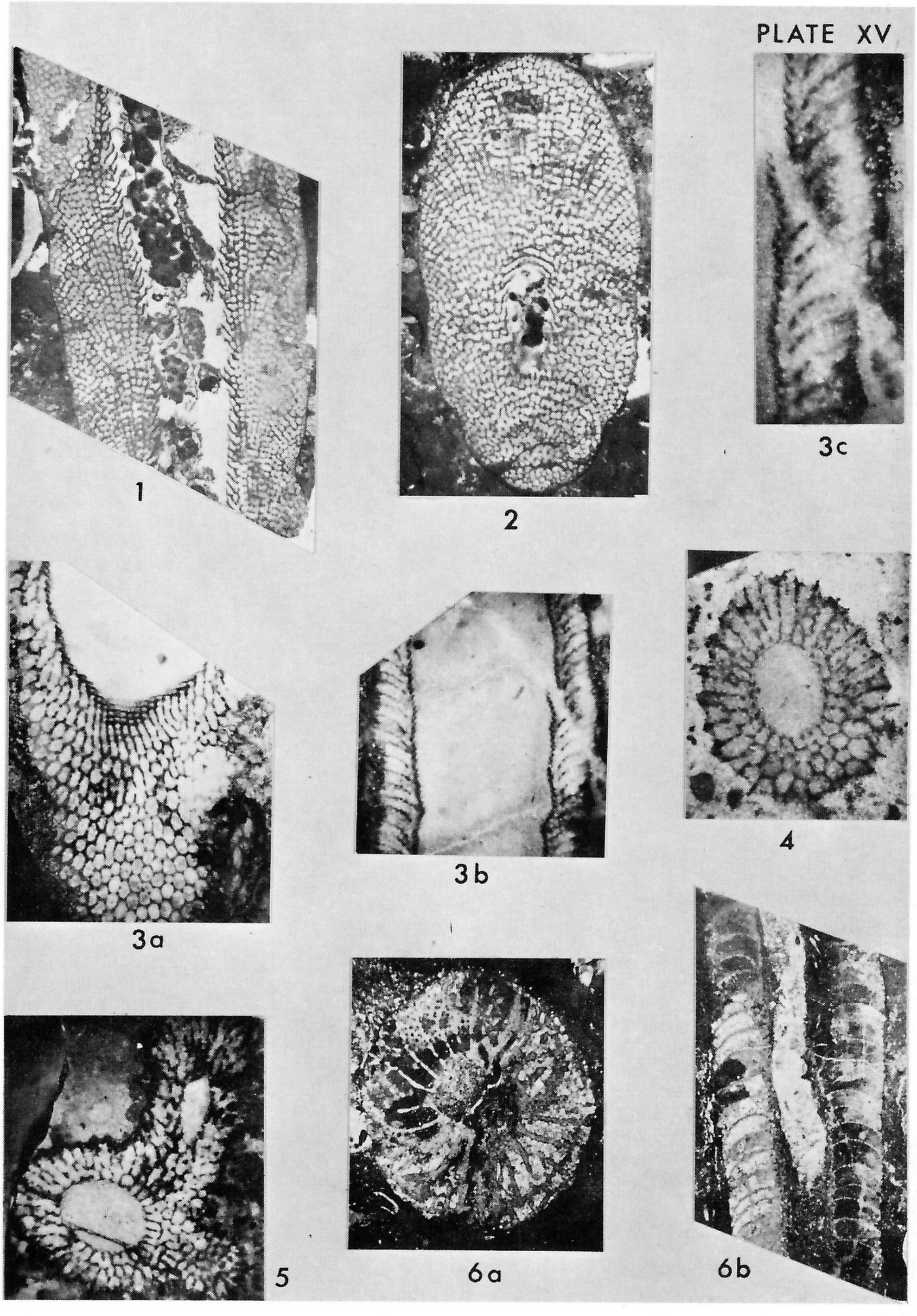


Plate XVI

Claruscoscinus billingsi (Vologdin) (Page 74)

Figures 1a-c. Hypotype 25398 from locality 75205; 1a, transverse section, x3.5; 1b, longitudinal section, x3.5; 1c, detail of tabula from 1a, x6.

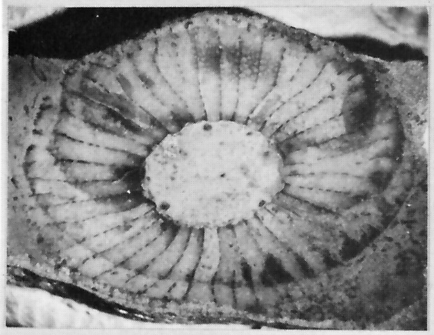
Pycnoidocoscinus sp. (Page 75)

Figures 2a,b. Figures specimen 25399 from locality 68958; 1a, longitudinal section, central cavity to the right, x3.3; 1b, transverse section, x3.

Exothecal growth (Page 8)

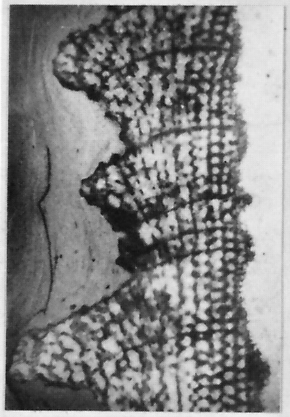
Figure 3. Transverse section through Protopharetra sp. and Ladaecyathus aff. L. fischeri n. sp. showing exothecal growth connecting the different genera, x2; hypotype 25382 from locality 75206.

PLATE XVI



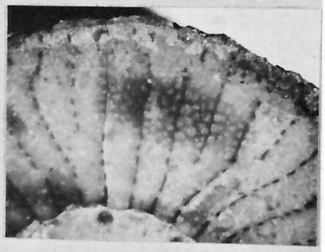
1a

1b



2a

2b



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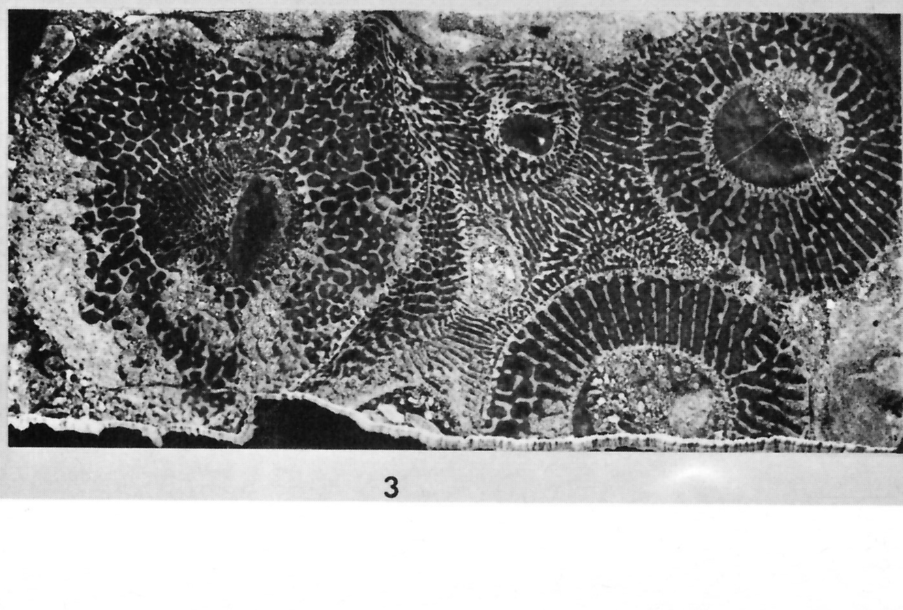

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