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THE BIOSTRATIGRAPHY AND PALAEONTOLOGY OF ARCHAEOCYATHA, (CAMBRIAN), SOUTH AUSTRALIA

by

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ABSTRACT.

Seventy three species of Archaeocyatha from the Early Cambrian carbonates of the Flinders Ranges, South Australia are described and discussed herein. Of these, forty one species of Regulares and twenty two species of Irregulares are new. Most of the species discussed belong to the oldest two recognized faunal assemblages containing Archaeocyatha, but some are known only from younger faunal assemblages and are included to clarify points of taxonomy.

None of the described species is known to occur outside the Australian region. Consequently, intercontinental biostratigraphic correlation is based only on the stratigraphic ranges of genera found in the USSR. The maximum age assigned to the oldest fossiliferous Cambrian carbonates in the Flinders Ranges appears to be either Bazaikhian or Early Atdabanian in terms of the stratigraphic schemes applied to the Cambrian Siberian sequences. A Kameshky or Late Atdabanian age is envisaged for the youngest Archaeocyatha found in Faunal Assemblage II. Archaeocyatha in younger faunal assemblages are of Sanashtykgol (Botomian) age.

Rapid lateral and vertical facies changes in the Ajax Limestone, Mount Scott Range, contrast with uniform facies in the Wilkawillina Limestone at Wilkawillina Gorge. Facies changes recorded in the shallow marine carbonates found in the Mount Scott Range had a marked effect on the distribution of Archaeocyatha and other shelly fossils.

Detailed studies of outer wall structures of Regulares complement earlier studies by other workers and have revealed greater diversity and structural complexity than was previously envisaged. Studies of the wall structures of non-tabulate Irregulares have led to a proposed new superfamily classification. It is anticipated that the same principles of classification can be applied to tabulate Irregulares. Ontogenetic studies of Irregulares have shown that main outer wall

structures were fully developed before those of the inner wall, but where supplementary subdivided pores were formed on the outer wall, they accompanied the development of, or were later than main inner wall structures. Main outer wall structures have been used to designate superfamily rank, corresponding inner wall structures - family rank, but supplementary wall structures in the form of subdivided pores have been used to distinguish generic rank in the proposed new classification. Thus subdivided pores in Irregulares, regarded as analogous to microporous sheaths in Regulares, have been proposed to designate a much lower taxonomic rank in the former than in the latter.

Attention was paid to the problem of measuring septal porosity of Regulares, with the result that a new quantitative and reproducible method of measurement is proposed herein for the first time. With the limited data available it has been possible to show that septal porosity decreased in general with cup growth in a manner which appears to be related to the rate of insertion of septa. A new appreciation of the value of the radial coefficient as a sensitive indicator of these changes resulted from this study. Changes in the radial coefficient with cup growth can be derived mathematically when septa were added as a straight line function of cup growth. When this condition applied, the radial coefficient rose or fell at the same time as septal porosity increased or decreased with cup growth. This aspect of the study of Regulares has great potential for following evolutionary changes of septal porosity in a quantitative fashion and will assist in the construction of phylogenetic lineages.

During this study it became apparent that two pathways of septal pore reduction with ontogenetic growth could be postulated instead of only one that has in the past been considered likely. The alternative pathway of septal pore reduction explains why several genera with very low septal porosity appeared so early in the stratigraphic record. Ways of distinguishing such genera from others are discussed and related to important differences in their ontogenetic development, established previously by workers in the USSR.

The enigmatic species Somphocyathus coralloides Taylor is redescribed herein and its taxonomic position clarified. The species is a Regulare with a non-independent microporous sheath. Examination of the exothecal tissue has confirmed Taylor's opinion that the outgrowths served as anchoring processes. Study of other Regulares with similar sheaths and exothecal outgrowths has shown that the sheath which had formed initially on the outer wall was probably resorbed to allow growth of the exothecal tissue, and a substitute modified sheath constructed in its place.

Special attention was devoted to outer wall structures because rapidly accumulating data of other workers has resulted in changes in the taxonomic classification of Archaeocyatha. Septal porosity was studied because previous treatments of this aspect of archaeocyathid morphology and development were considered inadequate by the present writer.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any University, nor to the best of my knowledge and belief, does it contain any material previously published or written by any other person except where due reference and acknowledgement is made in the text.

D.I.Gravestock.

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CHAPTER 1.

INTRODUCTION.

Aim of the present study.

Early Cambrian rocks in South Australia are characterized by shallow marine carbonates, many of which contain rich faunal assemblages of which Archaeocyatha form an important component. Eleven Early Cambrian faunal assemblages and a twelfth Middle Cambrian faunal assemblage, were identified by Daily (1956), and form the basis for biostratigraphic correlation of the Cambrian carbonate sequences in South Australia. The oldest rocks containg Archaeocyatha were assigned by Daily (1956) to his Faunal Assemblage I. Faunal Assemblage II in the overlying limestone is richly fossiliferous and includes Archaeocyatha, brachiopods, abundant problematica, and in the upper part - trilobites. Eight species of Archaeocyatha found by the present writer in Faunal Assemblage II have been described previously by Taylor (1910) and R. and J. Bedford (1937). Walter (1967) listed several genera of Archaeocyatha collected from two measured stratigraphic sections at Wilkawillina Gorge, and determined the age of the Hawker Group by comparing the stratigraphic ranges of these genera with those found in Siberia.

The aim of the present study was to systematically collect and describe the Archaeocyatha occurring in Faunal Assemblages I and II in the Wilkawillina Gorge and Mount Scott Range areas, in order to:

1) Provide a sound basis for local, regional and intercontinental correlation based on the biostratigraphy of Archaeocyatha.

2) Carry out detailed systematic and quantitative studies of the morphology and ontogeny of the Archaeocyatha, from which a better understanding of the Phylum could be deduced.

The study has been limited to an examination of Archaeocyatha from Faunal Assemblages I and II because very few have been described from this stratigraphic interval, and also because a detailed examination of all the Archaeocyatha bearing limestones would require far more time than was available for this study. In contrast, Archaeocyatha from the classic Ajax Mine locality (Ajax Hill), although not collected in sequence by Taylor and the Bedfords, are moderately well known. Wilkawillina Gorge was chosen for study because the type section for the Wilkawillina Limestone is located there. The Mount Scott Range area was chosen because of its proximity to the Ajax Mine locality where Faunal Assemblages I and II are less well preserved and the sequence is complicated by extensive faulting. The facies represented at both of the chosen localities are more typical of a stable shallow shelf, in contrast to the darker coloured basinal carbonates found elsewhere. Archaeocyatha occur in the basinal carbonates but are sparse by comparison.

Previous studies of Archaeocyatha in South Australia.

Daily (1956) has provided a comprehensive account of recorded occurrences of Cambrian fossils found in South Australia. This section presents a brief historical review of the most important published works connected with the discovery and study of Archaeocyatha in South Australia.

J.G.O. Tepper (1879) was the first to discover fossils in the Ardrossan area on Yorke Peninsula, among which were coral-like forms, subsequently identified provisionally as Archaeocyatha by R.Etheridge (1890). Etheridge assigned a Cambrian age to the Ardrossan fauna which had been regarded by Tepper as Silurian. Etheridge (op.cit.) described three species from Ardrossan, Kanyaka, Blinman and Wirrealpa, which he named Ethmophyllum hindei, Coscinocyathus tatei and Protopharetra scoulari. Later R. Tate (1892) restricted C.tatei to specimens from Ardrossan and separated a new species C.etheridgei for specimens from the Flinders Ranges. The generic and specific determinations of

Etheridge and Tate can be regarded as doubtful, judging by the poor preservation of the specimens now housed in the South Australian Museum. Archaeocyatha were first discovered in the Normanville-Sellick Hill region south of Adelaide, by W. Howchin (1897).

T.G. Taylor produced a preliminary note (1907), describing the morphology of some Archaeocyatha from the Flinders Ranges and Sellick Hill, and made two important statements therein:

a) "One is led to assume that in this latter (flabellate) type of Archaeocyathinae the organism is of a compound nature; and if this is true for the flabellate form, it is most probably true for the in-folded or turbinate type." (op.cit., p.13).

b) "Further study of the small nepionic forms will undoubtedly assist greatly in determining the classification." (ibid. p.14).

In a memoir subsequently published in 1910, Taylor described a number of new species collected from a low hill adjacent to the Ajax Mine (Ajax Hill herein). Additional species from Sellick Hill, Wilson and Wirrealpa were also described. Taylor erected the first classification of Archaeocyatha, dividing the then known genera into five families, based on differences in intervallum structure. Within the Family Archaeocyathidae, genera were segregated into one or more groups according to modifications of cup shape, septal structure, inner wall modifications, and development of exothecal tissue and dissepiments. In the Family Coscinocyathidae, two groups were distinguished on the basis of tabular separation. The families Dictyocyathidae, Spiro-cyathidae and Syringocnemidae each consisted of only one group; the Family Spirocyathidae contained genera which Taylor had the greatest difficulty in classifying.

Each group had no taxonomic value per se since different species of the same genus could occur in all of the groups in the Archaeocyathidae and Coscinocyathidae. The purpose of each group was to unite species in a graded series, whose end members could be linked with end members of another group belonging to a separate family. As Taylor stated "(But) in all these striking modifications we can trace the steps leading from one genus to another by means of intermediate species." (Taylor, 1910, p.105).

Thus Taylor was the first to recognize the value of skeletal elements in the intervallum for classification, and explained at length the fact that cup shape played no part in his scheme of classification. He did assume however, that species in Group 1 of the Family Archaeocyathidae formed the most primitive type, because their narrow conical shape resembled that of the spitz or first stage of growth seen in most of the forms he examined. The study of very small specimens played no part in the classification adopted by Taylor, but from studies of the order of septal insertion in serially sectioned cups he found no discernible order of septation and hence doubted the possibility of affinity with corals. Taylor also discussed affinities with algae and sponges, concluding that Archaeocyatha formed a separate class nearer to the calcareous sponges than to the coelenterates, and were possibly derived from a common ancestor.

In a series of memoirs published between 1934 and 1939, R., W.R., and J. Bedford described a number of new taxa principally from Ajax Hill. Several species were described by R. and J. Bedford (1937) from the "Paint Mine" approximately 2km from Ajax Hill. R. and W.R. Bedford (1934) initially followed Taylor's classification, but were subsequently influenced by the work of Okulitch (1935). In their second memoir they made the following important note:

"We think that our results show that the problem of classification presents great difficulty, and that not only must fine structures of mature specimens be taken into account, but also that of the developmental stages." (R. and W.R. Bedford, 1936, p.19).

The author's recognition of the importance of early stages of cup growth for classification influenced their subsequent work, culminating in a classification of Archaeocyatha by R. and J. Bedford (1939). This work was based mainly on studies of different types of spitz which gave rise to the various orders, families and genera known to the authors at that time. Notwithstanding the fact that the Bedford's specimens were silicified and not always truly representative of the earliest stages of cup growth, their recognition of two distinctive types of spitz has led to the subsequent separation of the two classes, Irregulares and Regulares, and has had a profound influence on the classification adopted today.

Studies of Archaeocyatha were discontinued in South Australia for several decades which in that time saw great advances by investigators in the USSR, notably by A.G. Vologdin, I.T. Zhuravleva and A.Yu. Rozanov. Important studies of Archaeocyatha in Morocco, Sardinia and France were carried out by F. Debrenne. As a result of their work, increasing importance was placed on the biostratigraphic value of Archaeocyatha which led to a renewed effort by M.R.Walter (1967) to establish the value of Archaeocyatha from South Australia for a global stratigraphic scheme of the Early Cambrian. Debrenne has published numerous much needed revisions of Archaeocyatha collected originally by Taylor and the Bedfords, which are now housed at the British Museum (Natural History) and Princeton University, as well as in the South Australian Museum. Studies of Archaeocyatha from Antarctica by D.Hill (1964b, c; 1965) have indicated close links with genera known from Ajax Hill and found elsewhere in South Australia. The volume devoted to Archaeocyatha in the <u>Treatise on Invertebrate Paleontology</u>, written by Hill (1972), was the first major work in the English language to produce a comprehensive account of the most recent advances made by investigators to that time.

The studies of South Australian Archaeocyatha by Debrenne and Walter, and studies of older Cambrian trace-fossil and shelly fossil assemblages by Daily, have pointed out the need to re-establish the Australian region and South Australia in particular, as an indispensable part of the Early Cambrian stratigraphic scheme. With this view in mind, the work described herein is presented.

Geological setting.

The localities and formations mentioned herein are shown on the locality map and correlation chart of the Mount Scott-Wilkawillina Gorge areas. (Text-figs. 1 and 2). Text-figures, tables and photgraphic plates are presented in Volume 2 of the present work.

Wilkawillina Gorge.

The Wilkawillina Limestone type section was measured by Daily (1956) in the vicinity of Ten Mile Creek (31°16'S.;138°54'E.), mapped on the PARACHILNA 1:250,000 map sheet (Dalgarno and Johnson, 1966), and the ORAPARINNA 1:63,360 map sheet (Dalgarno and Johnson, 1965).

Howchin (1922) gave an early account of the geology in Wilkawillina Gorge, noting the abundance of Archaeocyatha. Mawson (1939) gave a detailed account of lithology, thickness and faunal content of the strata which was subsequently remeasured and examined in detail by Daily (1956). The Wilkawillina Limestone in this vicinity is the lowest formation of the Hawker Group (Dalgarno, 1964); two older Cambrian formations, the Parachilna Formation (Dalgarno, 1962; Dalgarno and Johnson, 1962) and the Uratanna Formation (Daily, 1973) are absent.

At its type section the Wilkawillina Limestone disconformably overlies the Bonney Sandstone Member of the Pound Quartzite (Forbes, 1971), while to the southeast the Wilkawillina Limestone disconformably overlies the Rawnsley Quartzite Member of the Pount Quartzite. In the vicinity of the biostromal bank at the eastern extremity of the graben, Wilkawillina Limestone containing the upper part of Faunal Assemblage II is faulted against the Rawnsley Quartzite Member.

The Wilkawillina Limestone in the type section is overlain disconformably by the Parara Limestone (Daily, 1956), while to the southeast, intertonguing relationships have been mapped by Dalgarno (1964), Dalgarno and Johnson (1965) and Walter (1967).

The Hawker Group was deposited in a graben developed over the Oraparinna Diapir (Dalgarno, 1964), with greater thicknesses of the Parara Limestone, Bunkers Sandstone and Oraparinna Shale being found here than in corresponding sequences to the northwest. These formations intertongue with the Wilkawillina Limestone at the southeastern extremity of the graben, an area to which Walter (1967) referred as a biohermal bank. An examination of this area by the present writer failed to reveal the presence of bioherms, and the term biostromes first used by Dalgarno (1964) is more suitable.

Mount Scott Range.

Daily (1956) applied the name Ajax Limestone to include all of the limestones in the Mount Scott Range between the now known Parachilna Formation and Billy Creek Formation. Previously it had been restricted to the "Archaeocyathinae Limestones" of the Ajax Mine area. Mount Scott (30°36'S.; 138°20'E.) is formed from the Pound Quartzite disconformably underlying the Cambrian formations of the Hawker Group mapped on the COPLEY 1:250,000 map sheet (Coats et al., 1973). The COPLEY 1:63,360 map sheet compiled by Parkin and King (1952) shows the extent of the "Archaeocyathinae Limestones" in the Ajax and Mount Scott areas.

Early measurements of stratigraphic thicknesses given by Segnit (1939) disagreed with those measured by Daily (1956) and the present writer. In the Mount Scott Range the Ajax Limestone conformably overlies the Parachilna Formation, which disconformably overlies either the Uratanna Formation (basal Cambrian) or the Rawnsley Quartzite Member of the Pound Quartzite (upper Precambrian) (Daily, 1973).

The Ajax Limestone is overlain conformably by the Billy Creek Formation. According to Moore (1979) red shales of the Billy Creek Formation are draped over domed stromatolites forming the upper part of the Ajax Limestone, in an excavated contact. The contact between the two formations in most places is covered by Recent outwash deposits.

The Ajax Limestone in the Mount Scott Range outcrops on the southern limb of a northwest-southeast trending syncline with a closure to the southeast some distance beyond the Mount Scott Range, indicated by Coats (in Thomson et al., 1976, Fig.21). Discontinuous, and in most places extensively recrystallized outcrops of Ajax Limestone occur on the northern limb of the syncline, which has largely been removed or drastically thinned by faulting; these outcrops do not form part of the Mount Scott Range.

An east-northeast trending fault cuts obliquely across the strike of the Ajax Limestone approximately 1.5km northeast of Mount Scott. A displacement of 40m was measured on the southeast side of the fault at the contact with the Billy Creek Formation. However, no fault displacement could be found at the Parachilna Formation contact, or in the upper part of the Pound Quartzite. The same fault has caused a major displacement at the base of the Pound Quartzite; its passage through the Billy Creek Formation is marked by a zone of cleavage, and through the younger Aroona Limestone by an outward fanning series of minor faults. Facies distributions in the Ajax Limestone indicate possible fault control at the time of deposition.

Location of stratigraphic sections.

Wilkawillina Gorge.

Five stratigraphic sections - E, F, G, H and I - were measured across the strike of the Wilkawillina Limestone. Section E was measured through the type section of Daily (1956). The remaining sections were measured south of the type section at more or less evenly spaced intervals, over a total strike length of 1.5km. Section C-D of Walter (1967) is 5.4km distant along strike from the type section. Sections E, G, H and I were measured from the base to the top of the Wilkawillina Limestone. Section F was measured from the base of the formation into limestone containing Faunal Assemblage I, but was not measured further because difficult terrain rendered accurate measurement impossible. The position of the stratigraphic sections is shown on the geological map of the Hawker Group at Wilkawillina Gorge (Map 1, back pocket, Volume 2 of the present work).

Mount Scott Range.

Five major stratigraphic sections - J, K, L, M and N - were measured across the strike of the Ajax Limestone. Three additional sections were measured, chiefly for thickness and lithological control. The sections were spaced over a strike length of 4.6km somewhat unevenly, in order to avoid the worst areas of dolomitization which is extensive in the lower parts of the Ajax Limestone. Every section was measured from the top of the Parachilna Formation to the base of the Billy Creek Formation, or to the last exposure of carbonates where this contact was covered. The position of the stratigraphic sections is shown on the geological map of the Ajax Limestone at Mount Scott (Map 2, back pocket, Volume 2 of the present work).

Faunal Assemblages I and II of Daily (1956).

Faunal Assemblages I and II contain the oldest shelly fossils found in the Cambrian limestones in South Australia. Underlying dolomites and limestones devoid of shelly fossils indicate restricted environments of deposition. Older clastic deposits of the basal Cambrian Uratanna Formation and Parachilna Formation, and their lateral equivalents on Yorke Peninsula and Fleurieu Peninsula, south of Adelaide, contain shelly fossil and trace fossil assemblages. The oldest faunas have been correlated with the lower part of the Baltic Stage of the

Russian Platform (Lontova Horizon) by Daily (1976).

The change from restricted to unrestricted marine environments in the Cambrian carbonates was accompanied by the appearance of shelly fossils in Faunal Assemblage I. This faunal assemblage is dominated by Archaeocyatha but other shelly fossils including hyolithids, brachiopods, Chancelloria and a variety of molluscs are found in sparse numbers. Elements of Faunal Assemblage I have not been found on Yorke Peninsula or Fleurieu Peninsula, where restricted conditions apparently still prevailed at this time. The best exposures of Faunal Assemblage I occur at Wilkawillina Gorge and in the Mount Scott Range. In the latter area this interval is dolomitized, consequently it is impossible to determine most species of Archaeocyatha.

Limestone containing Faunal Assemblage II is widespread and richly fossiliferous. The diagnostic fossil 'Micromitra' etheridgei (Tate) is restricted to this assemblage. According to Daily (1972b) it is a new genus related to the problematic Lower Cambrian organism Tannuolina multiflora Fonin and Smirnova. Faunal Assemblage II is well preserved in limestone at Wilkawillina Gorge although poor preservation is sporadically encountered in the type section. At Mount Scott certain areas of outcrop are extensively dolomitized, but it is possible to find outcrops with good preservation in unaltered limestones.

Younger established faunal assemblages do not occur in the Wilkawillina Limestone at its type section, but are found where this formation intertongues with other formations of the Hawker Group at the southeastern extremity of the Wilkawillina graben. In the Mount Scott Range the uppermost 100m of Ajax Limestone contains younger faunal assemblages. Several breaks, and facies changes are evident in this uppermost interval but faunal assemblages younger than those found in the Ajax Mine vicinity may be present. This part of the Ajax Limestone at Mount Scott is the lateral equivalent of all the other formations of the Hawker Group younger than Faunal Assemblage II, which at Wilkawillina Gorge total over 1000m in thickness.

CHAPTER 2.

THE BIOSTRATIGRAPHIC CORRELATION OF ARCHAEOCYATHA FROM FAUNAL ASSEMBLAGES I AND II.

Introduction.

Archaeocyatha from Faunal Assemblage I are described herein for the first time. The species Somphocyathus coralloides Taylor, Beltanacyathus wirrialpensis (Taylor) Metaldetes dissepimentalis (Taylor) and some species from the "Paint Mine" (Bedford R. and J., 1937) are now known to occur in Faunal Assemblage II. Most other species from Faunal Assemblage II described herein are new.

Biostratigraphic correlations of Faunal Assemblages I and II, based on shelly fossils other than Archaeocyatha, have been made for various localities in South Australia and the Northern Territory (Daily, 1956, 1972b, 1974, 1976). The purpose of this chapter is to demonstrate precise correlation of Archaeocyatha in these faunal assemblages from the Wilkawillina Limestone at Wilkawillina Gorge, with those in the Ajax Limestone in the Mount Scott Range, and to show that a maximum age which can be assigned to the oldest South Australian Archaeocyatha may correlate with the Lower Atdabanian Substage of the Siberian Platform and the Bazaikhian Horizon of the Altai-Sayan region. The most likely minimum age for the Archaeocyatha is Late Atdabanian.

Despite the fact that the Mount Scott Range is only 94km northwest of Wilkawillina Gorge, certain difficulties arise in the precise biostratigraphic correlation of the archaeocyathid faunas at these localities because:

i) Faunal Assemblage I occurs in dolomitized limestone in the Mount Scott Range, consequently very few species can be determined.

ii) Lateral facies changes in the lower part of Faunal Assemblage II in the Mount Scott Range have had a marked effect on the relative abundance and variety of species of Archaeocyatha. Most of the species described herein from the Mount Scott Range, occur principally in only one stratigraphic section (section N). Relatively few species in this interval are known from both localities. The influence of facies changes on species diversity is discussed in Chapter 3.

iii) The upper part of Faunal Assemblage II at Wilkawillina Gorge is overlain by a disconformity, capped by a calcrete layer. It is considered herein that a considerable proportion of limestone containing fossils from the uppermost part of Faunal Assemblage II has been eroded. Consequently, Faunal Assemblage II at Wilkawillina Gorge is truncated by the disconformity, at least between the type section and section C-D of Walter (1967) and possibly as far as the biostromal bank of Dalgarno (1964). Some elements of Faunal Assemblage II occur above this disconformity.

Despite these difficulties, biostratigraphic correlation has been achieved at species level between Wilkawillina Gorge and the Mount Scott Range.

1. ARCHAEOCYATHA FROM FAUNAL ASSEMBLAGE I.

a) Wilkawillina Gorge in the vicinity of the type section.

The following species of Archaeocyatha occur in Faunal Assemblage I and are described in Chapters 6 and 7.

Class Regulares: *Dokidocyathus* sp.; ? *Rasetticyathus* sp.; ? *Gordonicyathus walteri* sp.nov.; *Rowanpectinus clarus* gen.et sp.nov.; ? *Thalamopectinus merus* sp.nov.; *Erugatocyathus krusei* sp.nov..

Class Irregulares: *Dictyofavus obtusus* gen.et sp.nov.; *Copleicyathus cymosus* sp.nov.; *Hawkercyathus insculptus* gen.et sp.nov.; *Warriootacyathus wilkawillinensis* gen.et sp.nov.; *W.irregularis* sp.nov.; *Bayleicyathus bowmani* gen.et sp.nov.; *B.diversus* sp.nov.; *Beltanacyathus digitus* sp.nov.

b) Wilkawillina Gorge at section C-D of Walter (1967).

The following genera listed by Walter (1967, p.144, Table 1) from his Collection 1, have been redetermined at species level:

Robustocyathus sp.1 and *Nochoroicyathus* sp. are specimens of *Rowanpectinus* clarus gen.et sp.nov..

Cyclocyathellidae gen.nov. is a specimen of ? Gordonicyathus walteri sp.nov.

Ethmophyllidae gen.nov.1, and possibly Robustocyathus sp.2 are specimens of Warriootacyathus wilkawillinensis gen.et sp.nov.

Spirocyathella sp. is a specimen of Hawkercyathus insculptus gen.et sp.nov.

Archaeocyathidae gen.nov. is Dictyofavus obtusus gen.et sp.nov.

Thus Collection 1 of Walter (1967) as stated by that author, correlates with Faunal Assemblage I.

c) Mount Scott Range.

As mentioned above, the limestone containing Faunal Assemblage I is dolomitized with the result that very few species are recognizable with any certainty. It has been possible to identify specimens belonging to only two species; Copleicyathus cymosus sp.nov. and Warriootacyathus wilkawillinensis gen. et sp.nov.. The latter species superficially resembles species of the genus Beltanacyathus Bedford, from which it differs by having a simpler outer wall and much larger septal pores. According to Daily (1976, p.51), Beltanacyathus wirrialpensis (Taylor) was identified by Rozanov in dolomitized limestone containing Faunal Assemblage I. These specimens which are presumably housed in the Geological Institute, USSR Academy of Sciences in Moscow, have not been seen by the present writer. They are considered herein to belong probably to Warriootacyathus wilkawillinensis. The species Beltanacyathus wirrialpensis (Taylor) has been found in the lower part of Faunal Assemblage II and the holotype, from the Wilkawillina Limestone at Wirrealpa, is now known to be associated with species of Archaeocyatha found only in the lower part of Faunal Assemblage II.

2. ARCHAEOCYATHA FROM FAUNAL ASSEMBLAGE II.

Faunal Assemblage II is subdivided herein into two subassemblages: Lower Faunal Assemblage II and Upper Faunal Assemblage II, separated on the basis of clearly marked differences between species of

Archaeocyatha contained in each interval. A vertical change in the relative abundances of shelly fauna other than Archaeocyatha is also evident between Lower and Upper Faunal Assemblage II. Relatively few new species of Archaeocyatha appear in Upper Faunal Assemblage II, but in the Mount Scott Range numerous species disappear because of facies changes occurring within Lower Faunal Assemblage II, well below the boundary with Upper Faunal Assemblage II. Many of the species in Lower Faunal Assemblage II have not been found as yet at Wilkawillina Gorge where no marked vertical facies changes occur. Despite the continuity of facies between Lower and Upper Faunal Assemblage II at Wilkawillina Gorge, species of Archaeocyatha and other shelly fossils are nevertheless found to be separated into the same two subassemblages. Facies changes are discussed in Chapter 3.

a) Archaeocyatha from Lower Faunal Assemblage II at Wilkawillina Gorge in the vicinity of the type section.

Limestones containing Lower Faunal Assemblage II overlie limestones containing Faunal Assemblage I with a sharp paraconformable contact. The basal 10m of limestone containing Lower Faunal Assemblage II is locally conglomeratic, the clasts are well rounded and contain fragments of Archaeocyatha from Faunal Assemblage I. The absence of species of Archaeocyatha common to both Faunal Assemblage I and Lower Faunal Assemblage II suggests a hiatus between them.

The following species of Archaeocyatha occur in Lower Faunal Assemblage II:

Class Regulares: *Dokidocyathus genuinus* sp.nov.; *Loculicyathus alternus* sp.nov.; *Joanaecyathus caecus* gen. et sp.nov.; *J.cyclopeus* sp.nov.; *J.cupulosus* sp.nov.; ? *Tumulocyathus transitus* sp.nov.; *Somphocyathus coralloides* Taylor; *Erugatocyathus madigani* sp.nov.; *E.aquilinus* sp.nov.; *E.inflexus* sp.nov.; *E.oppositus* sp.nov..

Class Irregulares: *Agastrocyathus araneosus* sp.nov.; *Metaldetes* dissepimentalis (Taylor); M.ferulae sp.nov.; Ardrossacyathus grandis sp.nov.; Spirillicyathus tenuis Bedford R. and J.; Jugalicyathus tardus gen. et sp.nov.; Pycnoidocyathus cribrus sp.nov.; Fridaycyathus biserialis gen. et sp.nov..

b) Wilkawillina Gorge at section C-D of Walter (1967).

No species from Collection 2 of Walter (1967, p.144, Table 1) have been identified because of the sparseness of material now housed in the Department of Geology and Mineralogy, University of Adelaide. However, the limestone matrix in the few available fragments is pale grey with pink to reddish mottles. This lithology is known to occur no more than 30m below the disconformity surface which truncates Upper Faunal Assemblage II at Wilkawillina Gorge. One specimen listed by Walter (op.cit.) as Robustocyathus sp.3, appears to be a small cup of Pycnoidocyathus Taylor.

c) Archaeocyatha from Lower Faunal Assemblage II in the Mount Scott Range.

The following species of Archaeocyatha occur in Lower Faunal Assemblage II:
Class Regulares: Dokidocyathus genuinus sp.nov.; D.osseus sp.nov.; Aroonacyathus gregarius gen.et sp.nov.; Prethmophyllum ? brunhilda (Bedford R. and J.); Joanaecyathus caecus gen. et sp.nov.; J.cyclopeus sp.nov.; J.cupulosus sp.nov.; Deceptioncyathus synapticulosus gen.et sp.nov.; Baikalocyathus squamosus sp.nov.; B.rimosus sp.nov.; ? Gordonicyathus levis sp.nov.;?Taylorcyathus malleus sp.nov.; Baikalopectinus capulus gen. et sp.nov.; Coscinocyathus vestitus sp.nov.; C.uratannensis sp.nov.; Rozanovicoscinus stellatus sp.nov.;Crucicyathus repandus gen. et sp.nov.; Mennericyathus dissitus Kruse (in prep.); Erugatocyathus madigani sp.nov.; E.tatei sp.nov.; E.mawsoni sp.nov.; E.aquilinus sp.nov.; E.inflexus sp.nov.; E.oppositus sp.nov.;E.howchini sp.nov.; ? Veronicacyathus c.f.complexus (Bedford R. and J.).
Class Irregulares: Auliscocyathus arcuatus sp.nov.; Paranacyathus

spinosus sp.nov.; Copleicyathus confertus Bedford R. and J.;C.scottensis sp.nov.; Metaldetes ferulae sp.nov.; M.gracilis sp.nov.; Ardrossacyathus grandis sp.nov.; Spirillicyathus tenuis Bedford R. and J.; S.pigmentum Bedford R. and J.; Jugalicyathus tardus gen. et sp.nov.; Pycnoidocyathus amplus sp.nov.; P.cribrus sp.nov.; ? P.strictus sp.nov.; Warriootacyathus lucidus gen.et sp.nov.; Beltanacyathus wirrialpensis (Taylor); Fridaycyathus biserialis gen. et sp.nov..

Phylum uncertain, Class Radiocyatha: ? Uranosphaera Bedford R. and W.R. Strongly recrystallized circular bodies have been found in thin sections of limestones containing Lower Faunal Assemblage II in the Mount Scott Range. Traces of "nesasters" (Debrenne et al., 1971) are present on the outer surface of one specimen. The bodies are thought to be radiocyathids, possibly belonging to the genus Uranosphaera Bedford R. and W.R.

The contact between the limestone containing Lower Faunal Assemblage II and the dolomitized limestone containing Faunal Assemblage I is not exposed in the Mount Scott Range, and consequently it is not known whether a stratigraphic break occurs between the two Faunal Assemblages.

d) Archaeocyatha from Upper Faunal Assemblage II at Wilkawillina Gorge in the vicinity of the type section.

Limestones containing Upper Faunal Assemblage II conformably overlie those containing Lower Faunal Assemblage II, with no change in facies. The following species of Archaeocyatha occur in Upper Faunal Assemblage II:

Class Regulares: Loculicyathus alternus sp.nov.; ? L.racemiferus sp.nov.; ? Gordonicyathus pledgei sp.nov.; ? G.systylus sp.nov.; Coscinocyathus vestitus sp.nov.; Rozanovicoscinus stellatus sp.nov.;Veronicacyathus radiatus sp.nov..

Class Irregulares: Metaldetes dissepimentalis (Taylor); M.incohatus sp.nov.;

Jugalicyathus tardus gen. et sp.nov.; *Pycnoidocyathus cribrus* sp.nov. As stated above, although there is insufficient material to identify species from Collection 2 of Walter (1967), the red mottling of the limestone fragments indicates that his specimens probably came from Upper Faunal Assemblage II.

e) *Archaeocyatha from Upper Faunal Assemblage II in the Mount Scott Range.*

Upper Faunal Assemblage II bearing limestone overlies Lower Faunal Assemblage II bearing limestone with a sharp contact. There is a basal intraformational limestone conglomerate in the carbonates containing Upper Faunal Assemblage II in two of the five measured stratigraphic sections. In two of the three remaining stratigraphic sections Lower Faunal Assemblage II is dolomitized and the boundary is not clear. In the fifth stratigraphic section, limestone containing Upper Faunal Assemblage II appears to conformably overlie limestone with Lower Faunal Assemblage II, but the entire sequence is poorly fossiliferious and no Archaeocyatha were identified.

The following species of Archaeocyatha occurs in Upper Faunal Assemblage II in the Mount Scott Range:

Class Regulares: *Dokidocyathus triangulus* sp.nov.; *Loculicyathus alternus* sp.nov.; ? *L.racemiferus* sp.nov.; *Prethmophyllum ? brunhilda* (Bedford R. and J.); ? *Gordonicyathus pledgei* sp.nov.; *Rowanpectinus occultus* gen.et sp.nov.; *Coscinocyathus vestitus* sp.nov.; *Rozanovicoscinus stellatus* sp.nov.; *Mennericyathus dissitus* Kruse (in prep.); *Erugatocyathus oppositus* sp.nov.; *Veronicacyathus radiatus* sp.nov.

Class Irregulares: *Metaldetes incohatus* sp.nov.; *Ardrossacyathus grandis* sp.nov.; *Jugalicyathus tardus* gen.et sp.nov.; *Pycnoidocyathus cribrus* sp.nov.

3. ARCHAEOCYATHA FROM ABOVE FAUNAL ASSEMBLAGE II.

Discussion.

Five species described herein occur in limestones stratigraphically above Faunal Assemblage II. They have been included in this work chiefly for comparison with other species of the same genera, thus a brief discussion of their stratigraphic position is warranted herein.

a) Wilkawillina Gorge.

One species, Bractocyathus curvus sp.nov.has been found in the uppermost part of the Wilkawillina Limestone in section I, 1.5km south of the type section. It occurs well above the disconformity which truncates limestone containing Upper Faunal Assemblage II, but a short distance below the Parara Limestone from which Faunal Assemblage III has been recorded (Daily, 1956). The species is considered to come from a fossil assemblage which overlies the 'Micromitra' etheridgei beds between Faunal Assemblage II and III. The same fossil assemblage occurs in sections on the eastern and western parts of the Flinders Ranges but is presumably absent from the Mount Scott Range. B. Daily (pers.comm.) considers this to be a new faunal assemblage but has previously included it in Faunal Assemblage II.

b) Mount Scott Range.

Three species, Bractocyathus projectus sp.nov.; Veronicacyathus limbatus sp.nov. and Pycnoidocyathus synapticulosus Taylor, occur in the upper part of the Ajax Limestone. The specimens were found at the top of a richly fossiliferous reddish to purple limestone 22m thick, immediately below an intraformational limestone conglomerate deposit. Daily (1956, p.120) has recorded 66 feet (20.3m) of purplish to greyish-red argillaceous limestone, whose upper beds contain Archaeocyatha and fragments of a large trilobite similar to one found in Faunal Assemblage $\overline{V}$ at Kulpara. The three species of Archaeocyatha mentioned above come from the uppermost part of the interval described by Daily, and thus may correlate with Faunal Assemblage $\overline{\underline{V}}$. Several specimens of species not described herein because of a lack of sufficient material, have been found in the same beds near the top of the Ajax Limestone. These include species of the genera Syringocnema Taylor, Sigmofungia Bedford R. and W.R., Flexicyathus Kruse and ? Thalamocyathus Gordon. The outer wall structure of a single specimen assigned to the last genus mentioned above, is briefly described in Chapter 4.

BIOSTRATIGRAPHIC CORRELATION BETWEEN WILKAWILLINA GORGE AND THE MOUNT SCOTT RANGE.

The stratigraphic ranges of species of Regulares and Irregulares are shown in Tables 1 and 2 respecively. The ranges shown are those of specimens assigned with certainty to each species. Specimens of doubtful specific affinity have been excluded. Because the thickness of the limestone containing each faunal assemblage or subassemblage differs considerably between the two localities, the ranges are shown as a proportion of the thickness of the limestone assigned to each assemblage or subassemblage in each separate locality. For example, the species Joanaecyathus caecus sp.nov. occurs through about one third of the limestone assigned to Lower Faunal Assemblage II at Wilkawillina Gorge. The thickness of Lower Faunal Assemblage II there varies from 90m to 112m. The same species occurs through about two thirds of the limestone assigned to Lower Faunal Assemblage II in only one stratigraphic section (section N) at Mount Scott. The thickness of Lower Faunal Assemblage II in section N is 69m, considerably less than the thickness of the limestone assigned to the same interval at Wilkawillina Gorge.

Variations in thickness for the faunal assemblages and subassemblages are as follows:

Faunal Assemblage I.

The thickness of the limestone containing Faunal Assemblage I at Wilkawillina Gorge varies from 47m to 69m. At Mount Scott the thickness of the dolomitized limestone containing Faunal Assemblage I varies from 32m to 41m.

Lower Faunal Assemblage II.

Limestone containing Lower Faunal Assemblage II at Wilkawillina Gorge varies in thickness from 90m to 112m. At Mount Scott, the thickness of limestone in the same interval varies from 57m to 69m.

Upper Faunal Assemblage II.

Limestone containing Upper Faunal Assemblage II at Wilkawillina Gorge varies in thickness from 50m to 75m. The uppermost bed is truncated by a disconformity capped by a calcrete layer. Possibly as much as 50m of Upper Faunal Assemblage II may be missing. Thus the upper range limits of species in this subassemblage at Wilkawillina Gorge are not precisely known. The upper limits of those species occurring immediately below the disconformity are shown in Tables 1 and 2 terminated by a vertical bar, indicating that their stratigraphic ranges are limited by the disconformity.

Limestone containing Upper Faunal Assemblage II at Mount Scott varies in thickness from 33m to 66m. The limestone containing Upper Faunal Assemblage II at Mount Scott is thinner on average than at Wilkawillina Gorge and is overlain paraconformably by limestone containing small shelly fossils belonging to Faunal Assemblage III.

It can be seen from Tables 1 and 2 that no species from Faunal Assemblage I range into Faunal Assemblage II. Lower Faunal Assemblage II contains the greatest number of species and these have been found principally in section N at Mount Scott. Upper Faunal Assemblage II has yielded fewer species to date, but many of these occur at both localities. A minority of species occur in both Lower and Upper Faunal Assemblage II.

Two conclusions can be drawn from the small number of species of Archaeocyatha common to both localities, particularly in Lower Faunal Assemblage II. First, insufficient sampling has resulted in the observed distribution. Second, the species distribution is controlled by facies changes. These are discussed in Chapter 3.

Correlation of Archaeocyatha from Faunal Assemblages I and II with the Early Cambrian of the USSR.

Preliminary discussion on taxonomic nomenclature.

The following brief discussion is treated more fully in Chapter 6, but some remarks are necessary here in order to avoid confusion in taxonomic nomenclature.

Zhuravleva and Elkina (1974) created the Superfamily Irinaecyathacea in the Suborder Ajacicyathina to accommodate species belonging to various genera and families previously placed in the Superfamily Ajacicyathacea. This was based on the recognition of the early appearance in ontogeny of diaphragms over the outer wall pores. In the same work the authors placed the Family Cyclocyathellidae in the Superfamily Irinaecyathacea with no accompanying revision of the constituent genera. Species placed with reservation in the genera Gordonicyathus and Taylorcyathus, with outer wall pore diaphragms, have been found in the Mount Scott Range and at Wilkawillina Gorge. There can be no guarantee that these species belong in the Cyclocyathellidae until type material in the USSR has been revised. Recent descriptions of species placed in the genus Gordonicyathus by workers in the Soviet Union, continue to refer to the outer wall porosity as "simple", or neglect to mention the presence of pore diaphragms. For the purposes of correlation it is assumed herein that the annulate forms named above from South Australia are closely related to those from the USSR.

Debrenne (1973) revised the diagnosis of Thalamocyathus Gordon to exclude the presence of pectinate tabulae, and erected the genus *Thalamopectinus* Debrenne for forms with pectinate tabulae. As discussed in Chapter 6, the known species of *Thalamopectinus* Debrenne have uniformly porous septa and new specimens from South Australia and western New South Wales (Kruse, written comm.) have outer walls with pore diaphragms. Despite Debrenne's revision, workers in the USSR retain the name *Thalamocyathus* for species having pectinate tabulae. Their species are considered herein to be synonymous with species of the genus *Thalamopectinus*. Thus *Thalamocyathus howelli* (Vologdin) is referred to herein as *Thalamopectinus howelli* (Vologdin) with reservation, since the presence of outer wall pore diaphragms on Siberian material and on the genotype *Thalamopectinus arterialis* Debrenne, has not yet been confirmed.

Debrenne and Rozanov (1974) separated the genus *Mennericyathus* to accommodate species with tabulae, simply porous inner walls and outer walls with independent microporous sheaths. These species had been previously placed in the genus *Tomocyathus* Rozanov (Rozanov and Missarzhevskiy, 1966), which is now restricted to apply to species having non-independent microporous sheaths and corrugated inner walls. Species of the genus *Mennericyathus* have still been referred to the genus *Tomocyathus* in more recent Russian works (e.g. Osadchaya, 1976).

No species occurring in the USSR or elsewhere outside the Australian region have been found in Faunal Assemblages I and II. Consequently correlation is based solely on the presence or absence of genera in the Siberian Platform and Altai-Sayan sections. These have presumably been accurately determined by workers in the USSR. Correlation is also based on evolutionary stages attained by Regulares in Faunal Assemblages I and II.

Correlation based on evolutionary stages attained by Regulares in Faunal Assemblages I and II.

Four stages of evolution of regular Archaeocyatha have been recognized (Rozanov in Rozanov and Missarzhevskiy, 1966; Rozanov, 1973; Rozanov and Debrenne, 1974). Three of these stages correspond to subdivisions of the Lower Cambrian of the Siberian Platform and the Altai-Sayan fold belt as follows:

The Tommotian Stage is the oldest Cambrian Stage in the USSR and it corresponds to the first appearance of Archaeocyatha, which are typically small and have simply porous skeletons.

The overlying Atdabanian Stage corresponds to the first appearance of a variety of complex structures on the outer and inner walls of Regulares.

In the succeeding Botomian Stage (= Lenian Stage of Rozanov, 1973) relatively few new skeletal characteristics appear, but there is a massive increase in the number of new genera, which arise as a result of modification of pre-existing skeletal characteristics. In the upper part of the Botomian Stage many of these characteristics are lost.

The youngest stage, the Lenian Stage (Elankian of Rozanov, 1973) is characterized by the rapid disappearance of most groups of Archaeocyatha and by the extinction of the Phylum as a whole. The Lenian Stage is considered to be uppermost Lower Cambrian Stage in the most recently published stratigraphic schemes from the USSR (Osadchaya et al, 1979, Table 8).

Other evolutionary trends accompanying the first appearance of new characteristics in the Atdabanian Stage and their modification in the Botomian Stage are those displayed by reduction in the number of wall pores, compensation involving the first appearance of microporous sheaths; possible reduction of sheath porosity; reduction of septal porosity. These trends are most pronounced in the Suborder Ajacicyathina where all of the above listed phenomena are apparent. Reduction of the number of wall pores and the formation of microporous sheaths is found in all of the other suborders in the Class Regulares. Reduction in septal porosity is evident in the Suborder Nochoroicyathina, but is not clearly documented for the Coscinocyathina. New data presented in Chapter 4 indicates that reduction in sheath porosity cannot on present evidence be demonstrated for non-independent sheaths of representatives of the Superfamily Anaptyctocyathacea. These trends where apparent, occur in different suborders at different times according to Rozanov (1973).

A list of morphological features and the timing of their first appearance in the USSR is given below. Only those suborders, also represented in South Australia, are included. The same morphological features also occur in other suborders found in the USSR, but representatives of these suborders have not yet been found in Faunal Assemblages I and II.

Morphological features of Regulares seen for the first time in the Atdabanian Stage and not known in the Tommotian Stage.

1. Non-independent and independent microporous sheaths in the Suborder Coscinocyathina. e.g. Tomocyathus Rozanov; Mennericyathus Debrenne and Rozanov.

2. Annulate inner walls in the Suborders Ajacicyathina and Nochoroicyathina. e.g. Gordonicyathus Zhuravleva; Taylorcyathus Vologdin; Thalamopectinus Debrenne.

3. Simple outer wall tumuli in the Suborder Dokidocyathina. e.g. Kaltatocyathidae Rozanov.

4. Pectinate forms (Suborder Nochoroicyathina) with one inner wall pore row per intersept (Debrenne et al., 1973, p.38, Fig.6).

5. Species of Dokidocyathidae with bars rather than cylindrical rods in the intervallum. According to Rozanov (1973, p.34), flat bars in the intervallum of dokidocyathids appear in general in the second half of Atdabanian time.

6. Outer wall pore diaphragms, Superfamily Irinaecyathacea.

A corresponding list given below, presents examples of genera having the same characteristics, from Faunal Assemblages I and II at Wilkawillina Gorge and in the Mount Scott Range.

1. Non-independent microporous sheaths: Erugatocyathus Debrenne, Veronicacyathus Debrenne (numerous species).
Independent microporous sheaths: Mennericyathus Debrenne and Rozanov. One species M.dissitus Kruse (in prep.).

2. Annulate inner walls: Suborder Ajacicyathina, Family Cyclocyathellidae: ? Gordonicyathus (four species); ? Taylorcyathus (one species). Suborder Nochoroicyathina, Family Stillicidocyathidae: ? Thalamopectinus (one species).

3. Simple outer wall tumuli: Suborder Dokidocyathina, Family Kaltatocyathidae: Aroonacyathus gen.nov. (one species).

4. Pectinate forms with one inner wall pore row per intersept: Rowanpectinus gen.nov. (two species). Strictly speaking, these new species have inner wall pore-tubes.

5. Dokidocyathids with intervallum bars rather than rods: three new species of Dokidocyathus from Faunal Assemblage II. One species from Faunal Assemblage I has very weakly flattened bars in the intervallum, but these nevertheless do not appear to be true cylindrical rods.

6. Superfamily Irinaecyathacea. In addition to the annulate forms mentioned above there are two species of the genus Baikalocyathus in Lower Faunal Assemblage II.

Out of a total of 43 species of Regulares described herein from Faunal Assemblages I and II, 28 have one or more of the morphological characteristics listed above. Of the remaining 15 species, two belong to the genus Coscinocyathus which has a long stratigraphic range; one is placed with reservation in the genus Tumulocyathus which ranges from the Upper Tommotian to the Botomian Stage. The other 12 species either belong to other genera appearing for the first time in the Atdabanian Stage, or have doubtful affinities, or have not been found elsewhere.

It is quite clear that Archaeocyatha from Faunal Assemblages I and II, based on the morphological characteristics of the Regulares, are younger than Tommotian in age.

It is impossible to make a corresponding list of morphological characteristics for Regulares typical only of the Botomian Stage, because this stage of archaeocyathid evolution involves a modification of characteristics first acquired in the Atdabanian Stage. However, certain evolutionary trends which may originate from the Atdabanian, emerge clearly in the Botomian and continue into the Lenian Stage. These trends involve reduction in septal porosity which is most clearly seen in the Suborder Ajacicyathina, and increasing complexity of "ethmophylloid" inner walls in the Subfamily Irinaecyathinae Zhuravleva.

Reduction in septal porosity.

Apart from *Leptosocyathus* Vologdin and a few other genera occurring in the Atdabanian Stage, genera with species having sparsely porous septa first appear in abundance at the base of the Botomian Stage. The stratigraphically early appearance of *Leptosocyathus* Vologdin is discussed in Chapter 5, where an alternative pathway of septal pore reduction is proposed for species of this genus, and for species of *Joanaecyathus* gen.nov. from Lower Faunal Assemblage II. There appears to be a continued reduction in septal porosity in successively younger species found in the Botomian and Lenian Stages on the Siberian Platform and in the corresponding horizons of the Altai-Sayan fold belt.

In the Subfamily Irinaecyathinae, reduction in septal porosity is accompanied by increasing complexity of the inner wall pore canals in some of the constituent genera (Zhuravleva and Elkina, 1974, p.52). Species having uniformly porous septa and non-intercommunicating (i.e. simple) inner wall pore canals belong to the Subfamily Baikalocyathinae and are found in both the Atdabanian and

Botomian Stages, but occur in greatest abundance in the Atdabanian. Species having sparsely porous septa and intercommunicating (i.e. complex) inner wall pore canals are placed in the Subfamily Irinaecyathinae, whose species are restricted mainly to the Botomian Stage. Only one species - Irinaecyathus optimus Osadchaya is known from the Bazaikhian Horizon of the Altai-Sayan fold belt, which correlates with the Lower Atdabanian of the Siberian Platform. None have yet been found in Faunal Assemblages I and II.

Apart from species of the new genus Joanaecyathus, whose septal porosity is discussed in Chapter 5, there are no species in Faunal Assemblages I and II with sparsely porous septa. Similarly, there are no species with complex "ethmophylloid" inner walls. Species with these characteristics are known to occur abundantly in limestones containing Archaeocyatha in younger faunal assemblages. The upper part of the Ajax Limestone at Ajax Hill and the upper part of the Wilkawillina Limestone at Wirrealpa contain numerous species of Thalamocyathus Gordon. Species of this genus differ from species of Gordonicyathus Zhuravleva by their lower septal porosity (Debrenne, 1973). Numerous other genera whose species have sparsely porous septa occur in limestones containing the younger faunal assemblages. Similarly, species with complex "ethmophylloid" inner walls occur in great abundance in the much younger strata. Most of these species are yet to be described.

Archaeocyatha from the Ajax and Wilkawillina Limestone thus fall into two major categories based on morphological characteristics of their skeletons.

The first category includes Archaeocyatha from Faunal Assemblages I and II, whose characteristics (in the Regulares) are typical of those found in the Atdabanian Stage.

The second category includes Archaeocyatha in younger faunal assemblages, whose characteristics are typical of those found in the Botomian Stage.

Archaeocyatha from the much younger Wirrealpa Limestone which contains Faunal Assemblage $\overline{X}$, may correlate with the Lenian Stage, but these have not yet been studied.

Correlation with the Atdabanian Stage of the Siberian Platform.

Only six genera are considered from both the Siberian Platform and Faunal Assemblages I and II. They are Loculicyathus Vologdin; Taylorcyathus Vologdin; Gordonicyathus Zhuravleva; Thalamopectinus Debrenne; Baikalocyathus Yazmir and Mennericyathus Debrenne and Rozanov. Other genera common to both localities have long stratigraphic ranges and are unsuitable for biostratigraphic correlation. The genera Loculicyathus Vologdin and Baikalocyathus Yazmir have stratigraphic ranges spanning both the Atdabanian and Botomian Stages, but are most abundantly represented in the Atdabanian Stage. The annulate genera Gordonicyathus Zhuravleva; Taylorcyathus Vologdin and Thalamopectinus Debrenne have been found in the lowest zone of the Lower Atdabanian Substage of the Siberian Platform, but are very rare.

The genera ? Gordonicyathus and ? Thalamopectinus are each represented by one species in Faunal Assemblage I. Despite the fact that few whole specimens were found, there are numerous small fragments in the limestone, which indicate that they were quite abundant. One species of ? Taylorcyathus and one of ? Gordonicyathus occur in Lower Faunal Assemblage II. Two species of ? Gordonicyathus described herein, and two additional species of the same genus, as yet undescribed, occur in Upper Faunal Assemblage II. Thus annulate genera are relatively common in the two oldest faunal assemblages from South Australia, suggesting that a maximum age possible for Faunal Assemblage I is Early Atdabanian. The species Mennericyathus dissitus Kruse (in prep.), first appearing in Lower Faunal Assemblage II, has a microporous sheath porosity suggesting a possible mid Atdabanian age for this interval. Further discussion of the sheath porosity of this species is given in

Chapter 4. A minimum age considered likely for Upper Faunal Assemblage II is Late Atdabanian, based on the absence of species of Botomian age from this subassemblage. Quite obviously, greater precision in stratigraphic resolution cannot be achieved at this stage with the data available.

Correlation with the Bazaikhian and Kameshky Horizons of the Altai-Sayan fold belt.

Okuneva and Osadchaya (1972) compared Archaeocyatha from South Australia with those occurring in the southern part of the Altai-Sayan region (Tuva), and Primorie. From a study of specimens sent by M.R. Walter to the USSR, the authors considered that at the end of Aldan time (Bogradskiy Horizon) there were 9 families of Archaeocyatha common to Tuva and South Australia. They noted the presence of the genus *Alphacyathus* in the South Australian material and stated that *Dokidocyathus simplicissimus* Taylor or a similar species was found in material from Primorie as well as from South Australia. The genus *Alphacyathus* and the species *D.simplicissimus* are known only from above Faunal Assemblage II which suggests that the specimens came from younger strata.

Okuneva and Osadchaya indicated close correlation between Tuva and South Australia for the first half of Lenian time (Sanashtykgol Horizon) and noted 18 genera common to the two regions. They also noted the presence of abundant species with sparsely porous to non-porous septa in the younger material provided by Walter.

More recently Osadchaya (1976) gave a detailed account of the biostratigraphy of the Altai-Sayan region, particularly of the Bazaikhian Horizon which is at present considered to correlate with the Lower Atdabanian Substage of the Siberian Platform (Osadchaya *et al.*, 1979, Table 8). Two zones were recognized, the lower zone being the oldest known from the Altai-Sayan region and characterized by

Archaeocyatha which notably do not have annulate inner walls. Trilobites have not yet been found in this zone. Of the 35 genera reported from this level, the following also occur in Faunal Assemblages I and II: Loculicyathus Vologdin; Baikalocyathus Yazmir and Mennericyathus Debrenne and Rozanov. The overlying zone, named the Thalamocyathus howelli zone is regarded as corresponding to the upper half of the Lower Atdabanian Substage of the Siberian Platform. The species Thalamocyathus howelli has pectinate tabulae and is referred to herein as Thalamopectinus howelli. However, in the stratigraphic scheme shown in Table 3 the original name applied by Osadchaya has been retained. This zone is characterized by the initially gradual appearance of annulate forms of which only species of Thalamopectinus occur in abundance. Other species from this zone which also occur in Faunal Assemblages I and II are Loculicyathus Vologsin, Taylorcyathus Vologdin; Gordonicyathus Zhuravleva; Baikalocyathus Yazmir and Mennericyathus Debrenne and Rozanov.

Osadchaya (op.cit., p.118) stated that the Thalamocyathus howelli Zone marked a new stage in the evolutionary development of Archaeocyatha, namely the first appearance of annulate forms. The presence of the genera Gordonicyathus and Thalamopectinus in Faunal Assemblage I appears to indicate that the maximum age assigned to the oldest Archaeocyatha known at present from South Australia may correlate with the upper zone of the Bazaikhian Horizon which is the equivalent of the upper part of the Lower Atdabanian Substage of the Siberian Platform. According to Osadchaya (1976) the first zone of the Bazaikhian Horizon, the Nochoroicyathus mariinskii Zone, incorporates the Kundat Horizon of Repina et al. (1964) and the Bazaikhian Horizon of Rozanov (Rozanov and Missarzhevskiy, 1966).

As stated above, a minimum age for Upper Faunal Assemblage II can only be based on the absence of Archaeocyatha typical of the

Sanashtykgol Horizon, which is the temporal equivalent of the Botomian Stage of the Siberian Platform. At present there is no basis for subdividing Faunal Assemblages I and II into zones because breaks in the stratigraphic record and lateral and vertical facies changes are primarily responsible for the stratigraphic ranges of the species shown in Tables 1 and 2. Table 3 shows the stratigraphic ranges of the most important genera common to both the USSR and South Australia.

Discussion.

The maximum age assigned to the oldest Archaeocyatha from South Australia is Early Atdabanian according to the accepted scheme for the Siberian Platform or Late Bazaikhian in terms of the schemes proposed by Osadchaya (1976) and Osadchaya et al (1979) for the Altai-Sayan fold belt. However, the most recently proposed correlation between the Altai-Sayan and Siberian Platform regions differs sharply from previous correlations with regard to the age of the oldest Archaeocyatha found in the Altai-Sayan region. This discrepancy greatly impedes biostratigraphic correlation with regions outside the USSR.

According to the latest proposed schemes, no Tommotian Archaeocyatha exist in the Altai-Sayan fold belt. However, numerous earlier investigations have quite clearly correlated the oldest archaeocyathid complexes of this region with the upper zones of the Tommotian Stage of the Siberian Platform (Repina et al, 1964; Rozanov and Missarzhevskiy, 1966; Konyushkov, 1972). These authors have listed several species from the Altai-Sayan fold belt which also occur in the Kenyadian Horizon of the Tommotian Stage, including: Dokidocyathus regularis Zhuravleva, Nochoroicyathus mirabilis Zhuravleva, Coscinocyathus rojkovi Vologdin, Aldanocyathus tkatschenkoi (Vologdin), Robustocyathus robustus (Vologdin) and Retecoscinus retetabulae (Vologdin). All of these species occur in beds now correlated with the Nochoroicyathus mariinskii Zone which occurs stratigraphically below the interval containing the first trilobites. Considering the number of species, their stratigraphic position, and particularly the presence of D.regularis, it seems highly improbable that this zone is Atdabanian and not Tommotian in age.

Further evidence in favour of a Tommotian age for the N.mariinskii Zone comes from the fact that trilobites are known from the earliest Atdabanian Retecoscinus zegebarti - Leptosocyathus polyseptus Zone of the Siberian Platform, at least in upper parts of this zone in eastern sections (Rozanov, 1973, p.113) and in transitional sections (Missarzhevskiy and Rozanov, 1973, p.97, Fig.11). Thus there is no distinct pre-trilobite horizon of Atdabanian age on the Siberian Platform.

It seems likely that precision in correlation between the Siberian Platform and Altai-Sayan fold belt will continue to be discussed and refined, and intercontinental correlation of strata of this age with the USSR sequences remains somewhat doubtful at present.

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CHAPTER 3.

FACIES CHANGES AND THEIR EFFECT ON FAUNAL DIVERSITY.

Introduction.

The first part of this chapter presents a brief account of the lateral and vertical facies changes occurring in the Lower Cambrian carbonates prior to and during deposition of Faunal Assemblages I and II. The account is restricted to areas in the vicinity of the type section of the Wilkawillina Limestone at Wilkawillina Gorge, and to the Ajax Limestone in the central part of the Mount Scott Range. The second part of the chapter demonstrates the effect of these facies changes on the distribution of Archaeocyatha in particular, and also shows that other shelly faunas are similarly affected. Facies changes occurring above rocks containing Faunal Assemblage II at both localities are briefly examined.

Lateral and vertical facies changes.

Previous accounts of facies changes at Wilkawillina Gorge have been made on a broad scale, chiefly documenting the major lithological changes between formations which constitute the Hawker Group (Daily, 1956; Dalgarno, 1964; Dalgarno and Johnson, 1965; Walter, 1967). In the Mount Scott Range Daily (1972b) subdivided the Ajax Limestone into an unfossiliferous Lower Member and a fossiliferous Upper Member. More recently, Daily (1976) considered the Ajax Limestone to consist of at least three intervals:

a) A lower dolomitized unit containing stromatolites.

b) A fossiliferous unit, initially dolomitic and oolitic, overlain by red fossiliferous limestones.

c) An upper unit separated from those below by a disconformity. The upper unit is variable in facies and contains Archaeocyatha known also from Ajax Hill.

In the present work four informal stratigraphic units have been recognized within the Wilkawillina and Ajax Limestones at both localities. These cover the interval from the base of each formation to the top of Faunal Assemblage II as follows:

Unit 1. Carbonates preceding the first appearance of Archaeocyatha.

Unit 2. Carbonates containing Faunal Assemblage I.

Unit 3. Carbonates containing Lower Faunal Assemblage II.

Unit 4. Carbonates containing Upper Faunal Assemblage II.

One or more facies may be present in each of the units at either locality. No units were separated for the carbonates above Faunal Assemblage II in the Mount Scott Range although several are recognizable in the field. The units above the Wilkawillina Limestone at Wilkawillina Gorge constitute separate formations of the Hawker Group. Different facies can be distinguished in each formation but their discussion is beyond the scope of the present work. That part of the Wilkawillina Limestone which outcrops between the disconformity near the top of Faunal Assemblage II and the base of the Parara Limestone is discussed later in this chapter.

The facies associated with each of the four units in the interval studied herein are compared for the two localities. Stratigraphic columns illustrating these facies changes at Wilkawillina Gorge and the Mount Scott Range are presented in Text-figs. 3 and 4. The distinct carbonate facies have been separated on the basis of clast type and size, sorting, proportion of clast to matrix and on fossil content. The terminology follows that suggested by Dunham (1962) for the classification of carbonate rocks. Where Archaeocyatha constitute the dominant fauna in a facies, their presence is indicated by the term "archaeocyathid" e.g. archaeocyathid packstone. Other fauna dominating the skeletal fraction of a facies are likewise indicated. Where there is a variety of shelly fossils the term "skeletal" is used e.g. skeletal packstone. The inorganic characteristics of a facies are readily recognized in outcrop, but estimates of floral and faunal content require examination of thin sections and acid residues.

Haslett (1976) recognized six regional lithofacies and employed a similar terminology in his account of the Cambrian carbonates preceding and containing Faunal Assemblages I and II from a large area north of Wirrealpa. Several of Haslett's lithofacies have been recognized in the areas studied by the present writer but because of the wider scope of Haslett's work, his lithofacies are somewhat broader in meaning than those used herein.

Unit 1. Carbonates preceding the first appearance of Archaeocyatha.

In the vicinity of the type section at Wilkawillina Gorge the Wilkawillina Limestone disconformably overlies the Bonney Sandstone Member of the Pound Quartzite. The red shales and siltstones of this Member are leached at the contact with the overlying dolomitized limestone. Two distinct facies occur in Unit 1:

Intraclast-ooid mudstones. Pale to dark grey massive dolomitized micrite with minor thin (up to 1m thick) bands of finely laminated micrite. Elongate tabular intraclasts are common, ooids are either scattered or occur in small lenses within the massive micrites. Well rounded quartz sand is locally abundant. Composite pebbles of quartz sand, ooids and carbonate intraclasts also occur.

Ooid-composite ooid grainstones and packstones. Massive to well-bedded pale grey limestone. Ooids displaying radial and concentric structure occur discretely or more often as composite clasts. Pellets of micrite with no internal fabric are common. Composite clasts consist of ooids and pellets cemented by micrite with a thin micrite outer envelope (Plate 1, Fig. 1).

In the Mount Scott Range the Ajax Limestone conformably overlies the Parachilna Formation with a transitional contact. Two distinct facies occur in Unit 1:

Ooid-composite ooid grainstones and packstones. This facies is similar to that found at Wilkawillina Gorge. Near the contact with the

Parachilna Formation the ooids are not composite, they frequently have quartz sand nuclei and quartz sand commonly forms the bulk of the matrix. Higher in the sequence flat pebble conglomerates, edgewise conglomerates and desiccation cracks are common. Stromatolitic interbeds and reworked clasts are common (Plate 1, Fig. 2). This facies is interbedded to a minor extent with the overlying facies described below.

Stromatolite boundstones. Thinly bedded dolomitized flat to wavy laminated and laterally linked domed stromatolites. Thin interbeds of the preceding facies are occasionally found, chert nodules are locally common.

Environments of deposition.

The facies of Unit 1 at both localities indicate a shallow restricted marine environment, with desiccation cracks indicating brief periods of emergence. Composite clasts, edgewise conglomerates and reworked stromatolitic clasts indicate periods of vigorous current activity. The facies in Unit 1 at both localities are typical of those found in the laterally equivalent Woodendinna Dolomite (Haslett, 1975). B.Daily (pers.comm.) and the present writer consider it desirable to map Unit 1 of the Ajax and Wilkawillina Limestones as Woodendinna Dolomite. In the present work however, this unit is retained as basal Ajax and Wilkawillina Limestone in the maps and stratigraphic sections presented herein to conform with the presently adopted terminology.

Unit 2. Carbonates containing Faunal Assemblage I.

A lower facies and two interbedded upper facies occur at Wilkawillina Gorge. The lower facies immediately follows the ooid-composite ooid grainstones described above:

Ooid grainstones and archaeocyathid-algal packstones and wackestones. The first Archaeocyatha occur immediately above a thin sequence of interbedded birdseye and wavy laminated limestones. The fossils occur either as broken cups in an ooid packstone, or as whole cups in an archaeocyathid-algal wackestone with relatively little intermixing between the two lithologies. Quartz sand is locally abundant in the archaeocyathid-ooid packstone particularly near section I. Renalcis Vologdin forms the dominant algae in the wackestone, occurring between, and encrusting unbroken cups of Archaeocyatha, some of which are in growth position (Plate 1, Figs. 3, 4). The first Archaeocyatha are overlain by a cross-bedded unfossiliferous ooid grainstone (Plate 1, Fig. 5). The following interbedded facies overlie the ooid grainstone: Archaeocyathid-algal packstone-wackestones and archaeocyathid-algal wackestone-mudstones.

The two facies contrast strongly. The first mentioned above consists of few large whole cups and many broken fragments of Archaeocyatha together with an algal-like form described below. Epiphyton Bornemann commonly encrusts broken fragments; oncolites with archaeocyathid cores are common. This facies is well bedded (Plate 2, Fig. 1). In contrast, the massive archaeocyathid-algal wackestones and mudstones are composed mainly of micrite. Archaeocyatha are whole and in growth position, Epiphyton Bornemann is common, Renalcis Vologdin, is rare, hyolithids and sponge spicules occur in the micrite. One very common distinctive algal-like form occurs in growth position in this facies and as broken plate-like fragments in the interbedded facies. The organism is silicified, consisting of a basal saucer-like calyx up to 10mm across, from which grows a series of upright, occasionally branching finger-like projections up to 7mm long (Plate 2, Figs. 2, 3).

Limestone containing Faunal Assemblage I in the Mount Scott Range is dolomitized and the original sedimentary fabric is largely obliterated. However, it is possible to see a relict fabric of alternating massive and thinly bedded bioclastic limestones (Plate 2, Fig.4), and in some places chert nodules have preserved the original archaeocyathid-ooid grainstone and packstone lithology (Plate 2, Fig. 5). The uppermost part of Faunal Assemblage I in the Mount Scott Range is marked by a thin band containing numerous poorly preserved small shelly fossils with abundant sand size grains of glauconite, which stand out in relief on weathered bedding planes. This is overlain by up to 10m of very poorly outcropping dolomitized archaeocyathid limestone which may be in either Faunal Assemblage I or II. The shelly band is a marker horizon which is considered herein to be the uppermost boundary of carbonates which can be confidently assigned to Faunal Assemblage I.

Environments of deposition.

A change from a restricted to an unrestricted shallow marine environment is indicated by the first appearance of Archaeocyatha. Below the unfossiliferous ooid grainstone, deposits with Archaeocyatha and algae in growth position are predominant at the type section. These pass laterally into thinly bedded bioclastic limestone, locally quartz sand rich and oolitic in the vicinity of section I, indicating an increase in current intensity to the south. The overlying unfossiliferous ooid grainstones suggest some environmental instability during the initial transgressive phase, with periods of shoaling, moderate turbulence and mobility of the seafloor sediments not suited to the permanent establishment of Archaeocyatha. Archaeocyatha were quickly established above the ooid grainstone in a more stable environment. The interbedded archaeocyathid-algal mudstones and packstones distinguish sites of low energy with local trapping of micrite by algae,with Archaeocyatha in growth position, separated by areas of moderate turbulence with a high degree of reworking of skeletal debris. These resemble biohermal and interbiohermal facies, but no topographic relief of the mudstone facies compared with the packstone facies can be demonstrated, largely due to the bold massive nature of the outcrop.

Unit 3. Carbonates containing Lower Faunal Assemblage II.

This interval is represented by one facies in every section measured at Wilkawillina Gorge. Recrystallization has altered the bulk of the matrix to sparry calcite and has affected fossil preservation to some extent, particularly in the type section. The outer walls of Archaeocyatha are often poorly preserved. Phosphatic shelly fossils which were abundant, now appear as "ghosts" in the matrix, however it is possible to find them well preserved in some places. The following facies is typical for all sections:

Skeletal-algal wackestones.

The sequence initially contains a great deal of reworked shelly and inorganic debris, usually glauconitic, and locally forming conglomerates with clasts derived from limestone of the underlying Unit 2. Large Archaeocyatha are relatively uncommon and all fossils are abraded. Above the basal conglomerate the remainder of the sequence is thinly bedded and sometimes cross-bedded, although outcrop is massive. Fossils are well sorted, consisting of small cups or fragments of large cups. Small radiating masses of Epiphyton Bornemann are occassionally preserved. Masses of calcified algal filaments (? Girvanella) are common.

In the Mount Scott Range three stratigraphic sections, J, M, and N are considered separately because each displays different facies. Section K is too extensively dolomitized to yield information, section L is dolomitized but the relict fabric on weathered surfaces indicate facies similar to those found in the lower part of section N.

Section J: Skeletal wackestones.

The shelly band mapped as uppermost Faunal Assemblage I occurs 10m below this facies. The intervening 10m consists of dolomitized limestone with Archaeocyatha and brachiopods, which might be basal Faunal Assemblage II. The facies consists of brick red limestone containing sparse whole cups of large and small Archaeocyatha, numerous small fragments of broken cups and abundant sponge spicules including Chancelloria. The micrite matrix contains abundant small dolomite crystals. Algal remains are not evident in the lower part, but scattered small oncolites are present in the upper part.

Section M: Hyolithid mudstones and wackestones.

This facies is separated from carbonates containing uppermost Faunal Assemblage I by 10m of dolomitized limestone containing Archaeocyatha, which may belong either to Faunal Assemblage I or Faunal Assemblage II. The facies consists of pale grey to off-white calcareous mudstone containing abundant but poorly preserved hyolithids scattered in bedding planes. Chancelloria, brachiopods and gastropods are common. Archaeocyatha are rare, only one specimen (poorly preserved) was found.

Section N.

Two facies occur one above the other in this section. The lower facies has yielded more than 30 percent of the total number of species of Archaeocyatha described herein, but very few of these species occur in the upper facies.

Skeletal packstones and wackestones.

This facies is separated from carbonates containing uppermost Faunal Assemblage I by a 10m interval with no outcrop. The facies consists of pink to red alternating thinly and thickly bedded bioclastic limestone. Archaeocyatha, brachiopods and other phosphatic shelly fossils are very abundant. The thicker beds are poorly sorted and contain small and large Archaeocyatha which are very well preserved. Most cups lie in bedding planes with their inner cavities partly filled with geopetal micrite. Cups encrusted by algae are rare. Flat masses of algal filaments (? Girvanella) are sparse. The thinner beds are well sorted and contain small or fragmented Archaeocyatha, brachiopods and sparse small radiating clusters of Epiphyton Bornemann.

Archaeocyathid-algal wackestones.

This facies conformably overlies that mentioned above. The skeletal fauna is dominated by several species of Archaeocyatha, only a few of which were found stratigraphically below. Brachiopods have not been found although other shelly fossils including tommotiids occur. Archaeocyatha, some very large, occur in growth position, with extensive masses of Epiphyton Bornemann growing from their outer surfaces. Algal growths extending outwards up to 40mm from the cups have been found (Plate 3, Fig. 1).

Environments of deposition.

This unit at Wilkawillina Gorge is characterized by the uniformity of facies in the area studied. The presence of conglomerates and abraded fossils in the basal part of the unit indicate a hiatus of unknown duration, during which time lithified beds containing Faunal Assemblage I were reworked. Archaeocyatha in this part of the sequence (but not within the reworked clasts) are commonly abraded indicating some degree of transportation. The remainder of the sequence is well sorted and thinly bedded although the beds appear massive in outcrop. The presence of a micrite matrix, commonly recrystallized to calcite spar, indicates that currents at the final site of deposition were too weak to winnow the muddy fraction. No Archaeocyatha were found in growth position and some degree of transportation from their growth site is inferred.

In the Mount Scott Range the different facies in sections J, M and N indicate a variety of environments, some not suited to optimum growth of Archaeocyatha. Section N is 1.7km northwest of M, section J is 2.9km southeast of M. Section L is situated 1.8km south-east of M. Dolomitized limestone containing Lower Faunal Assemblage II in section L, judging by the size and abundance of fossil remains, indicates a facies similar to that found in the lower part of section N. A fault situated midway between sections L and M appears to have influenced seafloor topography in its vicinity in the Early Cambrian.

Although a shallow marine environment is envisaged for section M, it is nevertheless considered to be relatively deeper than adjacent areas further from the fault. A thickness of only 10m for lower Faunal Assemblage II and the paucity of Archaeocyatha indicate that this section was not receiving sediments from surrounding shallower areas.

In contrast, section N (and possibly section L) has a great abundance of shelly fossils in its lower part which is 48m thick. Few Archaeocyatha are in growth position, the majority lie in bedding planes but are very well preserved indicating rapid burial and minimal transport. The cups probably grew in situ and were toppled by strong currents of brief duration, which deposited thinner beds of smaller, well sorted skeletal remains. The overlying archaeocyathid-algal wackestone facies (14m thick) contains Archaeocyatha in growth position surrounded by extensive algal growths. A possibly deeper and certainly calmer environment of deposition is envisaged.

In section J, which is some distance southeast from the remaining sections, the abundance of micrite, lack of algal remains and relative scarcity of Archaeocyatha, suggest that the water was too turbid for optimum growth of Archaeocyatha. Brachiopods which are numerous in section N, are noticeably absent from section J, whereas "Micromitra" etheridgei (Tate) does occur.

Unit 4. Carbonates containing Upper Faunal Assemblage II.

At Wilkawillina Gorge the majority of the sequence is a continuation of the skeletal-algal wackestones found in Unit 3. As before, this facies is found in every measured section. Upper Faunal Assemblage II can only be distinguished from Lower Faunal Assemblage II on palaeontological evidence. Large Archaeocyatha are more common in the upper part of the sequence, cups are often surrounded by algae but their preservation is poor in places, particularly in the type section. Initially the limestone is pale to dark grey, but a strong pink staining appears in the matrix close to the disconformity which marks the top of archaeocyathid rich Faunal Assemblage II limestone. The uppermost few centimetres of limestone immediately below the disconformity in some sections contains a rich fauna of small shelly fossils in a red micrite matrix.

Limestones containing Upper Faunal Assemblage II in the Mount Scott Range consist of two sequences. The lower sequence contains three different facies, the upper sequence is characterized by a uniform facies in every measured section. Facies in the lower part are considered separately as follows.

Section K: Skeletal packstones and wackestones.

In this section, measured adjacent to the fault, limestone containing Faunal Assemblage I is missing, limestone containing Lower Faunal Assemblage II is very thin and dolomitized. The facies is the same as that found the lower part of the sequence containing Lower Faunal Assemblage II at section N. The fossils are abundant but often fractured by numerous calcite veins. This part of the section is correlated with Upper Faunal Assemblage II on palaeontological evidence and by the fact that the packstones and wackestones intertongue with the uniform facies which constitutes the upper sequence in other sections.

Sections L and M: Skeletal mudstones and wackestones.

The facies consists of pale to mid-grey micrite with scattered fragments of Archaeocyatha, hyolithids, *Chancelloria* and gastropods. Algal remains have not been found. Glauconite is abundant in the basal part of the sequence at section L. In these sections the mudstones and wackestones are interbedded with the uniform facies of the upper sequence.

Sections J and N: Skeletal-algal packstones and wackestones.

In both sections the basal beds consist of well sorted bioclastic limestones, locally conglomeratic, overlying rocks containing Lower Faunal Assemblage II with a sharp contact. Archaeocyatha are small or fragmentary, brachiopods are rare, but "Micromitra" etheridgei (Tate) is very abundant. Small rounded masses of Epiphyton Bornemann are common. The micrite matrix is preserved as geopetal infilling within cups of Archaeocyatha, but elsewhere it is altered to calcite spar and minor dolomite. Higher in the sequence the skeletal packstones are interbedded with wackestones, Archaeocyatha are larger and frequently surrounded by algal growths which form a grey clotted fabric which contrasts with the red matrix. A variety of small shelly fossils appears in the uppermost beds.

Skeletal wackestones and packstones.

This is the uppermost facies containing Faunal Assemblage II and is found in every section in the Mount Scott Range. The uppermost few centimetres of limestone with Upper Faunal Assemblage II, immediately below the disconformity at Wilkawillina Gorge, display a similar facies.

The rocks consist of richly fossiliferous bioclastic limestone, Archaeocyatha are common and reach a large size, but are by no means the dominant fauna. Specimens of "Micromitra" etheridgei (Tate) are very abundant and there are numerous specimens of Chancelloria, gastropods, hyolithids, tommotiids and other problematica. Brachiopods are rare and algal remains appear to be absent. In section M, sponge spicules form the dominant fauna. Fossils are very well preserved, the sediment within and surrounding fossils consists of pale pink to blood-red micrite (Plate 3, Fig.2). In general, the rock has a grain supported fabric, but inverted cups of some large Archaeocyatha and even shells of "Micromitra" etheridgei (Tate), enclose a microfacies which is essentially a mudstone bioturbated by burrowing fauna (Plate 3, Fig. 3). Some archaeocyathid cups found in section K show clear evidence of microboring (Plate 4, Fig. 1). Coarse sand size grains and granules of glauconite are abundant in section L and less common elsewhere.

Environments of deposition.

At Wilkawillina Gorge an environment similar to that suggested for rocks containing Lower Faunal Assemblage II is envisaged, namely a calm shallow marine environment receiving sediment from a nearby source. In contrast to the Mount Scott Range sections, the limestone containing Faunal Assemblage II at Wilkawillina Gorge has practically no terrigenous detritus. The upper part of the sequence contains larger Archaeocyatha often surrounded by algal growth, suggesting more or less in situ accumulation. The relatively poor fossil preservation in the upper part of the sequence is thought to be due to diagenetic processes associated with subaerial exposure during the temporal break indicated by the calcrete capped disconformity surface.

In the Mount Scott Range the first influx of sediments in sections J and N indicate rapid deposition with local reworking of the underlying beds in a shallow, moderately high energy environment. This is in marked contrast to the calm conditions indicated for carbonates containing the upper part of Lower Faunal Assemblage II at section N. Interbedded wackestones with Archaeocyatha encrusted by algal growths in the upper part of the sequence, suggest a return to calmer conditions.

In section M, an environment similar to that described previously continued during this time. Archaeocyatha are rare and the only abundant fossils are hyolithids and sponge spicules. As before, there is no evidence of sediment influx from the Archaeocyatha-rich surrounding areas. A similar environment is also envisaged for section L during the time of deposition of sediments containing Upper Faunal Assemblage II. As stated previously, rocks containing Lower Faunal Assemblage II are dolomitized, but an environment similar to that found in section N is suggested by the relict fabric which indicates an abundance of fossils. Rocks containing Upper Faunal Assemblage II in section K indicate a shallow marine environment similar to that described for the lower sequence in section N during the time of deposition of Lower Faunal Assemblage II.

The uppermost facies represented by rocks containing Upper Faunal Assemblage II in the Mount Scott Range is found in all of the measured stratigraphic sections. In sections L and M it is represented by one metre thick interbeds, but this facies varies from 10m to 13m thick in sections J and N, and reaches approximately 50m in section K. The environment is considered to be shallow to very shallow, but there is no evidence of subaerial exposure. Bottom currents were sufficiently strong to winnow the muddy fraction of the sediment except in sheltered niches beneath inverted cups where the mud is preserved. The presence of microboring in some of the archaeocyathid cups indicate a possible source of some of the micritic sediment. James and Kobluk (1978) have reported algal microboring from the periodically exposed upper surfaces of Cambrian "patch reefs" of Lenian age from Labrador.Archaeocyatha from Upper Faunal Assemblage II are considered herein to be Upper Atdabanian in age and the associated microborings may be the oldest known from the Early Cambrian. The facies in which they are found is a bioclastic limestone with no topographic relief to suggest bioherms or "patch reefs".

The distribution of Archaeocyatha in Faunal Assemblage II.

The distribution of species of Archaeocyatha from Faunal Assemblage I cannot be compared between Wilkawillina Gorge and the Mount Scott Range because of dolomitization of the limestone at the latter locality. This discussion is therefore concerned only with species distribution in Faunal Assemblage II.

A large number of samples was collected from closely spaced measured stratigraphic sections at both localities. More than 2800 thin sections, some up to 90mmx50mm in dimensions were prepared and examined by the present writer, thus it is considered that a representative sample has been obtained. A number of species occur in abundance at only one or other of the two localities examined herein. If these had been present at both localities, fragments at least, would have been seen in the large number of thin sections prepared. The fact that some species occur only in one locality or the other suggests that there were genuine environmental factors controlling the species distribution. Geographic separation is not considered to be a major factor because a number of other species occur commonly or sporadically at both Wilkawillina Gorge and the Mount Scott Range. Fifty three species of Regulares and Irregulares have been identified in limestone containing Faunal Assemblage II, whose Lower and Upper subdivisions are considered separately as follows:

Lower Faunal Assemblage II.

Only three species have been found exclusively at Wilkawillina Gorge. Specimens have been found in each of the four stratigraphic sections measured in this interval. The fifth stratigraphic section (section F) was measured only into Faunal Assemblage I. In contrast, five stratigraphic sections were measured in the Mount Scott Range through the same interval. Sections K and L were measured through dolomitized limestone and yielded no reliably identifiable species, although Archaeocyatha were abundant. Section M contained very rare specimens of Archaeocyatha, none of which could be positively identified. In the remaining two sections, section J yielded one species which was found nowhere else but section N yielded twenty three species which were found nowhere else in the Mount Scott Range. Thus forty three percent of the total number of species from Faunal Assemblage II have been found only in section N.

Ten species were found at both localities in Lower Faunal Assemblage II. In the Mount Scott Range they are found only in section N. At Wilkawillina Gorge however, specimens belonging to these species have been found in all measured stratigraphic sections.

Upper Faunal Assemblage II.

Of the seven species found only in Upper Faunal Assemblage II, four are known from both localities. In the Mount Scott Range they were found in sections J, K and N, but not in sections L or M. At Wilkawillina Gorge they were found in sections G, H and I, but not section E where fossil preservation is poor.

Lower and Upper Faunal Assemblage II.

Nine species range throughout Faunal Assemblage II. Of these, six have been found at both localities. They occur in sections J, K and N in the Mount Scott Range and in sections E, G, H and I at Wilkawillina Gorge.

The distribution of other shelly fossils.

Phosphatic and phosphatized shelly fossils were obtained from hand specimens dissolved in acetic acid. Section N was sampled in particular because of good fossil preservation, and a representative sample of small shelly fossils was obtained. Other stratigraphic sections were sampled and compared with section N. Fewer fossils were obtained from Wilkawillina Gorge because of recrystallization. With the exception of "Micromitra" etheridgei (Tate) the fossils were not identified at species level, they are grouped in higher taxonomic categories to show overall changes in their abundance. The following results were obtained from hand specimens from section N.

Unit 3. Lower Faunal Assemblage II.

Skeletal packstone and wackestone facies.

Apart from Archaeocyatha, brachiopods form the dominant shelly fauna. "Micromitra" etheridgei (Tate), Hyolithids and Chancelloria are scarce. Tommotiids are abundant; many of the specimens probably belong to the genus Dailyatia Bischoff, whose affinity to the Tommotiidae has been criticized by Bengston (1977). No specimens of gastropods were found.

Archaeocyathid-algal wackestone facies.

Brachiopods are noticeably absent, specimens of "Micromitra" etheridgei (Tate) are rare initially but become more common upwards, tommotiids are relatively abundant. Hyolithids which are initially sparse, suddenly appear in great abundance in the upper few metres of the facies, while at the same time Epiphyton Bornemann disappears abruptly.

Unit 4. Upper Faunal Assemblage II.

Skeletal-algal packstone and wackestone facies.

Brachiopods are rare or absent and "Micromitra" etheridgei (Tate) forms the bulk of the phosphatic shelly fauna, estimated to constitute 80 percent or more of the total. Tommotiids are common, Chancelloria fragments are sparse, hyolithids are present, but considerably less abundant than in the uppermost part of the underlying facies.

Skeletal wackestone and packstone facies.

This uppermost facies is dominated by a diverse shelly fossil assemblage, Archaeocyatha are relatively sparse. "Micromitra" etheridgei (Tate) is abundant, together with tommotiids, hyolithids and Chancelloria. Fossils appearing for the first time in section N (at least in Faunal Assemblage II), include lapworthellids, helcionellid and pelagiellid gastropods and new species of brachiopods, besides a variety of unidentified problematica. Trilobites appear for the first time at this stratigraphic level.

The paraconformably overlying Faunal Assemblage III occurs in a similar facies. The boundary is marked by the abrupt disappearance of "Micromitra" etheridgei (Tate) and the equally abrupt first appearance of elements of Faunal Assemblage III, including Hyolithes planoconvexa (Tate), numerous pelagiellid and helcionellid gastropods and sparse ? conchostracans.

Discussion.

There is a marked contrast in the distribution of species of Archaeocyatha from Lower Faunal Assemblage II at the two localities studied herein. At Mount Scott the highest species diversity is found in the lower skeletal packstone - wackestone facies in section N. Very few species occur in the overlying archaeocyathid-algal wackestone facies. At Wilkawillina Gorge, species are uniformly distributed in all sections in rocks containing Lower Faunal Assemblage II. Species in limestone containing Upper Faunal Assemblage II occur in sections J, K and N in the Mount Scott Range, and in every section at Wilkawillina Gorge except the type section where fossil preservation is poor.

The distribution of species corresponds to facies distributions at both localities in rocks containing Lower and Upper Faunal Assemblage II. Uniform facies at Wilkawillina Gorge contain uniformly distributed species of Archaeocyatha, whereas lateral and vertical facies changes in Lower Faunal Assemblage II at Mount Scott give rise to a non-uniform distribution of Archaeocyatha. The more uniform facies in rocks containing Upper Faunal Assemblage II match the more uniform species distribution in the Mount Scott Range.

Vertical facies changes affecting the distribution of

Archaeocyatha in Faunal Assemblage II at section N have also affected the distribution of other small shelly fossils. At present there is insufficient data to trace the distribution of phosphatic shelly fossils through lateral facies changes in other sections measured in the Mount Scott Range, although section M as described above is different from section N. The sparse data from Wilkawillina Gorge shows that there is no lateral variation in the distribution of phosphatic shelly fossils. However, there is a vertical change seen in all sections which principally involves the replacement of abundant brachiopods in rocks containing Lower Faunal Assemblage II by "Micromitra" etheridgei (Tate) in rocks containing Upper Faunal Assemblage II. At both Wilkawillina Gorge and the Mount Scott Range trilobites are first found high in Upper Faunal Assemblage II.

The facies at Wilkawillina Gorge and the Mount Scott Range indicate shallow marine environments of deposition on a broad stable shelf. Water depth and geographic separation do not appear to be major factors controlling the observed species distribution between the two localities. The relatively high content of terrigenous material at Mount Scott suggest that this locality was closer to land and it is possible that fluctuations in turbidity, current intensity and salinity may have influenced species distribution. Until more localities are studied in detail the factors controlling species diversity suggested above are purely speculative.

Facies changes in carbonates above rocks containing Faunal Assemblage II.

At Wilkawillina Gorge the following discussion is concerned only with that part of the Wilkawillina Limestone which outcrops between the disconformity and the Parara Limestone in the vicinity of the type section i.e. before the first appearance of elements of Faunal Assemblage III. In the vicinity of the biostromal bank where Walter (1967) measured his section A-B, the Wilkawillina Limestone intertongues with other formations of the Hawker Group and thus contains fossils which correlate with younger faunal assemblages. A study of that locality is beyond the scope of the present work.

In the Mount Scott Range facies changes in limestones containing Faunal Assemblage III and younger assemblages are examined briefly for the sake of completeness since several species of Archaeocyatha from this interval have been described herein. Each locality is discussed separately as follows:

Wilkawillina Gorge in the vicinity of the type section.

Archaeocyatha-rich Wilkawillina Limestone at Wilkawillina Gorge is truncated by a disconformity capped by a red calcrete layer indicating subaerial exposure. The calcrete has a wide geographic extent and has long been recognized as a regional disconformity (Daily, 1972a, 1976; Daily in Thomson et al, 1976, Haslett, 1976; Moore, 1979 and others). Although the calcrete horizon is rarely more than 10cm thick it is remarkably presistent laterally and has been recognized from Wirrealpa, Balcoracana Creek and Wilkawillina Gorge around the margin of the Wirrealpa Basin, and from Brachina Gorge to Bunyeroo Gorge along the western margin of the Heysen Range.

Haslett (1976) described the occurrence of the calcrete surface and associated palaeokarst features from an area northwest of Wirrealpa and did not report any occurrence of a calcrete layer at the top of the Wirrapowie Limestone 15km north of Wirrealpa (Haslett, 1975). The Wirrapowie Limestone is poorly fossiliferous and is overlain by Parara Limestone. It intertongues with the Wilkawillina Limestone north of Wirrealpa Hill and is probably the same age as limestone containing Faunal Assemblage II.

At Wilkawillina Gorge the calcrete surface has been traced from a locality 1.1km north of the type section where it is overlain directly by Parara Limestone, southwards as far as section C-D of

Walter (1967) where it is overlain by approximately 70m of Wilkawillina Limestone, then by Parara Limestone. It is not known at present whether the calcrete surface extends as far east as the biostromal bank. In the study area the overlying Wilkawillina Limestone increases in thickness from 33m at the type section (section E) to 82m at section I. The Wilkawillina Limestone in this interval consists of two units. The lower unit is 20m thick at the type section, increasing to 57m at section I. It consists of intensely ferruginized mottled grey limestone containing sparse thin, abundantly fossiliferous bands. Archaeocyatha are rare and extremely fragmented, often present only as coarse sand size clasts. The beds immediately overlying the calcrete are richly fossiliferous, consisting chiefly of ferruginized hyolithids with less common fragments of trilobites and "*Micromitra*" *etheridgei* (Tate).

In contrast, the upper unit, which varies in thickness from 9m in section E to 25m in section I, consists of pale to medium grey thinly bedded limestone with argillaceous partings. Fossils are abundant in widely separated thin bands which outcrop to within 2m of the Parara Limestone. In the remaining 2m, pale to dark grey laminated limestone shows evidence of disruption in the form of pinch and swell structures and angular clasts of intraformational conglomerate. The fossils in this unit include abraded archaeocyathid cups and numerous very well preserved phosphatic shelly fossils, including brachiopods, lapworthellids, gastropods, tommotiids, hyolithids and trilobites. "*Micromitra*" *etheridgei* (Tate) has not been found in the upper unit by the present writer and the Archaeocyatha cannot be related to species in Faunal Assemblage II. One species described from this unit is *Bractocyathus curvus* sp.nov. No species of *Bractocyathus* Kruse have been found in Faunal Assemblage II, but species of this genus are known from younger faunal assemblages.

It is considered herein that the lower unit immediately above the disconformity contains Faunal Assemblage II, but the upper unit contains a new assemblage between Faunal Assemblage II and Faunal Assemblage III. The first fossils diagnostic of Faunal Assemblage III occur in the lower 37m of the Parara Limestone (Daily, 1956).

Mount Scott Range.

In most stratigraphic sections measured in the Mount Scott Range limestone containing Faunal Assemblage II is overlain by limestone containing Faunal Assemblage III of similar facies. The boundary between the two faunal assemblages is a paraconformity which can only be located on palaeontological evidence. Elements of the new faunal assemblage discussed above have not been found in the Mount Scott Range.

Up to 100m of Ajax Limestone contains fossils younger than Faunal Assemblage II, Archaeocyatha are less common than other fossils but several archaeocyathid-rich lenses have been found. Some species described herein may belong to Faunal Assemblage V, these were found in section M which yielded no identifiable Archaeocyatha from Faunal Assemblage II. Lateral facies changes are evident and the sequence is complicated by three limestone conglomerate and breccia deposits. The breccia deposits are localized in erosional channels in the vicinity of the fault, whereas the conglomerates are widespread and occur along the entire length of the Mount Scott Range. The following sequences have been observed:

Sections J and N.

Faunal Assemblage III and possibly Faunal Assemblage IV occur in red bioclastic limestone 23m to 26m thick containing predominantly phosphatic shelly fossils and trilobites. The upper 18m of limestone in section J contains sparse unidentified Archaeocyatha. In section J, the limestone is overlain by 6m of red intraformational limestone conglomerate followed by a sequence of stromatolites which are dolomitized. An estimated 60m of dolomite, stromatolitic in the lower and uppermost parts is overlain by the Billy Creek Formation. In section N, limestone containing Faunal Assemblages III and IV is overlain by 13m of dolomitized limestone conglomerate stratigraphically above that found in section J. The conglomerate is overlain by a thin stromatolite unit but the contact with the Billy Creek Formation is obscured by Recent alluvium.

Sections L and M.

In section L, limestone with Faunal Assemblage II is overlain by 43m of grey limestone with numerous trilobites and hyolithids but few Archaeocyatha. The lower part of the sequence contains Faunal Assemblage III. The grey limestone is overlain by 26m of glauconitic, poorly fossiliferous pale grey to pink limestone, 20m of dolomitized limestone conglomerate and 62m of dolomite which is stromatolitic at the base and the top. The dolomite between the two stromatolite beds may have been conglomeratic. The top stromatolites are overlain by red shales of the Billy Creek Formation.

In section M, limestone with Faunal Assemblage II is overlain by 100m of grey to buff massive limestone with abundant trilobites and hyolithids and less common gastropods and brachiopods. Three specimens of *Scenella* Billings were found in the lower part of the interval corresponding to Faunal Assemblage III. The unit is overlain by 6m of red and grey limestone with abundant Archaeocyatha, trilobites and small shelly fossils probably correlating with Faunal Assemblage V. Oncolites are locally abundant. The fossil limestone is overlain by up to 5m of red intraformational limestone conglomerate, followed by up to 15m of stromatolites. Between the conglomerate and stromatolites a unit of buff, thinly bedded, fissile and platy dolomite outcrops. This strongly resembles the Edeowie Limestone Member of the Oraparinna Shale (Moore, 1979). The stromatolites are overlain by at least 1m of grey intraformational limestone conglomerate which rapidly becomes dolomitized upwards. Up to 40m of dolomite whose uppermost beds are stromatolitic, outcrop below the Billy Creek Formation.

Section K.

Section K was measured on the southeast side of the fault which bisects the study area. Only limestone with Upper Faunal Assemblage II and younger faunal assemblages are fairly well preserved. Limestone with Upper Faunal Assemblage II is overlain by 44m of strongly recrystallized grey limestone with poorly preserved Archaeocyatha, trilobites and small shelly fossils possibly belonging to Faunal Assemblage III. The limestone is overlain by 8m of red intraformational limestone conglomerate, 10m of thinly laminated red limestone and approximately 40m of dolomite whose basal and uppermost beds are stromatolitic. The uppermost stromatolites are overlain by the Billy Creek Formation.

One hundred metres southeast of section K, limestone containing Upper Faunal Assemblage II is overlain by 10m of massive grey limestone containing trilobites belonging to Faunal Assemblage III. A channel deeply scoured into the overlying limestone plunges to the northeast. The base of the channel contains poorly sorted angular clasts of limestone breccia up to 20cm diameter. The matrix consists of coarse, well rounded quartz sand and coarse calcarenite. The breccia clasts consist of grey glauconitic limestone with abundant trilobite fragments and sparse fragments of unidentified Archaeocyatha. The channel deposits are overlain by red limestone conglomerate. A similar channel or series of channels occurs on the northwest side of the fault between sections K and M. Up to 60m of limestone containing Faunal Assemblage III (at least in the lower beds) underlies the channel floor. On this side of the fault the channel contains basal breccias passing upwards into calcareous sandstone. The remainder of the channel is filled with pink to red limestone lenses rich in trilobites, brachiopods and small shelly fossils, intercalated with lenses rich in Archaeocyatha which possibly belong to Faunal Assemblage V. The limestone is overlain by the intraformational limestone conglomerate and stromatolite sequence found elsewhere.

Discussion.

Despite the fact that facies changes and periods of erosion have complicated the stratigraphic sequence in the upper part of the Ajax Limestone at Mount Scott, the limestones are richly fossiliferous and warrant detailed study. This locality will provide important information about younger faunal assemblages, some of which may be absent due to diapirism at the classic Ajax Mine locality.

CHAPTER 4.

OUTER WALL STRUCTURES OF SOME SOUTH AUSTRALIAN REGULARES AND IRREGULARES.

Introduction.

This chapter summarizes the results obtained from a detailed examination of the outer wall structures of Regulares and Irregulares. Particular attention is drawn to the formation of supplementary porous structures on the outer wall. This aspect of skeletal morphology has been studied for three reasons:

1. Because the outer wall is the first skeletal element to appear in ontogeny the taxonomic rank of superfamily has been designated to its structure (Debrenne, 1964; Hill, 1972; Rozanov, 1969, 1973; Kashina, 1979). Thus, refined taxonomic discrimination of Regulares starts with an understanding of the various extant types of outer wall.
2. Debrenne (1970b, 1974a) has suggested a scheme of classification for Irregulares along the same lines as that used for Regulares. Therefore it is necessary to determine a) the nature of the outer wall, and b) its ontogenetic development, in order to test the validity of her proposal.
3. Most of the Archaeocyatha hitherto described from South Australia are silicified. Consequently their outer walls are often poorly preserved and dimensions are distorted by the silicification process. Archaeocyatha which form the basis of this study are unsilicified and have been chosen specifically for their exceptionally good preservation.

Although the present study concentrates on an examination of Archaeocyatha from the lowest levels of the Ajax and Wilkawillina Limestones, additional examples from younger strata are used for comparison. Three major types of supplementary outer wall structures are examined for Regulares:

1) pore diaphragms 2) independent microporous sheaths 3) non-independent microporous sheaths.

In contrast, only one type of microporous system has been found for Irregulares in the lowest fossiliferous strata studied, but this is often modified by the complexity of the underlying main wall structure (carcass)*. In addition, some simpler outer wall types are compared for Irregulares to show that it is difficult to find a clear distinction between them. A new scheme of classification of Irregulares is proposed at superfamily level. The taxonomic rank assigned to microporous systems on the outer walls of Irregulares is discussed.

*Investigators in the USSR. employ the term "karkass" when referring to basic wall structures. Its English equivalent "carcass" is used herein in the same sense.

COMPLEX OUTER WALLS OF *REGULARES*.

A. Outer Walls with Pore Diaphragms.

Pore diaphragms are seen on the external surface of the outer walls of some genera of regular Archaeocyatha in the Suborders Ajacicyathina and Nochoroicyathina. In a description of *Archaeocyathus trachealis*, Taylor (1910, p.125) stated; "Outer wall is rather delicate with numerous close set pores. In the larger specimens this seems to have been invested by a thin layer, by which the pores were almost closed.". However, only recently South Australian specimens have been examined with particular emphasis on describing the morphology of this type of outer wall modification (Debrenne, 1973).

The early appearance in ontogeny of outer wall pore diaphragms in some species of *Baikalocyathus* Yazmir and *Irinaecyathus* Zhuravleva has led to the separation of the Superfamily *Irinaecyathacea* Zhuravleva (Zhuravleva and Elkina, 1974) in the Suborder Ajacicyathina. Thus pore diaphragm outer walls are diagnostic for this superfamily (*op. cit.* p.67). Prior to this time, species with outer wall pore diaphragms had been included with those having simple outer walls in the Superfamily *Ajacicyathacea* Bedford R. and J.

to be revised for including only the pore-diaph which is not the case presently

The terminology used by specialists in the USSR for this type of outer wall refers to its appearance in thin section. They employ the expression "molotochki" (little hammers), but the term "diaphragm" first used by Debrenne in 1973 seems more appropriate and is used herein.

Debrenne (*op. cit.*) described two different types of pore diaphragms for species in the genus *Thalamocyathus* Gordon and separated two species; *Thalamocyathus trachealis* (Taylor) and *Thalamocyathus tectus* Debrenne. However, she included the latter species in the genus with reservation because its diaphragms closely resemble simple tumuli or possibly S-shaped pore tubes. These are diagnostic of other superfamilies in the Ajacicyathina.

The two types of diaphragm were described and illustrated by Debrenne (1973, p.6, Fig.5A,B) who used the expressions "obturation en diaphragme" ("flat" pore diaphragm herein) for the type seen on the outer wall of Thalamocyathus trachealis (Taylor), and "obturation avec bombement du diaphragme" ("bulging" pore diaphragm herein) for the type seen on the outer wall of Thalamocyathus tectus Debrenne. More detailed study, based on a number of well preserved specimens belonging to several genera has shown that there are a number of modifications of the first mentioned type. There are three components of the outer wall pore system when viewed in longitudinal section: [text fig. 5]

The horizontal or oblique lintel between adjacent pores in a single vertical or horizontal row; the diaphragm, which is the thin membrane partly closing the outer wall pore at the external surface; and the foot which refers to a thickening at the base of the lintel on the intervallum side of the outer wall. The lintel and diaphragm are always present but a foot may not be developed. It is emphasized here that these terms do not refer to separate skeletal parts but simply refer to different areas of what appears to be a single homogeneous section of the outer wall. Besides describing the morphology of the skeletal parts between adjacent wall pores, the shape of the pores themselves can be obtained from grazing sections parallel to the outer wall. There are two pores to consider; first, those between the lintels just below the diaphragm i.e. the main pores of the carcass itself; second, the pores which pierce the diaphragm and communicate to the exterior.

"Flat" Pore Diaphragm.

This type of pore diaphragm is very important since it forms the principal diagnostic feature of the Superfamily Irinaecyathacea Zhuravleva. In their description of this diaphragm type, Zhuravleva and Elkina (1974, p.22) state:

Little Hammer Outer Wall Pores. The outer wall pores have in this case usually a circular or slightly flattened shape in the vertical axis of the cup: the pore diameter is constant both on the intervallum side and on the outer side of the cup. On the outside the pores are covered by thin plates - membranes with an opening in the centre. The thickness of such walls, the thickness of the membranes, the pore diameter and even their number of rows per intersept are very constant in value. (Translated from Russian by the present author). The authors illustrated their description with a sketch (op. cit., p.23, Fig.7A) and with photographs of grazing outer wall sections of Irinaecyathus grandiperforatus (Vologdin) and Thalamocyathus trachealis (Taylor) (op. cit. Pl.1, Figs. 2,3). Their inclusion of the latter species makes it clear that workers from the USSR , Debrenne (1973) and the present writer are dealing with the same morphological feature.

Thalamocyathus trachealis (Taylor) is found in younger strata than those studied herein. The silicified fossils from Ajax Hill are in general either too poorly preserved or not suitably cut to allow a proper determination of the fine details of the outer wall. However, one specimen from the Taylor collection (T 1585) clearly shows the outer wall pore diaphragms in an etched longitudinal section and on an etched portion of the outer wall (Plate 5, Figs. 1,2).

There are two types of diaphragms which can be considered as "flat". The first type has the shape of the letter T in longitudinal thin sections, the outer surface of the cup is perfectly smooth, the lintel tapers slightly outwards and is perpendicular to undulations of the outer wall where present; the diaphragm is flat and a foot is not developed. Species having this form of pore diaphragm are Thalamocyathus trachealis (Taylor); ? Gordonicyathus (4 new species), and Rowanpectinus gen. nov. (2 species), (see Text-fig. 5A Plate 5, Figs. 3 to 7). The pores piercing the carcass are circular and/or oval (slightly stretched in a horizontal direction), the pores piercing the diaphragm are usually circular but may also be slit-like, in a horizontal direction (notably in Thalamocyathus trachealis); the lintel length does not exceed the diameter of the carcass pores so that pore tubes are not formed.

The second "flat" type of diaphragm bulges outward slightly, but to an insignificant degree when compared with the lintel length. As a result of the small bulge the outer surface of the cup is slightly raised to form minute pustules surrounding each outer wall pore, the lintel is horizontal, or inclined upward to the exterior at an angle of approximately 10° and a foot is developed as a slight increase in thickness on the intervallum side of the lintel. Species with this form of diaphragm are Baikalocyathus (2 new species), ? Taylorcyathus malleus sp. nov. and Baikalopectinus capulus gen. et. sp. nov. (Text-fig.5B, Plate 6, Figs 1 to 4). The carcass and diaphragm pores are circular or slightly stretched in a horizontal direction, pore tubes are not formed.

In the new species mentioned above, which are all from Faunal Assemblages I and II, the lintel length does not exceed the carcass pore diameter so that pore tubes are not formed. In two specimens from above Assemblage II the reverse is true and they are included here for the purpose of comparison (Text-fig.5C,D;Plate 6, Fig. 5; Plate 7, Figs. 6,7). The first, ? Thalamocyathus sp. from the upper part of the Ajax Limestone in the Mount Scott Range (? Faunal Assemblage V) has an outer wall with a long lintel inclined downward to the exterior at an angle of 20°, a flat thick diaphragm pierced by a pore directed obliquely upward, and a well developed asymmetric foot. The second, a specimen of Cyathocricus sp. from the upper part of the Wilkawillina Limestone near Wirrealpa (? Faunal Assemblage V) has a long, thin horizontal lintel, a slightly bulging diaphragm pierced by a central pore of unknown shape and a small symmetrical foot. In both cases the lintel length exceeds the carcass pore diameter so that pore tubes are formed on the outer wall.

All of the varieties described above are considered to be types of "flat" pore diaphragms, but the "bulging" diaphragm of Thalamocyathus tectus described by Debrenne (1973) is quite different and is thought to resemble a simple tumulus. This type is described below.

"Bulging" Diaphragm or Simple Tumulus

Debrenne (1973) suggested two possible origins for the "bulging" diaphragm seen over the outer wall pores of Thalamocyathus tectus. First, it could have been derived from the "flat" pore diaphragm described above. Second, it could have been an independently developed simple tumulus. Because of the uncertainty of its origin she placed the species provisionally in the genus Thalamocyathus.

The holotype of Thalamocyathus tectus Debrenne is at Princeton University and has not been examined by the present writer, but one additional specimen was found in the Bedford collection (P958-102) (Plate 7, Figs. 4,5). Additional specimens of a similar species have been collected from above Faunal Assemblage II in the Wilkawillina Limestone near Wirrealpa. The chief difference between the specimens from Wirrealpa and specimens of Thalamocyathus tectus is the magnitude of the radial coefficient, which varies between 7 and 7.5 for T.tectus and 9.3 to 12.5 for the Wirrealpa specimens; the latter specimens are herein referred to as "Thalamocyathus" c.f.tectus and the detailed structure of the outer wall is shown in Text-fig. 5E , Plate 8, Figs. 1 to 4.

The outer wall shows major differences in its construction compared with forms having "flat" pore diaphragms; the lintel is a triangular wedge with the apex pointing outwards so that the outer wall carcass pores (usually only 2 per intersept) are funnel shaped, widening to the exterior. The simply perforated "diaphragm" or tumulus supported on the triangular lintels bulges outwards to form a hemispherical dome whose convexity is equal in magnitude to the height of the triangular lintel. By comparison, the slight bulging seen in some "flat" diaphragms is insignificant when compared with their lintel length. The dome is pierced by a minute circular central pore.

The Growth of "Flat" and "Bulging" Diaphragms.

Data concerning the timing of the first appearance of diaphragms is based on the study of very few specimens. The inital formation of "flat" diaphragms has not been preserved, but they are certainly well developed at a cup diameter of 1.0mm for ? Taylorcyathus malleus sp. nov. and at 1.09mm cup diameter for ? Gordonicyathus pledgei sp. nov. One specimen of "Thalamocyathus" c.f. tectus shows that rudimentary bulging domes are formed at a cup diameter of 1.18mm and they are well developed at 1.23mm cup diameter, although the lintels at this stage seem to be rectangular rather than triangular (Plate 8, Fig. 4). In all cases the outer wall diaphragms are formed before the first appearance of annuli on the inner wall, which develop at 1.7-2.0mm for ? T.malleus; 1.16-1.30mm for ? G.pledgei, and 1.47mm for "Thalamocyathus" c.f. tectus.

Discussion

It is still impossible from the data available at present to determine whether species with "bulging diaphragms" were derived from stratigraphically earlier forms with "flat" diaphragms, or whether they were formed independently as true tumuli. Numerous ontogenetic studies have shown that species with tumulose outer walls develop simple tumuli at very different stages of cup growth (Zhuravleva 1960b; Zhuravleva et al. 1967; Rozanov 1963, 1973; Okuneva 1969; Belyaeva 1974). Cup diameters at which tumuli are first formed vary from 0.22-0.25mm for Tumulocyathus pustulatus Vologdin, to 2.5-3.0mm for Tumulifungia certa Okuneva.

The early appearance of both "flat" and "bulging" diaphragms in ontogeny does not necessarily indicate a close phylogenetic link between the two types and their morphological dissimilarity in adult cups tends to indicate a degree of difference above species rank. It is interesting to note that "bulging diaphragms" have not yet been found among annulate forms from the older limestones of Faunal Assemblages I and II. Another point of difference between the two types in the species mentioned above is found in the porosity of septa of young cups with diameters of 1.0 to 1.5mm. Small specimens of ? Gordonicyathus levis, ? G. pledgei and ? Taylorcyathus malleus have 2-3 rows of closely spaced septal pores across the intervallum (pore diameter 0.07-0.10mm), whereas the smallest known specimen of "Thalamocyathus" c.f. tectus has 3-4 rows of widely spaced septal pores across the intervallum (pore diameter 0.03-0.05mm). A discussion of the possible significance of differences in septal porosity at early stages of growth is given in the next chapter.

B. Outer Walls with Microporous Sheaths. [text fig 6]

Supplementary microporous sheaths are found on the outer walls of many Regulares and have been described by numerous authors (Missarzhevskiy and Rozanov, 1962; Repina et al., 1964; Rozanov and Missarzhevskiy, 1966; Rozanov, 1969, 1973; Debrenne, 1964, 1973; Kashina, 1979). Three major categories of microporous sheaths have been described, only two of which have been found in the stratigraphic interval under consideration. These are described below.

1. Independent Microporous Sheaths. text fig 6 A

Independent microporous sheaths have been found in numerous one walled and two walled Regulares. Among the two walled Regulares they are well known in the Dokidocyathina, Ajacicyathina and Coscinocyathina. Hitherto, the only species from South Australia thought to have an independent microporous sheath is Polycoscinus contortus (Bedford R. and J., 1937) known from a single silicified specimen now at Princeton University (See Debrenne, 1973). A new species in the genus Mennericyathus Rozanov and Debrenne, 1974 has been found in the Ajax Limestone near Mount Scott, South Australia and in the Mount Wright Volcanics and Cymbric Vale Formation from the Mount Wright area New South Wales. This is the only species known to have an independent microporous sheath in the stratigraphic interval under consideration.

The Mount Scott specimens form the basis of the description given below, illustrated in Plate 8, Fig. 5; Plate 9, Figs. 1,2; Text-Fig. 6A. The specimens from New South Wales were found by P. Kruse.

The basic carcass forming the outer wall has 2-3 rows of pores per intersept. Each pore is circular on the intervallum side and widens outward to form an oval or subrectangular shape at the external surface of the cup. The skeletal material surrounding each pore thus forms a triangular wedge shaped lintel with the apex pointing outward. In transverse and longitudinal sections the apices of the lintels appear to be extended outward by short rods or pillars. This is clearly shown in a grazing section (Plate 8, Fig. 5) which indicates that the wedge shaped lintels actually support a series of short pillars around the mouth of each carcass pore. The pillars are quite evenly spaced and number 6-8 around each pore. The outer ends of the pillars form supports for the microporous sheath which consists of a thin skeletal membrane pierced by numerous closely spaced circular micropores. The sheath micropores have no apparent symmetrical arrangement with respect to the underlying coarse carcass pore system. The smaller specimens tend to have smaller carcass and smaller sheath pores than larger specimens so that the number of micropores covering the area of each carcass pore is fairly constant at 9-12 micropores.

Growth of the Independent Microporous Sheath.

Unfortunately the initial development of the microporous sheath of this species is obscured by secondary thickening of the outer wall but it is clear that a sheath is present at a cup diameter of 2.2mm. At a smaller cup diameter of 1.8mm within the same specimen the outer wall pores are covered by a membrane of skeletal material, but it is impossible to say whether this is a sheath or dissepimental tissue. At a cup diameter of 1.6mm the lintels between the outer wall pores are rectangular rather than triangular and no covering membrane can be seen over the pores. Septa and tabulae are well developed before the first certain appearance of the microporous sheath. The inner wall appears to be relatively more spinose at the small cup diameters mentioned above than in large cups and the inner wall pores themselves are smaller (0.07-0.10mm compared with 0.085-0.12mm for large cups). They are present in only one row per intersept, compared with two to four rows per intersept for large cups.

Discussion

From a description of the outer wall of the South Australian material of Mennericyathus dissitus Kruse (in prep.) given above, the microporous sheath is clearly independent and removed from the underlying carcass. There is no growth of skeletal material across the carcass pores which are always quite smooth in outline.

Rozanov (1973, p.72) has suggested that the number of sheath micropores in the genus Mennericyathus is reduced in successively younger species appearing in the stratigraphic record. Thus the oldest species M. kundatus and M. gini from the lower Early Atdabanian have 14-32 micropores over each carcass pore; M. schoriensis from the upper Early Atdabanian has 12-20 micropores per carcass pore and the youngest species M. compositus from the Late Atdabanian has 4-7 micropores. If this sequence of reduction is correct and if it can be extrapolated over large geographic distances then Mennericyathus dissitus with 9-12 micropores per carcass pore might be considered to have a mid-Atdabanian age. Rozanov (op. cit. p. 71) has also demonstrated a similar series of reduction of sheath porosity for the atabulate genus Robertocyathus Rozanov, which suggests that there may be some validity in such a scheme. However a similar picture is not seen for species having sheaths of non-independent type described and discussed below.

2. Non-Independent Microporous Sheaths. (text fig 6A 6B)

Debrenne (1969a, 1973) has described some of the best preserved specimens of Regulares with non-independent microporous sheaths from the collections of Taylor and the Bedfords, taken originally from Ajax Hill. Also, Kruse (1978) illustrated this type of sheath on specimens of Erugatocyathus and Veronicacyathus from Lens L100 in the Cymbric Vale Formation, New South Wales. Both of the above-mentioned localities contain species typical of the stratigraphically youngest Early Cambrian horizons, while the species whose outer walls will be described later in this section come from the older stratigraphic interval covered by Faunal Assemblage I and II. The excellent preservation of species of Erugatocyathus and Veronicacyathus found at Wilkawillina Gorge and in the Mount Scott Range shows that there is greater variety and complexity of the outer wall than had previously been described by Debrenne and Kruse.

Debrenne (1973) suggested that there are two categories of non-independent microporous sheaths: a) continuous non-independent sheaths covering both the carcass pores and the interpore lintels, and b) non-independent sheaths restricted only to the openings of the carcass pores, often with a certain convexity to the exterior so that they resemble multiperforate tumuli. She further stated that type b) develops from type a) by the disappearance of that part of the sheath which covers the interpore lintels. This happens when the interpore lintel width is greater than the space between the pores of the covering sheath.

A somewhat different picture has resulted from a close examination of the specimens described below but it must be remembered that these are from stratigraphically older horizons, and Debrenne's observations may be correct for the younger species that she has studied. Thus, the present writer's ideas are intended to add to, rather than replace those of Debrenne.

There are so many different varieties of non-independent sheath that each could be described as a separate category. However, such a fine degree of splitting would only lead to confusion. Some species are gouped together informally and others are described separately to show the similarities and differences between the various types of sheath morphology. For the sake of brevity the terminology used is purely descriptive. Other differences in skeletal morphology and numerical data are supplied separately with each species description in Chapter 6.

i) Non-Independent Continuous Microporous Sheaths.

Three species are assigned to this group: Erugatocyathus krusei sp. nov., E. howchini sp. nov. and E. mawsoni sp. nov., this type of sheath is illustrated in Text-Fig. 6B.

Erugatocyathus krusei sp. nov. (Plate 9, Fig. 3) has an outer wall carcass of hexagonal pores, the lintels between each pore are wedge shaped, almost triangular in cross-section with the apex pointing outward; the carcass pores are circular on the intervallum side. The outer edge of the wedge shaped lintels form a sharp narrow ridge around each carcass pore. Stretched across each hexagonal orifice is a flat membrane pierced by numerous closely spaced circular micropores. The micropores around the periphery of each hexagonal opening are notched into the lintel ridge so that the microporous membrane is continuous over the outer surface of the cup. The resulting ridge is sinuous.

Erugatocyathus howchini sp. nov. (Plate 9, Figs, 4 to 6) is a colonial form with a similar continuous and even more finely perforated non-independent microporous sheath. The carcass pores are oval rather than hexagonal just below the sheath. The lintels form a similar wedge shaped ridge, triangular in cross-section and in the best preserved specimens, a minute flange is present near the base of the lintel some distance below the sheath. It is not certain whether this flange is part of an internal "diaphragm", a porous sieve, or possibly a series of inward radiating spinules. Secondary thickening on the outer wall of E. krusei sp. nov. obscures the finest details so that a similar flange, if present, cannot be seen.

Erugatocyathus mawsoni sp. nov. (Plate 10, Figs 1 to 3) is similar to the two species mentioned above in one respect only - the lintels usually form a sinuous narrow ridge so that the sheath micropores which notch into it tend to form part of a continuous membrane. However, where some carcass pores are smaller than average the sheath is restricted only to their circular external orifices. Unlike the two species mentioned above the sheath micropores of E. mawsoni are larger and more variable in size. Over the central carcass pore orifice there is no microporous opening, but a solid spinose boss. The lintels between the micropores also support a series of fine spinules projecting to the exterior. In longitudinal section the lintels between the carcass pores are shaped somewhat like an isosceles triangle with the apex pointed outward and with a bulbous base. Just above the bulbous base an exceedingly fine membrane can be clearly seen crossing the opening of each carcass pore some distance below the microporous sheath (Plate 10, Fig. 1). Details of the membrane in grazing sections are not clear but it may form part of a "diaphragm", a finer microporous sheath or a series of spines.

ii) Non-Independent Discontinuous Microporous Sheaths.

The remaining species are assigned to this group, although in certain cases, sometimes on a single specimen, there is a degree of partial sheath continuity whenever carcass pores happen to be sufficiently large or close to neighbouring pores to reduce the lintel width significantly. The following species have this type of microporous sheath: Somphocyathus coralloides Taylor, 1910; Erugatocyathus tatei sp. nov.; E. aquilinus sp. nov.; E. inflexus sp. nov.; E. madigani sp. nov.; E. oppositus sp. nov.; Veronicacyathus radiatus sp. nov.;

? V. c.f. complexus (Bedford R. & J., 1937).

The principal feature which determines whether a sheath is continuous or discontinuous is the width of the lintels at the outer surface of the carcass pores. Where the lintels are narrow (almost triangular) at their apex a continuous non-independent sheath is formed. Where the lintels are broad (not triangular in cross-section) at their outer extremity a discontinuous non-independent microporous sheath is formed. The peripheral pores are still notched into the lintels but there is sufficient space between the carcass pores to isolate the sheath (Text-fig.6C). Individual differences between species having a discontinuous sheath are displayed by variations in the number, arrangement and shape of the micropores, and by variations in the shape of the underlying carcass pores. For Example, E. tatei (Plate 10, Fig. 4) has quite numerous petaloid micropores, often incompletely closed and radially arranged around the centre of the underlying orifice. E. aquilinus (Plate 10, Figs. 5,6) has fully formed pores usually symmetrically arranged although one micropore may be larger than its neighbours and occupy most of the opening. An internal flange is also clearly visible across the carcass pore openings of this species. Somphocyathus coralloides Taylor and Erugatocyathus madigani sp. nov. (Plate 10, Fig. 7; Plate 11, Figs. 1,2) have discontinuous microporous sheaths restricted by buttress-like extensions from the outer wall lintels which form zones of canaliculate exothecal tissue around the cup. E. inflexus (Plate 11, Figs. 3,4) has a sheath formed by the extension of straight very fine rod-like threads across the orifice of each carcass pore, subdividing it into a variable number of sectors. Other species are shown in Plate 11, Figs. 5,6 ; these may be compared with the morphologies briefly described above.

It can be seen that category a) of Debrenne (1973) has no counterpart in the above groupings but those informally grouped as having a non-independent discontinuous type of sheath correspond quite well with her category b). One principal difference is that none of the sheaths described above have any kind of outward convexity so that there is no similarity with multiperforate tumuli seen on the outer walls of, for example, Coscinoptycta convoluta (Taylor, 1910) from Ajax Hill, shown herein in Plate 11, Fig. 7, and Lenocyathus illustrated by Debrenne (1973, Fig. 4).

Growth of Non-Independent Microporous Sheaths in the Superfamily Anaptyctocyathacea Debrenne.

The only species whose ontogenetic development can be traced down to very small cup sizes is Veronicacyathus radiatus sp. nov.; a study of several very small cups shows that a microporous sheath is formed between the lintels of the outer wall at a cup diameter of 2.0mm. At smaller cup diameters down to 1.0mm the outer wall consists of a carcass pierced by simple pores which are surrounded by tapering peaked lintels sloping obliquely outward and downward to the exterior (Plate 12, Figs. 1,2). The precise manner in which the sheath first forms over the simple carcass pores is not known but the change occurs very rapidly between cup diameters of 2.0mm and 2.2mm. The inner wall is of this species spinose at a cup diameter of 1.2mm and these are clearly directed across the inner wall pore openings at cup diameters of 2.0mm. Thus the adult morphology of both the inner and outer walls of V. radiatus sp. nov. is reached practically simultaneously.

Several other specimens which cannot be assigned with certainty to any particular species of the genera Erugatocyathus and Veronicacyathus also show a similar early phase of development of outer wall "peaks" before the first appearance of a sheath, these are shown in Plate 12, Figs. 3,4.

Discussion

As has been stated above, the possibility exists for a reduction in the number of sheath micropores for successively younger species of the genus Mennericyathus. The great variation in the number of micropores seen in the non-independent sheaths of Erugatocyathus and Veronicacyathus, both from the oldest and youngest fossiliferous levels of the Ajax and Wilkawillina Limestones described above and by Debrenne (1969a, 1973), and the Cymbric Vale Formation described by Kruse (1978), indicate that no such scheme of reduction is apparent at present at least for these tabulate genera.

Rozanov (in Rozanov and Missarzhevskiy, 1966) suggested the possibility of a reduction in the number of micropores in the non-independent sheath of genera belonging to the Superfamily Erbocyathacea in the Suborder Ajacicyathina. Kashina (1979, p.52) observed that the oldest genera Syringocyathus and Ladaecyathus from the Sanashtykgol Horizon, have up to 20 sheath micropores, whereas species of the genus Erbocyathus from the Obruchev Horizon, have 2-3 sheath micropores.

Thus it appears that reduction in sheath porosity of both independent and non-independent sheaths can be demonstrated for genera in the Suborder Ajacicyathina. However, in the Suborder Coscinocyathina it is not possible at present to demonstrate reduction in the porosity of non-independent microporous sheaths.

The Outer Wall Sheath of Bractocyathus Kruse, 1978.

Kruse (1978) described a new genus Bractocyathus which he considered to have an independent microporous sheath, and accordingly placed the genus in the Superfamily Mrassucyathacea Vologdin. Fragments of a single specimen of a new species Bractocyathus projectus have been found in the upper part of the Ajax Limestone near Mount Scott. Its outer wall is well preserved and is described below:

The outer wall carcass of B. projectus sp. nov. has 2-3 rows of oval to rectangular pores per intersept. The lintels surrounding each pore taper outwards in cross-section and each septum projects well beyond the outer wall (Plate 12, Fig. 5). A thin microporous sheath is draped over each septal extension and sags onto the carcass pores of the outer wall. Only the carcass pores in the middle of each intersept come into full contact with the sheath, whilst carcass pores adjacent to each septum are only partly covered due to the fact that the sheath rises upward to connect with the outermost part of the septal projections. The sheath micropores are circular and of uniform diameter. The lintels surrounding the carcass pores are notched where they come into contact with the sheath micropores (Plate 12, Fig. 6).

Discussion.

This type of sheath is quite different from those described previously since it is independent from the carcass when draped over the septa but is obviously bound to the carcass in the mid parts of the intersepts. This sheath is interpreted herein as a non-independent variety and consequently the genus Bractocyathus Kruse is placed in the Superfamily Anaptyctocyathacea Debrenne rather than in the Superfamily Mrassucyathacea Vologdin as proposed by Kruse (1978). However, its systematic position cannot be finally settled until specimens showing early stages of sheath development are found.

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Outer Walls of Irregulares from South Australia.

Introduction.

One of the greatest difficulties in the classification of Irregulares stems from the fact that there are gradations in complexity of the outer wall of the cup from species to species. A continuum of gradual change in morphological complexity of the outer walls of Regulares is so rare that there is no problem in separating superfamilies based on the presence of absence of pore diaphragms,tumuli,various types of sheath etc.For instance, when well preserved material is available it is easy to determine whether or not a pore diaphragm or a sheath is present and arguments usually revolve around what type of diaphragm or what type of sheath is displayed by the specimens. Arguments of this nature, although important for the classification of Regulares, dwindle to insignificance in comparison with the questions arising from a study of the outer wall of Irregulares. The chief questions are: 1) Is an outer wall present at all ? 2) How can such a complex array of pores be described as "simple"? 3) How can such a rudimentary protuberance across an outer wall pore be described as a "sheath"? From a study of South Australian Irregulares it was quickly realized that boundaries would have to be drawn and fixed across a continuum of change in wall complexity if the classification of Irregulares at superfamily level was to be achieved. Types of outer wall porosity are therefore separated into three major groups arranged in order of increasing complexity. Within each group the species, where possible are arranged in order of increasing complexity of the outer wall carcass.

Structural Types of Outer Wall of Irregulares.

1. Rudimentary Outer Walls.

Rudimentary outer walls formed by the outer edges of the intervallum elements which open directly to the exterior constitute the simplest type of outer wall studied herein. The best example is provided by *Auliscocyathus arcuatus* sp. nov.(Plate 13, Figs. 1 to 3) whose intervallum is composed of a scaffolding of linked rods arranged to form a very open curved, three dimensional lattice. There is no perforated sheet or carcass between the outer edges of the rods and the exterior of the cup, simply a termination of the outward growth of the rod system. One species having this type of outer wall structure is *Auliscocyathus irregularis* (Taylor, 1910). Possibly *Dictyofavus obtusus* gen. et sp. nov. and Agastrocyathus araneosus sp. nov. may also belong to this group, although details of the outer walls of these species are obscured by dissepiments.

2. Basic Outer Walls.

The first porous system which covers openings framed by the outer edges of the intervallum elements consitutes a basic outer wall. This may consist of:

a) a simply perforate sheet with one or more vertical rows of pores per intersept.

b) of vertical rows of pore tubes.

c) of a membrane with peripherally arranged pores.

Other types of basic outer wall may exist.

a) Carcass Consisting of a Simply Perforate Sheet, Pores in Vertical Rows.

The first example Paranacyathus spinosus (sp. nov.) (Plate 13, Figs. 4,5) has a well defined and quite thick outer wall carcass pierced by a single row of pores per intersept. The intersepts do not open directly to the exterior. The second example is a specimen of Graphoscyphia graphica (Bedford R. and W.R.) from the Wilkawillina Limestone near Wirrealpa. The species has only been found above Faunal Assemblage II, but has been included here as a good example of a basic outer wall with a simply perforate carcass (Plate 14, Fig.1). The outer wall carcass is pierced by 2 to 3 regularly spaced vertical rows of circular pores per intersept. The third example, Ardrossacyathus grandis sp. nov. (Plate 14, Fig. 2) has a thick carcass pierced by rounded pores of varying size, arranged in irregular vertical rows.

b) Carcass Consisting of Pore Tubes in Vertical Rows.

Warriootacyathus wilkawillinensis gen. et sp. nov. has an outer wall carcass composed of pore tubes directed obliquely upwards to the exterior of the cup. The tubes are in regularly arranged vertical rows, numbering 8 to 13 per intersept. Their openings are circular in cross-section with no suggestion of any skeletal material protruding across their orifices (Plate 14, Fig. 3). Secondary skeletal material often partly closes the pores but this is readily identified in thin sections.

c) Simply Porous Carcass Consisting of a Membrane of Peripherally Arranged Pores.

This type of outer wall has been found so far only in species of the genera Pycnoidocyathus Taylor and Hawkercyathus gen. nov. The best example of this type of wall is shown by Hawkercyathus insculptus gen. et sp. nov. (Plate 14, Fig. 4; Plate 15, Fig. 1). The outer wall of adult cups (early stages are apparently imperforate) consists of more or less rectangular openings framed by the outer edges of adjacent septa and successive horizontal lintels i.e. there is a single vertical row of rudimentary openings per intersept. Stretched across each opening is a porous membrane pierced by circular pores with a definite peripheral arrangement. In this species the peripheral pores are notched into the edges of the septa and lintels. The network of pores forms a continuous mesh over the outer surface of the cup and constitutes a basic, simply porous outer wall. Another example is provided by Pycnoidocyathus cribrus sp. nov. which again has a porous mesh stretched over the openings formed by the outer edges of the intervallum elements (Plate 15, Fig. 2). In this case the pores are smaller, more numerous and more angular than those seen in Hawkercyathus insculptus. Similar peripherally arranged networks of outer wall pores are seen in the species Pycnoidocyathus decepiens (Bedford R. & J., 1937) and Pycnoidocyathus circliporus (Bedford R. & J., 1937), which have been clearly illustrated by Debrenne (1974a, Fig. 14b and Fig. 19b respectively).

Despite the fact that the porous membrane has a peripheral arrangement superficially similar to non-independent microporous sheaths described previously for many Regulares, this type of porosity is considered to be simple because the pores are the first ones formed over the outer openings from the intervallum.

3. Compound Outer Walls.

A compound outer wall is formed by the partial or complete subdivision of the first porous system to form a second porous system. The basic underlying carcass may be simple or composed of pore tubes.

Other types of carcass may form the basis for a compound wall.

a) Simply Porous Carcass with Incipient Subdivision of the Pore Openings.

The first example is provided by a species questionably assigned to the genus *Pycnoidocyathus* - ? *P. strictus* sp. nov. (Plate 15, Fig. 3). Unfortunately, the sole specimen is preserved in a red micrite which makes details difficult to see. It appears that the carcass has 2 or 3 irregular rows of polygonal pores per intersept. The lintels between the pores are quite straight but are thickened by short, knob-like protrusions which extend partly across the pore openings. The pore openings are incompletely subdivided into 3 or 4 subrounded lobes of variable size. There is no complete subdivision of the carcass pores to form a separate microporous system.

The second example, *Metaldetes incohatus* sp. nov. has an outer wall carcass composed of 1 or 2 rows of rounded, frequently anastomosing pores. Some, but apparently not all of these pores, are partly closed by skeletal knobs protruding from the lintels to form the most rudimentary subdivision of the outer wall pore openings (Plate 15, Fig. 4). It is worth noting here that the inner wall microporous systems in the genus *Metaldetes* are formed in a similar fashion and in the species described above the inner wall is somewhat better developed in this respect than the outer wall.

b) Carcass Consisting of Pore Tubes and with Partial to Complete Subdivision of the Pore Openings.

The outer wall of *Beltanacyathus wirrialpensis* (Taylor) consists of several rows of short, oblique pore tubes per intersept. The upper opening of each tube is irregular in shape and partly subdivided in the manner described above to form a number of lobes (Plate 15, Figs. 5,6). *Beltanacyathus wirrialpensis* (Taylor) is known from Faunal Assemblage II. An older species, *B. digitus* sp. nov. from Faunal Assemblage I, has rounded pore tube openings which are only very slightly reduced by short protrusions to form partial lobes (Plate 15, Fig. 7). Another species with subdivided tube openings is *Fridaycyathus biserialis* gen. et sp. nov. (Plate 15,Fig. 8), in this case there can be a more complete subdivision of the pore tube openings to form 2 or 3 circular pores.

c) Simply Porous Carcass with Well Expressed Subdivision of the Pore Openings.

This category deals with species having compound outer walls whose pore openings are subdivided to a greater degree than those described previously (3a) and 3b) above). The degree of subdivision may be partial but is more often complete. Variations are often seen on a single specimen. Most species of *Metaldetes* and *Copleicyathus* belong to this category and one example of *Metaldetes dissepimentalis* Taylor (Plate 16, Fig. 1) is illustrated for comparison with examples given previously. *Spirillicyathus pigmentum* Bedford R. & J. displays a high degree of subdivision of the outer wall pore openings (Plate 16, Figs. 2,3). The basic outer wall carcass of this species is modified by the fact that septa are frequently linked to the outer wall by pairs of oblique struts. Septa reach the outer wall only between successive vertical pairs of struts (Plate 16, Fig. 4).

Ontogenetic Development of Irregulares with Compound Walls.

Ontogenetic data for irregular Archaeocyatha from South Australia is still very sparse, especially with respect to forms having compound outer walls. The details of early growth stages for individual species, where known, is provided together with their descriptions in Chapter 7. Some generalizations arising from this data are presented here because they have a great effect on the new scheme of classification for Irregulares which will be outlined in the next section.

Some genera such as *Metaldetes* and *Copleicyathus* have a compound outer wall consisting of a simple carcass with subdivided pore openings as described above. In the cases where data is available, the subdivided openings are apparent shortly after the outer wall becomes well defined above a base filled with disoriented rods, platelets and dissepiments. The genera *Spirillicyathus* and *Jugalicyathus* gen. nov. have a slightly more complex carcass because of the development of struts linking septa to the outer wall. In each of the three known species belonging to these genera the formation of struts takes place at an earlier stage in ontogeny than does the subdivision of the outer wall pores. The most complex carcass consisting of pore tubes is found in the genera *Beltanacyathus*, *Fridaycyathus* gen. nov. and *Bayleicyathus* gen. nov. Species of each genus have their outer wall pore tubes subdivided only in large cups. Early stages of growth of specimens belonging to the two latter genera show that in each case the outer wall pore tubes are formed before subdivision of the pores takes place. Unfortunately no ontogenetic data is available for *Beltanacyathus wirrialpensis*. It is also clear that the smallest cups of *Fridaycyathus* and *Bayleicyathus* have an outer wall of simple pores before the pore tubes themselves are formed.

For species with a more complex carcass having compound outer walls formed by the addition of skeletal material across the pores, the following growth stages are always observed: (arranged in order of increasing cup size).

basic carcass with simple porosity - more complex carcass with simple porosity - more complex carcass with subdivided pore openings.

The genera Fridaycyathus, Bayleicyathus and Jugalicyathus contain species in which rudimentary or well developed pore tubes are formed on the inner wall. In every case where ontogenetic data is available a complex outer wall carcass is formed either together with or before pore tubes appear on the inner wall. Complication of the outer wall carcass is never observed to form at a later stage than the development of inner wall pore tubes.

Such a clear picture is not seen for the first appearance of subdivided outer wall pores compared with complication of the inner wall carcass. For the genus Metaldetes both walls are compound, consisting of a basic carcass with subdivided pores and as far as is known, the subdivided pores appear simultaneously on both the inner and outer walls. For the genera Jugalicyathus, Fridaycyathus and Bayleicyathus the outer wall pores are subdivided in some cases before pore tubes are formed on the inner wall, and in other cases significantly later than the formation of the inner wall pore tubes.

It is appropriate now to compare the ontogenetic development of the walls of Regulares and Irregulares. According to Rozanov (1973), Zhuravleva and Elkina (1974) and others, complex features of the outer walls of Regulares are established at an earlier growth stage than comparable features of the inner walls. In particular, outer wall sheaths as a rule are formed before the final features of the inner wall are established. The ontogenetic data provided by specimens of Regulares examined in this work support their observations.

The present studies on South Australian Irregulares show a similar earlier development of the outer wall carcass in comparison with the development of the inner wall carcass, but the formation of subdivided pores (analogous to the microporous sheath of Regulares) may occur before or after the final features of the inner wall are established.

It must be stressed that these results have been obtained from studies of the ontogenetic development of relatively few genera of non-tabulate Irregulares. Despite this it has been possible to place all of the genera studied into a satisfactory new scheme of classification given below.

Classification of Non-Tabulate Irregulares from South Australia. [Tab. 4] !

The scheme of classification used herein for two walled non-tabulate Irregulares differs from that suggested by Debrenne (1970b, 1974a) and that adopted in the Treatise on Invertebrate Paleontology by Hill (1972). It parallels the scheme universally adopted for the Regulares but differs in one major respect, namely, the taxonomic rank assigned on the basis of the presence or absence of subdivided pores on the outer and inner walls of Irregulares. The corresponding structures on the outer and inner walls of Regulares are microporous sheaths to which are assigned the taxonomic ranks of superfamily and family respectively. The ontogenetic studies of Irregulares outlined above, indicate that the carcasses of the outer and inner walls should also be used to designate superfamily and family ranks respectively. Further, subdivided wall pores which are herein regarded as analogous to microporous sheaths, whether on the inner or outer walls or both, are given the rank of genus in this proposed new classification.

Four major types of outer wall carcass are recognized:

1) RUDIMENTARY.
2) BASIC. With simple porosity, pores in linear rows.
3) BASIC. With simple porosity, pores form a peripherally arranged network.

4) BASIC. With pore tubes.

Compound outer walls are formed by the partial or complete subdivision of the first porous system formed over a basic carcass. A compound outer wall clearly cannot be formed over a rudimentary carcass because there is no underlying pore system to be subdivided. Each of the three types of basic carcass listed above corresponds to a superfamily designation. Two superfamilies are recognized in forms having basic carcasses of the first type. In the first superfamily, septa are attached directly to the outer wall; in the second superfamily, septa are attached to the outer wall by paired oblique struts and the septa only reach the outer wall between successive pairs of struts in longitudinal section.

Thus four new superfamilies are proposed. No new superfamily is proposed at this stage for cups having a rudimentary outer wall for reasons given below. Other types of carcass may be discovered which will form the basis for additional future superfamilies. It is expected that the above classification may also apply to Irregulares with tabulae although these have not been studied herein due to the sparseness of material.

Each superfamily is subdivided into one or more families based on the type of inner wall carcass present. In the present work only inner walls with simple porosity or with pore tubes have been recognized, but other types of inner wall carcass not yet found in South Australia are known to exist, e.g. annulate inner walls of the Family Protocyclocyathidae Vologdin, 1956.

Within each family, genera are separated based on the presence or absence of compound outer or inner walls i.e. subdivided pore openings over the various types of basic carcass. Other generic characteristics include the complexity of spines (in the case of Copleicyathus); length of pore tubes and their mode of attachment to the walls (in Beltanacyathus Bedford R. & J., Fridaycyathus gen. nov. and

Bayleicyathus gen. nov.).

The presence and distribution of synapticulae and dissepiments in adult cups, and the porosity of septa are presently regarded as having only specific rank. The porosity of septa formed an important part of Debrenne's scheme of classification (1974a, Table 1), with the Order *Metaldetida* including forms with septal pores of greater area than that of the interpore lintels, and the Order *Paranacyathida* including forms with septal pores of lesser area than that of the interpore lintels. Present studies indicate that a large variation can be seen in the septal porosity of species in the same genus, notably in *Pycnoidocyathus* Taylor. The specific rank given to this characteristic in the present work may with further studies turn out to be unsatisfactory, but separating orders or suborders with septal porosity as a diagnostic feature seems most unlikely. Significant new approaches to the measurement of septal porosity in Regulares are presented in the following chapter.

An outline of the diagnostic characteristics of the proposed new superfamilies is given as follows:

1) *Rudimentary Outer Walls*. No new superfamily proposed.

This type of outer wall has so far been seen only in South Australian Irregulares whose intervallum is composed of a scaffolding of rods.

Debrenne (1970b, 1974a) proposed two orders:

a) *Chouberticyathida* - with radial and oblique cylindrical rods.

b) *Archaeopharetrida* - with vertical and oblique rods and "booklets".
Most other workers, including Zhuravleva (1955, 1960b) and Hill (1965, 1972) place forms with an intervallum of rods together with those having an intervallum of septa in the Suborder *Archaeocyathina* Okulitch, 1935, as Debrenne had done earlier (1964).

Whilst it is considered desirable to erect a suborder in the

Irregulares to accommodate species having an intervallum of rods, a number of difficulties arise from an inadequate knowledge of the most important constituent genera. The original diagnosis of *Dictyocyathus* given by Bornemann (1891, p.500) is inadequate. The holotype of *D. tenerrimus* has been lost and no neotype has been chosen. The species referred by Taylor and the Bedfords to *Dictyocyathus* are more likely to be juvenile cups of other genera, notably of *Pycnoidocyathus* (see Chapter 7). It is also quite possible that some species of *Choubert-icyathus* and *Archaeopharetra* are also juvenile cups of other genera (Debrenne, written comm.). The only species from South Australia with an undisputable scaffolding of rods in the intervallum at large cup diameters (up to 22mm) is *Auliscocyathus arcuatus* sp. nov., known from a single specimen whose early growth stages are missing.

Inadequate knowledge of the genera named above forces the writer to reluctantly adhere to the commonly used subordinal classif-ication which unites forms with rods and forms with septa in the *Arch-aeocyathina* Okulitch.

Until a revision of all of the above named genera allows a more precise knowledge of their outer walls, those with a rudimentary outer wall are placed with reservation in the Family *Dictyocyathidae* Taylor.

2) Basic Outer Wall Carcass with Pores in Vertical Rows. Pores May Be Simple or Subdivided.

Two new superfamilies.

METACYATHACEA superfam. nov.

Diagnosis. Outer wall as above. Wall linked directly to septa.

SPIRILLICYATHACEA superfam. nov.

Diagnosis. Outer wall as above. Wall linked indirectly to septa by paired oblique struts, septa only reach the outer wall between successive vertical pairs of struts.

3) Basic Outer Wall Carcass. Pores Form a Peripherally Arranged Network.

One new superfamily.

FLINDERSICYATHACEA superfam. nov.

Diagnosis. Outer wall with a network of peripherally arranged pores covering the outer edges of the intervallum elements.

4) Basic Outer Wall Carcass Consisting of Pore Tubes. Pore Tube Openings may be Simple or Subdivided.

One new superfamily.

BELTANACYATHACEA superfam. nov.

Diagnosis. Outer wall composed of oblique pore tubes whose outer openings may be simple or subdivided.

The distribution of families and genera within each superfamily is given in Table 4. So much better if the reader is aware of that at the beginning of the section!!

CHAPTER 5

THE SEPTAL POROSITY OF REGULAR ARCHAEOCYATHA.

INTRODUCTION.

A quantitative method for measuring the septal porosity of species of Regulares is presented herein for the first time. The variation in septal porosity with cup growth closely follows a curve which appears to be characteristic for a given species. Septal porosity studies of species belonging to genera in the Suborders Ajacicyathina, Nochoroicyathina and Coscinocyathina have yielded highly significant results which include the following:

1. In the Suborder Ajacicyathina there appear to be two pathways by which reduction in septal porosity with cup growth can be achieved. Previously only one pathway of septal pore reduction was considered likely.
2. In all septate suborders the rate of change of septal porosity is closely linked to the rate at which new septa were added. Variations of the radial coefficient with cup growth seem to reflect variations in septal porosity. Usually the radial coefficient decreases with cup growth, but sometimes an increase in the radial coefficient is seen. The changes in the radial coefficient can be readily explained mathematically. Evolutionary trends appear to be dependent on such changes in septal porosity through the Early Cambrian and consequently have great stratigraphic significance.

Before presenting the new method of measuring septal porosity and discussing the results summarized above, an account of the present taxonomic status assigned to septal porosity is briefly outlined below.

The taxonomic status assigned to the septal porosity of Regulares.

Zhuravleva (1960b, p.24) recognized four different types of septal porosity as follows:

i) Septa with frequent, uniformly distributed pores.

ii) Septa with sparse, irregularly distributed pores.

iii) Septa with stirrup-pores at the junction of either the outer or inner wall, and very rare additional pores.

iv) Non porous septa.

In a discussion of the phylogenetic development of the genus Archaeocyathellus Ford, Zhuravleva suggested that evolution was in the direction of reduction, followed by the total disappearance of septal porosity. (op.cit., p.147). Zhuravleva (op.cit., p.173) subdivided the genus Tumulocyathus Vologdin into two subgenera based on differences in their septal porosity.

Debrenne and Voronin (1971) created a new genus Aldanocyathus Voronin to accomodate forms previously placed in the genus Ajacicyathus Bedford, based on the observation that two clearly distinguishable types of septal porosity exist in representatives of the latter genus. The genus Aldanocyathus includes species with fully porous septa and Ajacicyathus has been restricted to include species with sparsely perforate septa, often with stirrup-pores. The authors further stated that no transitional forms have been observed between those having completely perforate septa and those with practically imperforate septa, but early stages of growth of species of Ajacicyathus as redefined by them, have porous septa. The stratigraphically later appearance of Ajacicyathus compared with Aldanocyathus, coupled with ontogenetic data, led the same authors to state that the genus Ajacicyathus originated from either the genus Aldanocyathus or allied genera as a result of loss of septal perforation.

Voronin (1974) raised the taxonomic rank assigned on the basis of septal porosity when he subdivided the Family Ajacicyathidae into the Subfamily Ajacicyathinae and the Subfamily Robustocyathinae, each distinguished solely on the basis of differences in septal porosity. The Subfamily Ajacicyathinae includes species having sparsely porous and non porous septa; the Subfamily Robustocyathinae includes species having fully porous septa.

Debrenne (1973) maintained Thalamocyathus Gordon as a distinct genus from Gordonicyathus Zhuravleva because of the lower septal porosity displayed by species in the genus Thalamocyathus. Yazmir (1975) described a new species with non porous septa under the generic name of Gordonicyathellus, as distinct from Gordonicyathus whose species have fully porous septa.

Briefly it is clear that there is no universal agreement about the taxonomic status which ought to be applied to the types of septal porosity displayed by various species belonging to different genera in the Suborder Ajacicyathina.

Most of the arguments concerning the taxonomic rank assigned to septal porosity are restricted to species belonging to the Suborder Ajacicyathina and the Suborder Nochoroicyathina. On the other hand there has been no argument concerning the taxonomic status of septal porosity for species belonging to the Suborder Coscinocyathina.

Previous measurements of septal porosity.

Previous workers have isolated different types of septal porosity in a qualitative fashion along similar lines to those set out by Zhuravleva as described above. The various patterns of septal porosity have been categorized by visual examination, so that different workers place various interpretations on the patterns that they have seen, chiefly in adult cups. In particular, the distinctions between sparsely porous and fully porous septa, or between evenly distributed small septal pores and large septal pores with a restricted distribution, are subject to a variety of interpretations. The problem is also compounded by the fact that the pattern of septal porosity changes with ontogeny.

The only semi-quantitative definition of septal porosity used hitherto, is defined as follows:

$$\text{Septal porosity} = \frac{\text{Septal pore diameter}}{\text{Distance between adjacent pores}}$$

This is the ratio "C" or "PKP" used by workers in the USSR.

The ratio is obviously unsatisfactory in examples where septal pores are unevenly distributed or are oval in shape. The ratio varies with cup size within a single specimen so that it cannot be used adequately as a parameter to distinguish between different species.

For example, adult cups belonging to the species Aldanocyathus sunnaginicus (Zhuravleva) have septal pores whose diameter varies from 0.08mm to 0.10mm; the distance between adjacent pores varies from 0.05mm to 0.08mm (Zhuravleva, 1960b, p.116). The resulting ratio "C" varies from 1 to 2, and at very early stages of cup growth where septal pores are oval, the ratio is even more variable.

The lack of precision in determining septal porosity by this means, especially at very early stages of septal development, led the present writer to devise a more precise method. Although it is somewhat laborious it gives consistently reproducible results which may be plotted graphically to give a picture of the continuous change of septal porosity with cup growth for a given species.

A new method of measuring septal porosity.

The following conditions must be met for the specimens to be suitable for study:

1. Fossils must be unsilicified, undistorted and well preserved.
2. Specimens whose septal pore area is reduced by secondary thickening (unless the original pore area is clearly defined), or whose pore outlines are indistinct, are excluded.

3. Large areas of the septa must be visible on longitudinal or nearly longitudinal thin sections.

4. The following parameters must be measurable on the thin section: cup diameter, intervallum width, the number of septal pores across the intervallum, the septal pore dimensions. At least two successive horizontal rows of septal pores must be visible so that their vertical separation can be measured.

The following assumption is made:

In regular septate Archaeocyatha (Suborders Ajacicyathina Nochoroicyathina, Coscinocyathina), a plane perpendicular to the axis of the cup represents an isochronous growth plane. That is, the cup grows by adding new skeletal material to its upper surface. A series of such planes isolates different stages of cup growth.

Assuming this to be true, a growth plane is represented in two dimensions on a longitudinal thin section by a straight line perpendicular to the axis of the cup. A series of lines perpendicular to the cup axis represents a series of isochronous growth stages. The interval between two closely spaced lines represents a small growth increment; it is between two such closely spaced lines that the septal porosity is measured (Text-fig. 7A.). By measuring the septal porosity within a small growth increment for specimens of various size within a species, it is possible to build a composite picture of the total change in septal porosity with cup growth.

Septa are normally straight radial, vertical partitions pierced by pores of varying size and distribution. The pores are normally circular to oval in shape. Septal pores are usually described as being in vertical rows across the intervallum. They may be equally considered as horizontal rows, each row separated from the neighbouring row above or below by an expanse of imperforate skeletal material. The combination of one horizontal pore row and one horizontal inter-row expanse of non-perforate material across a septum, represents a repeating unit within a small growth increment. Because the pore diameter and the number of pores in a horizontal row across a septum change with cup growth, the repeating unit changes in a corresponding fashion (Text-fig. 7B). The smallest growth increment in which septal porosity is measured is a single repeating unit as defined above.

The method of measuring septal porosity used herein is simply the total area of all septal pores within a repeating unit compared with the total area of the entire repeating unit at a given cup diameter. The total area of the repeating unit is the area occupied by the septal pores plus the area occupied by interpore skeletal material. This area is obtained by multiplying the intervallum width by the height of the repeating unit. The height of the repeating unit is the distance between the top of a horizontal septal pore row and the top of the horizontal septal pore row immediately below (or above). This distance is herein termed the Period (see Text-fig. 7B). The resulting ratio of septal pore area to repeating unit area is expressed as a percentage, which is the Septal Porosity (S.P.) at the cup diameter where the repeating unit is measured. The Septal Porosity is expressed mathematically as follows:

$$\text{Septal Porosity} = \frac{n \times \frac{\pi d^2}{4}}{\text{W.I.} \times \text{Period}}$$

d = septal pore diameter (mm), hence $\frac{\pi d^2}{4}$ is the area occupied by a single septal pore $(\text{mm})^2$.

n = the number of septal pores in a horizontal row within the repeating unit.

W.I. = the intervallum width (mm).

Period = the repeating unit height i.e. the vertical distance between the top of one horizontal pore row and the top of the neighbouring horizontal pore row immediately above or below (mm).

The Septal Porosity thus calculated is plotted on a graph as a function of the cup diameter at which the value is obtained. By measuring a large number of specimens in a species over a range of cup diameters it is possible to obtain a picture of the total variation in Septal Porosity and hence to trace its variation with ontogeny in a quantitative fashion for the species.

The above method of calculating septal porosity is based on an ideal model with septa having circular regularly spaced pores, but many species differ significantly from the ideal case and it is necessary to make certain approximations to allow for non-ideal but more realistic situations. It is considered that if the approximations are consistently applied for each case then the accuracy of the method is not significantly reduced.

The following approximations are necessary in order to apply the method to non-ideal cases.

1. <u>Non circular pores</u>.

Many species have oval septal pores. Most species have oval pores in small cups at initial stages of septal growth. The area of an oval pore is calculated as the area of a circular pore whose diameter is the average of the major and minor axes of the pore. However, the Period is still measured as the vertical distance between the top of one row of oval pores and the top of the pore row immediately above or below.

2. <u>Closely spaced pores in quincunx</u>.

In species which have closely packed septal pores in quincunx it is impossible to define horizontal rows without cutting across pores. In these cases the Period is measured as the vertical distance between every second horizontal pore row. The area of each complete and partial pore is measured within a repeating unit chosen in this manner (Text-fig. 7C).

3. Stirrup-pores.

Stirrup-pores may be present at the junctions of septa with either the inner or outer wall (sometimes at both walls). The pore is not completely enclosed in the septum. To obtain a closed area a straight line is drawn across the opening at the exterior or at the central cavity. The area is obtained by approximating the enclosed space to a circular pore of average dimensions. The Period is measured as the vertical distance between the top of one stirrup-pore and the top of the next successive stirrup-pore above or below. Additional pores, if present in the septum within the repeating unit so defined, are included in the summation of the total septal pore area (Text-fig. 7D)

4. Irregularly distributed pores.

Many species have irregularly arranged septal pores, usually concentrated near the inner or outer walls. Horizontal pore rows cannot be defined. However, a suitably small growth increment can be chosen for a given cup diameter, based on data obtained from other species whose septal pores are regularly spaced. The graph illustrated in Text-fig. 8 shows the ratio of the Period to the Intervallum Width plotted as a function of cup diameter for species of Regulares with evenly distributed septal pores. The ratio of the Period to the Intervallum Width changes in a regular fashion as the cup diameter varies. For most species whose specimens are 6mm or more in diameter, the Period is approximately one fifth of the Intervallum Width. For smaller specimens the Period becomes proportionately larger.

A suitable Period can thus be chosen for species whose septal pores are irregularly distributed by referring to a graph of this type. The graph shown herein has been drawn from data obtained from various species in the different septate suborders. More suitable reference graphs could be obtained by restricting the data to species of the same genus or the same family as that to which the species being examined belongs.

Species with sparse irregularly distributed septal pores have not been found in the stratigraphic interval studied herein. However, there are numerous species of the genus Thalamocyathus Gordon in younger strata, whose septal pores are irregularly distributed. Had these been studied, a reference graph would have been drawn from data obtained from species of the genus ? Gordonicyathus Zhuravleva, described herein, and other suitable species belonging to the Family Cyclocyathellidae.

A specific example to illustrate the method of determining septal porosity is now given for the longitudinal section through part of a septum of Aldanocyathus sunnaginicus (Zhuravleva), shown by Zhuravleva (1960b, p.26, Text-fig. 19). Her diagram is reproduced herein in Text-fig. 7E , but measurements were made from the published work so that other workers can readily check the calculations given below. This particular example has been chosen because the diagram is clear and unambiguous, and also because it is in a readily available publication. One may also compare the results of the new method with those given earlier using the ratio "C" employed by workers in the USSR.

From the diagram it is clear that there are 5 repeating units, each consisting of a nearly horizontal row of pores plus an expanse of skeletal material between one row and the next. The repeating units (Periods) are numbered from 1 to 5 from the base to the top of the diagram in Text-fig. 7E . Each repeating unit is considered separately as follows:

Measurements are taken directly from Zhuravleva's diagram using a millimetre rule.

Repeating Unit 1. Two large elliptical pores, dimensions 7.5x9.5mm and 8.5x6.0mm. These may be approximated as circular pores of diameter 8.0 and 6.75mm respectively, and the average diameter of the two pores is 7.4mm. Period (repeating unit) = 10.5mm; intervallum width (W.I.) = 21.0mm

$$\text{Septal Porosity} = \frac{(2\pi/4)(7.4)^2}{10.5\text{x}21} = \frac{86.2}{221} = 39.0\%.$$

Repeating Unit 2. Two pores, one circular with diameter = 5.0mm, one elliptical with dimensions 8.5x6.5mm. The elliptical pore approximates to a circular pore with diameter 7.5mm. The average diameter for both pores is 0.5x(5.0+7.5) = 6.25mm, Period = 8.5mm, W.I. = 22mm.

$$\text{Septal Porosity} = \frac{(2\pi/4)(6.25)^2}{8.5\text{x}22.0} = \frac{61.3}{187} = 32.8\%.$$

Repeating Unit 3. Three elliptical pores, each with dimensions 5.0x4.0mm, average circular pore diameter = 4.5mm, Period = 8.7mm, W.I. = 22.3mm.

$$\text{Septal Porosity} = \frac{(3\pi/4)(4.5)^2}{8.7\text{x}22.3} = \frac{47.7}{194} = 24.6\%.$$

Repeating Unit 4. Three elliptical pores with dimensions 5.0x3.0mm, 5.0x3.0mm, 4.25x2.5mm. These approximate to circular pores with diameters 4.0mm, 4.0mm, 3.4mm respectively. The average diameter of all three circular pores = 3.8mm, Period = 7.5mm, W.I. = 23.5mm.

$$\text{Septal Porosity} = \frac{(3\pi/4)(3.8)^2}{7.5\text{x}23.5} = \frac{34.0}{176} = 19.3\%.$$

Repeating Unit 5. Four elliptical pores with dimensions 3.0x2.0mm, 3.0x2.0mm, 3.0x2.0mm, 2.7x1.5mm. These approximate to circular pores with diameters 2.5mm, 2.5mm, 2.5mm, 2.4mm respectively. The average circular pore diameter = 2.5mm, Period = 6.0mm (approx.), W.I. = 25.0mm.

$$\text{Septal Porosity} = \frac{(4\pi/4)(2.5)^2}{6.0\text{x}25.0} = \frac{19.6}{150} = 13.1\% \text{ (approx.)}$$

The value of Septal Porosity for repeating unit 5 is somewhat approximate because the Period is not known with accuracy due to the fact that the overlying horizontal pore row is not shown in the diagram.

By using this method one can trace the decrease in septal porosity from 39.0 percent at the bottom of the diagram, to approximately 13.1 percent at the top. If the cup diameter was known at the level of each repeating unit it would be possible to plot a graph of septal porosity as a function of cup diameter and thus quantitatively follow its variation with ontogeny for the species. This is the method used herein, and some results are presented below.

Two other important considerations are apparent from the example just given. The first is the consistent use of the approximation from elliptical pores to circular pores. Because the elliptical pores in each repeating unit are of similar size, their circular counterparts have been further averaged to give a single value representative of the whole repeating unit. In cases where septal pores vary considerably in size within a repeating unit, this is not done, and individual pore areas are separately calculated, then added to give the total septal pore area. The second important point is that the Period changes from one repeating unit to the next, so that in repeating unit 1. the Period is half the intervallum width whereas in repeating unit 5. the Period is approximately one quarter of the intervallum width.

In certain cases, such as in very small cups where the septal pores are in a single row occupying the whole of the intervallum, the Period may be as great as, or even greater than the intervallum width. This necessarily follows from the definition of the Period given previously, which is taken to be the height of one horizontal pore row plus the expanse of skeletal material between that row and the one immediately above or below. Thus the Period continually changes in response to the septal pore size and vertical separation (See Text-fig. 7B).

One can also see from the same example how inaccurate the measurement of the ratio "C" is, in comparison with the values calculated above. The measurement of septal pore diameter can be made with no less accuracy, but the distance between adjacent pores is highly variable and can be measured in a variety of ways by different workers. The new method leaves comparatively little scope for individual interpretation as to how the measurements can be made and thus reproducibility of results is ensured.

The septal porosity of some species of Regulares.

Introduction.

The Septal Porosity of several species of Regulares is discussed below. The results are presented as a series of graphs of Septal Porosity plotted as a function of cup diameter. Each graph is a composite built from data obtained from several specimens of each species. The increase in the number of septa (N) in transverse sections is also plotted on the same graph as a function of cup diameter. The significance of the variation in the number of septa, and hence the Radial Coefficient, is discussed in a later section.

Suborder Ajacicyathina.

The Septal Porosity of *Joanaecyathus* gen.nov.

The new genus *Joanaecyathus* is similar to *Prethmophyllum* Debrenne, but differs by having stirrup-pores at the junctions between the septa and the outer wall. Approximation 3 for stirrup-pores, given above, has been applied in order to obtain the Septal Porosity for the three new species discussed below.

Septal Porosity of *Joanaecyathus caecus* gen.et sp.nov. (Text-fig. 9)

The Septal Porosity rapidly decreases with early cup growth, to reach a more or less constant value at a cup diameter of 1.5mm.

At about 3.6mm cup diameter the Septal Porosity decreases along a very shallow curve. The septal pores in the smallest cups are wholly contained in the intervallum. Stirrup-pores are formed at a cup diameter of 1.16-1.45mm, slightly before the Septal Porosity reaches a stable value. It is significant that rudimentary inner wall pore tubes form in this species at a cup diameter of 2.5mm, after the Septal Porosity has reached a stable value.

Most species in the Suborder Ajacicyathina with fully porous septa, have their inner wall characteristics stabilized before the septal porosity is stabilized. This reversal has been discussed by Rozanov (1973, p.38) and is enlarged upon in the next section.

The graph of the variation in the number of septa with cup diameter shows a significant change between approximately 4.2mm and 6.2mm cup diameter. The function is composite, consisting of three straight line segments. This is not a coincidental occurrence; it appears to occur widely in numerous species of Regulares examined by the present writer.

The values of Septal Porosity for this species were obtained from measurements of twelve different specimens. No attempt was made to mathematically fit the curve to the data points for this and all other species discussed, because it is considered that there is as yet insufficient data to justify such an approach.

Septal Porosity of *Joanaecyathus cyclopeus* sp.nov. (Text-fig. 10)

Data obtained for the Septal Porosity of this species is very sparse as seen from the graph. The Septal Porosity follows a similar trend to that seen on *J.caecus*, but is somewhat higher overall. The number of septa added for different cup diameters is consistently lower, leading to a lower Radial Coefficient than that shown by *J.caecus*. The three-segment straight line pattern is still evident, but the change occurs at a somewhat smaller cup diameter. Although the data is sparse, the Septal Porosity of J.cyclopeus appears to change at about the same time as the rate of change in the number of septa varies.

Septal Porosity of Joanaecyathus cupulosus sp.nov. (Text-fig. 11)

Data for this species is also rather sparse, but the rapid initial reduction in Septal Porosity, followed by an apparently prolonged period of stability is evident. There appears to be some variation, both in Septal Porosity and in the number of septa at about 4mm cup diameter but there is as yet not enough data to resolve these differences. It must be mentioned here, that data for Septal Porosity can only be obtained from longitudinal sections, but the number of septa can only be obtained from transverse sections. Consequently, data for these two curves are obtained either from different specimens or from different parts of the same specimen. For this reason, changes in Septal Porosity which occur at the same time as changes in the rate of addition of septa, have greater significance. In J.cupulosus, stirrup-pores form at 1.02-1.22mm cup diameter; S-shaped bracts on the inner wall form later at about 2.7mm cup diameter; but the Septal Porosity apparently does not reach a stable value before about 3mm cup diameter.

The Septal Porosity of ? Gordonicyathus Zhuravleva.

One species; ? Gordonicyathus pledgei sp.nov. has provided sufficient data for discussion. The species has been placed with reservation in the genus Gordonicyathus because of the presence of diaphragms over its outer wall pores. Pore diaphragms and their taxonomic significance are discussed herein in Chapters 4 and 6.

Septal Porosity of ? Gordonicyathus pledgei sp.nov. (Text-fig. 12)

Data is sparse for this species, but the characteristic curve of reduction in Septal Porosity with cup growth is again evident.

Septal Porosity reaches a stable value at about 2.25mm. In this species, annuli are first formed on the inner wall at a cup diameter of 1.16-1.30mm, i.e. before Septal Porosity is stabilized. This is the normal pattern followed by most species of the Ajacicyathina with fully porous septa, contrasting strongly with the reversed pattern of development seen for two of the species of *Joanaecyathus* gen.nov., described above. The addition of septa in ? *G.pledgei* appears on present evidence to follow a straight line trend with no rapid changes in gradient.

Suborder Nochoroicyathina.

Septal Porosity of *Baikalopectinus capulus* gen.et sp.nov. (Text-fig. 13)

Data for *Baikalopectinus capulus* is scattered and restricted to a very small growth interval, but it is the only species with pectinate tabulae for which sufficient specimens are available. The results are quite significant. For an obvious reason no attempt has been made to draw a curve through the scattered points representing the Septal Porosity. There appears to be a trend towards increasing Septal Porosity with cup growth in contrast to the normally seen decrease in Septal Porosity for the other species under study. The number of septa added with cup growth appear on present evidence to follow a straight line function with a very steep gradient. Note that this line, if projected downwards, would intersect the vertical axis at a negative value, whose significance is discussed in a later section.

Suborder Coscinocyathina.

Septal Porosity of *Crucicyathus repandus* gen.et sp.nov. (Text-fig. 14)

This species has a simply porous, regularly stellate outer wall. Septa always cross the intervallum to meet the outer wall in the troughs between the stellations. The cup diameter shown on the horizontal axis of the graph is measured diametrically across opposing troughs and thus does not represent the maximum cup diameter. As is evident from the graph there is some variation in Septal Porosity between cup diameters of 2mm and 11mm. A straight line has been drawn through the scattered points, but this may be modified when new data becomes available. There are variations in the number of septa present at small cup diameters. The anomalously high value of Septal Porosity was obtained from the holotype, which also yielded the anomalously low value of the number of septa. Both data points are indicated by asterisks. The general shape of the curve for Septal Porosity is similar to that seen for most of the species described in this chapter. The Septal Porosity is quite high and the gradient of the line representing addition of septa is quite low (hence the Radial Coefficient is also relatively low).

Septal Porosity of *Veronicacyathus radiatus* sp.nov. (Text-fig. 15)

This is the final example for which sufficient data is available. There is considerable variation in Septal Porosity at small cup diameters. The Septal Porosity appears to reach a stable value at about 3mm cup diameter. Spines across the inner wall pores, characteristic for the genus, are present at 2mm cup diameter. This is a reversal of the normal pattern of development seen in the Suborder Ajacicyathina, but according to Rozanov (1973,p.48),there is conflicting data for the order of stabilization of the inner walls and septa of species belonging to the Suborder Coscinocyathina.

Two pathways of reduction in septal porosity for species in the Suborder Ajacicyathina.

Several workers in the USSR have described the phenomenon of reduction in septal porosity with cup growth for species in the Suborder Ajacicyathina. Hitherto only one pathway of septal pore reduction has been described and it has been assumed that all species having non-porous or almost non-porous septa were derived from stratigraphically older forms by an acceleration of reduction in septal porosity seen during ontogeny. The loss of septal porosity as a result of evolution is important stratigraphically. Tommotian and Atdabanian species having fully porous septa were supplanted by species with lower septal porosity in the Botomian. Finally, species having the lowest septal porosity are more frequent in the Late Botomian and Lenian, and predominate over species having fully porous septa. Kashina (1979) has observed this trend towards reduction in septal porosity for species belonging to the Superfamily Erbocyathacea.

One strikingly anomalous species - Leptosocyathus polyseptus (Latin) led Rozanov (1973) to discuss the problem in some detail. L.polyseptus (Latin) first appears at the base of the Atdabanian Stage on the Siberian Platform. At very early stages of cup growth, its septa are porous, but the early porosity is very rapidly lost and stirrup-pores are formed at the junctions of septa and the inner wall. The remaining expanse of septa is non-porous. Most other species in the Suborder Ajacicyathina with practically non-porous septa first appear at the base of the Botomian Stage (Lenian Stage *sensu* Rozanov, 1973).

Three species in the new genus Joanaecyathus from Lower Faunal Assemblage II in South Australia display a very similar development of septal porosity to that described for L.polyseptus (Latin). The chief difference is that stirrup-pores are formed on the outer wall for species of Joanaecyathus, whereas they are formed on the inner wall of L.polyseptus (Latin). Species in Lower Faunal Assemblage II are thought to correlate with the Lower Atdabanian Substage. Thus these species also appear anomalously early in the Cambrian.

The early appearance of these species, as well as L.polyseptus (Latin) and probably others, can be explained by postulating an alternative pathway of reduction in septal porosity during ontogeny. Before discussing this possibility, the normally accepted pathway of septal pore reduction is described. Rozanov (1973, p.37) stated the following:

> The most widespread type of development for porous septa is that where initially one large pore is observed, then netlike porosity in two to three rows and subsequently normal (porosity). An analogous type is found in the ontogeny of septa for forms with non-porous septa. In this case initially we see in a shortened form, all three stages of the preceding cases, and then very quickly the porosity disappears. Often stages with uniform porosity are completely absent, utterly analogous to that observed for Leptosocyathus polyseptus (Latin).

Rozanov further stated (op.cit. p.38):

> In spite of the fact that L.polyseptus appears to be the oldest representative of the group of Archaeocyatha with a scaly inner wall, it has non porous septa. However in ontogeny we observe the natural course of the process of loss of septal porosity, peculiar to the majority of groups of regular Archaeocyatha in "phylogeny".

(The above passages were translated from Russian by the present author).

The present writer agrees that for the majority of Regulares the ontogenetic development of septal porosity described by Rozanov and translated above, is typical for forms having normally porous septa. Some examples shown in (Plate 16, Figs. 5, 6; Plate 17, Fig.1) support this. Many workers have observed that septal porosity is reduced during evolution, at least in the Suborder Ajacicyathina. Many species having stirrup-pores in addition to other sparsely distributed septal pores, probably also follow the same phylogenetic trend of reduction. It has already been stated that Debrenne and Voronin (1974) consider that the genus Ajacicyathus was derived from the stratigraphically older Aldanocyathus or some similar genus, by reduction of septal porosity.

However, it is considered herein that an alternative pathway of septal pore reduction can be postulated for species such as L.polyseptus (Latin) and those in the new genus Joanaecyathus. In these species, stirrup-pores are the dominant ones formed on the septa. Additional septal pores are extremely small and very rare, or are localised close to one of the walls. Joanaecyathus cupulosus gen.nov., for example, has an additional row of large pores very close to the outer wall, together with the stirrup-pores. In other genera such as Ajacicyathus, the species have stirrup-pores which are important, but not dominant,and there are always sparse additional septal pores.

Rozanov stated that for L.polyseptus (Latin), the stage with uniform porosity is completely absent. The same absence of a uniformly porous stage is also seen in Joanaecyathus caecus sp.nov., shown in Plate 17, Fig. 2. The present writer considers that the two stages of septa with netlike porosity followed by uniform porosity were not lost in these species. They were never formed.

It is considered herein that the loss during ontogeny of septal porosity in L.polyseptus (Latin) and J.caecus sp.nov. was caused by an arrested first stage of development. The earliest stage with one large pore was formed in J.caecus, and two pores may have been formed in L.polyseptus (Latin), (Rozanov, 1973, p.39, Fig.54). In succeeding stages of septal growth of J.caecus, the pore was situated closer to the outer wall and successive pores broke through the outer wall as stirrup-pores. It is suggested herein, that in L.polyseptus (Latin) successive pores close to the inner wall emerged there as stirrup-pores and that one of the two pores in the second Period subsequently disappeared. There was no development of the stages with netlike and normal porosity formed in other Regulares with normally porous septa, hence there was no acceleration leading to subsequent loss of these stages. Thus the stratigraphically early appearance of these species (and probably others) can be explained. There has been no prolonged stage during which septal porosity has been lost during evolution seen for other species in the Suborder Ajacicytahina with normally porous septa.

The problem is to distinguish between species similar to L.polyseptus (Latin) which have not lost septal porosity, and other species with sparsely porous septa which have passed through accelerated stages of loss of septal porosity during phylogeny, which may be coeval in younger Cambrian strata. One significant difference appears to be in the size of the stirrup-pores of species with "arrested" development, in comparison with the size of the septal pores of species with "accelerated" development. The septal stirrup-pores of J.caecus at small cup diameters are quite large (0.10-0.12mm). Those of L.polyseptus (Latin) are up to 0.2mm diameter (Zhuravleva, 1960b,p.158). Species of Regulares with normally porous septa passed through the three stages of septal development described by Rozanov. These stages involved a reduction in the size and an increase in the number of septal pores per Period with cup growth. If these stages were accelerated during evolution to produce species with sparsely porous septa, their earliest formed septa should have small, uniformly distributed pores. This appears to be the case for Tegerocyathus edelsteini (Vologdin), which is another example quoted by Rozanov (1973,p.38). According to the data of Zhuravleva (1960b, p.195, Table 14), the first septal pores seen in cups of T.edelsteini have a diameter of 0.05mm and are sparsely distributed. Adult cups have similar sparsely distributed septal pores and stirrup-pores at the outer wall. The species T.edelsteini first appeared in the upper part of the Botomian Stage on the Siberian Platform. Species from Faunal Assemblage III are considered herein to be Early Botomian in age but unfortunately the youngest Faunal Assemblages have not been studied in this work. However, several examples from younger strata whose early growth stages have been seen (chiefly species of Thalamocyathus Gordon), have small, sparse septal pores at initial stages of septal growth. The pores remain small during subsequent cup growth and usually become more widely spaced.

Rods or bars are present in the intervallum before the first appearance of septa for L.polyseptus (Latin), T.edelsteini (Vologdin) and for species of Joanaecyathus, although precise species determinations were not possible for the very small cups of the latter genus. It appears that this very early stage of cup development (rods or bars) has not been lost during the process of reduction affecting septal porosity. This is the Dokidocyathus stage of other workers - a term rejected herein. The practice of assigning generic names to stages of cup growth is considered to give rise to preconcieved ideas of phyletic links which may prove to be wrong. Furthermore the genera which the growth stages are assumed to resemble may have a completely different ontogenetic pattern of septal pore development.

One other significant difference between L.polyseptus (Latin) and other species with porous septa belonging to the Sub-order Ajacicyathina was noticed by Rozanov (1973,p.38 and Fig.54). He noted that the scales on the inner wall of L.polyseptus were formed after the septal stirrup-pores. This is a reversal of the succession seen for species with normally porous septa, whose inner wall characteristics were established before the septal pores attained a uniform distribution. The same reversed succession has been seen for the species Joanaecyathus caecus sp.nov. and J.cupulosus sp.nov.. As stated in the previous section, the inner wall characteristics were established after the stirrup-pores were formed for both species, although the quantitative value of Septal Porosity for the latter species did not reach a stable value until after the first inner wall bracts were formed. A third species, J.cyclopeus sp.nov. appears to have a simple inner wall, but it is evident that the septa do not become wavy at the inner wall below a cup diameter of 3mm, stirrup-pores are formed at 1.04-1.09mm and the Septal Porosity approaches a "stable" value at about 2.5mm.

It is quite clear that in every case, stirrup-pores form before the more complex inner wall characteristics. This reversal of the normal trend appears to be characteristic for species whose septal development follows the proposed pathway of "arrested" first stage development.

However, Rozanov also noted a similar reversal for the stratigraphically younger species T.edelsteini (Vologdin). He stated (op.cit. p.40):

It is interesting that T.edelsteini has non-porous septa in its adult stage. In ontogeny a partial loss of septal porosity occurs later than complication of the outer wall, but somewhat earlier or simultaneously with complication of the inner wall. Data on the ontogeny of T.edelsteini agrees well with stratigraphic data. (Translated from Russian by the present writer).

Species having sparsely porous septa belonging to the Suborder Ajacicyathina become more numerous in the Early Botomian and predominate over species with fully porous septa in the youngest strata of Botomian and Lenian age. Species with fully porous septa belonging to the Suborder Ajacicyathina are most common in the oldest strata of Tommotian and Atdabanian age. In the stratigraphically older species with fully porous septa, complication of the inner wall occurs before the final stage of uniform septal porosity is reached. However, if a loss of septal porosity by acceleration and disappearance of the early single pore stage and the stage with netlike porosity has occurred in stratigraphically younger species during evolution, then it follows that eventually a partial loss of septal porosity will be seen at successively earlier stages of cup growth. If complication of the inner wall at successively earlier stages of cup growth does not occur at the same rate of acceleration as that evident for loss of septal porosity, a stage will be reached when the latter occurs before the former (i.e. septal porosity is lost before complication of the inner wall). This appears to be the case for T.edelsteini and for other species belonging to the Superfamily Erbocyathacea.

The following tentative scheme is suggested for species belonging to the Suborder Ajacicyathina. Two groups of species are proposed. Group A includes the majority of species. The stratigraphically older forms have fully porous septa and the younger forms have sparsely porous septa. Group B includes a minority of species such as L.polyseptus, the three species belonging to the genus Joanaecyathus, and probably others. They have sparsely porous septa of the "arrested first stage" type.

Group A.

i) Species with fully porous septa.
   Age: Tommotian and Atdabanian (plus some species of Botomian age).
   Morphological characteristics: inner wall complication precedes septal porosity stabilization.

ii) Species with sparsely porous septa descended from predecessors in A i).
   Age: Botomian and Lenian (plus possibly some species of Atdabanian age).
   Morphological characteristics: inner wall complication occurs together with, or slightly after septal porosity stabilization.

Group B.

Species with sparsely porous septa of the "arrested first stage" type.
Age: Atdabanian (and ? Botomian).
Morphological characteristics: inner wall complication occurs after

septal porosity stabilization.

Adult cups in species belonging to Group B have a septal porosity similar to that seen in some species belonging to Group A ii), but this is achieved by a totally different ontogenetic development of the septal porosity.

The change in Septal Porosity with ontogeny for various species in the septate suborders has been discussed. Variations in the number of septa added with cup growth were also shown on the Text-figures. The significance of these results is discussed below.

The measurement of Radial Coefficient and its significance.

The Radial Coefficient is derived by dividing the number of septa in a transverse section by the cup diameter at that level. The Radial Coefficient is not constant but variable with cup growth, increasing or decreasing slightly or strongly for different species. Some species show both an increase and a decrease in Radial Coefficient with cup growth. For this reason, no great importance has been attached to its measurement as a means of distinguishing between species in the past.

The present writer asserts that the Radial Coefficient is perhaps the most important parameter for following the ontogenetic and phylogenetic development of the septate Regulares because its variation can be explained mathematically and presented graphically as a function of cup growth. Its inherent variability provides a clue to those developments and is intimately related to the changes in Septal Porosity. This is clearly shown by the graphical presentation of the data discussed above and elaborated below.

In a study of the individual development of Regulares, Zhuravleva (1951a, p.99) stated:

As regards such an important character as the septal coefficient (=Radial Coefficient herein) according to numerous observations it is fixed quite late, approximately for a cup diameter of 4-5mm., and in some cases even later. For the youngest cups the septal coefficient is significantly higher than for adult cups of the same species.

Later Zhuravleva stated (ibid)

> The fact is that when the cup measures fractions of a millimetre, only one or two septa arise, which must have strongly changed their ratio. It is no coincidence that all cups with a small diameter (up to 3mm.) often have a septal coefficient exceeding a magnitude of 10.0 and even 20.0. (Both passages were translated from Russian by the present author).

The importance of Zhuravleva's statements appears to have been overlooked by subsequent specialists, apparently because the Radial Coefficient was measured directly and plotted as a function of the cup diameter. The significance of the resulting curves was thus not appreciated.

The present writer saw a similarity between the curve of the variation in Septal Porosity and the curve of the variation in Radial Coefficient for each species studied. The data from which the Radial Coefficient is obtained (i.e. variations in the number of septa for each cup diameter) was thus looked at carefully. For all of the species examined, the number of septa added with cup growth plots as a straight line function with positive gradient. In many cases the function is a composite of two or more intersecting straight lines with different positive gradients. The gradient is positive because septa are always added and never subtracted with cup growth.

The equation of a straight line with positive gradient for positive values of x and y is:

$$y = mx \pm b$$

where y is the value of the function for a given value of x.

x is the value of the variable in the range $x \geqslant 0$

m is the positive gradient.

? intersect b is the intersept on the y axis when x = 0. The value of b is a constant which may be positive, zero, or negative.

For a graph depicting the number of septa with cup growth, the equation becomes:

$$N = mD \pm b \qquad \text{Equation 1.}$$

where N is the number of septa for a given value of D.

D is the cup diameter at which N is measured.

m and b are as stated before. the statement is not clear How are they calculated. Precision please.

The ratio $\frac{N}{D}$ is the Radial Coefficient.

By dividing equation 1. by D, the following equation is obtained:

$$\frac{N}{D} = \text{Radial Coefficient} = m \pm \frac{b}{D} \qquad \text{Equation 2.}$$

The Radial Coefficient derived methematically by dividing Equation 1. by D is a curve for non zero values of b and a straight line when b = 0. When b is positive the curve is concave upwards. When b is negative the curve is convex upwards.

It is clear that when D is very small compared with b, the Radial Coefficient will have very high positive or negative values.

Four examples of curves showing the variation in Radial Coefficient for different cup diameters are shown in Text-fig. 16 . The gradient m is fixed at the value of 5 for the equations. The constant b is given two positive and two negative values. The similarity between the curves representing equations (1) and (3) on the Text-figure and Radial Coefficient curves typical for many Regulares is obvious. Equations (2) and (4), for which b is negative are less obvious. Quite clearly the Radial Coefficient cannot be zero or negative, so that cups with diameter less than 0.4mm for equation (2) and less than 2mm for equation (4) cannot have septa. However, if the gradient m is increased, the curve gives positive values of the Radial Coefficient at smaller cup diameters.

Some specific examples are presented below to show the similarity between the shape of the Radial Coefficient curve and the shape of the Septal Porosity curve. It is again stressed that these have been derived from completely different measurements. Data for both curves cannot be derived from measurements at the same cup diameter for a given specimen, since Septal Porosity measurements require longitudinal sections and Radial Coefficient data requires transverse sections. No attempt is made to compare the absolute values of the curves, only their shape. The present writer suspects that there may be a link between their absolute values but as yet there is insufficient data to examine this possibility.

Selected examples to illustrate Radial Coefficient variation.

a) Suborder Coscinocyathina. Species *Veronicacyathus radiatus* sp.nov. (Text-fig. 17).

This species has been chosen first because the addition of septa appears to follow a single straight line function.

The straight line equation for the addition of septa with cup growth is:

$$N = 3.79D + 1.25$$

The Radial Coefficient has the equation.

$$\text{Radial Coefficient} = 3.79 + 1.25/D$$

The gradient $m = 3.79$; the constant $b = +1.25$.

The curve is plotted from this equation, and the values of the Radial Coefficient measured in the normal fashion are also shown.

The rapid decrease in Radial Coefficient is evident; this reaches a more or less stable value at a cup diameter of about 3mm. A comparison with the Septal Porosity curve given previously shows that the latter stabilizes at about 4mm cup diameter. Some inaccuracy, particularly at cup diameters less than 2mm is evident on both curves for this species. This is thought to arise from two sources:

i) Variation between different individuals within a species.

ii) Very small cups have relatively few septa and at early stages of growth there appears to be some variation in pore size and spacing from one septum to another. Consequently longitudinal sections may not necessarily reveal a "typical" septum at this level. Longitudinal sections through large cups, with correspondingly greater numbers of septa, are more likely to yield results closer to the expected mean for the species.

The results for this and for all of the other species discussed below in this section suffer from a lack of data because of the small number of specimens available. One promising aspect of measuring Septal Porosity and Radial Coefficient variations by the techniques described herein, is the fact that when new data becomes available it can be added directly to the existing graphs. It is expected that eventually statistic analyses will yield more accurate results. In this section the writer wishes to show only the similarity between the two functions, namely Septal Porosity and Radial Coefficient, and not their precise congruence.

b) Suborder Nochoroicyathina. Species Baikalopectinus capulus gen.et sp.nov. (Text-fig. 18).

The results obtained for this species, although sparse, shed new light on the development of septal porosity for other species belonging to the suborder.

The number of septa added with cup growth appear to plot on a single straight line, at least for cups 1.8mm to 5mm in diameter.

The straight line equation for this species is:

$$N = 15.5D - 12 \qquad (1.8 \leqslant D \leqslant 5)$$

The Radial Coefficient is:

$$\text{Radial Coefficient} = 15.5 - 12/D \qquad (1.8 \leqslant D \leqslant 5)$$

The gradient $m = 15.5$; the constant $b = -12$.

The curve is plotted from this equation and values of Radial Coefficient measured in the usual fashion are shown.

It is immediately obvious that the gradient is very high and the constant b has a high negative value at least within the range of cup diameters studied. This constraint is important because the slope of the straight line representing the addition of septa may be different at lower and higher cup diameters,with correspondingly different curves of the Radial Coefficient. However, within the specified range of cup diameters the Radial Coefficient increases with cup growth. Although no attempt was made to fit a curve to the Septal Porosity data, this also appears to increase with cup growth for the same range of cup diameters.

In discussions concerning the septal porosity of _Lenocyathus lenaicus_ Zhuravleva and other species belonging to the Suborder Nochoroicyathina, Debrenne, Zhuravleva and Rozanov (1973, p.37) have stated:

Thus, in the way of amalgamating Nochoroicyathina and Ajacicyathina there are considerable difficulties. Furthermore, at the present time it cannot be done. no but one can notice that there are more features in commun between Aj + Noc ≠ Coscino.

Firstly there is ontogenetic data for some Nochoroicyathina, when in the initial stages non-porous and practically non-porous septa are seen, utterly in contradiction to adult examples. Such a phenomenon is observed for example, for _Lenocyathus lenaicus_ Zhur..
It rather indicates a profound parallelism in the development of

independent groups (Nochoroicyathina and Ajacicyathina), when the possibility of morphological transformations of one group has appeared only in ontogeny. (Translated from Russian by the present writer). Rozanov (1973, p.45, 46) also mentioned that L.lenaicus has non-porous septa initially, which develop normal porosity at adult stages. He also mentioned that an increase in septal porosity with cup growth is a common phenomenon for species with tumulose outer walls belonging to the Nochoroicyathina.

Zhuravleva (1960b, p.239) has indicated that the Radial Coefficient of L.lenaicus decreases with cup growth, but Belyaeva (1974, p.120) has noted an increase in the Radial Coefficient for cups 4-5mm in diameter. This conflicting information suggests that the graph of septal addition with cup diameter may be a composite of two or more intersecting straight lines of different gradient m, and possibly positive and negative values of the constant b.

Without this information, and without measuring Septal Porosity in the manner described herein, no conclusions can be drawn at this stage. However, the increase in septal porosity with cup growth for several species in the Nochoroicyathina found in the USSR certainly deserves closer study.

c) Suborder Ajacicyathina. Species ? *Gordonicyathus pledgei* sp.nov. (Text-fig. 19)

The number of septa added with cup growth plot close to a straight line whose equation is:

$$N = 7.06D + 4.64$$

The Radial Coefficient is:

$$\text{Radial Coefficient} = 7.06 + 4.64/D$$

The gradient m = 7.06; the constant b =+4.64

The shape of the Radial Coefficient curve is similar to that of the Septal Porosity curve, although the former reaches a stable value much later than the latter. This is probably the result of insufficient data for either curve but it is quite clear that they are similar. Note that the constant b is positive.

d) Species _Joanaecyathus caecus_ sp.nov. (Text-fig. 20)

The Radial Coefficient curve for this species is complex. It has been derived from the three straight line segments which comprise the septal addition graph presented previously. The equations for the three part Radial Coefficient curve are shown on the Text-figure. The Radial Coefficient initially decreases in a similar fashion to the Septal Porosity until a cup diameter of about 4mm is reached. For cup diameters between 4 and 6mm, no data was obtained either for Septal Porosity or for the Radial Coefficient, although it is evident that the Radial Coefficient must increase rapidly in order for the curve to link with data obtained for cups greater than 6mm in diameter. It is possible that the Septal Porosity may also rise in this interval but there is no data to support this possibility as yet. The third part of the Radial Coefficient curve decreases once more and a similar decrease in Septal Porosity is also evident.

e) Species _Joanaecyathus cyclopeus_ sp.nov. (Text-fig. 21 .)

The composite Radial Coefficient curve for this species is derived from the three straight line segments for the graph of septal addition with cup diameter shown previously. The Radial Coefficient curve is similar to that shown for _J.caecus_ sp.nov. but has lower overall values and shows an abrupt change at a smaller cup diameter. No information was available for the graph of septal addition for the interval between 2 and 2.5mm cup diameter, but it is evident that the number of septa added must rise rapidly to link with the values shown for larger cups. The Radial Coefficient rises rapidly in this interval along a portion of a convex upward curve, with a corresponding negative value of the constant b. (Equation 2 on the Text-figure).

Although the data for Septal Porosity is very sparse, it does indicate a rapid initial drop at small cup diameters, followed by an apparent increase in the interval where the Radial Coefficient rises, between 2 and 2.5mm cup diameter. For larger cups, the Septal Porosity again appears to fall, as does the Radial Coefficient.

Discussion.

Seemingly random changes in the Radial Coefficient for the species presented above are more easily understood if derived mathematically from data provided by the changing number of septa added with cup growth, rather than by direct calculation of the coefficient. The Radial Coefficient is shown to be a simple or composite curve depending on whether the data for the rate of addition of septa falls on one or more straight line segments. The Septal Porosity calculated in the manner described previously, appears to fall and rise at the same time as the Radial Coefficient decreases and increases.

The results presented above were obtained from very few species in the three septate suborders and it is evident from data published by workers in the USSR that there are many, more complex cases than those described herein. For instance, Rozanov (in Rozanov and Missarzhevskiy, 1966, p.42, Fig. 21) has shown data for the change in Radial Coefficient with cup growth for the species Aldanocyathus sunnaginicus, one of the oldest species found in the Tommotian Stage on the Siberian Platform. If the Radial Coefficient data presented by Rozanov is recalculated to show the change in the number of septa added with cup growth, the resulting function is not a straight line, but a smooth curve (Text-fig. 22 .)
Data for the species Tegerocyathus edelsteini (Vologdin) given by Zhuravleva (1960b, p.195, Table 14) shows that the Radial Coefficient

rises for very small cups and subsequently decreases in larger cups. This suggest a two segment straight line graph for the addition of septa. In her discussion of the growth development of this species, Zhuravleva states that the first formed septal pores are quite small and stirrup-pores are not seen. At a slightly larger cup diameter, relatively large stirrup-pores are formed and the small pores in the septa have practically disappeared. With increased cup growth, only stirrup-pores occur. Zhuravleva's description indicates an overall decrease in septal porosity, but it is possible that there is an initial slight increase in septal porosity when the first large stirrup-pores were formed.

The examples quoted above and those provided by the writer show that there is considerable variation in Septal Porosity and the Radial Coefficient during the ontogeny of a single species. A lineage of successively younger species found in Lower Cambrian strata can only be constructed when the ontogeny of each species is known. Two pathways of septal pore reduction for species belonging to the Sub-order Ajacicyathina have been proposed herein, each representing a different pattern of ontogeny of the septal pore systems. It is therefore stressed that the earliest stages of septal growth must be known before phylogenetic trends can be considered. Furthermore, the stratigraphic ranges of the constituent species in a lineage must be accurately known. Because all of the specimens were obtained from a limited stratigraphic interval, no attempt is made to predict trends based on the available data.

Conclusions.

Many workers have found no regular pattern for the addition of septa with cup growth (Taylor, 1910; Okulitch, 1935; Okulitch and de Laubenfels, 1953; Zhuravleva, 1959b). While it is true that septa are apparently not inserted in a specific pattern, they do appear to be added at a controlled rate. Their rate of addition and the cup diameter at which they are added determine whether the Radial Coefficient increases or decreases. The variations in Radial Coefficient can be derived mathematically when septa are added as a linear function of cup growth. Changes in the Septal Porosity appear to closely follow changes in the Radial Coefficient. It is not known at present whether the Septal Porosity controls the Radial Coefficient, or whether the reverse is true.

Quantitative measurements of the change in Septal Porosity described herein provide useful ontogenetic patterns characteristic for a given species. It is hoped that as more data becomes available, similar patterns of ontogeny will be used to construct phyletic lineages which will more clearly illustrate evolutionary trends in the Regulares.

CHAPTER 6.

SYSTEMATIC DESCRIPTIONS, CLASS REGULARES VOLOGDIN, 1937.

Introduction.

Chapters 6 and 7 contain species descriptions of Regulares and Irregulares collected from Wilkawillina Gorge and the Mount Scott Range. The majority of species come from Faunal Assemblages I and II. In addition, some species, mostly Irregulares from the Taylor and Bedford collections have been redescribed. Several specimens identified to generic level by Walter (1967) have been described at species level, augmented by new material from Wilkawillina Gorge. Only specimens from Walter's Collections 1 and 2 have been revised, since they are from Faunal Assemblages I and II respectively. Collections 3 and 4 of Walter belong to much younger faunal assemblages and consequently are beyond the scope of the present work.

The descriptive format used herein is explained below.

Specimen Numbers.

All specimens belonging to each species described herein bear the prefix P. They will eventually be housed in the South Australian Museum. The Bedford's specimens housed there also bear the prefix P (= Palaeontology section).

Specimens from the Taylor collection are from the Tate Museum Collection, formerly housed in the Department of Geology and Mineralogy, University of Adelaide. These bear the prefix T (= Tate Collection) and are now housed in the South Australian Museum.

Specimens figured by Walter (1967) and bearing the prefix F (= Fossil) are also housed in the South Australian Museum.

Specimens collected by Walter from his stratigraphic section C - D (Walter, 1967, Fig. 1) and bearing the prefix OA, are housed in the Department of Geology and Mineralogy, University of Adelaide.

Type Formation and Type Locality.

These refer to the location of the holotype only. The Faunal Assemblage stated in each case refers only to the stratigraphic position of the holotype. The stratigraphic range of each species is shown in Tables 1 and 2.

Dimensions.

Measurements (in mm) obtained for each species follow the taxonomic description. The terminology and abbreviations used are as follows.

Diameter. = Cup diameter measured diametrically across a specimen between the outer surfaces of the outer wall.

Intervallum width. = Width of space enclosed by the outer and inner walls.

N = The number of septa in transverse sections.

ds = The distance between adjacent septa. here

IK = Intervallum Coefficient, measured as the ratio of the intervallum width to the cup diameter.

RK = Radial Coefficient, measured as the ratio of the number of septa to the cup diameter.

Loculi = Ratio of interseptum width to intervallum width, expressed as a proper fraction with the numerator equal to 1. (measurements taken in the mid-part of the intervallum).

Outer wall:n = The number of outer wall pores per intersept.

Inner wall:n = The number of inner wall pores per intersept.

Septa: n = The number of septal pore rows across the intervallum.

Tabulae: n = The number of tabular pores in a single loculus.

Outer wall sheath:n = The number of sheath micropores for each carcass pore.

d = Pore diameter or dimensions where pores are oval.

l = Lintel width, which is the distance between adjacent pores.

t = Thickness of the skeletal element.

Other terms used in the text are self explanatory. Where the stated dimension varies from the cup diameter stated initially, the diameter at which the dimension was measured is included in parenthesis.

The writer has not measured the ratios of pore diameter to lintel width, because of variations in their dimensions. These are considered to be of limited taxonomic value and sometimes misleading. They have a valid application to Archaeocyatha with simply porous walls pierced by circular pores, whose interpore lintels are rectangular. Pore ratios are considered to be totally inadequate for the expression of septal porosity as discussed in the previous Chapter.

CLASS REGULARES Vologdin, 1937.

ORDER AJACICYATHIDA Bedford R. and J., 1939.

SUBORDER DOKIDOCYATHINA Vologdin, 1957.

DIAGNOSIS. Two walled solitary or colonial cups. Outer and inner walls have simple or complex porosity. Both walls connected by radial rods of circular cross-section, or by radial bars of vertically stretched oval cross-section.

SUPERFAMILY DOKIDOCYATHACEA Debrenne, 1970.

DIAGNOSIS. Outer wall with simple porosity.

FAMILY DOKIDOCYATHIDAE Bedford R. and J., 1936.

DIAGNOSIS. Outer and inner walls with simple porosity.

Genus DOKIDOCYATHUS Taylor, 1910.

Type species. Dokidocyathus simplicissimus Taylor, 1910.

DIAGNOSIS. Solitary two walled cups with simply porous walls. Intervallum contains radial bars which link both walls. The bars are oval, stretched vertically in longitudinal section, each bar has a concave upper surface and convex lower surface. When coplanar, successive bars in longitudinal section enclose a space which resembles a single large oval pore. The oval pore may be stretched vertically when successive bars are distant, becoming circular to horizontally stretched when successive coplanar bars are closer.

DISCUSSION ??? comparison and restatement of the problem of Dokidocyathus

Dokidocyathus genuinus sp. nov.

(Plate 17, Figs. 3 to 6)

NAME. From Latin genuinus = pertaining to the teeth.

HOLOTYPE. P21411-1 (seven thin sections).

PARATYPES. P21412-2; P21413-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Three specimens from the Mount Scott Range, section N; two specimens from Wilkawillina Gorge, section H. Holotype and paratype as above. Additional specimens: P21414; P21415.

DIAGNOSIS. Two walled solitary cups. In transverse section the outer and inner walls have several rows of simple pores between adjacent radial bars. Outer and inner walls are robust, thickened by vertical ridges between the pores. Intervallum crossed by thick radial bars arranged in quincunx. Each bar has a concave upper surface and convex lower surface in longitudinal section. The inner wall is thicker than the outer wall.

DESCRIPTION. Two walled conical cups. The intervallum width increases rapidly with cup growth up to a cup diameter of 9mm, then more slowly in larger cups. The outer wall of small cups has 3-6 pore rows between adjacent radial bars, large cups have 5-14 rows of pores. The simple pores of the outer wall are circular and oval in shape. The inner wall of small cups has 1-3 rows of pores between adjacent radial bars, in large cups the number of pore rows increases to 4-10. Inner wall pores are circular to oval in shape. Blunt vertical ridges between adjacent pores considerably thicken both walls, particularly the inner wall. The outer wall ridges project an equal distance to the exterior and the intervallum. Those on the inner wall project mainly into the central cavity. Both walls are linked by radial bars arranged in quincunx. The bars are oval in cross-section and are very thick near the walls. The upper surface of each bar is concave and the lower surface is convex in longitudinal section. The vertical separation of bars increases considerably with cup growth.

DIMENSIONS (mm)

Note. Dimensions vary considerably with cup growth. Consequently, the cup diameter is included in parenthesis after certain dimensions to indicate the cup size at which the measurements were made.

	Holotype P21411-1	Paratype P21412-2
Diameter.	max. 17.9	max. 16.3
Intervallum width.	0.74(3.10)-2.22(17.3)	1.20(5.7)-2.96(15.8)
Outer wall:		
n	7-8(10.0)-14(17.7)	-
d	0.12(4.8)-0.36(17.3)	0.17(5.7)-approx.0.29(15.8)
l	0.07-0.16	0.07-0.11
t	0.07(3.1)-0.29(17.3)	0.12(5.7)-0.29(15.8)
Inner wall:		
n	1(approx.2.9)-4-10(17.7)	1-2(5.2)-4(approx.9.0)
d	0.19(3.1)-0.36(17.3)	0.27(5.7)-0.36(15.8)
l	0.12	0.07-0.12
t	0.14(3.1)-0.34(17.3)	0.19(5.7)-0.31(15.8)
Intervallum bars:		
Radial separation	1.9-2.4	2-6
Vertical separation	0.78(3.8)-0.97(4.4)	2.3(8.7)-3.9(10.6)
Width (transverse section)	0.15-0.19	0.12-0.18
Thickness (longitudinal section)	approx.0.73	0.29 in their centre - 1.16 at walls

ONTOGENY. At the smallest known cup diameter of 1.0mm the inner wall, central cavity and bars have been formed. The outer and inner walls are smooth. Outer wall thickness 0.04mm, inner wall thickness 0.07mm. The inner wall has one row of circular pores between adjacent radial bars. Bars in the intervallum have a concave upper and convex lower surface. Ridges thickening the outer wall are well developed at 6.6mm cup diameter, at this stage they are just forming on the inner wall. At 10mm cup diameter the ridges on the inner wall are thicker than those on the outer wall. The intervallum width increases rapidly up to a cup diameter of 9mm and more slowly thereafter.

COMPARISON AND REMARKS. Dokidocyathus genuinus sp. nov. differs from D. simplicissimus Taylor by its greater number of outer and inner pores between adjacent radial bars and by the presence of ridges on the central cavity side of the inner wall. The inner wall of D. simplicissimus is thick but smooth. Zhuravleva et al (1964, p.79) stated that the inner wall of D.simplicissimus has vertical ribs on the intervallum side, similar to those found in Dokidocyathella incognita Zhuravleva. These, however, appear to be portions of the radial bars in D. simplicissimus. Vertical ribs projecting into the central cavity as seen in D. genuinus sp. nov. have not been described in species of Dokidocyathus from the USSR.

Dokidocyathus osseus sp. nov.

(Plate 18, Figs. 1 to 5)

NAME. From Latin osseus = bony.

HOLOTYPE. P21416-1 (three thin sections)

PARATYPES. P21417-1; P21418-1; P21419-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Eleven specimens from the Mount Scott Range, Section N;

Holotype and paratypes as above. Additional specimens: P21420-1; P21421; P21422; P21412-4; P21423-3; P21424-1; P21425-1.

DIAGNOSIS. Conical cups whose walls bulge irregularly between adjacent bars in transverse section. Intervallum increases slowly with cup growth but may contract rapidly in width at irregular intervals in some cups. Outer and inner walls with several rows of circular pores between adjacent radial bars. Both walls are linked by radial bars arranged in quincunx. In longitudinal section bars are often oblique. Spines are sporadically developed on the lintels between inner wall pores.

DESCRIPTION. Conical cups whose walls may bulge between adjacent bars in transverse section. The intervallum width increases slowly with cup growth, but irregular contractions of the outer wall cause the intervallum width to be restricted in some cups. The outer wall has 2-6 rows of circular pores in quincunx between adjacent bars in transverse section. Both walls are connected by radial bars arranged in quincunx. Bars are often oblique in longitudinal section; each has a concave upper and convex lower surface. The inner wall has 1-4 rows of circular pores in quincunx between adjacent bars in transverse section. Sharp spines curving upwards into the central cavity are present on the lintels between the inner wall pores. They appear to be sporadically developed. Earliest stages of growth are not known.

DIMENSIONS (mm)	Holotype P21416-1	Paratype P21417-1	Paratype P21419-1
Diameter	5.3-8.1	6.6	8.9
Intervallum width	0.85-0.97(5.3)	0.97	1.18-1.68

Outer wall:			
n	3-6	2-3	4-6
d	0.17	0.10-0.17	0.15-0.18
l	0.07-0.10	0.07-0.10	0.10
t	0.10-0.15	0.07-0.12	0.12
Inner wall:			
n	1-3	1-3	2-4
d	0.24-0.27	0.27-0.29	0.19-0.27
l	0.07-0.12	0.12-0.17	-
t	0.12-0.24	0.10-0.12	0.12-0.29
Intervallum bars:			
Radial separation.	0.50-0.72	0.29-0.56	0.59-0.89
Vertical separation.	0.74-1.23	0.78-2.10	2.22-3.20
Width (transverse section).	0.12-0.15	0.09	0.12-0.15
Thickness (longitudinal section).	0.22-0.85*	0.19-0.73*	0.29-0.73*
	* (at walls)	* (at walls)	* (at walls)

COMPARISON AND REMARKS. D. osseus sp. nov. differs from D. genuinus sp. nov. by its narrower and fluctuating intervallum width; fewer wall pores in large cups; the absence of pillars from the walls, and by sporadic occurence of spines on the inner wall. Species from the USSR. having bars, rather than rods in the intervallum are D. tuvaensis Rozanov; D. lentus Osadchaja and D. knorringiensis Okuneva. These have intervallum widths comparable to that found in D. osseus sp. nov. However, D. tuvaensis has considerably thicker walls with more widely spaced pores; D. lentus has outer wall pores conical in cross-section, narrowing outwards, and very small bracts on the inner wall; D. knorringiensis has smaller outer and inner wall pores with minute bracts on the inner wall.

Dokidocyathus triangulus sp. nov.

(Plate 18, Figs. 6 to 8; 19, Fig. 1)

NAME. From Latin triangulus = triangular.

HOLOTYPE. P21426 (three thin sections)

PARATYPE. P21427-1.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section K.

MATERIAL. Two specimens from the Mount Scott Range, section K.

DIAGNOSIS. Two walled cylindro-conical cups. Outer wall with several pore rows between adjacent bars in transverse section. The outer wall pores are circular on the intervallum side and expand outwards to a hexagonal shape at the outer surface of the cups. Lintels between the pores are triangular in cross-section with their apices pointing outwards. Both walls are connected by radial bars which are arranged in quincunx but are quite distant in longitudinal section. The inner wall has several rows of rounded to subangular pores between adjacent radial bars. Both walls lack spines.

DESCRIPTION. Cylindro-conical cups with relatively narrow intervallum. The outer wall has 6-11 rows of quincunxially arranged pores between adjacent radial bars. Pores are circular on the intervallum face, expanding outwards to a hexagonal shape at the outer surface of the cup. Interpore lintels are triangular in cross-section with their apices pointing outwards. Both walls are connected by radial bars arranged in quincunx. Bars are quite distant in longitudinal section; each has a concave upper and convex lower surface. The inner wall has 4-7 rows of pores in quincunx between adjacent radial bars. Pores are circular to subangular, roughly hexagonal in shape. Both walls lack spines or pillars. Early stages of growth are not known.

DIMENSIONS (mm)	Holotype P21426	Paratype P21427-1
Diameter	5.7	5.7
Intervallum width.	0.90	1.17
Outer wall:		
n	11	6-9
d	0.10-0.22	0.17-0.19
l	0.04-0.10	0.07-0.12
t	0.07-0.15	0.10-0.12
Inner wall:		
n	7	4-6
d	0.17-0.22	0.22-0.27
l	0.07	0.07-0.10
t	0.07-0.09	0.07
Intervallum bars:		
Radial separation.	0.77-1.55	1.00-1.74
Vertical separation.	approx. 2.90	2.40-3.70
Width (transverse section)	0.10	0.07-0.10
Thickness (longitudinal section)	0.15-0.29	0.16-0.27

COMPARISON AND REMARKS. D. triangulus sp. nov. differs from the two species described above by the shape of its outer wall pores and by the absence of spines or ribs on either wall. In addition the radial bars are further apart in longitudinal section. D. regularis Zhuravleva has pores of similar shape but their diameters are different. The species D. regularis has rods rather than bars in the intervallum.

Dokidocyathus sp.

(Plate 18, Fig. 9)

FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

LOCALITY. Wilkawillina Gorge. Section E.

MATERIAL. Two specimens from section E. P21428; P21429-1.

DESCRIPTION. Small conical cups with smooth, thin walls. The outer wall has approximately 4-7 rows of pores between adjacent radial bars, but their exact shape and arrangement is unknown. Both walls are connected by bars which are almost circular in cross-section. Bars have a weakly concave upper and weakly convex lower surface. The inner wall has 1-2 rows of circular pores between adjacent radial bars. Earliest stages of growth are not known.

DIMENSIONS (mm) Specimen number. P21429-1

Diameter 1.31-3.35; intervallum width 0.34-0.68.

Outer wall: n approx. 4-7; d 0.07; l ?; t 0.04-0.07.

Inner wall: n 1-2, d 0.10-0.22; l 0.07-0.10; t 0.05-0.10.

Intervallum bars: radial separation 0.63-0.80; vertical separation 0.73-0.92; width (transverse section) 0.08-0.10; thickness (longitudinal section) 0.10-0.22.

COMPARISON AND REMARKS. The small cup sizes and sparseness of material prevent an accurate specific determination at this time. These are the only known specimens of Dokidocyathus from Faunal Assemblage I. The specimen listed by Walter (1967, p. 144, Table 1) as Dokidocyathus sp. from Faunal Assemblage I at Wilkawillina Gorge was described by him as follows*:

"Small conical form (4-5mm diameter). Outer wall very sparsely porous, with slight horizontal constrictions. Inner wall coarsely porous, retiform. Intervallum with sparse, radial, slightly irregular rods (some discontinuous and bent). No synapticulae."

Judging by his description the specimen is probably an Irregulare. (Specimen number: University of Adelaide OA1600F-3, no thin section available).

Debrenne (1974b, p.101) has proposed a new genus *Dokidolynthus* to accommodate species in which the intervallum has radial rods of circular cross-section, rather than oval bars. Species with rods of this type are restricted mainly to the Tommotian and Early Atdabanian Stages of the Siberian Platform. It is worth noting that the specimens from Faunal Assemblage I have bars in the intervallum which are nearly circular in cross-section (almost rods), whereas species from Faunal Assemblage II have definite oval bars.

*Walter, M.R., (1965). Archaeocyatha and the biostratigraphy of the Hawker Group near Wirrealpa, S. Aust. (B.Sc. (Hons.) Thesis, University of Adelaide, unpublished).

SUPERFAMILY KALTATOCYATHACEA Rozanov, 1973

DIAGNOSIS. Two walled cups, walls linked by radial rods or bars. Outer wall pores covered by simple tumuli.

FAMILY KALTATOCYATHIDAE Rozanov, 1964

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with simple pores.

DISCUSSION. Rozanov (in Zhuravleva, Konyushkov and Rozanov, 1964, p.92) initially included in the family, species having simple or multiperforate tumuli on the outer wall and simply porous inner walls. The genus Kaltatocyathus Rozanov contains species with simple outer wall tumuli. Papillocyathus Rozanov contains species with multiperforate outer wall tumuli.

In 1973, Rozanov (p.85) created the Superfamily Papillocyathacea for species having multiperforate tumuli on the outer wall, and Kaltatocyathacea for species with simple outer wall tumuli. In his diagnosis of the genus Kaltatocyathus, Rozanov states that the intervallum contains radial rods; whereas in the genus Papillocyathus there are thickened rods (bars herein), in the intervallum (1964, pp.92,94).

Genus AROONACYATHUS gen. nov.

NAME. From Aroona Creek, near Mount Scott.

Type species. Aroonacyathus gregarius sp. nov.

DIAGNOSIS. Colonial, sometimes solitary, two walled cups. The outer wall pores are covered by simple tumuli, inner wall pores are simple. Both walls are connected by radial bars, each with a concave upper and convex lower surface.

DISCUSSION (see p. 138) or here.

<u>Aroonacyathus gregarius</u> sp. nov.

(Plate 19, Figs. 2 to 9) .

NAME. From Latin <u>gregarius</u> = belonging to a flock.

HOLOTYPE. P21417-4 (two thin sections).

PARATYPES. P21430-1; P21431; P21432; P21434.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Eight specimens from the Mount Scott Range, section N; holotype and paratypes as above. Additional specimens: P21433; P21435-1; P21436.

DIAGNOSIS. As for the genus.

DESCRIPTION. Colonial, sometimes solitary, tall slender, cylindro-conical cups. Colonial cups increase by opposed indentation of the intervallum, giving rise to new cups which tend to grow parallel and close together. The outer wall has 2-4 rows of circular pores between adjacent radial bars. Each pore is covered by a simple tumulus with a horizontal opening to the exterior. The intervallum is crossed by radial bars, each with a concave upper and convex lower surface. The bars are arranged in regular quincunx and are closely spaced vertically, so that the opening between successive bars in longitudinal section appears as a vertically stretched oval pore. The inner wall is simply porous with 1-2 rows of circular pores between adjacent radial bars. Early stages of growth are not known.

DIMENSIONS (mm)	Holotype P21417-4	Paratype P21430-1	Paratype P21434
Diameter	4.0	3.2	2.1
Intervallum width	0.56-0.70	0.65-0.73	0.46
Outer wall carcass:			
n	2-4	3	? 4
d	0.13-0.15	0.15-0.18	0.10
l	0.17	0.17-0.19	-
t	0.05-0.07	0.05-0.07	0.07
Outer wall tumuli:			
Height	0.03-0.12	0.03-0.07	0.03-0.05
Diameter of opening	0.05-0.07	approx. 0.07	0.03
Inner wall:			
n	1-2	2	2
d	0.19-0.24	0.24-0.29	0.19-0.24
l	0.12-0.25	0.12-0.27	0.10-0.12
t	0.07-0.09	0.06-0.09	0.05-0.07
Intervallum bars:			
Radial separation	0.29-0.68	approx. 0.73	approx. 0.70
Vertical separation	-	0.90-1.38	0.65
Width (transverse section)	0.05-0.10	0.07	approx. 0.08
Thickness (longitudinal section)	-	0.15-0.24	0.15-0.24

COMPARISON AND REMARKS. Aroonacyathus gen. nov. differs from Kaltatocyathus Rozanov by the presence of bars rather than rods in the intervallum, and from Papillocyathus Rozanov by the presence of simple and not multiperforate tumuli on the outer wall. This is the first recorded occurence of representatives of the Family Kaltatocyathidae from South Australia.

SUBORDER AJACICYATHINA Bedford R. and J., 1939.

SUPERFAMILY AJACICYATHACEA Bedford R. and J., 1939.

DIAGNOSIS. Two walled cups, walls linked by septa. Outer wall simply porous.

FAMILY AJACICYATHIDAE Bedford R. and J., 1939.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall simply porous with more than one row per intersept.

Genus LOCULICYATHUS Vologdin, 1931.

1931 Loculicyathus Vologdin, p.54.
1937 Loculocyathus Vologdin, p.468 (nom. null.)
1957 Mikhnocyathus Maslov, p.307.
1962 Zolacyathus Vologdin, p.10.
1964 Loculicyathus Voronin, p.18.
1972 Loculicyathus Hill, p.E62.
1974 Neoloculicyathus Voronin, p.134.

Type species Coscinocyathus irregularis von Toll, 1899.

DIAGNOSIS. Two walled cups. Outer wall simply porous with one or usually more pore rows per intersept. Intervallum filled with radial porous septa and dissepiments. Inner wall simple with one or usually more pore rows per intersept. Dissepiments often cross the central cavity, they may be absent in the upper parts of large cups.

DISCUSSION. Voronin (1974, p.134) separated species having three or more outer wall pores and two or more inner wall pores per intersept into a separate genus Neoloculicyathus. He further stated that its type species N. primus Voronin is the only member of the genus, which suggests that all of the earlier described species belong to the genus

Loculicyathus Vologdin, with presumably only one pore row per intersept.

However, many of the previously described species in the genus Loculicyathus have one or more inner wall pore rows per intersept. L. membranivestites Vologdin has 1-2 inner wall pore rows per intersept (see Vologdin, 1940, Pl.19, Fig.5, Text-fig. 54b); L. zolaensis (Maslov) has 2-4 inner wall pore rows per intersept (Maslov, 1957, p.308; Voronin, 1964, p.20). The lectotype of the type species is too poorly preserved to see the inner wall porosity and von Toll did not describe the porosity in his original description (1899, p.44, Pl. 7, Fig. 9). However, specimens illustrated by Krasnopeeva (1955, p.81, Pl. 2, Fig. 1b especially) and placed in the species Loculicyathus irregularis (Toll), indicate that there is one and sometimes two rows of inner wall pores per intersept.

Voronin's definition of Neoloculicyathus infers that the genus Loculicyathus has only one row of inner wall pores and should thus be placed in the Family Robustocyathidae Debrenne.

It is considered herein that there are insufficient grounds for separating the genera Loculicyathus with one or two rows of inner wall pores and Neoloculicyathus, with two or more rows of inner wall pores per intersept. Neoloculicyathus is thus considered herein to be a junior synonym of Loculicyathus which belongs in the Family Ajacicyathidae.

Loculicyathus alternus sp. nov.

(Plate 20, Figs. 1 to 7)

NAME. From Latin alternus = alternate.

HOLOTYPE. P21437 (seven thin sections).

PARATYPES. P21438; P21439; P21440-1.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section K.

MATERIAL. Six specimens from the Mount Scott Range, section K; nine specimens from Wilkawillina Gorge, sections G and H. Holotype and paratypes as above. Additional specimens: P21441 to P21446; P21447-1; P21448 to P21450; P21451-1.

DIAGNOSIS. As for the genus. This species has one row, or two alternating rows of outer wall pores per intersept. The inner wall has one or two rows of pores per intersept.

DESCRIPTION. Two walled slender conical cups. The outer wall is simply porous with one row or two alternating rows of pores per intersept. Pores are usually more closely spaced horizontally than vertically and may anastomose. The thick outer wall has minute pustules on its outer surface, these border the outer wall pores. Intervallum with numerous radial septa pierced by regular quincunxial rows of circular pores. Stirrup-pores are common at the junctions of septa and the inner wall, but not at the outer wall. The inner wall is simply porous with one or two pore rows per intersept. Stirrup-pores are common. The inner wall pores may anastomose laterally and vertically in larger cups. Very short spinules are present on the inner surface of the wall. Dissepiments are quite abundant in the intervallum and central cavity near the base of the cup, but are rare to absent in the upper parts. Exothecal tissue commonly surrounds the cup base.

DIMENSIONS (mm)	Holotype P21437	Paratype P21440-1	Paratype P21438
Diameter.	17.2	9.2	approx. 5-6
Intervallum width.	1.70	1.33	1.18
N	120	70	approx. 55
ds	0.42	0.34-0.39	0.19-0.27

IK	0.10	0.15	0.21
RK	7.0	7.6	approx. 9.8
Loculi	1/4 .1	1/3.4-1/3.9	1/4 .4-1/6.1
Outer wall:			
n	1-2	2	1-2
d	0.09-0.22	0.09-0.12	0.06-0.10
l	0.06-0.12	0.07.0.10	0.01-0.06
t	0.10-0.12	0.06-0.07	0.07
Inner wall:			
n	1-2	1	1-2
d	0.15-0.24	0.10-0.17	0.10-0.12
l	0.10-0.15	approx.0.12	0.05-0.07
t	0.09-0.12	0.10	0.07
Septa:			
n	7	6-8	approx. 7
d	0.10-0.15	0.10-0.15	0.07-0.09
l	0.07-0.15	0.10-0.12	0.05-0.10
t	0.05	0.05	0.03-0.05

ONTOGENY. The inner wall and central cavity have been formed at the smallest known cup diameter of 1.26mm. At this stage, septa have one large pore 0.15mm diameter close to the outer wall and a smaller stirrup-pore 0.11mm diameter at the inner wall junction. Both walls have one pore row per intersept, outer wall pores are reduced by secondary thickening. Dissepiments are abundant up to 5mm cup diameter but are rare to absent at higher levels.

COMPARISON AND REMARKS. *Loculicyathus lectus* Yazmir and *L. vologdini* Okuneva have a similar radial coefficient to that found in *L. alternus* sp. nov. Yazmir (1974, p.45) has suggested that there may be 4-6 rows of outer wall pores in L. lectus. Okuneva (in Okuneva and Repina, 1973, p. 108) states that there are 6-8 rows of very small circular pores per intersept on the outer wall of L. vologdini. Most other species in the genus have a radial coefficient of two to four.

? Loculicyathus racemiferus sp. nov.

(Plate 20, Figs. 8,9; 21, Figs 1 to 7)

NAME. From Latin racemiferus = bearing clusters.

HOLOTYPE. P21452 (two thin sections).

PARATYPES. P21453-1; P21454.

TYPE FORMATION. Wilkawillina Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. Two specimens from Wilkawillina Gorge, sections G and H; four specimens from the Mount Scott Range, sections K and N. Holotype and paratypes as above. Additional specimens: P21455-1; P21456; P21457.

DIAGNOSIS. Two walled, open conical cups. Outer wall with circular pores either isolated or in clusters over a coarsely porous underlying framework. The outer surface of the cup is pustulose. Intervallum with radial septa pierced by circular and oval pores, often forming stirrup-pores at junctions with the inner wall. The inner wall is simply porous with two or more rows of pores per intersept. Pores occasionally anastomose, stirrup-pores are present. Sparse dissepiments are present in the intervallum and central cavity near the base of the cup.

DESCRIPTION. Open conical cups with a comparatively narrow intervallum. The outer wall consists of rounded pores arranged in clusters or isolated. In large cups the clusters of pores are grouped over a coarser underlying framework of 1-2 subrectangular pores per intersept. In large cups this arrangement of pores strongly resembles a non-independent microporous sheath. The outer surface of the cup is pustulose. Intervallum with radial septa pierced by circular and oval pores arranged in irregular quincunx. Stirrup-pores at junctions of septa and the inner wall are common. The inner wall is simply porous with several rows of rounded pores per intersept. Adjacent pores may anastomose laterally; stirrup-pores are common. Sparse dissepiments are present in the intervallum and central cavity at small cup diameters and are sporadically developed in larger cups.

DIMENSIONS (mm)	Holotype P21452	Paratype P21453-1	Paratype P21454
Diameter.	11.0	10.7	30.3
Intervallum width.	1.28-1.50	1.28-1.36	1.79-1.94
N	62	approx. 70	approx. 164
ds	0.31-0.48	0.41-0.48	0.41-0.58
IK	0.12-0.14	0.12-0.13	0.06
RK	5.7	approx. 6.5	approx. 5.4
Loculi.	1/2.7-1/4.8	1/2.7-1/3.3	1/3.1-1/4.7
Outer wall carcass:			
n	1-2	1-2	1-2
d	0.24	0.22-0.26	0.24
l	0.08-0.12	-	approx. 0.10
t	0.07-0.12	0.10-0.12	0.10
Outer wall clustered pores:			
n	2-3	1-3	1-3
d	0.08-0.12	0.07-0.12	0.05-0.12
l	0.02-0.03	0.02-0.10	0.03-0.12
t	0.03-0.05	approx.0.03	-

Inner wall:			
n	2-4	2-3	2-3
d	0.07-0.08	0.12-0.15	0.10-0.13
l	-	0.04-0.12	0.07-0.11
t	0.08-0.10	0.07-0.10	0.10
Septa:			
n	6	5-7	8
d	0.10	0.10-0.17	av. 0.12
l	approx.0.10	0.07-0.12	0.07-0.12
t	0.05-0.07	0.05	0.05-0.07

ONTOGENY. The following data has been obtained from a single longitudinal section through the holotype.
At the smallest cup diameter of 0.95mm the inner wall and central cavity have been formed. Radial rods or bars are present in the intervallum at this stage. Septa with one large pore and a possible stirrup-pore are formed at a cup diameter of 1.14mm. Two small septal pores quickly develop after this stage. At a cup diameter of 2.0mm the inner wall has one pore per intersept with an additional stirrup-pore shared between adjacent intersepts. The outer wall is simply porous up to a cup diameter of 4 mm but details of the formation of clustered pores are not known.

COMPARISON AND REMARKS. The species described above is placed with great reluctance in the genus Loculicyathus Vologdin because the arrangement of the outer wall pores appears to be unique. Unfortunately no details are known of the way in which the outer wall pores cluster together. In large cups and fragments their arrangement strongly resembles a non-independent type of microporous sheath but this appears to be due to the convergence of simple pores rather than by subdivision of a pre-existing pore system. True microporous sheaths are usually formed at a cup diameter of 2mm but the outer wall of the species described above is still simply porous at 4mm cup diameter. A clarification of the affinities of this species must await the discovery of new material.

FAMILY ROBUSTOCYATHIDAE Debrenne, 1964.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall simply porous with one pore row per intersept.

Genus PRETHMOPHYLLUM Debrenne, 1974.

Type species Archaeocyathus subacutus Bedford R. and W.R., 1934.

"Traduttore Traditore"
The translation of my French

DIAGNOSIS. (Debrenne, 1974c, p.174)

into Russian and then into English is far from my first ideas

Two walled cups with porous walls and radial septa. Outer wall with sparse regular pores. Inner wall with one row of pores, almost canal forming, per intersept. Every opening in a vertical row is restricted by the inner edges of adjacent septa. The septa are wavy about a vertical plane near the inner wall, but the amplitude is not sufficiently marked to unite adjacent septal edges. Thus the intersepts are not completely closed to form a non-independent inner wall as for Ethmophyllum. Septa are non-porous or weakly porous, the usual porosity is to have pores only on the outer part of the septum, but not at the junction of the outer wall. (Translated from Russian by the present writer).

→ If you come back to the British Museum Prethmophyllum subacutus has priority on Zonacyathus monoporosus and are considered (by me) as synonymous

Prethmophyllum ? brunhilda (Bedford R. and J., 1937)

(Plate 22, Figs. 1 to 5)

1937 Archaeocyathus brunhilda Bedford R. and J., p.36, Pl.39, Fig.149.

1974 Prethmophyllum brunhilda (Bedford R. and J.); Debrenne, p.175, Pl.22, Fig.4.

HOLOTYPE. Princeton University 86598 (151).

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

TYPE LOCALITY. Ajax Hill.

MATERIAL. Nine specimens from the Mount Scott Range, sections J,K and N. P21453-2; P21458 to P21464; P21465-2.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups, both walls slightly undulating. The outer wall is simply porous with two rows of circular pores adjacent to the septa, leaving a considerable horizontal distance between the pores. A third row of circular pores is often present in the middle of an intersept. Septa are radial, straight through most of the intervallum, but become wavy about a vertical plane when very close to the inner wall. Septal pores are oval, in a single vertical row close to the outer wall; rare additional pores may be present in the mid parts of some septa but their exact size and distribution are not known. Stirrup-pores are not formed. The inner wall has one or two rows of circular pores in quincunx. The formation of a second pore row in some intersepts of the inner wall appears to be connected with the growth of new septa. Early stages of growth are not known.

DIMENSIONS (mm)	P21460	P21464	P21453-2
Diameter.	15.7	10.2	9.3
Intervallum width.	1.87	1.62	1.50

N	approx.61	52	-
ds	0.55	0.40-0.51	0.46-0.56
IK	0.12	0.16	0.16-0.17
RK	approx.3.9	5.1	-
Loculi.	1/3.4	1/3.2-1/4.1	1/2.6-1/3.4
Outer wall:			
n	2-3	2-3	2-3
d	0.13-0.15	0.11	0.15
l (between rows)	0.15-0.22	0.22	0.22
l (between successive pores)	0.10-0.12	0.12-0.15	0.05-0.07
Inner wall:			
n	1-2 (rare)	1-2 (rare)	1
d	approx.0.27	0.24	0.16
l	-	0.13	0.07
t	0.12-0.17	0.11-0.17	0.15
Septa:			
n	1	1	1
d	0.39x0.22	approx.0.24	0.16
l (vertical separation)	approx.0.29	approx.0.24	0.10-0.17
t	0.03-0.05	0.03-0.05	0.05

COMPARISON AND REMARKS. The holotype of P. brunhilda (not seen by the writer) is a cup 18-20mm in diameter. According to R. and J. Bedford (1937, p.36) the septa are about 1mm apart and there are 48 present in the specimen, giving a radial coefficient of 2.40-2.67. The intervallum width according to the Bedfords is 2.5mm. Debrenne (1974c, p.175) has reported a radial coefficient of 2.8 and an intervallum width of 3mm for the holotype, which is the only known specimen.

The specimens from the Mount Scott Range, described above, vary in cup diameter from 3.1mm to 15.7mm. Their intersept width varies from 0.4mm to 0.6mm; intervallum width varies from 0.78mm to 2.22mm; radial coefficient varies from 3.9 to 5.3. Thus their septa are closer, their radial coefficient is higher and intervallum width is narrower (even in cups almost as large as the holotype) than the corresponding characteristics displayed by the holotype. The specimens from the Mount Scott Range are therefore placed in the species Prethmophyllum brunhilda with reservation.

Walter (1967, p.146) reported a specimen of Robustocyathus sp. from an area 5km. north of Bunyeroo Gorge. An examination of his thin sections (F17235, Walter collection, South Australian Museum) shows that the specimen is very similar to Prethmophyllum ? brunhilda described above.

Genus JOANAECYATHUS gen. nov.

NAME. After Mrs. Joan Luscombe (née Bedford), a pioneer in the study of South Australian Archaeocyatha.

Type species. Joanaecyathus caecus sp. nov.

DIAGNOSIS. Two walled cups. The outer wall is sparsely but regularly porous with only stirrup-pores at junctions with the septa, and in one species with additional pore rows close to the septa. The intervallum contains radial septa which are straight throughout most of the intervallum. Close to the inner wall the septa become wavy in a sinusoidal fashion about a vertical plane. Septa are sparsely porous, usually with only stirrup-pores at the junctions of septa with the outer wall. In one species there is an additional row of pores close to the outer wall. The inner wall has one row of pores per intersept.

The inner wall is simple or with short pore canals or with bracts opening upwards into the central cavity.

DISCUSSION. The new genus *Joanaecyathus* differs from *Prethmophyllum* Debrenne by its outer wall porosity which has stirrup-pores instead of, or in addition to pores between the septa. Septa at early stages of growth of species in the genus *Joanaecyathus* have their first pores wholly within the intervallum. The restricted septal porosity of adult cups appears to result from the rapid migration of subsequently developed septal pores to the outer wall, where they emerge as stirrup-pores. This unusual mode of septal pore reduction has been discussed in Chapter 5. The development of inner wall pore canals and bracts takes place after the septal porosity reaches a stable state - a reverse of the situation found in most Regulares.

The patterns of distribution of the outer wall pores seen in *Prethmophyllum ? brunhilda* (Bedford R. and J.) and *Joanaecyathus caecus* sp. nov. (described below), are very similar to the outer wall pore distributions of *Archaeocyathellus rensselaericus* Ford and *Protocyathus rarus* Ford respectively. Unfortunately the porosity of the septa and inner walls of these latter species is ~~unknown~~. The fact that these species are coeval in two widely separated localities is surprising.

preserved Debrenne 4 p.117

Joanaecyathus caecus sp. nov.

(Plate 17, Fig. 2; Plate 22, Figs. 6 to 11; Text-figs. 9,20.)

NAME. From Latin *caecus* = blind.

HOLOTYPE. P21466-1 (four thin sections).

PARATYPES. P21467; p21424-3; P21469; P21481.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Sixteen specimens from the Mount Scott Range, section N; four specimens from Wilkawillina Gorge, sections H and I. Holotype and paratypes as above. Additional specimens: P21423-4; P21470; P21471; P21412-9; P21473-1; P21474-1; P21475-1; P21476-2; P21477; P21419-3, -4; P21479-3; P21480-1; P21482-2; P21483-1.

DIAGNOSIS. As for the genus. This species has a single row of stirrup-pores at junctions of the outer wall and septa, but no additional outer wall pores. The inner wall lintels extend steeply upwards into the central cavity to form very short pore-canals.

DESCRIPTION. Slender conical cups. The outer wall is smooth to slightly undulose and is perforated only by circular stirrup-pores at junctions with the septa. The intervallum contains numerous relatively straight, radial septa. Immediately adjacent to the inner wall the septa become wavy in a sinusoidal fashion about a vertical plane. Septal troughs and crests partly delineate the inner wall pores. Stirrup-pores at the junctions of septa with the outer wall are oval or kidney-shaped with the upper part of each pore opening to the exterior. Extremely rare minute pores may be found in the remaining parts of the septa. The inner wall has one row of pores per intersept,adjacent rows are in quincunx. The interpore lintels extend obliquely upwards into the central cavity to form very short pore canals.

DIMENSIONS (mm)	Holotype P21466-1	Paratype P21467	Paratype P21469
Diameter	9.0	7.9	6.4
Intervallum width	1.83-1.97	1.48-1.77	1.26-1.50
N	57+3 partial	53+1 partial	45
ds	0.32-0.42	0.29-0.46	0.24-0.34

IK	0.20-0.22	0.19-0.22	0.20-0.23
RK	6.34	6.81	7.00
Loculi	1/4.4-1/6.2	1/3.2-1/6.1	1/3.7-1/6.3
Outer wall:			
n	$\frac{1}{2}+\frac{1}{2}$	$\frac{1}{2}+\frac{1}{2}$	$\frac{1}{2}+\frac{1}{2}$
d	0.17	0.17	0.15-0.17
l (vertical separation)	0.10-0.15	0.19	0.10-0.18
t	0.07	0.07	0.07
Inner wall:			
n	1	1	1
d	0.17-0.24	0.24	0.17-0.19
l	0.07-0.12	0.10	approx.0.12
t	0.07	0.10	0.05-0.07
Septa:			
n	1 stirrup-pore	1 stirrup-pore	1 stirrup-pore
d	0.16x0.25	0.15x0.19	0.15x0.19
l (vertical separation)	0.07-0.10	0.10-0.17	0.07-0.12
t	0.05	0.03	0.03

ONTOGENY. The inner wall and central cavity have been formed at the smallest known cup diameter of 0.61mm. The first stirrup-pores appear at 1.16-1.45mm cup diameter. At smaller cup diameters the pores are in a single row close to the outer wall, pores are oval with dimensions 0.12x0.08mm. The nature of the intervallum elements before the first appearance of septa is not known. The outer wall may have one row of pores between adjacent septa before the first stirrup-pores are formed. Septa begin to undulate at the inner wall at a cup diameter of approximately 2.2mm. The inner wall is simple to a cup diameter of 2.5mm, when the interpore lintels rotate to form very short pore canals.

COMPARISON AND REMARKS. See remarks after the description of Joan-aecyathus cyclopeus sp. nov. given below. The significance of the development of septal porosity of this species has been discussed in Chapter 5.

Joanaecyathus cyclopeus sp. nov.

(Plate 23, Figs. 1 to 5; Text-figs.10,21.)

NAME. From Cyclops of Greek Mythology.

HOLOTYPE. P21484-1 (three thin sections)

PARATYPE. P21412-6; P21485-1

TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. Six specimens from Wilkawillina Gorge, sections E, G, H and I; seven specimens from the Mount Scott Range, section N. Holo-type and paratypes as above. Additional specimens: P21419-5, -6; P21416-2; P21412-7; P21486; P21480-2; P21487; P21488-3; P21489-2; P21416-3.

DIAGNOSIS. As for the genus. This species has a slightly furrowed outer wall at septal junctions with large stirrup-pores in the furrows. There are some additional outer wall pores. The inner wall is poorly preserved but appears to be simply porous.

DESCRIPTION. Small conical cups. The outer wall has slight vertical furrows at each septal junction where one row of circular stirrup-pores is formed. Some cups have one or two additional pore rows per intersept but their shape and distribution are not known. The intervallum is crossed by thin radial septa which are straight through most of the intervallum but become regularly wavy in vertical section in a sinusoidal fashion immediately adjacent to the inner wall, where opposing septal crests and troughs partly delineate the inner wall pores. Septa are thickened close to the walls. Septa are apparently non porous except for large oval and circular stirrup-pores at junctions with the outer wall. The pore opening to the exterior is horizontal and the outer wall forms a slightly raised lip around the orifice (not shown on figured specimens). The inner wall has one row of large circular pores per intersept, adjacent rows are in quincunx. As far as is known, the inner wall lintels do not form pore canals or bracts.

DIMENSIONS (mm)	Holotype P21484-1	Paratype P21412-6	Paratype P21485-1
Diameter	5.03	4.73	1.69
Intervallum width	1.14-1.28	1.14	0.41-0.48
N	21 + 1 partial	-	9
ds	0.61-0.73	0.34-0.41	0.34-0.48
IK	0.23-0.26	0.24	0.24-0.29
RK	4.27	-	5.33
Loculi	1/1.6-1/2.1	-	1/0.9-1/1.4
Outer wall:			
n	$\frac{1}{2}+\frac{1}{2}$	$\frac{1}{2}+\frac{1}{2}$	$\frac{1}{2}+\frac{1}{2}$+?1
d	0.19-0.24	-	-
l (vertical separation)	0.08	-	-
t	0.04-0.07	0.04-0.05	0.03
Inner wall:			
n	1	1	1
d	0.24-0.36	0.29	approx.0.17
l	0.10-0.24	0.07-0.15	-
t	0.07	0.07	0.02-0.04

Septa:

n	1 stirrup-pore	1 stirrup-pore	1 stirrup-pore
d	0.15-0.20	0.17-0.27	approx.0.12
l (vertical separation)	0.09-0.11	0.08-0.12	-
t	0.03-0.08* *(at walls)	0.03-0.07* *(at walls)	0.02-0.07* *(at walls)

ONTOGENY. Earliest stages of growth are not known. Stirrup-pores are first formed at the outer wall at cup diameters of 1.04-1.09mm. In slightly smaller cups there is a single large septal pore contained wholly within the intervallum; pore diameter 0.17mm. Vertical furrows on the outer wall are conspicuous at a cup diameter of 1.04mm. Septa are initally straight near the inner wall and become wavy at a cup diameter of approximately 3mm.

COMPARISON AND REMARKS. Joanaecyathus cyclopeus differs from J. caecus by its furrowed outer wall, larger wall and septal pores and lower radial coefficient. There appear to be additional outer wall pores in some cups of J. cyclopeus. The inner wall of J. caecus has short pore canals; that of J. cyclopeus appears to be smooth but the species is only known from small cups which may not have attained all of the adult characteristics of the inner wall.

Joanaecyathus cupulosus sp. nov.

(Plate 23, Figs. 6 to 8; Plate 24, Figs. 1 to 5; Text-fig. 11)

NAME. Cupulosus refers to the bracts or half-cupules formed on the inner wall.

HOLOTYPE. P21490 (three thin sections)

PARATYPES. P21491; P21492; P21493; P21494.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Twelve specimens from Wilkawillina Gorge, sections E,G, and H; three specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21489-1; P21495 to P21497; P21498-2; P21499 to P21503.

DIAGNOSIS. As for the genus. This species has stirrup-pores at septal junctions with the outer wall and, less commonly, pairs of flanking outer wall pores close to the septa. Septa have an additional row of pores close to the outer wall. The inner wall pores are partly shielded by S-shaped bracts or half-cupules extending from the inter-pore lintels.

DESCRIPTION. Solitary cups, initially conical, then flaring outward to form a bowl-like form. The intervallum does not increase in width significantly with cup growth. The outer wall has a single row of stirrup-pores at junctions with the septa. Less commonly there are two rows of pores per intersept, each situated close to the adjacent septa. These flanking pores often anastomose across a septum with pores in neighbouring intersepts. Septa are numerous, pierced by either stirrup-pores at the outer wall or by a single row of rounded pores close to the outer wall. Rare, additional septal pores are present in the mid parts of some septa but their exact distribution is not known. Septa become slightly wavy in vertical section in a sinusoidal fashion close to the inner wall. The inner wall has one row of circular pores per intersept, adjacent rows are in quincunx. The lintel below each inner wall pore projects outwards and upwards to form an S-shaped bract of half-cupule opening upwards into the central cavity.

DIMENSIONS (mm)	Holotype P21490	Paratype P21491	Paratype P21493
Diameter	18.3	38.6	5.2
Intervallum width	0.87-0.97	0.99	0.86
N	137	-	approx.38
ds	0.44	0.28-0.35	0.30-0.36
IK	0.05	0.03	0.15
RK	7.5	-	approx.7.3
Loculi	1/2	1/2.8-1/3.5	1/2.4-1/2.8
Outer wall:			
n	$\frac{1}{2}+\frac{1}{2}+1$	$\frac{1}{2}+\frac{1}{2}+1$	$\frac{1}{2}+\frac{1}{2}$
d	0.12-0.17	0.15	0.13-0.16
l (vertical separation)	0.11	0.12	-
t	0.07-0.10	0.05-0.07	approx.0.07
Inner wall:			
n	1	1	1
d	0.19	0.19-0.27	0.19
l	0.10-0.16	0.15-0.19	-
t	0.07-0.09	0.07	0.07-0.10
Septa:			
n	1+1 stirrup-pore	1+1 stirrup-pore	1+1 stirrup-pore
d	0.20	0.13-0.15	approx.0.15
l (vertical separation)	0.07-0.10	0.10	-
t	0.03	0.03	approx.0.04

ONTOGENY. The intervallum and central cavity have been formed at the smallest available cup diameter of 1.0mm. Stirrup-pores form at 1.02-1.22mm cup diameter. Early stages of septal growth are not known. S-shaped bracts form on the inner wall at a cup diameter of about 2.7mm.

The stage at which septa become wavy is not known.

COMPARISON AND REMARKS. J. cupulosus differs from other species in the genus by the presence of outer wall and septal pores in addition to stirrup-pores, and by the development of bracts or half-cupules on the inner wall.

FAMILY ZONACYATHELLIDAE Zhuravleva, 1974.

DIAGNOSIS. Outer wall with one row of large simple pores per intersept. Intervallum with septa ranging from porous to non porous. Inner wall thick with one row of pore canals per intersept.

Genus DECEPTIONCYATHUS gen. nov.

NAME. From Mount Deception, 12.5 km south of Mount Scott.

Type species. Deceptioncyathus synapticulosus sp. nov.

DIAGNOSIS. Two walled conical cups. Outer wall with one large circular pore, usually midway between adjacent septa. Septa in the intervallum are initially straight but become wavy with increasing cup growth. Synapticulae link opposite septal crests. Septa are porous with several rows of large oval pores in quincunx. The pore rows curve gently from the inner to the outer wall. The inner wall consists of a single row of very large pores per intersept, adjacent rows are in quincunx. The interpore lintels are oblique so that short, wide pore tubes are formed.

DISCUSSION. Deceptioncyathus gen. nov. has been placed with the greatest reluctance in the Family Zonacyathellidae. The outer wall is typical of the family, but the intervallum elements and the short inner wall pore tubes are very similar to structures seen in some Irregulares, notably in Pycnoidocyathus Taylor. Stages of growth below a cup diameter of 2.4mm are not known. However, the outer wall and early stages of growth are totally unlike those of Pycnoidocyathus.

Deceptioncyathus synapticulosus sp. nov.

(Plate 24, Figs. 6 to 9)

NAME. Synapticulosus refers to the presence of synapticulae.

HOLOTYPE. P21504-1 (four thin sections)

PARATYPES. P21505-1; P21506; P21507-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Six specimens from section N. Holotype and paratypes as above. Additional specimens: P21425-2; P21508-1.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary two walled conical cups. The outer wall has a single row of large circular pores per intersept usually in the centre, but sometimes displaced towards a septum. The intervallum contains straight to wavy septa which sometimes bifurcate. Synapticulae link opposite crests of adjacent wavy septa. The septa are pierced by large oval pores in rows which curve gently from the inner to the outer wall. The inner wall consists of very large circular pores in one row per intersept, adjacent rows are in quincunx. The lintels between successive pores are oblique, so that short wide pore tubes are formed.

DIMENSIONS (mm)	Holotype P21504-1	Paratype P21505-1	Paratype P21507-1
Diameter	16.6	4.9	9.8
Intervallum width	4.0-5.0	1.3	2.4
N	approx.41+6 partial	14	30

ds	0.85-1.20	0.48-0.85	0.44-0.74
IK	0.24-0.30	0.27	0.25
RK	approx.2.5	2.84	3.08
Loculi	approx.1/4.0	approx.1/2.0	1/2.7-1/5.0
Outer wall:			
n	1	1	1
d	0.29-0.34	0.22	0.34
l (vertical separation)	0.40-0.53	-	0.27-0.32
t	0.05-0.07	0.07	0.05-0.07
Inner wall:			
n	1	1	1
d	approx.0.6	0.34-0.48	0.51x0.73
Tube length	max.1.09	not formed	max.1.40
Tube wall thickness	0.06-0.17	lintels0.10-0.15	0.07-0.17
Septa:			
n	-	2	3-5
d	0.22x0.17-0.36x0.22	approx.0.3	0.46x0.27-0.65x0.39
l	0.17-0.34	-	0.15-0.29
t	0.07	0.07-0.10	0.07-0.10
Synapticulae:			
Horizontal separation	0.73-1.10	Absent	0.58-0.73
Vertical separation	1.10-1.50	-	-
Thickness	0.05-0.07	-	0.05-0.07

Note. Secondary thickening may double the thickness of the walls, pore-tube walls and septa.

ONTOGENY. At the smallest known cup diameter of 2.4mm the inner wall and central cavity have been formed. At this stage the outer wall appears to have its characteristic porosity, septal porosity is not known. The inner wall is simply porous, pore tubes are not formed. Synapticulae are absent. Synapticulae are rare at 4mm cup diameter and become more abundant with cup growth. The inner wall pore tubes appear to form at about this stage.

COMPARISON AND REMARKS. Two other monospecific genera have been placed in the Zonacyathellidae. The species Zonacyathellus monoporosus (Zhuravleva) has an inner wall of long, curved almost horizontal pore canals in one row per intersept. The species Degeletticyathellus lebedevae Zhuravleva has one row of oblique stirrup-pore canals per intersept. Neither species has wavy septa linked by synapticulae.

SUPERFAMILY IRINAECYATHACEA Zhuravleva, 1974.

DIAGNOSIS. Solitary and colonial cups. Outer wall pores covered by pore diaphragms.

FAMILY IRINAECYATHIDAE Zhuravleva, 1974.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with one row of pore canals or pore tubes per intersept.

COMPOSITION (with revised statement of genera with "simple" pores

SUBFAMILY BAIKALOCYATHINAE Zhuravleva, 1974.

DIAGNOSIS. Inner wall pore canals or pore tubes do not communicate laterally.

Genus BAIKALOCYATHUS Yazmir, 1975.

1940 Ethmophyllum Vologdin, p.65 (pars.).
1940 Leptosocyathus Vologdin, p.145 (pars.).
1943 Ethmophyllum Okulitch, p.64 (pars.).
1955 Ethmophyllum Okulitch, p.E12 (pars.).
1960 Ethmophyllum Zhuravleva, p.163 (pars.).
1974 Baikalocyathus Zhuravleva, p.68.
1975 Baikalocyathus Yazmir, p.50.

Type species. Ethmophyllum rossicum Zhuravleva, 1960.

DIAGNOSIS. Outer wall pores covered by pore diaphragms. Septa in the intervallum are porous. Inner wall with a single row of pore tubes per intersept inclined obliquely downwards into the central cavity. Pore tubes do not communicate laterally. The pore tube openings into the central cavity are partly obscured by bracts or plates inclined upwards. The pore tubes and attached plates are V-shaped in longitudinal section.

DISCUSSION. In her list of synonymies, Zhuravleva (in Zhuravleva and Elkina, 1974, p.68) refers to an unpublished Ph.D. thesis by Yazmir in 1968 as the source for the generic name. Although the first published reference to Baikalocyathus appeared in 1974 (Zhuravleva and Elkina op.cit.), Yazmir (1975, p.50) has assumed responsibility for the name Baikalocyathus.

Baikalocyathus squamosus sp. nov.

(Plate 6, Fig. 1; Plate 25, Figs. 1 to 4)

NAME. From Latin squamosus = scaly.

HOLOTYPE. P21509-1 (two thin sections).

PARATYPE. P21510-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Two specimens from the Mount Scott Range, section N.

DIAGNOSIS. As for the genus.

DESCRIPTION. Small, two walled conical cups. The outer wall has 2-4 rows of circular pores per intersept in regular quincunx. Each outer wall pore is covered externally by a very slightly bulging diaphragm with a small central, circular opening to the exterior. The lintels between the underlying carcass pores are perpendicular to the wall. The intervallum contains straight radial septa pierced by small sparse pores in evenly distributed rows. Adjacent pore rows are in irregular quincunx. The inner wall has a single row of horizontally stretched oval pores per intersept, adjacent rows are in quincunx. Each inner wall pore lies at the base of a downwardly inclined pore tube whose lower wall bears a thin upturned plate partly obscuring the opening into the central cavity. In longitudinal section the pore tubes and attached plates form an open V-shape. A short tapering carina extends downwards from the junction between each pore tube wall and plate.

DIMENSIONS. See list of dimensions following the description of _Baikalocyathus rimosus_ sp. nov., given below.

ONTOGENY. At the smallest known cup diameter of 1.14mm the inner wall and central cavity have been formed. The outer wall pores are covered by pore diaphragms. The inner wall pore tubes are short and the plates attached to their lower edges are rudimentary.

COMPARISON AND REMARKS. See remarks following the description of _B. rimosus_ sp. nov. which follows.

Baikalocyathus rimosus sp. nov.

(Plate 6, Fig. 2; Plate 25, Figs. 5 to 8; Plate 26, Fig. 1)

NAME. From Latin rimosus = full of chinks.

HOLOTYPE. P21511-1 (three thin sections)

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCAILTY. Mount Scott Range. Section N.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus.

DESCRIPTION. Small conical cup. The outer wall has 3 pore rows per intersept in regular quincunx; pores are oval, slightly stretched horizontally. Each outer wall pore has its external opening covered by a very slightly bulging diaphragm with a central ? circular small pore leading to the exterior. The lintels between the underlying carcass pores are slightly oblique to the outer wall (inclined upwards). The intervallum contains straight radial septa pierced by evenly spread rows of pores in irregular quincunx, adjacent rows are closer than successive pores in a single row. Pores are circular and oval, stretched vertically. Sparse horizontally stretched oval pores also occur. The inner wall has a single row of horizontally stretched oval or chink-like pores per intersept. Adjacent pore rows are normally side by side, rarely in quincunx. Each inner wall pore opens into an obliquely inclined pore tube opening downwards into the central cavity. The lower wall at the end of each pore tube has a thin upturned plate which partly obscures the opening. In longitudinal section the pore tubes and attached plates are V-shaped. A short tapering carina extends downwards from the junction between each pore tube and plate. Early growth stages are not known.

DIMENSONS (mm)	*B. squamosus.* Holotype P21509-1	*B. squamosus.* Paratype P21510-1	*B. rimosus.* Holotype P21511-1
Diameter	3.36	1.99	4.28
Intervallum width	0.57	0.41	0.44-0.48
N	25 (1.97)	-	49
ds	0.15	0.15-0.17	0.19-0.23
IK	0.17	0.21	0.10-0.11
RK	12.7 (1.97)	-	11.45
Loculi	1/2.7-1/3.5	1/2.4	1/1.9-1/2.5
Outer wall carcass:			
n	2-4	2-4	3
d	0.05-0.06	0.05	0.07x0.04
l	0.02	0.02	0.02
t	0.05	0.05	0.05
Outer wall pore diaphragms:			
d	0.02	0.02	approx. 0.02
l	-	-	approx. 0.05
t	0.01	0.01	approx. 0.01
Inner wall:			
n	1	1	1
d	0.15x0.07	0.12x0.07	0.15x0.06-0.18x0.07
Tube length	0.07-0.10	0.05-0.07	0.06-0.07
Tube wall thickness	0.04	0.05	0.03-0.05
Plate length	0.07-0.12	0.02-0.05	0.05-0.10
Septa:			
n	3-6	3-6	4-5
d	0.03-0.06	0.03-0.05	0.05-0.07
l	0.05-0.07	0.03-0.07	0.05-0.10
t	0.02	0.02-0.03	0.02-0.03

COMPARISON AND REMARKS. *Baikalocyathus squamosus* sp. nov. and *Baikalocyathus rimosus* sp. nov. are the first species in the genus *Baikalocyathus* recorded from South Australia. Both species are very similar, *B. rimosus* differs from *B. squamosus* by having oval outer wall pores and inclined lintels between the pores. The inner wall pores are more chink-like and are arranged side by side more often than in quincunx. *B. squamosus* has its inner wall pores more often in quincunx than side by side. The septal pores of B. rimosus are slightly larger and less regularly arranged. B. rimosus has a lower intervallum coefficient.

Six species are known from limestones of Late Atdabanian and Early Botomian age at various localities in the USSR. The species are B. rossicus (Zhuravleva), B. shoriensis Zhuravleva, B. shevliensis Beljaeva, B. c.f. rossicus (Zhuravleva), B. chamsariensis Zhuravleva and B. baikalicus Yazmir.

It is difficult to compare the two new South Australian species with those listed above because of their small cup sizes. The number and size of the septal pores, the radial coeffioient and intervallum coefficient and the length of the inner wall pore tubes have not yet reached their adult dimensions. The radial coefficient in particular, decreases rapidly with cup growth. For example, the radial coefficient of B. chamsariensis Zhuravleva decreases from 14.3 to 5.3 with cup growth from 1.4mm to 9.0mm. (Zhuravleva and Elkina, 1974, p.71, Table 14). Most of the species from the USSR have larger septal and inner wall pores than those described above for the South Australian species, but those of B. c.f. rossicus and B. baikalicus are of similar size. Larger specimens of B. squamosus and B. rimosus are required for an accurate comparison to be made.

Genus RASETTICYATHUS Debrenne, 1971

Type species. Rasetticyathus iglesiensis Debrenne, 1971.

DIAGNOSIS. Solitary conical cups with a simply porous outer wall. Intervallum filled with sparsely porous septa. The inner wall consists of one row of S-shaped pore tubes per intersept, opening upwards into the central cavity.

? <u>Rasetticyathus</u> sp.

(Plate 26, Figs. 2,3)

FORMATION Wilkawillina Limestone. Faunal Assemblage I.

LOCALITY. Wilkawillina Gorge. Section E.

MATERIAL. Two specimens from Wilkawillina Gorge, section E. P21439-2; P21512.

DESCRIPTION. Very small conical cups. Outer wall with 2-3 rows of circular pores per intersept in quincunx. Each outer wall pore appears to be covered by a flat pore diaphragm but it is poorly preserved. The intervallum contains radial septa pierced by closely spaced rows of circular pores in regular quincunx. The inner wall consists of a single row of short, slightly curved pore tubes directed obliquely upwards into the central cavity. Adjacent rows of pore tubes are in quincunx. Initial stages and adult stages of growth are not known.

DIMENSIONS (mm)	P21512	P21439-2
Diameter	1.73	2.0
Intervallum width	0.39	0.55
N	-	24
ds	0.16	0.15-0.20
IK	0.23	0.28
RK	-	12
Loculi	1/2.4	1/2.8-1/3.7
Outer wall:		
n	2-3	3
d	approx.0.05	0.07
l	approx.0.03	0.02
t	0.03-0.05	approx.0.03
Inner wall:		
n	1	1
d	0.07x0.12	0.06x0.10

Tube length	approx.0.18	-
Tube wall thickness	0.01-0.05 (tapering)	-
Septa:		
n	5	5
d	0.06-0.08	0.08
l	0.04	-
t	0.02	approx.0.03

COMPARISON AND REMARKS. The very small cup sizes prevent any specific determination at this stage. The specimens are placed with reservation in the genus Rasetticyathus Debrenne for the following reasons:

1. There appear to be flat pore diaphragms over the outer wall pores. In Debrenne's original diagnosis (1971, p.193) the outer wall of Rasetticyathus is simply porous, composed of regular cells (alvéoles régulières). Zhuravleva (in Zhuravleva and Elkina, 1974, p.77) stated that the outer wall is simply porous, but nevertheless placed the genus in the Subfamily Baikalocyathinae, a subdivision of the Superfamily Irinaecyathacea whose diagnostic features of the outer wall are pore diaphragms.

2. The septal porosity of the specimens described above is considerably higher than that found in the type species of Rasetticyathus. Debrenne (1975b, p.105) has noted that Moroccan species have a higher septal porosity than that found in the type species which comes from Sardinia.

3. The inner wall pore tubes are slightly curved in the specimens described above but they do not have the S-shape typical of the genus.

4. The specimens described above are very small and very likely have not reached adult proportions. Consequently the septal porosity, radial coefficient and dimensions of the inner wall pore tubes are probably not those of adult cups. Pectinate tabulae have not been seen but the possibility of their appearance in larger cups cannot be excluded. Two species in a new genus having pectinate tabulae are

described on later pages.

FAMILY CYCLOCYATHELLIDAE Zhuravleva, 1960.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with annuli bordering the central cavity, attached directly to the septa.

DISCUSSION. Without any revision of its constituent genera, Zhuravleva placed the Family Cyclocyathellidae in the Superfamily Irinaecyathacea (Zhuravleva and Elkina, 1974, p.67). Zhuravleva illustrated the outer wall pore diaphragms of _Thalamocyathus trachealis_ (Taylor), (_op.cit_. Pl.1, Fig.3), as the only supporting evidence for so doing. The genus _Thalamocyathus_ Gordon is regarded herein as having no pectinate tabulae in accordance with the revised diagnosis of Debrenne (1973, p.7).

It is assumed herein that Zhuravleva has tacitly placed the genus _Thalamocyathus_ in the Cyclocyathellidae and not in the Stillicidocyathidae as she had done previously (Zhuravleva, 1959a, 1960b; Zhuravleva _et al_, 1960).

The removal of the Family Cyclocyathellidae from the Ajacicyathacea to the Irinaecyathacea without a thorough revision of the genotypes of such important genera as _Gordonicyathus_, Zhuravleva, _Taylorcyathus_ Vologdin and especially the type-genus _Cyclocyathella_ Vologdin is a most premature step.

However, the discovery of new species from South Australia supports such a move. Five new species, all with outer wall pore diaphragms and annulate inner walls have been placed with reservation in the genera _Gordonicyathus_ and _Taylorcyathus_ and are described below. They are placed questionably in these genera pending a revision of the genotypes.

Genus GORDONICYATHUS Zhuravleva, 1959.

Type species. Thalamocyathus gerassimovensis Krasnopeeva, 1955.

DIAGNOSIS. Conical cups. Outer wall simply porous. Intervallum with uniformly porous septa. Inner wall of annuli V-shaped in cross-section, opening upwards into the central cavity. Inner wall with one row of openings between adjacent cups.

DISCUSSION. Until the type species is revised, the diagnosis given above states that the outer wall is simply porous. For this reason, the four new species described below are placed with reservation in the genus. The genus Thalamocyathus Gordon, (sensu Debrenne, 1973) differs from Gordonicyathus Zhuravleva by the septal porosity of its constituent species. Species of the genus Gordonicyathus have uniformly porous septa whose pore area is greater than the interpore area. Species of the genus Thalamocyathus have septal pores localized usually near the outer wall and with a pore area less than the interpore area. This qualitative estimation of septal porosity is regarded herein as totally inadequate. A less arbitrary, quantitative means of measuring septal porosity has been described and discussed in Chapter 5.

? Gordonicyathus walteri sp. nov.

(Plate 26, Figs. 4 to 6)

1967 Cyclocyathellidae gen. nov. Walter, p.144, Table 1.

NAME. After Dr. M.R. Walter of the Bureau of Mineral Resources (Canberra), who collected the first specimen of this species.

HOLOTYPE. P21515-5 (three thin sections)

PARATYPES. P21514; P21515-3.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCAILTY. Wilkawillina Gorge. Section F.

MATERIAL. 0A1600F-7 (Univ. of Adelaide, Walter collection); four specimens from Wilkawillina Gorge, sections F and I. Holotype and paratypes as above. One additional specimen P21515-4.

DIAGNOSIS. As for the genus but the outer wall has pore diaphragms.

DESCRIPTION. Small conical cups with minor transverse corrugations of the outer, but not the inner wall. The outer wall has 2-3 rows of circular pores per intersept in regular quincunx. Each outer wall pore is covered externally by a flat pore diaphgram pierced by a central circular micropore. The intervallum contains numerous radial septa pierced by uniformly distributed rows of circular and oval pores. Adjacent rows are in irregular quincunx. The inner wall consists of annular shelves bordering the central cavity. In longitudinal section each annulus is a slightly curved wedge inclined obliquely upwards into the central cavity. A very short carina extends downwards from the thickest part of each annulus (not visible in the figures). There is a single row of oval openings between adjacent septa at the inner wall. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21513-2	Paratype P21514	Paratype P21513-3
Diameter	5.1	4.7	2.5
Intervallum width	0.71	0.95	0.63-0.68
N	52	47	approx.31
ds	0.17-0.24	0.20-0.25	0.17-0.22
IK	0.14	0.20	0.25-0.27
RK	10.2	10.0	approx.12.3
Loculi	1/3.0-1/4.2	1/3.8-1/4.8	1/2.9-1/4.Q
Outer wall carcass:			
n	2-3	3	3

d	0.06-0.07	0.06-0.08	0.05-0.07
l	0.03	-	0.03
t (including diaphragm)	0.05	0.05	0.03-0.05
Outer wall pore diaphragm:			
d	0.02	approx.0.02	-
l	approx.0.07	approx.0.07	-
t	0.01	0.01	approx.0.01
Inner wall:			
n	1	1	1
d	0.15x0.11	0.12x0.07	approx.0.10
Annular width	0.17-0.22	0.13-0.15	approx.0.12
Septa:			
n	6	6-8	5-6
d	0.07-0.10	0.05-0.10	0.06-0.10
l	0.06-0.07	0.05-0.06	-
t	0.03-0.04	0.03	0.03

ONTOGENY. Earliest stages of growth are not known. The smallest specimen apparently has a simply porous inner wall at 2.2mm cup diameter. The inner edges of the septa are thickened and at 2.4mm cup diameter, tapering wedges with a thick base and narrow tip are formed. The first stages of formation of annuli are not known. Outer wall pore diaphragms are not clearly seen on the smallest specimen below a cup diameter of 2.37mm.

? Gordonicyathus systylus sp. nov.

(Plate 26, Figs. 7 to 9; Plate 27, Figs 1,2)

NAME. From Greek systylos = close-set columns.

HOLOTYPE. P21516 (four thin sections).

TYPE FORMATION. Wilkawillina Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section G.

MATERIAL. One specimen from Wilkawillina Gorge.

DIAGNOSIS. As for the genus, but the species has an outer wall with pore diaphragms. In addition, a small vertical pillar is present on the intervallum side of the outer wall, in the middle of each intersept.

DESCRIPTION. Cylindro-conical cup with broad, low amplitude transverse undulations of the outer wall. The outer wall has usually 4 rows of pores (less commonly 3 rows) per intersept. A vertical pillar on the intervallum side of the outer wall in the middle of each intersept, separates the pore rows into two sets. The outer wall pores are closely spaced in regular quincunx. Each pore is circular to almost hexagonal in shape and is covered by a flat pore diaphragm which is poorly preserved. The intervallum contains straight radial septa pierced by 6-7 rows of pores, evenly distributed in irregular quincunx. Pores are oval, stretched vertically. Some circular pores are present. The inner wall consists of U-shaped annuli attached to the inner edges of the septa. The openings framed by adjacent septa and successive annuli are rectangular in shape. Each annulus is asymmetrical in longitudinal section, with the distal free limb markedly longer than the limb fixed to the septa. A short carina points obliquely downwards from the lowest part of each annular trough. Early growth stages are not known.

DIMENSIONS (mm) Holotype P21516

Diameter 4.64-7.25mm. The following dimensions are for a cup diameter of 4.64mm. Intervallum width 0.90;N 46; ds 0.22-0.24; IK 0.19; RK 9.91; loculi 1/3.7-1/4.1.

Outer wall carcass: n 3-4; d 0.07-0.09; l 0.02; t 0.05 (including diaphragm).

Outer wall pore diaphragm: d ? 0.03; l -; t approx.0.01.

Inner wall: n 1; d 0.18x0.15; width of free limb of annulus 0.17-0.24;

width of fixed limb 0.05-0.10.

Septa: n 6-7; d 0.07x0.11-0.09x0.15; l 0.07-0.10; t 0.03-0.04.

COMPARISON AND REMARKS. ? Gordonicyathus systylus differs from other South Australian species by the presence of a vertical pillar on the intervallum side of the outer wall, in the middle of each intersept.

? Gordonicyathus levis sp. nov.

(Plate 5, Figs. 3,4; Plate 27, Figs. 3 to 7)

NAME. From Latin levis = smooth.

HOLOTYPE. P21517 (three thin sections).

PARATYPES. P21518; P21519; P21520-1.

TYPE FORMATION. Ajax Limestone. Uppermost Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Thirteen specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21521 to P21523; P21524-1,-2,-3; P21525 to P21527.

DIAGNOSIS. As for the genus, but pore diaphragms are present on the outer wall.

DESCRIPTION. Solitary cylindro-conical cups whose outer wall is occasionally affected by irregular transverse constrictions. The inner wall is unaffected. The outer wall has 2-4 rows of circular pores per intersept in regular quincunx. Each outer wall pore is covered by a flat diaphragm pierced by a central circular micropore. The intervallum contains radial septa which are usually straight but are sometimes distorted. Some septa bifurcate; new septa are occasionally added from the outer wall. Rare, blunt irregularly distributed protuberances are present on some septa. The septa are pierced by pores which are normally evenly distributed, but some septa have limited expanses in which no pores are found. Septal pores are usually oval in shape but may also be circular or very elongate in a vertical direction. The inner wall consists of annuli attached to the inner edges of septa, with a single vertical row of oval openings between adjacent septa. The annuli are U-shaped in longitudinal section, but asymmetrical. The distal limb is markedly longer than the limb attached to the septa. The upper free edge of each annulus is surmounted by a series of very short comb-like spinules. A very short, blunt carina projects downwards from the base of each annulus.

DIMENSIONS (mm)	Holotype P21517	Paratype P21518	Paratype P21519
Diameter	5.42	6.10	8.12
Intervallum width	0.85	0.99	0.75-0.92
N	55 + 3partial	67	98 + 2partial
ds	0.19	0.17-0.29	0.19-0.24
IK	0.16	0.16	0.09-0.11
RK	10.3	11.0	12.1
Loculi	1/4.4	1/3.4-1/5.8	1/3.1-1/4.7
Outer wall carcass:			
n	2-4	3-4	3-4
d	0.07-0.09	0.06-0.07	0.07
l	0.03	0.03	0.03
t (including diaphragm)	0.07	0.06	0.06-0.07
Outer wall pore diaphragm:			
d	0.04	0.04	approx.0.04
l	0.07	0.07	0.07
t	0.01-0.02	0.01-0.02	0.01-0.02
Inner wall:			
n	1	1	1
d	0.15x0.10	approx.0.12	0.15x0.10
Annulus width free limb	max.0.17	max.0.24	max.0.24
Annulus width fixed limb	0.05-0.07	0.05-0.07	0.05

Septa:

n	5	4-6	4-6
d	0.09x0.11-0.04x0.12	0.04-0.10	0.05-0.12
l	0.06-0.12	0.04-0.10	0.05-0.10
t	0.03-0.04	0.03-0.04	0.03-0.04

ONTOGENY. At the smallest cup diameter of 1.41mm the inner wall and central cavity have been formed. Outer wall pore diaphragms are present at this stage. The inner wall is simply porous with one row of pores per intersept. The lintels between each pore support 3 or 4 short spines directed obliquely upwards into the central cavity. Septa have 2 rows of pores across the intervallum. At 1.7mm short spinose bracts are formed on the inner wall. These fuse to form annuli at cup diameters varying from 2.10mm to 2.40mm in different specimens.

COMPARISON AND REMARKS. The dimensions given above for ? Gordonicyathus levis are similar to those given by Zhuravleva (in Zhuravleva, Krasnopeeva and Chernysheva, 1960, p.106, Pl.2, Figs. 10,11) for Gordonicyathus loculatus (Vologdin). However, the latter species has a thinner outer wall with smaller pores, and no pore diaphragm has been described. In addition, the latter has somewhat smaller septal pores and more symmetrical annuli. Gordonicyathus loculatus is known from the Bazaikhian Horizon of Eastern Sayan.

Rare, irregularly spaced protrusions have been found on some septa in specimens of ? G.levis. These are found sporadically on the septa of many annulate species from both South Australia and Antarctica (Hill, 1965). They are not considered to be pectinate tabulae, which consist of regularly spaced pectinae arranged in discrete planes. Species with pectinate tabulae are described on later pages.

? Gordonicyathus pledgei sp. nov.

(Plate 27, Figs. 8,9; Plate 28, Figs. 1 to 4; Text-figs.12,19)

NAME. After Mr. N.S. Pledge, Curator of Fossils at the South Australian Museum.

HOLOTYPE. P21528 (two thin sections)

PARATYPES. P21440-2; P21440-3; P21529.

TYPE FORMATION. Ajax Limestone. Upper Faunal AssemblageII.

TYPE LOCALITY. Mount Scott Range. Section J.

MATERIAL. Fifteen specimens from the Mount Scott Range, sections J, K and N. One specimen from Wilkawillina Gorge, section I. Holotype and paratypes as above. Additional specimens: P21530-1,-2; P21531; P21532-1, -2; P21533-1 to P21533-6; P21534.

DIAGNOSIS. As for the genus, but the outer wall pores are covered by pore diaphragms.

DESCRIPTION. Solitary cylindro-conical cups whose outer wall has broad, low amplitude transverse undulations; the inner wall is unaffected. The outer wall has 3-4 rows of circular pores in regular quincunx. Each outer wall pore is covered externally by a flat pore diaphragm pierced by a central circular micropore. The intervallum contains straight radial septa pierced by uniformly spaced rows of pores in irregular quincunx. Septal pores are circular and oval in shape. Adjacent rows of pores are slightly closer than successive pores in a single row. The inner wall consists of annuli attached to the inner edges of the septa; there is a single row of horizontally stretched oval pores between adjacent septa. In longitudinal section each annulus is a symmetrical U-shape, with the distal limb equal in length to the limb fixed to the septa. A tapering carina extends downward and slightly inward from the base of each annular trough.

DIMENSIONS (mm)	Holotype P21528	Paratype P21440-3	Paratype P21529
Diameter	5.54	7.40	2.81
Intervallum width	0.97	1.13	0.61
N	51	-	24
ds	0.33	0.29-0.36	0.21-0.29
IK	0.19(4.9)	0.15	0.22
RK	9.21	-	8.55
Loculi	1/3.0	-	1/2.1-1/2.9
Outer wall carcass:			
n	3-4	4	3-4
d	0.05-0.06	0.06	0.06-0.07
l	approx.0.05	0.04-0.05	approx.0.02
t (including diaphragm)	0.05	0.07	0.05
Outer wall pore diaphragm:			
d	-	0.03	0.02-0.03
l	-	approx.0.10	-
t	approx.0.01	approx.0.01	0.01
Inner wall:			
n	1	1	1
d	0.15x0.12	-	0.12x0.06
Annulus width free limb	0.09-0.11	0.12	0.06-0.10
Annulus width fixed limb	0.09-0.11	0.12	0.06-0.07
Septa:			
n	5-6	? 7	3-4
d	0.07x0.09-0.09x0.12	0.07x0.12	0.07-0.09
l	0.07-0.12	0.10-0.12	0.05-0.07
t	0.04	0.05	0.04

ONTOGENY. The inner wall and central cavity have been formed at the smallest cup diameter of 1.09mm. Outer wall pore diaphragms are present at this stage. The inner wall is ? simply porous with one row per intersept. Septa have two rows of pores across the intervallum. At a cup diameter of 1.10mm small U-shaped bracts are very rapidly developed, these fuse to form annuli at 1.16-1.30mm cup diameter.

COMPARISON AND REMARKS. ? Gordonicyathus pledgei sp. nov. differs from ? G. stylus and ? G.levis by its symmetrical annuli. ? G.pledgei has a lower radial coefficient than ? G.levis and its inner wall annuli are formed at smaller cup diameters.

Genus TAYLORCYATHUS Vologdin, 1955.

Type species. Cyclocyathus subtersiensis Vologdin, 1940.

DIAGNOSIS. Solitary conical or cylindrical cups with a simply porous outer wall. Septa uniformly porous. Inner wall of annuli S-shaped in cross-section, opening upwards into the central cavity.

DISCUSSION. The outer wall is simply porous in the diagnosis given above. Until the type species is revised the new species described below, with pore diaphragms on the outer wall, is placed with reservation in the genus.

? Taylorcyathus malleus sp. nov.
(Plate 6, Fig. 3; Plate 28, Figs. 5 to 8)

NAME. From Latin malleus = hammer.

HOLOTYPE. P21535-1 (four thin sections)

PARATYPE. P21507-2; P21536; P21537-1; P21424-5.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Twelve specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21538; P21539-1; P21540-3; P21466-6; P21510-3; P21430-2; P21537-2.

DIAGNOSIS. As for the genus, but the outer wall pores are covered with pore diaphragms.

DESCRIPTION. Small, slender conical cups. Outer wall with smooth irregularly spaced transverse undulations; inner wall unaffected. The outer wall has 2-5 rows of circular and oval pores per intersept in quincunx. Each outer wall pore is covered externally by a very slightly bulging diaphragm pierced by a central circular or ? oval micropore. The intervallum contains straight radial, sometimes bifurcating septa pierced by evenly spaced rows of pores. Septal pores are circular and oval in shape, rows are in regular quincunx. The inner wall consists of annuli attached to the inner edges of the septa. Annuli are S-shaped in longitudinal section, opening upwards into the central cavity. Successive annuli in longitudinal section overlap by up to half their length. The inner wall has one row of subrounded quadrate openings between adjacent septa.

DIMENSIONS (mm)	Holotype P21535-1	Paratype P21507-2	Paratype P21536
Diameter	5.0	4.7	approx.4.3
Intervallum width	0.85-0.92	0.87-0.95	approx.0.8
N	54	approx. 51	approx. 52
ds	0.21-0.25	0.24	0.21-0.23
IK	0.17-0.19	0.19	approx.0.18
RK	10.85	approx.10.8	approx. 12
Loculi	1/3.4-1/4.5	1/3.6-1/4.0	approx.1/3.6
Outer wall carcass:			
n	3-4	3-4	2-5
d	0.05-0.06	0.06-0.07	0.05x0.07
l	0.02	0.02	0.02
t (including diaphragm)	0.05-0.07	0.05-0.07	0.05-0.06
Outer wall pore diaphragms:			
d	0.03	approx.0.02	0.03

l	-	-	0.05
t	approx.0.01	0.01	0.01
Inner wall:			
n	1	1	1
d	0.17x0.19	0.15x0.17	approx.0.15
Annular length	0.26-0.58	0.78	0.78
Septa:			
n	7-8	5-8	8-9
d	0.06-0.09	0.06-0.09	0.05-0.07
l	0.05	0.05	0.06-0.07
t	0.03	0.03	0.03

ONTOGENY. Earliest stages of cup growth are not known. At the smallest available cup diameter of 1.0mm the inner wall and central cavity have been formed. The outer wall pores are covered by diaphragms which bulge to a greater degree than for larger cups. The inner wall has very short, oblique louvre-like lintels. Septa have 3 rows of circular pores in regular quincunx. S-shaped annuli are formed at a cup diameter of 1.7-2.0mm.

COMPARISON AND REMARKS. Four described species of _Taylorcyathus_ have a radial coefficient of similar magnitude to that found in _? T.malleus_ sp.nov.. _T.polyseptus_ (Vologdin, 1931) has a radial coefficient of approximately 12.5, but other morphological features are imperfectly known (Vologdin, 1940, p.61, Fig.40). _T.olyndiacus_ Vologdin, 1962, has a radial coefficient of 14.0 for cups 10mm in diameter (Vologdin, 1962a, p.92). _T.vologdini_ Debrenne, 1964, has a radial coefficient of 8 to 10, but its septa are more robust with larger and more widely spaced pores (Debrenne, 1964, p.157-158). _T.speciosus_ Okuneva, 1972, has a radial coefficient of 11 but has only 2 rows of large outer wall pores per intersept and larger septal pores (Okuneva and Osadchaya, 1972, p.119). Outer wall pore diaphragms have not been described for any of the species mentioned above.

SUPERFAMILY TUMULOCYATHACEA Krasnopeeva, 1953.

DIAGNOSIS. Outer wall with simple or multiperforate tumuli.

FAMILY TUMULOCYATHIDAE Krasnopeeva, 1953. NO!

DIAGNOSIS. Outer wall as for ~~the superfamily~~ with simple tumuli. Inner wall simply porous, bracts and spines may be present.

Genus TUMULOCYATHUS Vologdin, 1937.

Type species Tumulocyathus pustulatus Vologdin, 1937.

DIAGNOSIS. Outer wall with one or two pore rows per intersept, each opening into a simple tumulus. Septa porous. Inner wall with one or two rows of pores per intersept; spines or bracts may extend from the interpore lintels.

DISCUSSION. A new species from South Australia described below, has been placed in the genus Tumulocyathus with considerable reservation because the simple tumuli formed early in ontogeny appear to be absent in larger cups but this condition may be a function of preservation.

? Tumulocyathus transitus sp. nov.

(Plate 29, Figs. 1 to 9)

NAME. From Latin transitus = a transition.

HOLOTYPE. P21541-1 (two thin sections)

PARATYPES. P21542-1; P21543.

TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section E.

MATERIAL. Fifteen specimens from Wilkawillina Gorge, section E, G, H and I. Holotype and paratypes as above. Additional specimens: P21541-2; P21544; P21545-1; P21546; P21547; P21482-3; P21548-1, -2; P21549; P21485-2; P21550-1; P21551-1.

DIAGNOSIS. Small, two walled conical cups. Outer wall with several rows of pores per intersept. At early stages of growth each pore is covered by a simple tumulus which is reduced to a slight projecting rim, or is even absent from the outer wall pores of larger cups. The intervallum is initially crossed by radial bars which gradually develop into true septa. The inner wall is simply porous. Long spines project obliquely upwards into the central cavity from the lintel below each pore.

DESCRIPTION. Slender conical cups. Outer wall with 2-6 rows of circular pores per intersept in quincunx. In very small cups, each outer wall pore is covered by a simple tumulus pierced by a single pore. In larger cups the tumuli are reduced to slightly raised rims bordering each pore and in the largest cups they appear to be completely absent. The intervallum is crossed by straight radial, coplanar bars. Initially, successive bars in longitudinal section enclose a single, vertically stretched oval pore. As the intervallum widens with cup growth the pores become circular and successive bars unite around each pore to form a continuous septal plate. In the largest cups, the septa have two rows of pores across the intervallum. The inner wall has one or two rows of circular pores per intersept in quincunx. Long spines project obliquely upwards into the central cavity from the lintels between each pore. The wall pore diameter and thickness of both walls increase with cup growth.

DIMENSIONS (mm)	Holotype P21541-1	Paratype P21542-1	Paratype P21543
Diameter	4.7	5.0	4.5
Intervallum width	0.95	approx.0.65	0.95
N	-	26	-
ds	0.80	0.50	0.70
IK	0.20	approx.0.15	0.21
RK	-	5.17	-
Loculi	1/1.2	1/1.5	1/1.4

Outer wall:			
n	-	2-4	approx.6
d	approx.0.10	0.13-0.15	0.10-0.12
l	-	0.09-0.13	0.07-0.09
t	0.10	0.10	approx.0.12
Inner wall:			
n	1-2	1-2	2
d	0.20	0.20-0.23	0.20
l	0.08	0.08	0.08
t	0.10-0.13	0.13-0.15	0.13
Septa:			
n	? 1	1-2	1
d	0.40	0.40	0.33
l	-	approx.0.2	approx.0.10
t	0.08	0.06-0.08	0.08-0.10

ONTOGENY. Smallest known cup diameter 0.20mm. Cups have a single wall to 0.36-0.39 mm diameter. Wall thickness 0.03mm, pore diameter 0.03mm. Rudimentary tumuli are present in some cups at this stage.

The inner wall appears at 0.36-0.39mm cup diameter.

At 0.5mm cup diameter tumuli are well developed; radial bars are first seen in the intervallum. Bars have a concave upper and convex lower surface. At this stage the bars appear to be in quincunx rather than side by side. The inner wall has one row of circular pores per intersept; pore diameter 0.10-0.12mm.

At a cup diameter of 1.2mm successive coplanar bars enclose a single circular pore, forming the first septa.

Spines appear on the inner wall at a cup diameter of about 2mm.

At 3-4mm cup diameter the number of septal pores increases from one to two. At this stage, tumuli are reduced to slightly raised rims around the outer wall pores or appear to be completely lost.

COMPARISON AND REMARKS. Unfortunately, the specimens from Wilkawillina Gorge are rather poorly preserved. Recrystallization has affected the outer wall in particular, so that the loss of tumuli cannot be established with absolute certainty. Furthermore, despite the large number of specimens available, it proved impossible to accurately cut longitudinal sections to reveal the development of septa in the larger cups. For these reasons the species described above is placed questionably in the genus Tumulocyathus Vologdin. Early stages of growth are similar to those found in species belonging to the genus Kaltatocyathus Rozanov. For example, the species Kaltatocyathus rigidus Belyaeva has a one walled cup to a cup height of 0.9mm when the inner wall appears. Radial rods appear at a cup diameter of 0.87mm. Inner wall spines appear at a cup diameter of 1.9mm (Belyaeva et al. 1975, p.65).

The retarded development of septa from radial bars in ? Tumulocyathus transitus sp. nov. is rarely seen in Regulares. In its ontogeny this species passes through a transition from the Dokidocyathina to the Ajacicyathina in a slow and steady fashion. In most other Regulares this very early stage of growth is very rapidly passed. It is hoped that the discovery of new specimens in the future will more clearly reveal this transition.

SUBORDER NOCHOROICYATHINA Zhuravleva, 1956.

SUPERFAMILY NOCHOROICYATHACEA Zhuravleva, 1956.

DIAGNOSIS. Two walled cups. Outer wall simply porous. Intervallum crossed by radial septa. Pectinate tabulae are present.

DISCUSSION. Four new species belonging to three genera are described below. All have pectinate tabulae and their outer wall pores are covered with pore diaphragms. Pectinate tabulae, despite their rarity in many species, are still regarded as characters of subordinal rank (Debrenne, Zhuravleva and Rozanov, 1973). In a study of ethmophylloid Archaeocyatha Zhuravleva has stated the following:

False tabulae. They are encountered sporadically. They look like spontaneous thickenings of septa at separate levels. They differ sharply from pectinate tabulae. (Zhuravleva and Elkina, 1974, p.24; present author's translation from Russian.)

M.M. Yazmir noted that simple, underdeveloped pectinate tabulae are found in several examples of the species Baikalocyathus baikalicus and stated:

These examples may possibly be placed in the genus Trininaceyathus Zhuravleva, 1960, if it were not for the similarity in their remaining characters with Baikalocyathus baikalicus. (Yazmir et al, 1975, p.52; present author's translation from Russian.)

In the new species described below the pectinae from the septa are not sporadic, nor do they occur at separate levels. They protrude from the septa as regularly spaced thorn-like projections at discrete levels and in horizontal or oblique planes to form pectinate tabulae and not false tabulae in the sense of Zhuravleva as stated above.

Because of the lack of information concerning the ontogenetic development of the outer wall pore diaphragms, the species are placed with reservation in the Superfamily Nochoroicyathacea. However, the writer maintains that if pectinate tabulae are to be assigned subordinal rank, then there should be a superfamily in the Nochoroicyathina, analogous to the Irinaecyathacea in the Suborder Ajacicyathina. One new family is erected herein to accomodate three of the four new species belonging to two new genera.

FAMILY BAIKALOPECTINIDAE fam. nov.

DIAGNOSIS. Outer wall porous. Each pore is covered by a pore diaphragm. The inner wall consists of a single row of pore tubes per intersept. Pore tubes do not communicate laterally.

DISCUSSION. The Family Baikalopectinidae fam. nov. has been erected to accomodate two new genera, Baikalopectinus gen. nov. and Rowanpectinus gen. nov.. Species lacking pectinate tabulae with the same inner wall characteristics are placed in the Subfamily Baikalocyathinae in the Suborder Ajacicyathina. At the stratigraphic level under consideration, no species have been found which have outer wall pore diaphragms and laterally intercommunicating pore tubes. Their future discovery in younger strata may necessitate the formation of two subfamilies, analogous to the Baikalocyathinae and Irinaecyathinae, but containing species with pectinate tabulae. At present, species with simply porous outer walls, pectinate tabulae and laterally communicating inner wall pore tubes, are placed in genera belonging to the Family Formosocyathidae Rozanov, (Hill, 1965, p.96; 1972, p. E86).

Genus BAIKALOPECTINUS gen. nov.

NAME. This genus is the pectinate analogue of Baikalocyathus Yazmir.

Type species. Baikalopectinus capulus sp. nov.

DIAGNOSIS. Two walled conical cups. Outer wall with several pore rows per intersept in quincunx. Each outer wall pore is covered externally by a very slightly raised pore diaphragm pierced by a central micropore. The intervallum contains uniformly porous septa and pectinate tabulae. The inner wall consists of oblique pore tubes, one row per intersept in quincunx, directed obliquely downwards into the central cavity. Pore tubes do not communicate laterally. At the lower open end of each pore tube there is a plate directed obliquely upwards into the central cavity. Adjacent plates fuse laterally to form a scalloped border around the central cavity. They do not form annuli because of the quincunxial arrangement of the pore tubes. A short tapering carina extends downwards from the junction between each pore tube and plate.

DISCUSSION. As stated above, Yazmir suggested that pectinate analogues of Baikalocyathus might be placed in the genus Trininaecyathus Zhuravleva. However, the genus Trininaecyathus has a single row of large, simple pores on its outer wall (Zhuravleva, 1960b, p.218).

Baikalopectinus capulus sp. nov.

(Plate 6, Fig. 4; Plate 30, Figs. 1 to 9; Text-figs. 13,18)

NAME. From Latin capulus = sword hilt.

HOLOTYPE. P21417-3 (three thin sections)

PARATYPES. P21552-3; P21424-6; P21553.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Twelve specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21554-1; P21555; P21466-7; P21417-6; P21556; P21557; P21558-1; P21559-2.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled, slender conical cups. The outer wall, and to a lesser extent the inner wall, are affected by minor transverse undulations causing the intervallum width to vary slightly. The outer wall has 3-4 rows of circular and horizontally stretched oval pores per intersept in quincunx. The interpore lintels are slightly oblique, commonly sloping upwards to the exterior. Each outer wall pore is covered externally by a very slightly raised pore diaphragm pierced by a central micropore. The intervallum contains radial septa pierced by uniformly spaced rows of small pores in irregular quincunx. Septal pores are circular and oval in shape. Horizontal or slightly convex pectinate tabulae are frequent but irregularly spaced in the intervallum. They consist of pectinae projecting perpendicularly and slightly upwards from the septa. In one specimen (the holotype), pectinae also project into the intervallum from the inner wall. Opposing rows of pectinae do not meet in the centre of each intersept. Branching projections from the pectinae are absent. The inner wall consists of a single row of pore tubes per intersept in irregular quincunx, directed obliquely downwards into the central cavity. A plate fixed to the lower end of each tube wall is directed obliquely upward, so that in longitudinal section each pore tube and attached plate is V-shaped. The tip of each pore tube projects beyond the attached plate at its junction as a short tapering carina. Subjacent plates fuse laterally to form a scalloped border around the central cavity. Early growth stages are not known, but one specimen 1.79mm in diameter has all of the characteristics of larger cups.

DIMENSIONS (mm)	Holotype P21417-3	Paratype P21424-6	Paratype P21553
Diameter	4.40	4.88	4.10
Intervallum width	0.48-0.61	0.44-0.53	0.48-0.53
N	52	approx.68	approx.50
ds	0.19-0.22	0.16-0.21	0.19
IK	0.11-0.14	0.09-0.11	0.12-0.13
RK	11.82	approx.14.1	approx.12.2
Loculi	1/2.2-1/3.1	1/2.1-1/3.4	1/2.5-1/2.7
Outer wall carcass:			
n	3-4	3-4	3-4
d	0.05-0.07(rare)	approx.0.05	0.04-0.06
l	0.03	-	0.02
t	0.05	0.05	0.05
Outer wall pore diaphragms:			
d	0.02-0.03	-	0.02
l	0.05	-	0.05
t	0.01	0.01	0.01

Inner wall:			
n	1	1	1
d	0.06x0.15	0.07x0.12	approx.0.15
Tube length	0.10	0.05-0.10	0.07-0.10
Tube wall thickness	0.02-0.05	0.04	0.05
Plate length	0.07-0.10	0.05-0.10	0.10
Septa:			
n	5	4-5	5
d	0.05-0.06	0.05-0.07	0.05-0.07
l	0.06	0.05-0.07	0.05-0.10
t	0.03	0.03	0.03
Pectinate tabulae:			
Vertical separation	0.99-3.75	one seen	two seen
Length of pectinae	0.07-0.09	-	0.05-0.07

COMPARISON AND REMARKS. Apart from the presence of pectinate tabulae in the intervallum, Baikalopectinus capulus sp. nov. closely resembles Baikalocyathus squamosus sp. nov. described above. Specimens of the latter species show no traces of pectinate tabulae and no sporadic thickenings of any kind on the septa. In addition, the lintels between the outer wall pores of Baikalopectinus capulus are slightly oblique; those of Baikalocyathus squamosus are horizontal (or perpendicular to the outer surface).

Genus ROWANPECTINUS gen. nov.

NAME. From St. Rowan Homestead, 3.6 km southwest of Mount Scott.

Type species. Rowanpectinus clarus sp. nov.

DIAGNOSIS. Two walled conical cups. Outer wall with two or more rows of pores per intersept. Each outer wall pore is covered externally by a flat pore diaphragm pierced by a central micropore. The intervallum contains uniformly porous septa. Rare pectinate tabulae are present. The inner wall consists of one row of short pore tubes per intersept in quincunx, directed obliquely upwards into the central cavity. Pore tubes to not communicate laterally.

DISCUSSION. The genus Voroninicyathus Zhuravleva, 1974 contains species which lack pectinate tabulae in the intervallum. The outer and inner wall structures of species belonging to Voroninicyathus are similar to those of species belonging to Rowanpectinus gen. nov.. However, the inner wall pore tubes of species of Voroninicyathus are horizontal or only slightly inclined upwards into the central cavity.

Kashina (in Osadchaya et al., 1979, p.156) described a new genus Kandatocyathus which she regarded as Family incertae sedis. Kandatocyathus Kashina has diaphragms over the outer wall pores, sparsely porous septa and pectinate tabulae in the intervallum, and an inner wall with one pore row per intersept opening into upward curved pore canals. The genus Kandatocyathus is thus very similar to Rowanpectinus gen. nov., but differs from the latter by having sparse septal pores in 2 to 3 rows close to the outer wall. In addition, Kashina mentions the occasional occurrence of stirrup-pores at the junctions of septa and the inner wall. Kandatocyathus Kashina belongs in the new Family Baikalopectinidae.

Rowanpectinus clarus sp. nov.

(Plate 5, Fig. 7; Plate 31, Figs. 1 to 4)

1967 Nochoroicyathus sp. Walter, p.144, Table 1, plate 7, fig. 6a,b.

NAME. From Latin clarus = distinct.

HOLOTYPE. P21560 (three thin sections)

PARATYPES. P21561; P21562.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section E.

MATERIAL. F17226 (Walter Collection, South Australian Museum); OA1600F-6 (Walter Collection, University of Adelaide); three specimens from Wilkawillina Gorge, sections E and F, as above.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups. Outer wall with irregular transverse undulations, inner wall smooth. The outer wall has 3-4 rows of circular pores per intersept in quincunx. Each outer wall pore is covered externally by a flat pore diaphragm pierced by a central circular micropore. The intervallum contains radial septa pierced by uniformly spaced rows of pores. Septa occasionally bifurcate; septal pores are circular and oval. Rare pectinate tabulae are present in the intervallum. The pectinae which project perpendicularly from the septa are arranged in rows inclined downward from the outer to the inner wall. The inner wall consists of short pore tubes, one row per intersept in quincunx, inclined obliquely into the central cavity. The pore tubes are circular in cross-section. The pore tube walls are wedge shaped in cross-section and slightly curved. Pore tubes do not communicate laterally. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21560	Paratype P21561	F17226
Diameter	6.7	6.0	7.0
Intervallum width	1.30	1.05	1.28
N	64	60	70
ds	0.27	0.27	0.22
IK	0.19	0.18	0.15-0.18
RK	9.5	10.0	10.0
Loculi	1/4.9	1/4.0	1/4.7-1/6.5
Outer wall carcass:			
n	3-4	3	-
d	0.08-0.09	0.05-0.08	-
l	0.03	0.02	-
t (including diaphragm)	0.08-0.10	0.08	-
Outer wall pore diaphragms:			
d	0.02-0.03	approx.0.03	-
l	approx.0.09	approx.0.09	-
t	0.01	0.01	-

Inner wall:			
n	1	1	1
d	0.20-0.25	0.15-0.20	0.12-0.19
Tube length	0.24	0.24	approx.0.24
Tube wall thickness	0.10 tapering to 0.0	0.10 tapering to 0.0	-
Septa:			
n	approx. 7	7-8	-
d	0.06-0.08	0.06-0.08	-
l	0.10	approx.0.13	-
t	0.03-0.04	0.03-0.04	0.03-0.05
Pectinate tabulae:			
Vertical separation	one seen	3.0-4.8(three seen)	one seen
Length of pectinae	max.0.12	0.07-0.12	-

COMPARISON AND REMARKS. Despite the poor preservation of its outer wall, the specimen listed by Walter (1967) as Nochoroicyathus sp. (F17226) is thought to belong to this species. A specimen listed by Walter (op.cit) as Robustocyathus sp. 1. (0A1600F-6) may also belong to this species, but no pectinate tabulae were seen. Two small specimens described above and placed with reservation in the genus Rasetticyathus Debrenne, possibly have pore diaphragms on the outer wall. Although no pectinate tabulae were seen in these specimens, the possibility of their presence cannot be excluded because of the very small cup sizes available. However, they are not considered to be juvenile specimens of Rowanpectinus clarus sp. nov. because of their distinctive septal porosity.

Rowanpectinus occultus sp. nov.

(Plate 5, Figs. 5,6; Plate 31, Figs. 5 to 9; Plate 32, Figs. 1,2)

NAME. From Latin occultus = hidden.

HOLOTYPE. P21563 (three thin sections).

PARATYPES. P21564; P21455-2.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section K.

MATERIAL. Three specimens from the Mount Scott Range, section K.

DIAGNOSIS. As for the genus.

DESCRIPTION. Slender conical cups with irregular transverse undulations affecting the outer wall, and to a lesser extent the inner wall. The outer wall has two rows of circular or oval pores per intersept in quincunx. Each outer wall pore is covered externally by a flat pore diaphragm pierced by a small central pore. The intervallum contains radial septa pierced by evenly distributed rows of pores in quincunx. Septal pores are usually circular in shape but may also be oval. Rare pectinate tabulae are present in the intervallum. They consist of short pectinae projecting perpendicularly from the septa, arranged in rows which incline downward from the outer to the inner wall. The inner wall consists of straight to slightly curved pore tubes, one row per intersept in quincunx. Pore tubes are directed steeply upwards into the central cavity. The upper opening of each pore tube is surrounded by a series of 6 or more long, narrow, parallel spines attached to the tube wall. The spines project obliquely upwards into the central cavity and partly obscure the pore tube openings. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21563	Paratype P21455-2	Paratype P21564
Diameter	3.0	4.6	5.2-5.8
Intervallum width	0.58-0.65	0.68-0.73	0.69-0.97
N	-	-	approx.46(Diam = 5.2)
ds	0.22	0.22	0.22-0.31
IK	0.19-0.22	0.15-0.16	0.13-0.17
RK	-	-	approx. 8.7
Loculi	1/2.8	1/2.8-1/3.4	1/2.2-1/3.7
Outer wall carcass:			
n	2	2	2
d	0.10	0.09-0.10	0.11-0.12

l	0.05	0.05-0.07	0.03-0.05
t (including diaphragm)	0.05-0.07	0.05-0.07	0.05-0.06
Outer wall pore diaphragms:			
d	-	approx.0.03	0.05
l	approx.0.07	0.07-0.10	0.07
t	0.01	0.01-0.02	0.01-0.02
Inner wall:			
n	1	1	1
d	0.15x0.20	0.17x0.24	0.15x0.23
Tube length	max.0.36	0.27-0.36	0.22-0.27
Tube wall thickness	0.06	0.06-0.10	0.12
Spine length	approx.0.12	approx.0.12	0.05-0.12
Septa:			
n	5	5	4-6
d	0.05-0.10	0.07-0.10	0.05-0.10
l	approx.0.05	0.05-0.10	0.05-0.10
t	0.03	0.03	0.03
Pectinate tabulae:			
Vertical separation	0.41(two seen)	One seen	One seen
Length of pectinae	0.05-0.10	-	max.0.10

COMPARISON AND REMARKS. Rowanpectinus occultus sp. nov. differs from the older species R. clarus sp. nov. by its smaller number of outer wall and septal pores and by the presence of long spines attached to the upper edges of the pore tube walls (not clearly seen on the Figures).

FAMILY STILLICIDOCYATHIDAE Ting, 1937.

1936 Bronchocyathidae Bedford R. and J., p.25 (pars).
1937 Stillicidocyathidae Ting, p.367.
1939 Bronchocyathidae Bedford R. and J., p.75 (pars).
1951 Thalamocyathidae Zhuravleva, p.98.
1959 Stillicidocyathidae Ting; Zhuravleva, p.426.
1960 Stillicidocyathidae Ting; Zhuravleva, Krasnopeeva and Chernysheva, p.119.
1965 Bronchocyathidae Bedford R. and J.; Hill, p.93.
1970 Glaessnericyathidae Debrenne, p.35.
1972 Bronchocyathidae Bedford R. and J.; Hill, p.E86.
1975 Bronchocyathidae Bedford R. and J.; Debrenne, p.339.

DIAGNOSIS. Two walled cups. Outer wall, ? simply porous. Intervallum with septa ranging from porous to practically non porous. Pectinate tabulae are present. The inner wall consists of annuli fixed directly to the inner edges of the septa.

DISCUSSION. No other families in the Suborder Nochoroicyathina have been misinterpreted as frequently as the Family Stillicidocyathidae Ting and the Family Bronchocyathidae Bedford R. and J. For clarification, the discussion given below is separated into three sections, each dealing with a particular problem pertaining to these families. One final problem still remains to be resolved; this concerns the structure of the outer wall which is discussed in the third section.

1. Synonymy of the family name.

R. and J. bedford (1936, p.25) erected the genus Bronchocyathus to include species formerly placed in various genera,with the following characteristics:

"Growth from a normal spitz, the presence of extremely numerous thin and straight septa, a very finely porous outer wall, inner wall pores quadrately arranged with a single vertical row of pores to each intersept, the presence of horizontal annular shelves projecting into the central cavity and their tendency to be produced into teeth, collars, or trabecular or vesicular masses within the central cavity, and the spasmodic presence of tabula-like structures."

The Bedfords chose Archaeocyathus trachealis Taylor, 1910 as the genotype and also stated that the tabulae of Coscinocyathus aulax Taylor might be pectinate, in which case "Coscinocyathus aulax will fall into the genus Bronchocyathus." (op.cit.,p.26).

Ting (1937, p.67) erected the Family Stillicidocyathidae to include all Archaeocyatha of annulate type in which pseudo-tabulae could be present or absent. He nominated Coscinocyathus aulax Taylor as the genotype. Hill (1965, p.94) and Debrenne (1969a, p.318) pointed out that Bronchocyathus is a junior synonym of Thalamocyathus Gordon, 1920. Debrenne (1969b, p.263) stated that the holotype of Coscinocyathus aulax Taylor has porous, not pectinate tabulae and consequently removed the genus Stillicidocyathus Ting to the Family Salairocyathidae Zhuravleva in the Suborder Coscinocyathina. For these reasons Debrenne created the Family Glaessnericyathidae to accommodate the pectinate equivalents of species belonging to the Cyclocyathellidae (Debrenne, 1970b, p.32).

The present writer has recently examined the holotype of Coscinocyathus aulax Taylor (specimen T1605 A,B). Its tabulae are pectinate. They consist of a horizontal series of pectinae which project perpendicularly from both sides of adjacent septa. The septa are 0.24mm apart; the pectinae project 0.06mm from the septa. There is no sign of any skeletal material between opposing pectinae in an intersept to suggest that tabulae are of the porous plate type. Two pectinate tabulae 6mm apart are visible on fragment T1605B. Debrenne (1969b, p.263) suggested that fragment T1605A should be referred to the non-tabulate genus Taylorcyathus Vologdin, but it is the writer's opinion that both fragments are counterparts of the same specimen. They fit together quite well if due allowance is made for the fact that both parts have been etched in acid. The paratype (T1555c) is an oblique etched section of a small cup with S-shaped annuli and very sparsely porous septa; pores are close to the outer wall. No tabulae are visible. The holotype has S-shaped annuli, pectinate tabulae and septa with sparse, but evenly distributed pores across the intervallum. The present writer considers that the holotype, but not the paratype of C. aulax Taylor has pectinate tabulae and belongs in the genus Stillicidocyathus Ting. The paratype (T1555c) of C. aulax Taylor appears to lack pectinate tabulae and may belong to a species of Taylorcyathus Vologdin.

Although Bronchocyathus Bedford R. and J., 1936 is an invalid name, Bronchocyathidae Bedford R. and J., 1936 is valid since the generic name is not a junior homonym (International Code of Zoological Nomenclature, 1961, Article 39). It thus has priority over Stillicidocyathidae Ting, 1937. However, P. Kruse (written comm.) has pointed out that according to Article 40 of the International Code of Zoological Nomenclature a family group name continues to be the valid name of the family that contains both the senior and junior synonyms. Because of the revised diagnosis of Thalamocyathus by Debrenne (1973), this genus now has been removed to the Family Cyclocyathellidae in the Suborder Ajacicyathina. Consequently, according to Article 40, Bronchocyathidae Bedford R. and J., 1936 has priority over Cyclocyathellidae Zhuravleva, 1960. Thus the Family Stillicidocyathidae Ting is a valid family in the Suborder Nochoroicyathina. It is strongly recommended herein that the name Bronchocyathidae is suppressed in the interest of taxonomic stability, especially since it is clear that genera belonging to the Cyclocyathellidae urgently require revision following the elevation of the taxonomic rank assigned on the presence of pore diaphragms to superfamily status.

Because the revision of C. aulax Taylor by the present writer has re-established that its tabulae are pectinate, it is now necessary to place species having annulate inner walls, simply porous outer walls and true porous tabulae in the Family Salairocyathidae Zhuravleva 1955, which is no longer a junior synonym of Stillicidocyathidae Ting, 1937.

Structure of the inner wall.

In the diagnosis of the Family Stillicidocyathidae above, the writer has restricted the inner wall structure to consist of annuli fixed directly to the inner edges of the septa.

R. and J. Bedford (1939, p.75) restricted their diagnosis of Bronchocyathus to apply to species with a more complex annulate inner wall like that of Ethmophyllum dentatum Taylor (= Cricopectinus dentulus Debrenne, 1970). This evidently misled Zhuravleva, who considered the Family Bronchocyathidae to include forms with complex inner wall pore-canals. (Zhuravleva, 1960b, p.220). It is still used in this sense by workers in the USSR. (e.g. Okuneva and Repina, 1973, p.140).

The species Cricopectinus dentulus Debrenne, 1970, has a complex inner wall consisting of pore canals shared by several intersepts and lined on the side of the central cavity by cogged annuli. The genus Cricopectinus was placed in the Glaessnericyathidae by Debrenne (1970b, p.32). The genus Cricopectinus is not the pectinate equivalent of Cyathocricus as stated by Debrenne (1970b, p.46) and Hill (1972, pp. E68, E86). The former has cogged annuli attached to a complex inner wall, whereas the latter has cogged annuli attached directly to the inner edges of the septa.

The present writer maintains that a new family is required to accomodate species having annuli attached to complex inner walls but considers that new specimens are required before a revised designation is made.

Structure of the outer wall.

The outer wall structures of most species placed in the Family Stillicidocyathidae are unknown. In the diagnosis given above, the outer wall is stated as being ? simply porous. However, a new species placed with reservation in the genus Thalamopectinus Debrenne, has been found at Wilkawillina Gorge. Its outer wall pores are covered by pore diaphragms. The genus Thalamopectinus Debrenne, 1973 was placed in the Family Bronchocyathidae by Debrenne (1975a, p.339).

It is possible that some or even all of the genera placed in the Stillicidocyathidae may turn out to have pore diaphragms on their outer walls when new specimens are found. This likelihood is increased when it is remembered that most of the non tabulate genera with annular inner walls from South Australia, contains species with outer wall pore diaphragms.

However, the discovery of one such species is not considered to provide sufficient evidence as yet, to alter the family diagnosis as given above.

The following genera and species are considered herein to belong to the Family Stillicidocyathidae as presently defined:

Genus STILLICIDOCYATHUS Ting, 1937.

Type species. Coscinocyathus aulax Taylor, 1910.

DIAGNOSIS. Outer wall ? simply porous. Intervallum with sparsely but uniformly porous septa. Pectinate tabulae are present. The inner wall consists of S-shaped annuli opening upwards into the central cavity. Annuli are attached directly to the inner edges of the septa. The inner wall has a single row of openings between adjacent septa.

GENERIC COMPOSITION. One species, Stillicidocyathus aulax (Taylor, 1910)

Genus GLAESSNERICYATHUS Debrenne, 1970.

Type species. Bronchocyathus sigmoideus Bedford R. and J., 1936.

DIAGNOSIS. As for Stillicidocyathus, but septa are aporose.

GENERIC COMPOSITION. One species, Glaessnericyathus sigmoideus (Bedford R. and J., 1936).

Genus THALAMOPECTINUS Debrenne, 1973.

Type species. *Thalamopectinus arterialis* Debrenne, 1973.

DIAGNOSIS. As for *Stillicidocyathus*, but annuli are V-shaped, opening upward into the central cavity.

DISCUSSION. Workers in the USSR refer to species of the genus *Thalamocyathus* Gordon as having pectinate tabulae. With the removal of *Thalamocyathus* from the Nochoroicyathina and the creation of the genus *Thalamopectinus* by Debrenne (1973), these species are placed herein in the latter genus with reservation.

CENERIC COMPOSITION. Five species, ? *Thalamopectinus howelli* (Vologdin, 1940); ? *Thalamopectinus apprimus* (Korshunov, 1969); *Thalamopectinus arterialis* Debrenne, 1973; *Thalamopectinus partitus* Debrenne, 1973; ? *Thalamopectinus merus* sp. nov.

Genus THALAMOPECTINUS Debrenne, 1973.

Type species. *Thalamopectinus arterialis* Debrenne, 1973 (= *Bronchocyathus trachealis* in Bedford R. and J., 1936,p.25, Pl.25, Fig.99)

DIAGNOSIS. Two walled cups with a ? simply porous outer wall. Intervallum with ? sparsely porous septa and sparse pectinate tabulae. The inner wall consists of annuli attached to the inner edges of the septa. Annuli are V-shaped, opening upwards into the central cavity. The inner wall has one row of openings between adjacent septa.

DISCUSSION. Debrenne (1973,p.8) gave no generic diagnosis when she first listed *Thalamopectinus*. In a later description of a specimen from South Africa which Debrenne placed in *Thalamopectinus arterialis*, she indicated that its septa are sparsely porous to non porous

(Debrenne, 1975a, p.339). However, the holotype of the genotype she chose (*Bronchocyathus trachealis*, in Bedford R. and J., 1936, p.25, Pl.25, Fig.99), has quite uniformly porous septa except adjacent to the inner wall, judging by Figure 99A (Bedford R. and J., *op.cit.*). The new species described below has uniformly porous septa, but it is placed in the genus with reservation because of the presence of pore diaphragms on the outer wall.

Osadchaya (in Osadchaya *et al.*, 1979, p.155) has recently described a new genus *Thalamocyathellus* with a simply porous outer wall, uniformly porous septa and pectinate tabulae. The inner wall consists of flat annular shelves directed upwards. The possible synonymy between *Thalamocyathellus* Osadchaya and *Thalamopectinus* Debrenne cannot be confirmed until the holotype of the type species *Thalamopectinus arterialis* Debrenne (housed at Princeton University), is restudied. or even simpler: why don't you ask me for the documents I have taken when I have examined this Princeton material?

? *Thalamopectinus merus* sp. nov.

(Plate 32, Figs. 3 to 8)

NAME. From Latin *merus* = genuine.

HOLOTYPE. P21565 (three thin sections)

PARATYPES. P21566; P21567.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section F.

MATERIAL. Three specimens from Wilkawillina Gorge, sections F and I.

DIAGNOSIS. Solitary cylindro-conical cups. The outer wall is corrugated by minor transverse undulations, the inner wall is affected to a lesser extent. The outer wall has several pore rows per intersept in quincunx. Each pore is covered externally by a flat pore diaphragm. The intervallum contains numerous radial septa pierced by uniformly spaced rows of pores. Rare pectinate tabulae are present. The inner wall consists of asymmetric U-shaped annuli attached directly to the inner edges of the septa. A tapering carina extends downwards from the base of each annular trough. The inner wall has one row of openings between adjacent septa.

DESCRIPTION. Solitary cylindro-conical cups. The outer wall, and to a lesser extent the inner wall is transversely corrugated, causing the intervallum to vary slightly in width. The outer wall has 3-4 rows of circular pores in regular quincunx. Each outer wall pore is covered externally by a flat diaphragm pierced by a central micropore. The intervallum contains numerous radial septa pierced by uniformly spaced rows of small pores in irregular quincunx. Pectinate tabulae are sparse and consist of pectinae projecting perpendicularly from the septa in rows which incline downward from the outer to the inner wall. The inner wall consists of annuli fixed directly to the inner edges of the septa. There is a single row of openings between adjacent septa. The annuli are an asymmetric U-shape in cross-section, with the distal free limb somewhat longer and more curved than the limb fixed to the septa. A short tapering carina extends downwards and inwards from the trough at the base of each annulus. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21565	Paratype P21566	Paratype P21567
Diameter	approx.6.4	4.3	approx.4.4
Intervallum width	0.84-1.28	0.97	0.90
N	approx. 88	50	approx. 52
ds	0.17	0.23	0.20
IK	approx.0.19	0.23	approx.0.19
RK	approx.13.7	11.65	approx. 11
Loculi	1/6.4	1/4.2	1/4.5
Outer wall carcass:			
n	3	4	3-4
d	0.05-0.07	0.05-0.06	0.06-0.08

l	-	approx. 0.02	0.03
t(including diaphragm)	0.05	0.05	0.05
Outer wall pore diaphragms:			
d	approx.0.02	approx.0.02	0.01-0.03
l	approx.0.07	approx.0.07	approx.0.07
t	0.01	0.01	0.01
Inner wall:			
n	1	1	1
d	approx.0.12	0.15x0.12	0.13x0.09
Annulus width free limb	0.15	0.07-0.15	0.10-0.12
Annulus width fixed limb	0.07	0.05-0.07	0.05-0.07
Septa:			
n	7-8	7-9	8
d	0.07-0.10	0.06-0.08	0.05-0.08
l	0.07-0.10	0.07	0.05-0.08
t	0.04	0.03	0.03
Pectinate tabulae:			
Vertical separation	one seen	approx.0.7 (two seen)	one seen
Length of pectinae	-	0.05-0.07	0.07

COMPARISON AND REMARKS. ? Thalamopectinus merus sp. nov. and a new species found in the Cymbric Vale Formation (P. Kruse, pers.comm.) are the only two known to have pore diaphragms on their outer walls. Korshunov (in Zhuravleva, Korshunov and Rozanov, 1969, p.43) described the outer wall of Thalamocyathus apprimus as consisting of small, upward directed geniculate pore canals. These may possibly be pores covered by pore diaphragms. ? Thalamopectinus apprimus (Korshunov) has a similar radial coefficient to that found in ? T. merus, but the outer wall and septal pores of the latter species are smaller.

SUBORDER COSCINOCYATHINA Zhuravleva, 1955.

SUPERFAMILY COSCINOCYATHACEA Taylor,1910.

1960 Coscinocyathacea Zhuravleva, p.245 (nom.transl. Zhuravleva, ex. Coscinocyathidae Taylor, 1910).

1970 Erismocoscinacea Debrenne, p.25 (nom.transl. Debrenne, ex. Erismacoscinidae Debrenne, 1964).
1972 Coscinocyathacea Taylor; Hill, p.E92.

DIAGNOSIS. Outer wall simply porous. Intervallum with septa and tabulae. Inner wall of simple pores, pore tubes or annuli.

FAMILY COSCINOCYATHIDAE Taylor, 1910

1910 Coscinocyathidae Taylor, p.137.
1956 Asterocyathidae Vologdin, p.879.
1964 Erismacoscinidae Debrenne, p.166.
1972 Coscinocyathidae Taylor; Hill, p. E92.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall simply porous or with pore tubes.

Genus COSCINOCYATHUS Bornemann, 1884.

1884 Coscinocyathus Bornemann, p.705.
1958 Erismacoscinus Debrenne, p.65.
1972 Coscinocyathus Bornemann; Hill, p.E92.

Type species. Coscinocyathus dianthus Bornemann (by decision of the International Commission for Zoological Nomenclature).

DIAGNOSIS. Two walled cups. The outer and inner walls, septa and tabulae are all simply porous.

DISCUSSION. Debrenne (1970a, p.207) proposed a change of the type species from Coscinocyathus tuba Bornemann, chosen by Ting (1937) to Coscinocyathus dianthus Bornemann. With the acceptance of this proposal, Erismacoscinus Debrenne becomes a junior synonym of Coscinocyathus Bornemann.

Coscinocyathus vestitus sp. nov.

(Plate 33, Figs. 1 to 7)

NAME. From Latin vestitus = a covering.

HOLOTYPE. P21568 (three thin sections).

PARATYPES. P21540-1; P21569.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Seven specimens from the Mount Scott Range, sections J and N; one specimen from Wilkawillina Gorge, section G. Holotype and paratypes as above. Additional specimens: P21570 to P21574.

DIAGNOSIS. Solitary conical cups with an extremely narrow intervallum. The outer wall is simply porous, with several rows of circular pores per intersept. Septa in the intervallum have sparse, uniformly distributed pores. Tabulae are sparse, flat, pierced by closely spaced pores. The inner wall is simply porous with several rows of circular pores per intersept. The outer wall is covered by successive lamellae of skeletal material reaching a considerable thickness. These may extend from the base to more than half the cup height. Endothecal tissue is present in the lower part of the central cavity. Rare dissepiments occur in the intervallum.

DESCRIPTION. Two walled conical cups with an extremely narrow intervallum. The outer wall is smooth and simply porous with 2-8 rows of circular pores per intersept. Pores in adjacent vertical rows are almost side by side. The intervallum contains radial septa pierced by 3-4 rows of circular pores in irregular quincunx. Tabulae are sparse and flat, pierced by circular and sub-polygonal pores. The inner wall has 2-8 rows of circular pores per intersept in quincunx. In a single intersept, the number of inner wall pore rows is nearly the same as the number of outer wall pore rows. The outer wall is invested by successive calcareous lamellae which extend from the base of the cup to nearly half the cup height. As the cup grows, a new lamella is added to the entire lower part of the cup, so that the number of lamellae and their aggregate thickness increase downwards to the cup base. The outer wall pores maintain an opening to the exterior through the first successively added lamellae via circular tubes up to 0.35mm long. However, subsequent lamellae finally seal the openings. Total thickness of the investment near the base of the cup may reach 3.5mm. The inner wall is covered to a much smaller degree by a similar coating. This rarely exceeds a thickness of 0.24mm and the inner wall pores maintain a connection with the central cavity. Anastomosing finger-like extensions from the interpore lintels of the inner wall cross the lower parts of the central cavity. Septa, but not tabulae, are slightly affected by secondary thickening near the base of the cup. Rare dissepiments cross the intervallum in some cups. Early stages of growth are not known.

DIMENSIONS (mm)	Holotype P21568	Paratype P21540-1	Paratype P21569
Diameter	25.0	2.2-16.2	8.6
Intervallum width	0.51	0.34-0.51	0.73
N	-	12(2.2)-90(16.2)	43
ds	0.64-0.89	0.24-0.77	0.46-1.31(rare)
IK	0.02	0.15(2.2)-0.03(16.2)	0.09
RK	-	5.28-5.57	5.0
Loculi	1/0.6-1/0.8	1/0.7-1/2.1	1/0.6-1/5.9
Outer wall:			
n	5-8	2-5	3-6
d	0.09-0.10	0.07-0.09	-
l	0.05-0.12	0.03-0.10	-
t	0.05	0.07	0.07
Inner wall:			
n	3-8	2-5	3-7
d	0.07-0.10	0.05-0.12	0.12

l	0.07-0.10	0.10-0.12	0.10-0.12
t	0.05	0.07	0.07
Septa:			
n	3	4	4
d	0.05-0.06	0.05	0.05-0.07
l	0.05-0.07	0.05-0.07	approx.0.06
t	0.03-0.05	0.03-0.05	0.05
Tabulae:			
n	6x?	5x4-6x7	-
d	approx.0.05	0.03-0.09	-
l	approx.0.03	0.02-0.03	-
t	0.03	0.03	0.03
Vertical separation	2.4-4.0	3.5-5.2	3.6

Note. The dimensions given above do not include the thickness of lamellae on the outer and inner walls.

COMPARISON AND REMARKS. Coscinocyathus fasciola Debrenne, from Southern Morocco is the only species in the genus with a comparably narrow intervallum. However, the outer and inner wall pores of C. fasciola are 0.02mm and 0.04mm diameter respectively (Debrenne, 1978, p.110). These are much smaller than the wall pores of C. vestitus sp. nov.

Coscinocyathus uratannensis sp. nov.

(Plate 34, Figs. 1 to 5)

NAME. After Uratanna Well, 3.4km south-southwest of Mount Scott.

HOLOTYPE. P21488-1 (three thin sections).

PARATYPES. P21504-2; P21511-2.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Seven specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21474-3; P21411-3; P21424-4; P21575.

DIAGNOSIS. Solitary conical cups with a narrow intervallum. The outer and inner walls bulge slightly and irregularly between septa. The outer wall has several rows of pores per intersept. Minute spines on the external surface,border and very slightly obscure the pore openings. The intervallum contains radial porous septa and flat or weakly convex tabulae. Tabulae are fairly frequent but irregularly spaced, with netlike porosity. The inner wall has several rows of pores per intersept. A short curving spine extends upwards from the lintel below each inner wall pore.

DESCRIPTION. Solitary conical cups with a narrow intervallum. Both walls bulge slightly and irregularly between septa in transverse section. The outer wall has 3-8 rows of pores per intersept which are normally side by side. Pores are circular in small cups. In large cups the pores are circular on the intervallum side and widen outwards to a subrectangular shape on the outer surface. Each outer wall pore is surrounded by a circlet of small spines radiating outwards and encroaching across each pore opening to a very slight degree. The intervallum contains radial septa pierced by closely spaced circular pores in irregular quincunx. Tabulae are fairly frequent but irregularly spaced. They are flat to weakly convex in longitudinal section; they are rarely weakly concave. The tabulae are pierced by circular to sub-polygonal pores which are very closely spaced. The inner wall is simply porous with 2-6 rows per intersept. Pores are circular and oval in shape. The lintel below each inner wall pore extends obliquely upwards into the central cavity as a sharp curved spine.

Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21488-1	Paratype P21504-2	Paratype P21511-2
Diameter	14.3	23.0	6.0
Intervallum width	0.79-1.18	0.82-1.02	0.69
N	58	-	approx.26
ds	0.69-1.09	0.58-1.02	0.46-1.16
IK	0.06-0.08	0.03-0.04	0.12
RK	4.1	-	approx.4.3
Loculi	1/0.7-1/1.7	1/0.8-1/1.8	1/0.6-1/1.5
Outer wall:			
n	5-6	4-5	3-6
d	0.11-0.15	0.10-0.17	0.07-0.10
l	0.05-0.07	0.03-0.05	0.06-0.17
t	0.10	0.07-0.10	0.07
Inner wall:			
n	3-6	4-8	3-6
d	0.12-0.15	0.12-0.15	0.10-0.12
l	0.05-0.07	0.07	0.05-0.07
t	0.05-0.07	0.05	0.05-0.07
Septa:			
n	5	5-7	3-5
d	0.07-0.15	0.07-0.13	0.07-0.12
l	0.05-0.07	0.06-0.09	0.05-0.07
t	0.03-0.05	0.04-0.06	0.03-0.04
Tabulae:			
n	7x7 approx.	9x9 approx.	5x5 approx.
d	0.05-0.16	approx.0.05-0.10	approx.0.05-0.15
l	0.02	-	-
t	0.03	0.03	0.03
Vertical separation	1.35-2.12	1.16-2.42	0.87-3.00

COMPARISON AND REMARKS. The species C. bedfordi Vologdin, 1939 from the USSR is similar to C. uratannensis sp. nov. but its outer and inner wall pores are smaller, there are fewer inner wall pores and the pores in the tabulae are smaller (Repina et al., 1964, p.221).

Genus ROZANOVICOSCINUS Debrenne, 1970.

Type species. Rozanovicoscinus fonini Debrenne, 1970, pro Cadniacyathus asperatus Bedford R. and J., 1937 (pro parte).

DIAGNOSIS. "Cylindrical cups with vertical fluting the furrows corresponding to the septa. Septa and tabulae with round quincunxial pores of the same type. Tabulae flat, frequent, but irregularly spaced. Outer wall with round regularly spaced pores, in quincunx. Inner wall with short honeycomb tubes two or three per intersept." (Debrenne, 1970b, p.41).

Rozanovicoscinus stellatus sp. nov.

(Plate 34, Figs. 6 to 8; Plate 35, Figs. 1,2)

NAME. From Latin stellatus = starry.

HOLOTYPE. P21427-2 (three thin sections).

PARATYPES. P21576; P21578.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section K.

MATERIAL. Nine specimens from the Mount Scott Range, sections J,K and N. One specimen from Wilkawillina Gorge, section I. Holotype and paratypes as above. Additional specimens: P21577; P21579; P21580-1; P21581 to P21584.

DIAGNOSIS. As for the genus. The inner wall may have a larger number of pores per intersept.

DESCRIPTION. Cylindro-conical cups whose outer wall is sharply stellate between adjacent septa. The inner wall is smooth. The outer wall is simply porous with 4-8 rows of circular pores per intersept. The intervallum contains septa pierced by evenly spaced rows of circular pores in quincunx. Tabulae are fairly frequent but irregularly spaced. They are flat to weakly convex and pierced by circular and oval pores. The inner wall has 2-5 rows of pores per intersept in quincunx. Pores are circular on the intervallum side and expand to form oval openings into the central cavity, where they frequently anastomose obliquely. The lintel below each inner wall pore extends obliquely upwards to form a jagged plate. The plates do not completely enclose the pores to form pore tubes. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21427-2	Paratype P21576	Paratype P21578
Diameter	9.8	6.9	4.6
Intervallum width	1.23	0.99-1.10	0.80
N	32	22	16
ds	0.77-1.18	0.80	0.59-0.74
IK	0.14	0.14-0.16	0.21
RK	3.52	3.21	4.10
Loculi	1/1.0-1/1.6	1/1.2-1/1.4	1/1.1-1/1.4
Outer wall:			
n	6-8	4	4-5
d	0.11	0.12-0.17	0.10-0.12
l	0.07	0.07-0.10	0.05-0.12
t	0.05	0.07	0.07
Inner wall:			
n	2-5	3	2-4
d	0.11x0.15	0.11x0.15	0.12x0.17
l	0.05-0.07	0.07	-
t	0.06-0.07	0.07	0.07
Septa:			
n	7-8	4-6	4
d	0.06-0.10	0.09-0.10	0.10
l	0.07	0.07	-
t	0.05-0.06	0.05-0.07	0.05-0.06
Tabulae:			
n	6x?8	?6x8	4x?6
d	0.07-0.12	0.06-0.12	0.12

l	0.04	0.03-0.05	0.03-0.04
t	0.05-0.07	0.05	0.05
Vertical separation	2.7-3.8	2.0-2.7	-

COMPARISON AND REMARKS. Rozanovicoscinus stellatus differs from R. fonini Debrenne by its narrower intervallum, higher radial coefficient and greater number of inner wall pores per intersept. In addition the septal pores of R. stellatus are smaller and closer, and the tabular pores are larger and closer than those seen in R. fonini Debrenne, The inner wall of R. stellatus does not have pore tubes; the plates extending from the lintels are very similar to those illustrated by R. and J. Bedford for the atabulate Cadniacyathus asperatus (R. and J. Bedford, 1937, Pl.39, Fig. 152D).

Genus CRUCICYATHUS gen. nov.

NAME. After the constellation Crucis (Southern Cross)

Type species. Crucicyathus repandus sp. nov.

DIAGNOSIS. Two walled conical cups. Outer wall sharply stellate between adjacent septa in transverse section. Inner wall smooth. The outer wall has several rows of circular pores per intersept in irregular quincunx. Successive pores in a single row are closer than pores in adjacent rows. A circlet of minute spinules projects radially inwards across each pore opening on the outer surface of the cup. These are often absent in large cups. The intervallum contains septa pierced by evenly spaced rows of pores in quincunx. Tabulae are flat, frequent but irregularly spaced. Tabulae have netlike porosity. The inner wall has several rows of long pore tubes per intersept. Pore tubes are S-shaped in longitudinal section, opening upwards into the central cavity.

Crucicyathus repandus sp. nov.

(Plate 35, Figs. 3 to 8; Plate 36, Fig. 1, Text-fig. 14)

NAME. From Latin repandus = upturned.

HOLOTYPE. P21585 (three thin sections).

PARATYPES. P21417-5; P21473-3; P21510-4; P21552-2.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Sixteen specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21413-2; P21505-2, -3; P21559-1; P21586; P21587; P21588-1; P21589; P21590-2; P21591-2; P21592-1.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups. The outer wall is sharply and regularly stellate with the troughs corresponding to the positions of the septa. The outer wall is simply porous with 3-9 vertical rows of circular pores per intersept in irregular quincunx. Adjacent pore rows are more widely separated than successive pores in a single vertical row. A circlet of minute spinules projects radially inwards to an insignificant degree across each pore opening, on the outer surface of the cup. Spinules appear to be absent in large cups. The intervallum contains straight, radial septa pierced by uniformly distributed rows of circular pores in quincunx. Tabulae are flat to weakly convex, fairly frequent but irregularly spaced. Pores in the tabulae are circular, oval and subangular with a net-like arrangement. The inner wall consists of 2-4 (rarely 1) rows of S-shaped pore tubes per intersept. The tube upper openings are oval or subrectangular in transverse section. The pore tubes open upwards into the central cavity and successive tubes in a single vertical row are sufficiently long to overlap by up to half their length. The upper free edges of the pore tube walls bear short, featherlike tufts of spines.

DIMENSIONS (mm)	Holotype P21585	Paratype P21552-2	Paratype P21473-3
Diameter between opposing crests	12.5	13.9	7.6
Intervallum width (in troughs)	1.14	1.21	1.33-1.53
N	27	48	approx.20
ds	0.94-1.43	0.61 -0.99	0.68-0.97
IK(measured in troughs)	0.09	0.09	0.21-0.24
RK (diameter measured across troughs)	2.16	3.62	3.14
Loculi	1/0.8-1/1.2	1/1.2-1/2.0	1/1.4-1/2.3
Outer wall:			
n	6-8	4-7	6-8
d	0.06-0.07	0.11-0.13	0.10
l	0.09-0.12	0.06-0.19	0.06-0.17
t	0.07	0.07	0.05-0.06
Inner wall:			
n	2-4	2-4	2-3
d	0.12x0.22-0.13x0.34	0.11x0.19-0.15x0.27	0.16x0.21
Tube length	0.61	0.61	0.48
Tube wall thickness	0.02-0.05	0.02	0.03-0.06
Septa:			
n	6	6	4-6
d	0.08-0.13	0.12	av.0.10
l	0.07-0.12	0.07 -0.12	0.06-0.12
t	0.05-0.06	0.04-0.05	0.05-0.06
Tabulae:			
n	8x?12	?5x7	10x4-10x8
d	0.05-0.12	0.11-0.15	0.05-0.18
l	0.04-0.05	0.03	0.02-0.04
t	0.05-0.07	0.04-0.06	0.05

NOTE. The outer wall thickness stated above does not include secondary thickening which may reach 0.40mm. Other skeletal parts are not significantly thickened.

ONTOGENY. At the smallest known cup diameter of 0.80mm the inner wall and central cavity have been formed. The intervallum apparently has radial bars, the outer wall is smooth and both walls are simply porous. At 1.16mm cup diameter small spinules are present around the outer wall pores, septa with 1-2 rows of pores are formed.
The first tabula is seen at 1.53mm cup diameter but the presence of earlier tabulae is not discounted.
At 2.5mm cup diameter the outer wall stellations form. The inner wall is simply porous with 3-4 rows per intersept. Just above this stage, short upward directed bracts are formed on the inner wall. These rapidly develop into pore tubes at a cup diameter of 2.7mm, but in some cups this stage is not reached before a diameter of 3.7mm.

COMPARISON AND REMARKS. The genus Geniculicyathus Debrenne differs from Crucicyathus gen. nov. by having a smooth outer wall and shorter S-shaped pore tubes. The genus Rozanovicoscinus Debrenne has either oblique plates or very short pore tubes on the inner wall. The inner wall of Coscinocyathus petersi Bedford R. and W.R. has pores aligned side by side and the horizontal lintels form a circular bar which supports short plates. Debrenne (1969a, p.332) has suggested that this structure is a precursor to the formation of annuli.

SUPERFAMILY MRASSUCYATHACEA Vologdin, 1960.

DIAGNOSIS. Outer wall pores covered by an independent microporous sheath.

FAMILY POLYCOSCINIDAE Debrenne, 1964.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall simply porous.

Genus MENNERICYATHUS Debrenne and Rozanov, 1974.

Type species. Tomocyathus kundatus Rozanov, 1966.

DIAGNOSIS. "Outer wall of double structure: the main wall with 2-4 large pores per intersept is externally shielded by an independent microporous sheath; tabulae slightly domed with simple pores; inner wall smooth, also with simple pores." (Debrenne and Rozanov, 1974, p.608).

Mennericyathus dissitus Kruse (in prep.)

(Plate 8, Fig. 5; Plate 9, Figs. 1,2; Plate 36, Figs. 2 to 6)

NAME. From Latin dissitus = distant.

HOLOTYPE. SUP 91236.

PARATYPES. SUP91230-91231; 91237-91241.

TYPE FORMATION. Cymbric Vale Formation. Locality L98.

TYPE LOCALITY. Mount Wright locality, western New South Wales.

MATERIAL. Four specimens from the Mount Scott Range. Faunal Assemblage II, sections K and N. South Australian specimens: P21505-4; P21593 to P21595.

DIAGNOSIS. As for the genus.

DISCUSSION. The following description is based on a study of specimens from the Mount Scott Range. Descriptions and photographs of specimens kindly supplied by P. Kruse have satisfied the present writer that specimens from the Mount Wright area and from the Mount Scott Range belong to the same species.

DESCRIPTION. Conical cups with smooth outer and inner walls. The outer wall has 2-3 rows of pores per intersept. Pores are funnel shaped, widening outwards from a circular to subrectangular shape. An independent microporous sheath is supported on short pillars projecting outward from the interpore lintels of the underlying carcass. There are 6-8 pillars projecting from the lintels surrounding each carcass pore. The sheath micropores are circular and have no apparent symmetrical arrangement with respect to the underlying carcass pores. The intervallum contains radial septa pierced by uniformly distributed rows of pores in irregular quincunx. Septal pores are mainly oval in shape; some are circular. Tabulae are frequent but irregularly spaced. They are flat to weakly convex, pierced by circular to subangular pores. Tabular stirrup-pores are formed at septal junctions. The inner wall is simply porous with 2-4 rows of circular pores per intersept in quincunx. Very short spines project into the central cavity from the lintels surrounding each inner wall pore. Spines are triangular in cross-section. Sparse dissepiments cross the intervallum and central cavity at small cup diameters.

DIMENSIONS (mm)	P21593	P21594	P21595
Diameter	12	13.4	3.4
Intervallum width	1.30	1.21	0.70-0.90
N	61+4partial	62+4partial	15+5partial
ds	0.58	0.41-0.68	0.34-0.44
IK	0.11	0.09-0.10	0.21-0.27
RK	5.08	4.64	4.46
Loculi	1/2.3	1/1.7-1/4.8	1/1.6-1/2.6
Outer wall carcass:			
n	2-3	2-3	2
d	0.22-0.24	0.24x0.16	approx.0.19
l (nearest sheath)	0.05	0.05	approx.0.05
t (excluding pillars and sheath)	0.10-0.12	0.07-0.10	0.07-0.10
Outer wall sheath:			
d	0.04-0.05	0.03-0.06	-
l	0.02	0.01-0.02	-
t	0.03	0.03	0.01-0.02

Separation from carcass	0.05	0.05-0.10	0.05
Inner wall:			
n	3	2-4	1-2
d	0.10-0.15	0.09-0.12	0.10
l	approx.0.05	0.07	0.04
t	0.08	0.07	0.10
Septa:			
n	7-8	6-7	4-5
d	0.08-0.10	0.10	approx.0.07
l	0.10	0.10	approx.0.07
t	0.05-0.07	0.05-0.06	0.05-0.07
Tabulae:			
n	9x4	approx.9x4	7x3-7x4
d	0.05-0.12	-	0.07-0.10
l	0.03-0.05	-	0.03-0.05
t	0.04	0.05	0.05
Vertical separation	0.30-1.78	1.83-3.94	approx.1.0

ONTOGENY. The following data has been obtained from a single specimen: P21593.

The inner wall and central cavity have just formed at a cup diameter of 0.6mm. The inner wall has one pore per intersept, pore diameter 0.07mm. The outer wall porosity is obscured by secondary thickening. Intervallum elements are not visible.

At 0.73mm cup diameter short spines are formed on the inner wall.

At 1.09mm the outer wall porosity can be seen through the secondary thickening; the pores are simple, lintels are rectangular. A tabula is present at a cup diameter of 1.56mm. Earlier intervallum elements are obscured by the growth of dissepiments. A sheath is present over the outer wall at a cup diameter of 2.2mm. It is not clear whether this is initially independent.

At 1.8mm the outer wall pores are covered by a skeletal membrane but it is not certain whether this is a sheath.

COMPARISON AND REMARKS. Specimens belonging to the same species have been found in lenses L97 and L98, Mount Wright Volcanics and

Cymbric Vale Formation respectively(P. Kruse, written comm.).

The species Mennericyathus echinus (Debrenne, 1964) and M. kundatus (Rozanov, 1966) are the only species of the genus known to have a spinose inner wall. M.echinus (Debrenne) differs from the species described above by its significantly wider intervallum. M.echinus has an intervallum coefficient of 0.26-0.30 for cups 10-18mm diameter; the species described above has an intervallum coefficient of 0.10 for cups 12-13mm diameter. The intervallum coefficient for M.echinus was recalculated from the figures supplied by Debrenne (1964, p.195, Table 20). At that time she measured the intervallum coefficient as the ratio of the intervallum width to the width of the central cavity (op.cit., p.119). M. kundatus (Rozanov) has smaller outer and inner wall pores, and the sheath micropores are also smaller for similar cup sizes.

SUPERFAMILY ANAPTYCTOCYATHACEA Debrenne, 1970.

DIAGNOSIS. Outer wall pores covered by a non-independent microporous sheath.

FAMILY ANAPTYCTOCYATHIDAE Debrenne, 1970.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall simply porous or with short pore tubes. The presence or absence of bracts and/or spines and their orientation, where present, constitute generic criteria.

DISCUSSION. The present writer has placed six genera in the Family Anaptyctocyathidae:

Somphocyathus Taylor, Anaptyctocyathus Debrenne, Erugatocyathus Debrenne, Lunulacyathus Debrenne, Veronicacyathus Debrenne and Bractocyathus Kruse.

Debrenne (1973, p.15) considered the continuity or discontinuity of the non-independent outer wall sheath to constitute a generic characteristic. New data discussed in Chapter 4 of this work, has shown that species of the same genus, and sometimes different parts of the same cup, can have a continuous or discontinuous sheath. No taxonomic value has been assigned to sheath continuity or discontinuity herein. However, the shape and arrangement of sheath micropores may constitute specific criteria. Kashina (1979, p.47) in an independent study of species belonging to the atabulate Superfamily Erbocyathacea, also observed that both continuous and discontinuous non-independent microporous sheaths could be found on one individual. Kashina concluded that these variations are of intraspecific value only.

Genus SOMPHOCYATHUS Taylor, 1910.

1910 Somphocyathus Taylor, p.134.
1937 Archaeocyathus Billings; Ting, p.359.
1939 Somphocyathus Taylor; Bedford R. and J., p.81.
1939 Somphocyathus Taylor; Simon, p.38.
1955 Somphocyathus Taylor; Okulitch, p.E19.
1960 ? Ajacicyathus Bedford R. and J.; Zhuravleva, p.110.
1965 Somphocyathus Taylor; Hill, p.62.
1972 ? Ajacicyathus Bedford R. and J.; Hill, p.E61.

Type species by monotypy. Somphocyathus coralloides Taylor, 1910.

DIAGNOSIS. Two walled conical cups. Outer wall with numerous rows of pores per intersept, each covered by a flat, non-independent microporous sheath. Extensive radial buttresses fixed to the exterior of the outer wall restrict the sheath to the pore openings. The intervallum has radial septa pierced by evenly spaced rows of pores. Sporadic, tabula-like structures occur in some intersepts. The inner wall has several pore rows per intersept. Each interpore lintel extends into the central cavity as a short beak-like bract. The central cavity of small cups is partly or completely filled with endothecal tissue, consisting of a skeletal mass pierced by large rounded, often anastomosing ? upward directed canals. Endothecal tissue is absent from the upper parts of large cups. Dissepiments are absent. The intervallum contains sporadically occuring rounded masses of isolated skeletal material in addition to the tabula-like structures. Secondary thickening of the walls and septa is common.

DISCUSSION. The diagnosis given above has been provided by two thin sections of the holotype prepared by the writer, augmented by data obtained from three new specimens found at Wilkawillina Gorge. Taylor (1910, p.137) placed the genus in the Archaeocyathidae because of its resemblance to A. sellicksi. R. and J. Bedford (1939, p.81) placed Somphocyathus in the Ajacicyathidae. The dense skeletal tissue in the central cavity of S. coralloides led Okulitch to place the species in a Family Somphocyathidae in his Order Anthomorphina (Okulitch, 1935, pp.97,98). Subsequently, Okulitch (1943,1955) placed the Somphocyathidae, containing only Somphocyathus coralloides, into a separate Order Somphocyathida.

Zhuravleva (1960b, p.110) tacitly placed Somphocyathus questionably in synonymy with Ajacicyathus. Debrenne (1964, p.232) concluded that Somphocyathus is a Regulare, of uncertain affinity. Hill (1965, p.62) considered Somphocyathus to be similar to Ajacicyathus and subsequently placed it questionably in synonymy with the latter (1972, p.E61).

The new data presented herein constitutes the first revision of this species. The holotype has a non-independent microporous sheath which is well displayed in thin section. The tabula-like structures in the intervallum are problematical. They are sporadic and apparently discontinuous, appearing only in some loculi.

It is not yet clear whether the fragments seen in thin section are genuine porous tabulae or the result of coalescing skeletal material in the intervallum, described as "styles" by Taylor. The material from Wilkawillina Gorge provides no additional information on these structures. Inner wall bracts are obscured by secondary thickening in the holotype which has been sliced into transverse or oblique sections. A longitudinal section through the upper part of a fragmentary specimen from Wilkawillina Gorge clearly shows the inner wall bracts, but is too incomplete to show tabulae.

If future new material reveals that tabulae of the porous plate type are present, then Erugatocyathus Debrenne sensu the writer's revised diagnosis (given on a later page) will become a junior synonym of Somphocyathus Taylor. They are maintained herein as separate genera because of the uncertainty regarding the tabular structure of Somphocyathus.

A longitudinal section prepared from a specimen of A. sellicksi Taylor has also revealed the presence of tabula-like structures. A sheath has not been seen on Taylor's specimens of A. sellicksi, but future material may show that this species belongs in the genus Somphocyathus. These two species are quite distinct. A. sellicksi has fewer outer and inner wall pores, closer septa and a correspondingly higher radial coefficient than S. coralloides.

Somphocyathus coralloides Taylor.

(Plate 11, Fig. 1,2; Plate 36, Figs. 7,8; Plate 37, Figs. 1 to 4)

HOLOTYPE. T1554, T1596 A,B,C. Four fragments of a single specimen.

TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Wirrealpa.

MATERIAL. T1554, T1596 A,B,C: three specimens from Wilkawillina Gorge, sections G and H: P21596; P21597-1; P21598.

DIAGNOSIS. As for the genus.

DISCUSSION. The hand specimen containing the holotype is cut from the same hand specimen which contains the holotype of Beltanacyathus wirrialpensis(Taylor). Two fragments of the holotype of B.wirrialpensis are contained in the matrix close to S.coralloides; these fragments are enumerated together with the holotype of B.wirrialpensis (See Chapter 7).

Hill (1965, p.62) erroneously stated that the age of S.coralloides is ? Middle Cambrian, thinking that it came from the Wirrealpa Limestone. The Wirrealpa Limestone contains Faunal Assemblage $\overline{X}$ which includes some Archaeocyatha, but not S.coralloides. (see Daily, 1956, p.115).

Somphocyathus coralloides is definitely from Lower Faunal Assemblage II. Evidence for this comes from the fact that other species on the same hand specimen are Beltanacyathus wirrialpensis (Taylor), Spirillicyathus pigmentum Bedford R. and J., and Copleicyathus scottensis sp. nov.. Specimens of all of these species have been found only in Lower Faunal Assemblage II in the Mount Scott Range. Finally, the three new specimens of S. coralloides all come from Lower Faunal Assemblage II at Wilkawillina Gorge.

DESCRIPTION. Solitary conical cups. The outer wall is surrounded by a more or less extensive zone of skeletal buttresses which radiate outward as extensions to the septa and interpore lintels. The outer wall has 4-9 rows of pores per intersept in irregular quincunx. Each outer wall pore is covered by a flat, non-independent microporous sheath, restricted only to the carcass pore openings. The sheath is open to the exterior through vertical slit-like canals between adjacent buttresses. The sheath has 2-4 circular or sector shaped micropores per carcass pore. The intervallum contains sparse radial septa pierced by evenly distributed rows of circular and oval pores. Tabula-like structures are sporadic and found only in certain intersepts; they do not appear to form continuous shelves like normal porous tabulae. The "tabulae" are pierced by large, rounded frequently anastomosing pores. Apparently isolated rounded masses of skeletal material are also sporadically developed in the intervallum ("styles" of Taylor). The inner wall has 4-6 rows of large rounded pores per intersept in irregular quincunx. The interpore lintels project a short distance into the central cavity as bracts with a shallow inverted U-shape. The apex of each bract supports a short vertical spine. The lower parts of the central cavity are filled with endothecal tissue which consists of a mass of skeletal material pierced by circular and oval canals of varying size and frequently anastomosing. The canals appear to open upwards into the central cavity. They are evidently a secondary growth. In one small specimen the central cavity is only partly filled. At higher levels, cups including the holotype, have an empty central cavity. Dissepiments are absent. Early stages of growth are unknown.

DIMENSIONS (mm)	Holotype T1554	Holotype T1596A	P21596
Diameter	9.7	17.2	13.3
Intervallum width	1.74-1.93	2.00-2.54	1.25-1.93
N	18	-	31
ds	1.28-1.65	1.38-1.93	1.09-1.21
IK	0.18-0.20	0.12-0.15	0.09-0.15
RK	1.86	-	2.33
Loculi	1/1.1-1/1.5	1-1/1.8	1-1/1.8
Outer wall carcass:			
n	6-8	6-9	5-8
d	0.15-0.19	approx.0.18	0.15-0.21
l	0.07-0.12	approx.0.07	0.05-0.10
t	0.12	approx.0.12	0.10
Outer wall sheath:			
n	2-3	? 3	2-4

d	0.05-0.07	0.05-0.06	0.05-0.07
l	0.01-0.02	approx.0.02	0.01-0.02
t	approx.0.02	approx.0.02	approx.0.02
Inner wall:			
n	3-4	4-6	4-6
d	0.17-0.24	approx.0.15-0.29	0.12-0.19
l	0.05-0.10	approx.0.07-0.12	0.07-0.12
Bract length	0.19-0.26	approx.0.24	0.17
Septa:			
n	6-8	7-8	? 6
d	approx.0.05-0.09	approx.0.10	approx.0.05-0.17
l	-	-	-
t	0.05-0.07	0.07	0.05-0.10
Tabula-like structures:			
n	-	-	-
d	0.15-?0.19	0.07-0.19	approx.0.17
l	0.05-0.12	0.03-0.12	approx.0.05-0.17
t	-	-	-

Note. The dimensions given above do not include secondary thickening which adds considerably to the thickness of walls and septa, and reduces septal and carcass pore dimensions. The septal pore sizes are approximate, obtained only from transverse and oblique sections.

COMPARISON AND REMARKS. Erugatocyathus madigani sp. nov. (described below) has similar growths of exothecal and endothecal tissue to Somphocyathus coralloides. However, E. madigani has tabulae of the normal type, a narrower intervallum, fewer wall pores, more numerous septa and a correspondingly higher radial coefficient. Specimens of E.madigani and S.coralloides have been found in the same hand specimen from Wilkawillina Gorge.

Specimens with non-independent sheaths and exothecal tissue similar to that described above for S.coralloides, have been found in Faunal Assemblage I at Wilkawillina Gorge. The material is at present too sparse to permit their identification, however, they differ from S. coralloides by having fewer, less regularly distributed outer wall pores and more frequent septa. Details of their tabulae, if present, are not known. Specimens of a similar type are also known from Upper Faunal AssemblageII in the Mount Scott Range. They differ from S. coralloides by having tabulae of the normal type, fewer wall pores and a higher radial coefficient. Again, the scarceness of the material does not yet permit their accurate identification.

The exothecal tissue of Somphocyathus coralloides Taylor.

A number of authors have suggested various explanations to account for the presence of exothecal lamellae around some Archaeocyatha. R. and J. Bedford (1937, p.33) suggested the possibility of parasitism and later erected a Suborder Cromnocyathina to accommodate the irregular commonly concentric forms (Bedford R. and J., 1939, p.79). Okulitch (1946), in a special study of exothecal lamellae, considered Taylor's opinion that they might be anchoring processes, was improbable. He concluded that exothecal tissue is built by the organism which constructed the cup, "by proliferation of the cells of the external covering or exotheca." (op.cit.p.81). Okulitch proposed several types of exothecal lamellae and illustrated Somphocyathus coralloides Taylor as an example of "exocyathomorphous exothecal tissue" (op.cit. Pl.6, Fig. 1. non Fig.3 (which is A. sellicksi Taylor)).

Recently Debrenne and Rozanov (1978) briefly reviewed the modes of occurrence of exothecal and endothecal structures and suggested that they might be compared with other organisms, in order to gain an understanding of their structure and function. They suggested a comparison of the skeletal microstructure of exothecal and endothecal tissue with that of Archaeocyatha lacking a central cavity, red or green algae and stromatoporoids.

The explanation of the function of the exothecal lamellae given below, is intended to apply only to Somphocyathus coralloides Taylor, but it may possibly apply to similar Regulares such as A. sellicksi Taylor. The present writer agrees with Taylor who stated that the exothecal lamellae attached the cup to the substratum.

Taylor (1910, p.135) described three well defined zones of exothecal lamellae. There is a fourth zone attached to the outer wall of the smallest known part of the cup (cup approximately 3mm in diameter). The zones are herein numbered one to four, the innermost zone at a cup diameter of approximately 3mm being zone one, and outer zones numbered successively two, three and four. Zone four is the outermost zone seen at all cup diameters.

Zone one is attached directly to the outer wall of the cup; it consists of outward radiating buttresses attached as extensions to the septa and interpore lintels - one buttress per lintel or septum. The outer circumference of zone one is thickened by transverse bars which connect adjacent buttresses.

Zone two consists of similar radial buttresses, attached to the thickened border which marks the outer circumference of zone one. Many of the buttresses bifurcate as they extend outwards. The outer circumference of zone two is marked by a thickening of the outer extremities of the buttresses.

Zone three is quite different in structure from the others. It is attached to the outer border of zone two, and initially consists of relatively few meandering or distorted buttresses which anastomose to enclose rounded spaces of varying size. This structure is very similar to the endothecal tissue found in the central cavity. The outer part of zone three consists of more regular, outward radiating buttresses. The outermost circumference of zone three is marked by

thickening and lateral linking of the buttresses.
Zone four is attached to this border. It consists of regular outward radiating buttresses which branch infrequently. The outermost circumference of this last zone is marked by slight thickening of the buttresses, but not enough to cause them to anastomose.

All of the above zones can be seen, at least in part, around the smallest available transverse section of the holotype. At a cup diameter of 9.7mm, only zones two, three and four are present. Zone one - originally the innermost - is missing. Zone two at this level is attached directly to the outer wall of the cup. Each buttress in zone two now corresponds to an extension of a lintel or septum at the outer wall. Zones three and four have the same structure as described above and are in the same relative positions; zone four still being the outermost. These are the zones described by Taylor; zone two - the innermost - is shown in his Fig.32 bis. at L. (See also Plate 37, Fig. 1, herein).

An additional thin section of the holotype, prepared by the writer, provides the following data.
At a cup diameter of 17.2mm zone two is missing. The irregular zone three is attached directly to the outer wall but there is no longer a one to one correspondence between the distorted buttresses and extensions to the lintels or septa. Zone four is still the outermost zone and has the same structure as described above. At this cup diameter the central cavity is empty (see Plate 37,Fig.2).

If the buttresses form anchoring processes, the following conditions should apply:

1. Small cups require a minimum of support.
2. With increasing growth new supports are added periodically to maintain cup stability.

3. The newly added supports must extend to the substratum.

These three conditions are exactly fulfilled by the exothecal tissue surrounding the holotype of S.coralloides. The smallest part of the cup is surrounded by all four zones of exothecal tissue because the outer zones have been successively added periodically during cup growth. The irregular zone three provides a good marker to indicate this fact. Numerical data also supports this, as follows. Because there is a one to one correspondence between each buttress attached directly to the outer wall and the lintels and septa of the outer wall of the cup, it follows that the number of buttresses in a given zone should correspond to the number of outer wall lintels and septa at the cup diameter when the buttresses were built.

The present writer counted the number of lintels and septal extensions for three different cup diameters on the holotype. For the same cup diameters the number of buttresses at the outer edges of zones two and four were counted, as well as the maximum diameter of each zone (measured diametrically across each transverse section). No attempt was made to count the buttresses of zone three because of its irregularity. The following data was obtained.

Cup diameter 9.7mm. Number of lintels and septa 116.
Diameter of zone two 13.8mm. Number of buttresses approx. 136.
Diameter of zone four approx. 23mm. Number of buttresses approx. 190.

Cup diameter 13.5mm. Number of lintels and septa 136.
Diameter of zone two 16.5mm. Number of buttresses approx. 160.
Diameter of zone four 26mm. Number of buttresses approx. 230.

Cup diameter 17.2mm Number of lintels and septa approx. 164.

Diameter of zone four 25.7mm. Number of buttresses approx. 220.

The results are shown graphically in Text-fig. 23. From the graph it is evident that the number of buttresses in a zone corresponds fairly well with the number of outer wall lintels and septa since the points plot more or less on a straight line. In particular, at a cup diameter of 9.7mm the diameter of zone two is 13.8mm and the number of buttresses it contains matches very closely with the number of lintels and septa at a cup diameter of 13.5mm.

This data indicates that the buttresses in each zone were initially fixed to the outer wall and they extended downwards to the substratum with no additional vertical branching once they had formed. The radial branching which increases the number of buttresses in a zone, probably corresponds to the addition of new lintels and septa as the cup grew.

The maximum diameter of the outermost zone four probably corresponds with the maximum diameter of the cup at the time the organism ceased to grow i.e. approximately twenty seven millimetres. The extensive zones of exothecal tissue around the smallest part of the cup were not connected with its functioning at that level; they were added later. Taylor indicated the similarity between the endothecal tissue and the exothecal tissue of the irregular zone three. They were possibly formed at the same time. Evidence in support of this suggestion is provided by a small cup from Wilkawillina Gorge. The cup diameter is 6.1mm; it is surrounded by only two zones of exothecal tissue with a maximum diameter of approximately 13mm, allowing for some removal of the buttresses by erosion. The cup was probably not much larger than 13mm at the time the organism died. The central cavity is only partly filled with endothecal tissue. This strongly suggests that the endothecal tissue is a secondary addition.

In conclusion it is suggested that the exothecal tissue of Somphocyathus coralloides Taylor served to anchor the cup to the substratum. Additional zones were built with increasing cup growth. The living tissue sited against the outer wall of the cup exerted total control over the growth of the buttresses and was capable of extending a "mantle" to the substratum in order to build them. It is worth noting that the outer wall sheath micropores were open to the exterior through slit-like channels between the buttresses. This contrasts strongly with Coscinocyathus vestitus sp.nov. whose outer wall is simply porous. The exothecal lamellae in the latter species are dense and compact, eventually sealing the outer wall pores. The exothecal tissue of C. vestitus is also believed to have been a support for the extremely fragile cup.

The writer hopes that the future discovery of new specimens of S.coralloides will support his conclusions. It is suggested that a similar method could be applied to other species with regular radial outgrowths to see whether or not they performed a role as anchoring processes.

Genus ERUGATOCYATHUS Debrenne, 1969.

1969 Tomocyathus (Erugatocyathus) Debrenne, p.334.
1970 Erugatocyathus Debrenne, p.33.
1972 Erugatocyathus Debrenne; Hill. p.E101.
1973 Erugatocyathus Debrenne, p.18.
1978 Erugatocyathus Debrenne; Kruse, p.36.

Type species. Coscinocyathus papillatus Bedford R. and W.R., 1934.

DIAGNOSIS. Solitary or colonial cups. The outer wall consists of a porous carcass covered by a non-independent microporous sheath. The microporous sheath may be continuous or discontinuous. The intervallum contains porous septa and tabulae. The inner wall is simply porous with several rows of pores per intersept. Curved bracts or spines are directed upward or downward into the central cavity, sometimes fused to the opposite lintel, and partly restricting the inner wall pore openings. No spines radiate across the inner wall pore openings. Additional spines may be present on the upper surfaces of the major bracts and spines.

DISCUSSION. Debrenne (1973, p.18) based her diagnosis of the genus Erugatocyathus on the species E. papillatus (Bedford R. and W.R.), which was the only one then known. The inner wall pores of this species are covered by curved bracts connected to the lintels above and below each pore, allowing only lateral openings into the central cavity. Kruse (1978, p.36) described a new species E. cymbricensis with inner wall bracts attached only to the lintels above the inner wall pores. New species from South Australia also have their bracts attached only to the lintels above the pores. Some species have very short bracts, others have long spines rather than bracts. One species has bracts attached to the lintel below each inner wall pore and directed upwards into the central cavity.

The diagnosis is revised herein to include species in which bracts or spines curve upward or downward into the central cavity as well as species whose bracts are fused to both the upper and lower lintels. Anaptyctocyathus differs from Erugatocyathus by the complete absence of significant bracts or spines on the inner wall, although small spines which do not obscure the inner wall pores may be present. Lunulacyathus differs from Erugatocyathus by the by the presence of bracts on both walls. Veronicacyathus differs from the other genera by the presence on the inner wall of spines which radiate inwards across the inner wall pore openings. The genus Bractocyathus Kruse is considered herein to belong to the

Anaptyctocyathidae. The inner wall pores of this species are partly obscured by spinose plates but its outer wall sheath is quite different from those of other genera in the family. (See Chapter 4 for discussion). Both *Veronicacyathus* and *Bractocyathus* may have their inner wall pores opening into pore tubes.

Erugatocyathus krusei sp. nov.

(Plate 9, Fig. 3; Plate 37, Figs. 5 to 8)

NAME. After P. Kruse, Department of Geology and Geophysics, University of Sydney.

HOLOTYPE. P21599 (four thin sections).

PARATYPE. P21600.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section F.

MATERIAL. Four specimens from Wilkawillina Gorge, sections E and F. Holotype and paratype as above. Additional specimens: P21601; P21602.

DIAGNOSIS. As for the genus. This species has a non-independent continuous microporous sheath where buttresses are not developed on the exterior of the outer wall. The growth of buttresses appears to modify the sheath.

DESCRIPTION. Solitary conical cups with a narrow intervallum. The outer was has 2-4 rows of pores per intersept in quincunx. Pores are circular on the intervallum side and expand outwards to form vertically stretched hexagonal openings at the outer surface. Each outer wall pore is covered by a non-independent microporous sheath which is continuous over the outer surface of the cup. The micropores are circular in shape, peripheral micropores are notched into the surrounding lintels. The intervallum contains radial septa pierced by oval pores. Pores are frequently covered by secondary skeletal tissue and their precise arrangement is not known. Tabulae are sparse, flat, pierced by circular pores. The inner wall is simply porous with 2-6 rows of pores per intersept in quincunx. The lintel above each pore is extended to form a short beak which curves slightly downwards into the central cavity. One or more short spines project upwards from the summit of each beak. Secondary thickening of the inner wall lintels gives a false impression of inner wall pore canals. Near the base of the cup and extending some distance upwards, the outer wall lintels and septa are extended as a zone of outward radiating buttresses, with intervening canals which allow the outer wall pores to have access to the exterior. Where buttresses are not formed on the outer wall, the sheath micropores form a continuous sheet over the outer surface of the cup. Where buttresses are present, the outer wall carcass pores are smaller. They are circular rather than hexagonal and the number of sheath micropores is reduced to 4-7. The sheath does not continue around the outer wall beneath the buttress material and is only formed in the canals between adjacent buttresses. Sparse dissepiments are present in the intervallum and central cavity near the base of the cup.

Early stages of growth are masked by secondary thickening and outgrowths from the walls. However, a microporous sheath is visible at a cup diameter of 2.0mm.

DIMENSIONS (mm)	Holotype P21599	Paratype P21600	P21601
Diameter	14.2	14.1	10.4
Intervallum width	0.62-1.24	0.86	0.87-0.97
N	64	-	55
ds	0.79	0.50-0.96	0.36-0.80
IK	0.065	0.061	0.084-0.094
RK	4.5	-	5.3
Loculi	1/0.6-1/1.6	1/0.9-1/1.7	1/1.1-1/2.7

Outer wall carcass:			
n	2-4	2-4	2-4
d	0.17 (at sheath)	0.17 (at sheath)	0.05(at base)
l	0.03-0.17	?0.03-0.12	0.07-0.10
t	0.12-0.15	0.10	0.12
Outer wall sheath:			
n (per carcass pore)	4(rare)-12	-	-
d	0.03-0.05	-	-
l	0.01	-	-
t	0.02	-	0.02
Inner wall:			
n	3-6	2-3	2-4
d	-	0.10-0.19x0.10	0.07-0.10
l	-	0.07-0.15	0.07-0.10
t	0.07	0.07	0.07
Septa:			
n	4-5	4	3-4
d	0.13x0.06	0.06-0.12	-
l	0.10-0.13	0.10	-
t	0.05	0.03	0.05
Tabulae:			
n	approx.4x4	-	-
d	0.06-0.10	-	-
l	0.05-0.10	-	-
t	0.05	0.05	0.05
Vertical separation	-	1.1-3.1	-

Note. The dimensions above do not include secondary thickening of the walls, septa and tabulae. average thickness ?

COMPARISON AND REMARKS. E. krusei sp. nov. differs from other species in the genus by the shape of its carcass pores and by the number, size and arrangement of the sheath pores. The bracts on the inner wall are very short if secondary thickening is excluded. At present the species is placed in the genus Erugatocyathus, but new material is required for a more accurate determination of the inner wall.

The modification of the microporous sheath in the presence of skeletal buttresses over the outer wall presents an interesting problem. Certainly a sheath was formed before the buttresses. Assuming that the buttresses are added for cup stability in a manner similar to that described for S.coralloides, it is clear that the very narrow lintels which support the sheath are not sufficiently wide to support newly added buttresses. The lintel width between the carcass pores at the sheath is 0.03mm, whereas the width of each buttress is 0.07mm. It appears that the sheath is resorbed and the carcass pore lintels thickened to support the buttresses. A modified sheath is then rebuilt between adjacent new buttresses.

Erugatocyathus madigani sp. nov.

(Plate 10, Fig. 7; Plate 38, Figs. 1 to 6)

NAME. After the late Dr. C.T. Madigan, geologist and explorer, formerly of the Department of Geology and Mineralogy, University of Adelaide.

HOLOTYPE. P21603 (seven thin sections).

PARATYPE. P21604.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Three specimens from the Mount Scott Range, section N, one specimen from Wilkawillina Gorge, section G. Holotype and paratype as above. Additional specimens: P21605-1; P21606.

DIAGNOSIS. As for the genus. This species has a discontinuous sheath due to the presence of exothecal tissue on the outer wall. Possible sheath continuity in the absence of exothecal tissue is not known.

DESCRIPTION. Tall cylindro-conical cups with a narrow intervallum. The outer wall has 2-4 rows of circular and oval pores per intersept in quincunx. Each outer wall pore is covered by a flat, non-independent microporous sheath. Exothecal tissue restricts the sheath to the openings of the underlying carcass pores. The intervallum contains frequent radial septa pierced by evenly distributed rows of oval pores in irregular quincunx. Pores are frequently sealed by secondary skeletal material. Tabulae are sparse, flat, pierced by closely spaced circular pores of variable size. The inner wall is simply porous with 2-3 rows of pores per intersept in quincunx. Pores are circular on the intervallum side and expand laterally to an oval shape on the side facing the central cavity. Each inner wall pore is partly obscured by a short beak-like bract which curves downwards into the central cavity. A short spine or wedge shaped plate projects upwards from the summit of each bract to partly obscure the opening of the pore above. Additional spinules project obliquely upward into the central cavity from the upper surface of each bract. Outward radial extensions of the septa and outer wall lintels forms a narrow zone of exothecal tissue (buttresses) around the cup. The sheath communicates with the exterior in the canal-like spaces between the buttresses. Endothecal tissue is present in the lower parts of the central cavity. Sparse dissepiments are present in the intervallum and central cavity near the base of the cup. Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21603	Paratype P21604
Diameter	6.1	16.8
Intervallum width	1.02	1.11-1.21
N	28	117
ds	0.46-0.58	0.24-0.63
IK	0.17	0.07
RK	4.6	7.0
Loculi	1/1.8-1/2.2	1/1.8-1/5.0
Outer wall carcass:		
n	2-4	2-4

d	0.12-0.17	0.12-0.15
l	0.06-0.10	0.03-0.05
t	0.05	0.10
Outer wall sheath:		
n	2	2-4
d	0.05-0.07	0.03-0.05
l	0.01	0.01-0.02
t	0.01-0.02	0.01-0.02
Inner wall:		
n	2-3	2-3
d	0.12-0.15	0.10x0.17
l	0.06-0.10	0.05-0.08
t	0.07	0.05-0.07
Septa:		
n	approx. 5	5-6
d	0.05-0.10	0.06-?
l	0.12	-
t	0.05	0.05
Tabulae:		
n	-	3x? 8
d	approx.0.05-0.12	0.03-0.15
l	-	0.03-0.04
t	0.05-0.07	0.04-0.05
Vertical separation	2.4-4.2	-

Note. The dimensions above do not include secondary thickening of the walls, septa and tabulae. average thickness

COMPARISON AND REMARKS. E. madigani sp. nov. differs from the older species E. krusei by its higher radial coefficient and different outer wall carcass pore shape. In addition, the sheath of E.madigani has fewer micropores per carcass pore. However, this may be due to the greater development of exothecal tissue around the outer wall of E. madigani in the specimens found to date. As stated above, the sheath of E. krusei has 4-7 micropores where buttresses are present.

Erugatocyathus tatei sp. nov.

(Plate 10, Fig. 4; Plate 38, Figs. 7 to 10)

NAME. After Professor R. Tate, Elder Professor of Natural Science (1876-1901), University of Adelaide.

HOLOTYPE. P21607 (three thin sections)

PARATYPES. P21608; P21609-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Nine specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21510-2; P21610; P21611-1, -2; P21612; P21613.

DIAGNOSIS. As for the genus. This species has a discontinuous micro-porous sheath.

DESCRIPTION. Two walled conical cups. The outer wall has 2-4 (rarely up to 5) rows of pores per intersept, usually in quincunx. Pores are circular and oval, increasing in size to the exterior. Each outer wall pore is covered by a flat, non-independent microporous sheath. The sheath is discontinuous, covering only each carcass pore opening. Circular carcass pores are usually subdivided into 4 sheath micropores; oval carcass pores may have up to 6 sheath micropores. Micropores are petaloid in shape and a central micropore is rarely present. Each carcass pore is bordered near the intervallum side by an extremely thin internal flange or rim. This may be a series of spinules radiating across the pore opening, or a second micro-porous sheath within the pore itself. The intervallum contains radial septa pierced by circular and oval pores. In most cases the pores are evenly distributed, but in some cups there are expanses of septa close to the inner wall where septal pores are very sparse. Tabulae are sparse, weakly convex, pierced by rounded pores of varying size. The inner wall is simply porous with 2-3 rows of pores per intersept in irregular quincunx. Pores are circular and oval in shape. The lintel between each inner wall pore arches into the central cavity as a bract with an inverted U-shape. A vertical flat to slightly curved wedge-shaped plate parallel to the inner wall, is fixed to the upper surface of each bract. The upper edge of each plate is surmounted by three or more tufts of spinules. Additional spinules project obliquely upward from the upper surface of each bract, and into the central cavity from the inner surface of each plate.

Early growth stages are not known.

DIMENSIONS (mm)	Holotype P21607	Paratype P21608	Paratype P21609-1
Diameter	approx. 9.0	7.5	6.0
Intervallum width	1.08	1.02	0.69-0.89
N	approx. 54	-	35
ds	0.39-0.58	0.46-0.48	0.34-0.44
IK	0.12	0.15	0.11-0.15
RK	approx.6.0	-	5.83
Loculi	1/1.9-1/2.8	1/2.3	1/1.6-1/2.6
Outer wall carcass:			
n	2-4	3-4	3-4
d	0.15	0.12-0.15	0.12-0.15
l	0.05	0.07	0.07
t	0.10-0.12	0.10	0.07-0.10
Outer wall sheath:			
n	4-6	-	2-6
d	0.05-0.06	-	0.04-0.06
l	approx.0.01	-	0.01
t	0.01-0.02	approx.0.01	0.01
Inner wall:			
n	2-3	2-3	2-3
d	0.12	0.11-0.19x0.13	approx.0.12
Bract length	0.12	0.12	0.10-0.12
Plate length	0.10	0.07-0.10	0.05-0.10

Septa:			
n	6	5-6	5
d	0.07x0.12	0.07x0.15	0.07
l	0.07-0.15	0.09-0.12	0.07-0.10
t	0.05	0.05	0.04-0.05
Tabulae:			
n	3x11-5x11	-	6x?
d	0.03-0.12	-	0.05-0.10
l	0.03	-	0.02-0.03
t	0.06	0.05	0.06
Vertical separation	One seen	Very distant	-

COMPARISON AND REMARKS. *E. tatei* sp. nov. differs from other species in the genus by the commonly petal-like arrangement of the sheath micropores and by the presence of a flat to curved plate fixed to the top of each bract.

Erugatocyathus mawsoni sp. nov.

(Plate 10, Figs. 1 to 3; Plate 39, Figs. 1 to 5)

NAME. After the late Sir Douglas Mawson, formerly head of the Department of Geology and Mineralogy, University of Adelaide.

HOLOTYPE. P21552-1 (four thin sections)

PARATYPES. P21473-2; P21474-2; P21614-1.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Seventeen specimens from the Mount Scott Range, section N. Holotype and paratypes as above. Additional specimens: P21417-6; P21420-2; P21465-3; P21466-2, -3; P21588-2; P21591-1; P21605-2; P21615-1; P21616-1; P21617 to P21619.

DIAGNOSIS. As for the genus. This species has a more or less continuous spinose sheath and long spines rather than bracts on the inner wall.

DESCRIPTION. Two walled conical cups. The outer wall has 2-5 rows of circular pores per intersept. In longitudinal section the pores are funnel-shaped, widening outwards. Each carcass pore is overlain by a flat, non-independent microporous sheath. This consists of a central boss, spinose on its outer surface, surrounded by a ring of peripheral micropores. The outer edges of the micropore lintels are also spinose. The sheath is continuous over larger carcass pores, but where the carcass pores are smaller than average the sheath is discontinuous. A second, extremely thin ? microporous membrane bulges outward from a flange which rims each carcass pore internally close to the intervallum side. The intervallum contains radial septa pierced by evenly spaced rows of circular and oval pores in quincunx. Pore rows in the outer part of the intervallum diverge gradually towards the outer wall. Tabulae are weakly convex and irregularly spaced, usually more frequent in the lower parts of the cup. Pores in the tabulae are circular to polygonal in shape, with the larger pores partly subdivided into lobes by short inward protrusions from the lintels. The protrusions do not completely subdivide the tabular pores. The inner wall has 2-3 rows of circular pores per intersept in quincunx. Two long spines project into the central cavity from the lintels between each pore. One spine projects more or less horizontally into the central cavity; the other spine is attached to the first spine close to the inner wall and projects obliquely upwards in front of the overlying pore. Where well developed, the second spine curves to become parallel to the first and may reach a similar length. Both spines bear tufts of small spinules on their upper surfaces.

Early growth stages are unknown.

DIMENSIONS (mm)	Holotype P21552-1	Paratype P21614-1	Paratype P21473-2
Diameter	7.8-18.5	8.7-10.5	6.6
Intervallum width	1.33-2.49	1.38-1.55	1.04
N	29(7.8)	37(8.7)	29
ds	0.59-0.76	av.0.49	0.25-0.70
IK	0.17-0.21(7.8)	0.16(8.7)	0.16
RK	3.7	4.3	4.4
Loculi	1/1.8-1/2.8	1/2.8	1/1.5-1/4.2
Outer wall carcass:			
n	3-4	3-5	3-4
d	0.22-0.25	-	0.20
l	0.05	-	0.03-0.07
t (excluding sheath)	0.08-0.12	0.08-0.12	0.12
Outer wall sheath:			
n	6	-	5-7
d	0.07-0.12	-	0.05-0.07
l	0.03	-	0.03
t (excluding spinules)	0.03	-	0.03
Inner wall:			
n	2-3	2-3	2-3
d	0.19-0.23	-	0.10 near base
l	0.07	-	approx. 0.10
t	0.07	0.07	0.10
Spine length	max. 0.63	max.0.38	max.0.50
Septa:			
n	8-10	8-9	6-7
d	0.18x0.10-0.23x0.12	0.10-0.12x0.17	0.12x0.07
l	0.10-0.19	0.12	0.10
t	0.06	0.05	0.05-0.07
Tabulae:			
n	-	2-7x?	-
d	0.10	0.06-0.12	0.07-0.10
l	0.04	0.04	0.03-0.05
t	0.05-0.10	0.05-0.10	0.05
Vertical separation	4.7-6.2	0.4-3.5	1.3-3.9

COMPARISON AND REMARKS. Erugatocyathus mawsoni sp. nov. differs from other species in the genus by its spinose sheath and by the shape and arrangement of its inner wall spines.

Erugatocyathus inflexus sp. nov.

(Plate 11, Figs. 3, 4; Plate 39, Figs. 6 to 9)

NAME. From Latin inflexus = curved.

HOLOTYPE. P21417-2 (five thin sections).

PARATYPES. P21620; P21621; P21424-2.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Five specimens from the Mount Scott Range, section N; one specimen from Wilkawillina Gorge, section H. Holotype and paratypes as above. Additional specimens: P21475-2; P21452-2.

DIAGNOSIS. As for the genus. This species has a discontinuous sheath; and spines, rather than bracts on the inner wall.

DESCRIPTION. Two walled conical cups. The outer wall has 2-5 rows of circular pores per intersept in quincunx. In longitudinal section the pores are funnel-shaped, widening outwards. Each carcass pore is covered by a flat, non-independent microporous sheath restricted only to the underlying carcass pore openings. Thin skeletal rod-like threads extend diametrically across the carcass pores separating sectors which constitute the micropores. A central micropore is absent. Each carcass pore has a very thin internal rim or flange a short distance below the sheath. This may form part of a second microporous system or a series of inward radiating spines; its exact nature is unknown. The intervallum contains radial septa pierced by evenly spaced rows of pores in irregular quincunx. Pores are circular and oval in shape. Tabulae are flat to weakly convex, infrequent and unevenly spaced. Pores in the tabulae are circular to subpolygonal in shape with no protrusions across their openings. The inner wall has 2-4 (rarely 1) rows of pores per intersept but their arrangement is not known. Pores are circular in shape. A long curved or geniculate spine extends into the central cavity from the lintel between each pore. Near the inner wall, each spine slopes obliquely downward, but reverses direction at its mid point so that its tip is directed obliquely upwards into the central cavity.

Early growth stages are unknown.

DIMENSIONS (mm)	Holotype P21417-2	Paratype P21620	Paratype P21621
Diameter	12.6	17.9	15.0
Intervallum width	1.58	1.50-1.68	1.57-1.87
N	50	-	62
ds	0.56-0.75	0.37-0.67	0.44-0.85
IK	0.13	0.09	0.11-0.13
RK	3.98	-	4.14
Loculi	1/2.1-1/2.8	1/2.2-1/4.0	1/1.9-1/4.3
Outer wall carcass:			
n	3-4	3-5	2-4
d	0.15-0.24	0.16-0.23	0.12-0.32
l	0.07-0.10	0.07	0.07-0.10
t (excluding sheath)	0.07-0.10	0.07-0.10	0.07-0.12
Outer wall sheath:			
n	3-5	3-6	3-5
d	0.07-0.10	0.07-0.09	0.07-0.10
l	approx.0.01	0.01-0.02	0.02
t	0.02	-	0.02
Inner wall:			
n	2-3	2	1-3
d	0.24	-	0.24
l	approx.0.06	-	0.05-0.12
t	0.05-0.07	0.07-0.10	0.12-0.15
Spine length	0.51	max.0.61	max.0.46
Septa:			
n	approx. 6	7	6
d	0.12x0.07-0.17x0.09	0.17x0.10	0.10-0.15
l	av. 0.12	0.12-0.15	0.10-0.17
t	0.05-0.06	0.06	0.05
Tabulae:			
n	3-5x?	2x8-5x9	3x8-4x8
d	0.05-0.10	0.07-0.24x0.15	0.05-0.17

l	-	0.03-0.05	0.05-0.07
t	0.05	0.05-0.07	0.07
Vertical separation	3.1-9.7	2.9-4.7	2.7-6.8

COMPARISON AND REMARKS. Erugatocyathus inflexus sp. nov. superficially resembles E. mawsoni, but its sheath is quite different. The arrangement of inner wall spines also differs. Specimens belonging to these two species could be confused if the outer wall sheath and inner wall spines are not preserved.

Erugatocyathus aquilinus sp. nov.

(Plate 10, Figs. 5, 6; Plate 40, Figs. 1 to 5)

NAME. From Latin aquila = eagle.

HOLOTYPE. P21535-2 (four thin sections).

PARATYPES. P21412-1; P21412-8; P21522-4; P21622.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Twelve specimens from the Mount Scott Range, section N; one specimen from Wilkawillina Gorge, section H. Holotype and paratypes as above. Additional specimens: P21412-3; P21419-2; P21509-2; P21539-4; P21559-3; P21616-2; P21623; P21624.

DIAGNOSIS. As for the genus. This species usually has a discontinuous sheath, but it is sometimes continuous across several carcass pores.

DESCRIPTION. Two walled conical cups with a narrow intervallum. Cups are cylindrical or conical; a fragment of a warped cup has also been found, in which the inner wall appears on the outer surface. The outer wall has 3-6 rows of circular pores per intersept in quincunx. Each outer wall pore is covered by a flat, non-independent microporous sheath which normally covers only the carcass pore opening, but in a single specimen the sheath may be either discontinuous, or continuous where carcass pores are sufficiently close. The number and size of micropores per carcass pore is variable. A central micropore is commonly absent, rarely present. Each outer wall carcass pore has an internal rim or flange which bulges outward a short distance below the sheath. The intervallum contains radial septa pierced by sparse, uniformly distributed rows of pores in quincunx. Septal pores are oval in shape. Tabulae are flat to weakly convex and very sparse. Pores piercing the tabulae are circular; larger pores are partly subdivided into lobes by skeletal protrusions from the lintels. The inner wall is simply porous with 1-5 rows of pores per intersept. On fragments of warped cups where the inner wall is strongly curved there may be up to 10 rows per intersept. The inner wall pores are circular and oval in shape, rows are in quincunx. Each inner wall pore is partly covered by a bract from the overlying lintel. The bract extends into the central cavity as a sharp downward curved spine. A very short spine extends upwards from the upper surface of the bract. Each combined spine and bract is S-shaped in longitudinal section. There are no additional spines or spinules on the bracts, which are quite smooth.

Early growth stages are unknown.

DIMENSIONS (mm)	Holotype P21535-2	Paratype P21412-1	Paratype P21622
Diameter	4.7	15.7-18.2	6.6
Intervallum width	0.89	0.83-0.85	1.09-1.18
N	-	85(15.7)	17
ds	0.99	0.39-0.78	0.90-1.02
IK	0.19	0.05	0.17
RK	-	5.4(15.7)	approx.2.5
Loculi	1/0.9	1/1.1-1/2.2	1/1.1-1/1.3
Outer wall carcass:			
n	3-6	3-5	3-5

d	0.12	0.15-0.17	approx.0.17
l	0.06-0.10	0.04-0.10	-
t (excluding sheath)	0.09	0.09-0.12	0.07-0.09
Outer wall sheath:			
n	2-5	5-8	-
d	0.06-0.07	0.04-0.05	-
l	0.02-0.03	0.01-0.02	-
t	0.02	0.02	approx.0.01
Inner wall:			
n	2-3	3-5	2-5
d	0.11-0.15	approx.0.10	0.19x0.10
Bract length	0.24	0.24-0.26	0.17-0.24
Septa:			
n	4-6	4-5	4-5
d	0.17x0.09	0.10x0.07-0.13x0.09	0.17x0.12
l	0.10	0.10-0.12	0.10-0.12
t	0.05-0.06	0.05-0.07	0.05-0.07
Tabulae:			
n	-	8x4-8x8	10x7
d	0.07-approx.0.17	0.04-0.10	0.07-0.12
l	-	0.04	0.03-0.04
t	0.05-0.07	0.07	0.05
Vertical separation	-	12.4	4.8-6.3

COMPARISON AND REMARKS. Erugatocyathus aquilinus sp. nov. differs from other species in the genus by its very narrow intervallum and irregularly folded or pipe-like form. The inner wall bracts have a distinctive shape and they lack additional spinules.

Erugatocyathus oppositus sp. nov.

(Plate 11, Fig. 6; Plate 40, Figs.6 to 9; Plate 41,Figs.1 to 3)

NAME. From Latin oppositus = opposite.

HOLOTYPE. P21507-4 (three thin sections).

PARATYPES. P21614-2; P21625.

TYPE FORMATION. Ajax Limestone. Lower Faunal AssemblageII.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Nine specimens from the Mount Scott Range, section N; one specimen from Wilkawillina Gorge, section H. Holotype and paratypes as above. Additional specimens: P21466-8; P21423-4; P21524-4; P21592-2; P21615-3; P21626; P21627.

DIAGNOSIS. As for the genus. This species has spines directed upward into the central cavity.

DESCRIPTION. Two walled conical cups. The outer wall has 3-6 rows of rounded pores per intersept. In longitudinal section the pores expand slightly outwards. Each carcass pore is covered by a non-independent microporous sheath which is usually restricted to the carcass pore opening, although there may be partial continuity across several adjacent carcass pores. There are 2-6 micropores per carcass pore. Micropores are circular and a central micropore is absent. There is no sign of any internal rim or flange in the carcass pores. In some specimens the lintels between the carcass pores slope obliquely upwards to the exterior near the tops of the cups. The intervallum contains radial septa pierced by evenly distributed rows of pores in irregular quincunx. Pores are circular and oval in shape; the pore rows diverge gradually towards the inner and outer walls and emerge there as stirrup-pores. Tabulae are weakly concave to weakly convex and frequent, but irregularly spaced. The tabulae are pierced by numerous small rounded pores. The inner wall has 2-4 rows of circular and horizontally stretched oval pores per intersept. Adjacent pores are side by side or in quincunx. Each inner wall pore opening is partly obscured by an upward curving spine projecting from the underlying lintel. The tip of each spine terminates in a tuft of spinules.

DIMENSIONS (mm)	Holotype P21507-4	Paratype P21614-2	Paratype P21625
Diameter	8.6	5.4	5.9
Intervallum width	1.67-1.77	1.23	1.40-1.45
N	approx.29	approx.18	-
ds	0.44-0.80	0.56-0.85	0.48-0.94
IK	0.19-0.21	0.23	0.24
RK	approx.3.4	approx.3.3	-
Loculi	1/2.1-1/4.1	1/1.5-1/2.2	-
Outer wall carcass:			
n	3-5	4-6	3-6
d	0.17-0.22	0.15	0.10-0.17
l	0.03	0.05-0.07	0.05-0.07
t (excluding sheath)	0.10-0.15	0.06-0.09	0.07-0.10
Outer wall sheath:			
n	3-6	3-?5	2-?4
d	0.06-0.07	0.05	0.04-0.05
l	0.02-0.03	0.02	0.01
t	approx.0.03	0.02	0.01
Inner wall:			
n	2-3	3-4	3-4
d	0.12-0.18	0.12x0.08-0.15	0.17x0.10
l	0.05	0.03-0.04	0.05-0.08
t	0.12	0.07	0.12
Spine length	0.24	0.22	0.24
Septa:			
n	9	7	8
d	0.06-0.11	0.07-0.12(rare)	0.08-0.12
l	0.09-0.12	0.05-0.10	0.07
t	0.05-0.07	0.04-0.05	0.05-0.07
Tabulae:			
n	13x5	13x?6	?8x?4
d	0.04-0.10	0.05-0.09	-
l	0.03-0.07	0.03	-
t	0.05	0.05	0.05
Vertical separation	0.87-2.70	0.29-1.48	0.17-2.12

ONTOGENY. At the smallest known cup diameter of 1.5mm the inner wall and central cavity have been formed. The inner wall lacks spines, secondary thickening obscures the outer wall. Septa have 2 rows of pores, one tabula is visible. Inner wall spines form at a cup diameter of 2.13mm. At this stage the outer wall sheath has formed but its moment of appearance is not known.

COMPARISON AND REMARKS. Erugatocyathus oppositus sp. nov. differs from other species in the genus by the upward inclination of the inner wall spines. Debrenne (1975a, p.341) has stated that the inner wall of E. scutatus (Hill) has upward directed bracts, but these are broad, spoon-like scoops and not relatively narrow spines as found on the inner wall of E. oppositus.

Erugatocyathus howchini sp. nov.

(Plate 9,Figs.4 to 6;Plate 41,Figs.4 to 9;Plate 42,Fig.1; Text-fig. 24.)

NAME. After the late Professor W.Howchin, formerly of the Department of Geology and Mineralogy, University of Adelaide.

HOLOTYPE. P21590-1 (four thin sections).

PARATYPES. P21539-2; P21615-2; P21628-1; P21629; P21630.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Six specimens from the Mount Scott Range, section N. Holotype and paratypes as above.

DIAGNOSIS. As for the genus. This species has a colonial form and a very finely porous, continuous sheath.

DESCRIPTION. Small colonial cups. New individuals are formed by indentation of the walls; three or four new cups may grow almost simultaneously. The outer wall has 3-6 rows of pores per intersept in quincunx. Pores are circular on the intervallum side and expand outward to an oval or rounded hexagonal shape. Each carcass pore is covered by a flat, thin, non-independent microporous sheath. The sheath is continuous over the outer surface of the cup. Each carcass pore is covered by 8-12 micropores; peripheral micropores are notched into the surrounding lintels. The micropores are circular in shape, very small and close together. In the best preserved specimens a thin internal rim or flange is present in the carcass pores a short distance below the sheath. The intervallum contains irregularly spaced septa pierced by sparse circular and oval pores. Pores are uniformly distributed across the intervallum. Adjacent vertical rows are in irregular quincunx. Tabulae are flat to weakly convex, fairly frequent but irregularly spaced. Pores piercing the tabulae are circular to subpolygonal and of varying diameters. The inner wall has 1-5 rows of circular pores per intersept in quincunx. Each pore is partly obscured by a hooked bract which curves downward into the central cavity from the overlying lintel. The summit of each bract is surmounted by a crest of short vertical spines which partly obscure the opening of the overlying pore. Early stages of growth are not known. A longitudinal section through one specimen shows the first formed cup in a colony. All of the adult characteristics are present at a cup diameter of approximately 3mm. New cups are formed when the original cup reaches a diameter of 6.8mm. The base of the original cup is surrounded by tersioid outgrowths. Sparse dissepiments are present in the intervallum and central cavity.

DIMENSIONS (mm)	Holotype P21590-1	Paratype P21628-1	Paratype P21615-2
Diameter	max.4.4	4.8	4.3
Intervallum width	0.67-0.78	0.74-0.84	0.73-0.75
N	27	-	24
ds	0.29-0.56	0.44	0.34-0.48
IK	0.15-0.18	0.15-0.17	0.17-0.18
RK	6.10	-	5.64
Loculi	1/1.2-1/2.7	1/1.7-1/1.9	1/1.5-1/2.2

Outer wall carcass:			
n	3-6	3-5	3-6
d	0.07-0.17	0.12-0.15	0.07-0.15
l	0.03-0.05	0.02-0.05	0.03-0.08
t (excluding sheath)	0.07-0.12	0.07-0.15	0.07-0.12
Outer wall sheath:			
n	approx. 8-12	approx. 12	9-?12
d	0.02-0.03	0.02-0.03	0.02
l	0.01	0.01	0.01
t	0.01-0.02	0.01	approx.0.01
Inner wall:			
n	1-3	2-4	2-5
d	0.09-0.10	0.08-0.12	0.07-0.10
l	0.05-0.07	0.05-0.07	0.04-0.06
t	0.07	0.05-0.07	0.05
Bract length	0.05-0.10	0.05-0.10	0.05-0.10
Septa:			
n	3-4	4	3-4
d	0.05-0.08	0.08x0.07-0.12x0.10	0.05-0.11
l	0.05-0.12	0.07-0.15	0.07-0.15
t	0.05	0.04	0.04
Tabulae:			
n	5x4	-	3x?6-4x?6
d	0.06-0.15	0.06-0.12	0.06-0.10
l	0.02-0.05	0.03	0.03-0.05
t	0.05	0.05	0.05
Vertical separation	1.64-3.50	2.13-3.78	1.55-2.90

COMPARISON AND REMARKS. Erugatocyathus howchini sp. nov. differs from other species of the genus by its colonial form and continuous non-independent sheath, which has minute but very numerous pores. The species described above very closely resembles Polycoscinus contortus (Bedford R. and J.) which is thought to have an independent microporous sheath (Debrenne, 1973, p.14). The species described above differs from P. contortus by its much narrower intervallum, even when the different cup sizes of the holotype and the specimens described above are taken into consideration (Text-fig. 24). However, in silicified specimens such as the holotype of P.contortus (not seen by the writer) it is considered unlikely that a sheath as finely porous as that described above for E.howchini, could be distinguished as either non-independent or independent.

The discovery of new specimens from the "Paint Mine" locality may reveal that P.contortus could have a non-independent but continuous microporous sheath.

Genus VERONICACYATHUS Debrenne, 1973.

Type species. Veronicacyathus frondeus Debrenne, 1973.

DIAGNOSIS. Two walled cups. The outer wall has a non-independent microporous sheath over the carcass pores. Septa and tabulae are porous. The inner wall consists of circular, oval or hexagonal pores or short pore tubes. Spines extend radially inwards from the inter-pore lintels to form a screen across each pore. The spines do not meet in the centre of the pore openings.

DISCUSSION. In her original generic diagnosis, Debrenne stated that the inner wall is composed of hexagonal pore tubes (Debrenne, 1973, p.19). Kruse (1978, p.39) observed that the pore tubes could equally be classed as simple pores. Two new species from the Mount Scott Range show similar variations in inner wall structure. The older species from Faunal Assemblage II has circular and oval pores which do not open into pore tubes. The younger species from Faunal Assemblage ? $\overline{\text{V}}$ has an inner wall with hexagonal pore tubes. The most important characteristic separating Veronicacyathus from Erugatocyathus is the presence in the former of spines which radiate inwards across the pore openings to form an incomplete screen. The diagnosis given above has been revised to accommodate the different inner wall pore modifications which have been found. A third species described below has been placed with reservation in the genus for reasons given after the species diagnosis.

? Veronicacyathus c.f. complexus (Bedford R. and J.,1937)

(Plate 42, Figs. 2 to 5; Text-fig. 24)

1937 Polycoscinus complexum Bedford R. and J., p.37, Pl.41, Fig. 158.
1973 Pluralicoscinus complexus (Bedford R. and J.); Debrenne, p.14.

HOLOTYPE. Possibly at Princeton University.

TYPE FORMATION. Ajax Limestone. Probably Faunal AssemblageII.

TYPE LOCALITY. "Paint Mine".

MATERIAL. Nine specimens from the Mount Scott Range, section N. P21412-5; P21418-2; P21508-4; P21540-4; P21554-2; P21580-2; P21609-2; P21614-3;P21628-2.

DIAGNOSIS. Small colonial cups forming short sinuous chains. Each outer wall pore is covered by a flat, non-independent microporous sheath. Septa have uniformly distributed pores. Tabulae are regularly spaced with close pores. The inner wall has several rows of pores per intersept. Short spines project from the lintels surrounding the inner wall pores. The spines are directed into the central cavity and radially inward across the opening of each inner wall pore; they do not meet across the pore opening.

DISCUSSION. The holotype, which hitherto was the only specimen known, has not been revised since its original designation and description by R. and J. Bedford. It is thought to be housed in the Geology Department at Princeton University and has not been seen by the writer.

In their original, very brief description, R. and J. Bedford (1937, p.37) stated that the species is similar to Polycoscinus contortus, but on a smaller scale. They did not mention the presence of a "finely porous pellis" similar to that seen on P.contortus .

Debrenne (1973, p.14) considered both walls to be simply porous and placed the species in the genus Pluralicoscinus.

The dimensions of specimens found in the Mount Scott Range match those of P.complexus as far as can be ascertained. It is thought that poor preservation of the holotype may have obscured details of the outer and inner walls. However, the species is referred questionably to that described by the Bedfords and placed with reservation in the genus Veronicacyathus. In the new specimens from the Mount Scott Range the inner wall spines are very short and only cross the inner wall pores to an insignificant degree. The specimens might equally be placed in the genus Anaptyctocyathus Debrenne, some species of which have small inner wall spines.

DESCRIPTION. Colonies of four or five small cups forming short sinuous chains. New cups appear to form by irregular indentation of the walls, but this is not certain. The outer wall is slightly to strongly furrowed at junctions with the septa. The inner wall is smooth or only slightly furrowed. The outer wall has 3-8 rows of circular pores per intersept in irregular quincunx. In longitudinal section the pores are funnel shaped, expanding outwards. Each carcass pore is covered by a flat, non-independent microporous sheath with 3-6 micropores per carcass pore. A central micropore may be present but is usually absent. The sheath can be either restricted to the carcass pore openings or continuous across adjacent carcass pores. There is an inner rim or flange within each carcass pore, a short distance below the sheath. The intervallum contains radial septa which enclose polygonal loculi at cup junctions in transverse section. The septa are pierced by uniformly spaced rows of circular and oval pores. Adjacent pores vary from irregular quincunx to almost side by side. Tabulae are weakly convex, fairly frequent and regularly spaced. The tabulae are pierced by close rounded pores. The inner wall has 1-8 rows of circular pores per intersept in quincunx. Small spines protrude from the interpore lintels into the central cavity and radially across the inner wall pores. A single vertical spine projecting vertically across each pore opening from the lower surface seems slightly more prominent than the others. The spines only obscure the inner wall pore openings to an insignificant degree. Early growth stages are not known.

DIMENSIONS (mm)	P21614-3	P21412-5	P21609-2
Diameter	3.30	2.91	1.63
Intervallum width	0.75-0.83	0.70	0.48-0.73
N	-	17	6
ds	0.53-0.94	0.24-0.34	0.44-0.77
IK	0.23-0.29	0.24	0.30-0.44
RK	-	5.85	3.68
Loculi	1/0.8-1/1.6	1/2.1-1/2.9	1/0.6-1/1.7
Outer wall carcass:			
n	3-8	3-6	6-8
d	-	0.05-0.15	0.10
l	-	0.03-0.05	-
t (excluding sheath)	0.07-0.10	0.07-0.10	0.07-0.10
Outer wall sheath:			
n	3-?	3-6	3-?4
d	0.03-0.04	0.03-0.04	approx.0.04
l	-	approx.0.01	0.02
t	0.01-0.02	approx.0.01	0.01-0.02
Inner wall:			
n	1-8	1-3	2-4
d	0.08	0.07-0.10	0.07-0.10
l	approx.0.07	0.05-0.07	0.06-0.07
t	0.07	0.07	0.07
Spine length	0.05-0.09	approx.0.05	0.05-0.09
Septa:			
n	4-6	4-5	4-5
d	approx.0.05	0.04-0.05	0.05-0.06

l	-	0.07-0.15	approx.0.10
t	0.05	0.05	0.05
Tabulae:			
n	6x?	6x3-7x3	7x5
d	approx.0.05	0.06-0.07	0.05-0.07
l	-	0.03-0.06	0.03-0.04
t	0.05-0.06	0.06-0.07	0.04-0.05
Vertical separation	0.82-0.97	approx.2.0	0.99-1.38

COMPARISON AND REMARKS. ? Veronicacyathus c.f. complexus (Bedford) occurs as small cups in colonies very similar in size to those of Erugatocyathus howchini sp. nov.. The two species occur in the same stratigraphic interval, and fragments of cups belonging to both species have been found on the same thin section. Specimens belonging to both species whose walls are poorly preserved, are difficult to distinguish. However, the furrowed walls and chain-like colonial habit of ? V. c.f. complexus differs from the smooth walls and clustered colonial habit of E. howchini. A fragment of a colonial form found in Lower Faunal Assemblage II at Wilkawillina Gorge (Section E) has poorly preserved walls. Its intervallum width is approximately 1.4mm for a cup diameter of about 4mm. This is a considerably higher intervallum width than that displayed by cups belonging to either of the two species mentioned above. It is closer to the intervallum width of Polycoscinus contortus (Bedford), but the specimen cannot be assigned with certainty to this species (See Text-fig. 24.

Veronicacyathus radiatus sp. nov.

(Plate 11, Fig. 5; Plate 12, Figs. 1,2; Plate 42, Figs. 6 to 10; Text-figs. 15,17)

NAME. From Latin radiatus = spoked.

HOLOTYPE. P21631 (three thin sections).

PARATYPES. P21632-1; P21633-1; P21634-1; P21634-5; P21635-1; P21636.

TYPE FORMATION. Wilkawillina Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section G.

MATERIAL. Thirty two specimens from Wilkawillina Gorge, sections G, H and I; five specimens from the Mount Scott Range, sections J and N. Holotype and paratypes as above. Additional specimens: P21633-2; P21634-2, -3, -4, -6; P21635-2; P21637-1, -2; P21638-1, -2; P21639; P21640; P21641-1; P21642-2, -3; P21643; P21644-1, -2; P21645;P21646-1, -2, -3; P21647; P21648-1; P21649; P21650 to P21652; P21653-1, -2.

DIAGNOSIS. As for the genus. This species has an inner wall with circular and oval pores which do not form pore tubes.

DESCRIPTION. Two walled conical cups sometimes expanding widely to bowl-like forms. The outer wall has 2-4 rows of pores per intersept in quincunx. In longitudinal section the pores are funnel shaped, widening outwards. Pores are circular and oval in shape. Each outer wall pore is covered by a flat, non-independent microporous sheath which covers only the carcass pore openings. The sheath is pierced by 3-9 micropores per carcass pore; these are circular in shape or occur as sectors subdividing the carcass pore. A central micropore may be present but is usually absent. Each outer wall carcass pore has an internal rim or flange a short distance beneath the sheath. The intervallum contains radial septa pierced by evenly spaced rows of pores in irregular quincunx. Pores are circular and oval in shape. Tabulae are weakly concave to weakly convex and fairly frequent. Tabulae tend to become further apart with cup growth. Tabular pores are circular to polygonal in shape. The inner wall has 2-4 (sometimes 1) rows of pores per intersept, adjacent rows are side by side or in irregular quincunx. Pores are circular and oval, occasionally anastomosing laterally. The interpore lintels extend into the central cavity as very short beaks with a downward curving tip. A series of 6 or more short spines projects radially inward across each inner wall pore opening. The spines are evenly spaced; some have forked tips. Opposing spines do not meet in the centre of the pore opening.

DIMENSIONS (mm)	Holotype P21631	Paratype P21633-1	Paratype P21634-1
Diameter	20.9	7.1	6.1
Intervallum width	approx.1.5	1.18-1.38	1.02
N	approx.80	31	25
ds	0.73-0.80	0.53-0.68	0.48-0.73
IK	approx.0.07	0.17-0.20	0.17
RK	approx.3.8	4.4	4.1
Loculi	1/2.0	1/1.7-1/2.6	1/1.4-1/2.1
Outer wall carcass:			
n	3-4	2-3	2-3
d	0.17-0.29x0.15	0.19-0.24x0.18	0.17-0.27x0.12
l	0.07-0.14	0.07-0.15	0.07
t	0.12-0.15	0.10-0.12	0.10
Outer wall sheath:			
n	3-9	-	3-7
d	0.06-0.07	-	0.05-0.07
l	0.01-0.02	-	0.01
t	approx.0.01	approx.0.01	0.01
Inner wall:			
n	3-4	2-3	3-4
d	0.12-0.15	0.15	0.12-0.15
l	-	0.10	0.10
t	0.10	0.10-0.12	0.10
Spine length	-	0.05	0.05
Septa:			
n	5-6	5-6	-
d	0.06-0.07	0.12x0.06-0.12x0.10	-
l	av.0.12	0.12-0.20	-
t	0.05-0.07	0.05-0.07	0.06
Tabulae:			
n	3x?9-5x?9	?x9	4x?7-6x?7
d	0.05-0.15	0.08-0.12	0.10-0.12

l	-	0.06-0.07	0.05-0.06
t	0.07-0.09	0.07	0.06
Vertical separation	-	-	approx.4.2

Note. Other specimens more suitably oriented have tabulae 1.2-1.8mm apart in small cups, and 4.2-6.2mm apart in cups up to 12.5mm diameter.

ONTOGENY. The smallest known cup diameter is 0.20mm. The intervallum and central cavity seemingly appear at a cup diameter of 0.24mm, but the thin section is slightly oblique, so this stage could be reached slightly earlier. The initial porosity of the outer and inner walls is obscured.

Rods or bars in the intervallum are first seen at a cup diameter of 0.8mm but they could be present earlier.

The first tabula is seen at a cup diameter of 1.1mm. Earlier tabulae might be present but have not been seen.

Rods in the intervallum are succeeded by true septa with 1 or 2 large pores ar a cup diameter 1.16mm. Septal pore diameter 0.12-0.15mm, intervallum width 0.24-0.29mm. There are 2-3 rows of septal pores at a cup diameter of 1.75mm.

At 1.0mm cup diameter the outer wall is simply porous. The interpore lintels taper to a peak and slope obliquely downwards to the exterior.

A microporous sheath is present at 2.0mm cup diameter but the stage of its initial formation is unknown.

The inner wall is spinose at a cup diameter of 1.2mm, these clearly radiate across the pore openings at a cup diameter of 2.0mm.

At 2.0mm cup diameter, all of the specific characteristics are evident.

The above data has been obtained from a study of six specimens.

COMPARISON AND REMARKS. Veronicacyathus radiatus sp. nov. differs from V.frondeus Debrenne which has a continuous microporous sheath

(Debrenne, 1973, p.20)., ? V.textilis (Bedford R. and W.R.) and ? V.cellularis (Bedford R. and W.R.) have fewer outer wall pores per intersept, more numerous septal pores (probably related to the larger cup sizes) and inner walls composed of pore tubes. V.concavus Kruse has 4 orthogonally arranged spines crossing the inner wall pores.

Veronicacyathus limbatus sp. nov.

(Plate 43, Figs. 1 to 6)

NAME. From Latin limbus = a fringe.

HOLOTYPE. P21654 (four thin sections).

TYPE FORMATION. Ajax Limestone. Faunal Assemblage ? $\overline{V}$.

TYPE LOCALITY. Mount Scott Range. Section M.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus. This species has inner wall pores opening into roughly hexagonal pore tubes.

DESCRIPTION. Conical cup, oval in transverse section. The outer wall has 2-4 rows of pores per intersept in quincunx. In longitudinal section the outer wall pores are funnel shaped, widening to the exterior. Pores are circular on the intervallum side and oval, strongly stretched laterally at the outer surface. Each carcass pore is covered by a flat, non-independent microporous sheath which is restricted to the pore openings. Micropores appear to be circular, but the sheath is not well preserved in thin sections grazing the outer wall. An internal rim or flange is present in the carcass pores close to the intervallum side. The intervallum contains radial septa pierced by sparse, evenly distributed rows of pores. Pores are circular in shape. Tabulae are flat to weakly convex, fairly numerous but irregularly spaced in longitudinal section. Tabulae are pierced by circular and oval pores of varying size. The inner wall has 2-3 rows of pore tubes per intersept in quincunx. The pore tubes are horizontal or tilted very slightly upwards into the central cavity. The pore tubes are circular in cross-section on the intervallum side and form slightly larger, roughly hexagonal openings into the central cavity. There is a series of radiating spines mid-way along each inner wall pore tube. The spines are slightly tilted obliquely towards the central cavity. The number of spines in each pore tube varies from 2 to 6 or more. Each spine has a forked tip. The inner extremities of the pore tube walls are fringed by spines projecting into the central cavity.

Early growth stages are not known.

DIMENSIONS (mm)

Dimensions of transverse section 22.4x17.2; intervallum width 1.48; N 70; ds 0.44-0.78; IK 0.07-0.09; RK 3.13-4.06; loculi 1/1.9-1/3.4.

Outer wall carcass: n 2-3; d 0.19x0.12-0.34x0.12; l 0.05-0.07; t 0.15-0.19.

Outer wall sheath: n ?4-8; d approx.0.06; l -; t 0.01-0.02.

Inner wall pore tubes: n 2-3; d 0.30x0.18-0.36x0.29; tube length 0.36; tube wall thickness 0.02-0.05; radiating spine length 0.10-0.12; spines fringing tubes, length 0.05.

Septa: n 4-5; d 0.06-0.10; l 0.10-0.22; t 0.04-0.06.

Tabulae: n 3x?12-6x?12; d 0.03-0.16; l 0.03-0.04; t 0.05; vertical separation 1.06-6.0.

COMPARISON AND REMARKS. Veronicacyathus limbatus sp. nov. differs from V.frondeus Debrenne, which has a much wider intervallum and more numerous septal pores. ? V.cellularis (Bedford R. and W.R.) has very numerous, minute septal pores. ? V.textilis has fewer outer wall pores and much smaller inner wall pores which lack spines. V.concavus Kruse does not have well defined inner wall pore tubes and the lintels or tube rims are not spinose at the central cavity. V.radiatus sp. nov. does not form pore tubes on the inner wall. ? V. c.f. complexus (Bedford R. and J.) is colonial with very short spines on a simple inner wall.

Genus BRACTOCYATHUS Kruse, 1978.

Type species. Bractocyathus labiosus Kruse, 1978.

DIAGNOSIS. Two walled cups. Outer wall smooth or with projections from the septa forming external pillars. Outer wall with a non-independent microporous sheath where it is in contact with the carcass pores. Where the sheath drapes over the septal projections it is independent. Septa and tabulae porous. The inner wall consists of several rows of pore tubes per intersept. A vertical wedge-shaped plate is fixed to the lower edge of each pore tube, partly obscuring the opening.

DISCUSSION. The type of sheath found on the outer wall of Bractocyathus Kruse has been described in Chapter 4. It is considered herein to be a non-independent microporous sheath and the genus is accordingly placed in the Superfamily Anaptyctocyathacea, rather than the Mrassucyathacea as Kruse has done (Kruse, 1978, p.41).

Bractocyathus projectus sp. nov.

(Plate 12, Figs. 5, 6; Plate 43, Figs. 7, 8)

NAME. From Latin projectus = jutting out.

HOLOTYPE. P21655 (three thin sections).

TYPE FORMATION. Ajax Limestone. Faunal Assemblage ? V.

TYPE LOCALITY. Mount Scott Range. Section M.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus. This species has outward projections from the septa.

DESCRIPTION. Two walled cup. The outer wall has outward projections from adjacent septa and less commonly from the interpore lintels. The outer wall has 2-3 rows of pores per intersept in irregular quincunx. In longitudinal section the pores are funnel shaped, widening outwards. The pores are circular and oval on the intervallum side and expand laterally to oval or rectangular shapes at the outer surface. Each carcass pore in the middle of an intersept is covered by a non-independent microporous sheath which is normally restricted to each carcass pore opening. There is limited continuity of the sheath across closely spaced carcass pores. Where the sheath rises to connect with the outermost parts of the septal projections it is not in contact with the carcass pores, which remain smooth in outline. Where the sheath is in contact with the carcass pores the bordering lintels are notched. The sheath micropores are circular and oval in shape. The intervallum contains septa pierced by evenly spaced rows of pores, possibly in irregular quincunx. Tabulae are flat, horizontal and oblique, pierced by large pores. The distribution of tabulae and their pore shapes are not known. The inner wall consists of 2-3 rows of pore tubes per intersept, whose arrangement is unknown. The pore tubes are circular on the intervallum side, expanding to an hexagonal opening into the central cavity. A vertical plate, fixed to the base in the centre of each pore tube, partly obscures the opening into the central cavity. The plate is long, narrow, and supports a series of short spines which project perpendicularly outward to partly screen the remaining pore opening. Additional short spines project downward from the roof of each pore tube;

these appear to be displaced from the plate's spines and do not meet them in the centre of the pore opening. Sparse, upward directed growths of endothecal tissue are present in the central cavity. Early growth stages are not known.

DIMENSIONS (mm) Holotype P21655

Diameter 7.35; intervallum width 1.23-1.48; N approx.24; ds 0.51-1.04; IK 0.17-0.20; RK approx.3.3; loculi 1/1.2-1/2.9.

Outer wall carcass: n 2-3; d 0.19x0.12-0.33x0.27; l 0.07; t (excluding septal projections) 0.17; length of septal projections from outer surface 0.19-0.27.

Outer wall sheath: n 8-?12; d 0.04-0.07; l 0.01-0.02; t approx.0.02.

Inner wall pore tubes: n 2-3; d 0.22-0.29; tube length 0.29-0.41; tube wall thickness 0.05-0.07; plate length 0.11-0.29; length of additional spines 0.05.

Septa: n 4-5; d 0.07-0.07x0.10; l 0.13-0.18; t 0.05-0.07.

Tabulae: n 4-6x?; d approx.0.05-0.18; l approx.0.05-0.10; t 0.05.

COMPARISON AND REMARKS. Bractocyathus projectus sp. nov. differs from B.labiosus Kruse which has slightly smaller outer wall pores, more numerous, closer septal pores and plates inside the inner wall pore tubes which are connected to the roof of each pore tube by rods. The sheath of B.labiosus Kruse has more numerous micropores which are rounded or angular in shape.

Bractocyathus curvus sp. nov.

(Plate 43, Figs. 9 to 12)

NAME. From Latin curvus = curved.

HOLOTYPE. P21656 (one thin section).

PARATYPES. P21657; P21658.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage ? nov.

TYPE LOCALITY. Wilkawillina Gorge. Section I.

MATERIAL. Three specimens from Wilkawillina Gorge, section I.

DIAGNOSIS. As for the genus. This species as far as is known, has a smooth outer wall.

DESCRIPTION. Two walled conical cups with a smooth outer wall in the sparse material available. The outer wall has 2-4 rows of pores per intersept; their distribution is unknown. In longitudinal section the pores are funnel shaped, expanding outwards. Pores appear to be oval in shape. Each outer wall carcass pore is covered by a flat, non-independent microporous sheath. The sheath has been removed from the outer wall by abrasion so that only fragments remain. It is impossible to see whether the sheath is continuous or is restricted to the carcass pore openings. The number, distribution and shape of the sheath micropores are unknown. A well preserved inner rim or flange is present in the carcass pores a short distance below the sheath. The flange bulges outwards and appears to support a finely porous screen. The intervallum contains septa pierced by uniformly distributed rows of small pores in quincunx. Septal pores are circular in shape. Tabulae are flat to weakly convex and are irregularly spaced in longitudinal section. The tabulae are pierced by numerous small pores whose shape and distribution are unknown. The inner wall consists of 2-4 rows of pore tubes per intersept in quincunx. The pore tubes are an inverted U-shape in longitudinal section, opening obliquely downwards at a low angle into the central cavity. The pore tubes are circular on the intervallum side with a rounded hexagonal opening into the central cavity. A broad vertical plate extends upwards from the base of each pore tube at its position of maximum curvature. The plate is parallel to the inner wall and is surmounted

by a tuft of spinules. No additional spines project into the pore openings, but the lower wall of each pore tube supports a tuft of spines which project obliquely into the central cavity.
Early stages of growth are obscured by secondary thickening, but the inner wall is spinose at a cup diameter of 1.9mm. Details of the outer wall at early growth stages are unknown.

DIMENSIONS (mm)	Holotype P21656	Paratype P21657	Paratype P21658
Diameter	2.76	approx.11.0	8.20
Intervallum width	0.64	1.65	1.23
N	-	-	34
ds	-	0.46-0.78	0.44-0.73
IK	0.23	-	0.15
RK	-	-	4.15
Loculi	-	1/2.1-1/3.6	1/1.7-1/2.8
Outer wall carcass:			
n	2-3	3-4	2-4
d	0.10-0.17	0.17-0.27	approx.0.19
l	0.05-0.15	0.03-0.17	0.07-0.17
t	0.07-0.12	0.15	0.12
Outer wall sheath:			
n	not preserved	-	-
d	-	approx.0.06	-
l	-	-	-
t	-	approx.0.02	approx.0.02
Inner wall pore tubes:			
n	2-3	3-4	2-3
d	0.15-0.17	0.24x0.17-0.27x0.20	0.24x0.15
Tube length	0.18-0.20	0.24-0.31	0.24
Tube wall thickness	0.02-0.05	0.02-0.05	0.02-0.05
Plate length	0.07	0.10-0.15	0.12
Septa:			
n	?5	7	6-7
d	0.05-0.06	0.07-0.15	approx.0.05
l	0.05-0.07	0.12-0.15	-
t	0.04-0.05	0.05	0.04-0.05

Tabulae:

n	?x9	6x?12	not preserved
d	approx.0.05-0.07	approx.0.05-0.07	-
l	0.02-0.05	approx.0.05	-
t	0.02	0.05	-
Vertical separation	1.0-2.5	approx. 6.0	-

COMPARISON AND REMARKS. The inner wall pore tubes of Bractocyathus curvus sp. nov. differ from those found in other species by their pronounced curvature. B. labiosus Kruse has very slightly curved pore tubes; B. projectus sp. nov. has straight pore tubes which curve downwards slightly only at the intervallum. The inner wall pore tubes of B.curvus sp. nov. lack additional spines projecting across the pore openings from the sides and roof of the enclosing lintels. The outer wall sheath of B. curvus sp. nov. is too poorly preserved to be compared with the sheaths found on the outer walls of the other two species. It is worth noting that a well preserved inner rim or flange is present in some of the outer wall carcass pore openings of B.curvus sp.nov.. This is identical in structure to the inner rim found in several species of Erugatocyathus and Veronicacyathus. This feature was not observed in B.labiosus by Kruse, although his figures show that an inner rim may be present (Kruse, 1978, p.43, Fig.11A,B). An internal flange is not preserved in the outer wall carcass pores of B.projectus sp.nov.. In the present writer's opinion, the presence of this feature in B.curvus sp.nov. and possibly in B.labiosus Kruse, suggests a closer affinity of the genus with the Anaptyctocyathacea than with the Mrassucyathacea.

Bractocyathus curvus sp. nov. is represented by three specimens collected from Wilkawillina Gorge 68 to 76 metres stratigraphically above the disconformity which truncates Upper Faunal Assemblage II. In this locality, the first elements of Faunal Assemblage III have been found in the lower 37m (110 feet) of the Parara

Limestone (Daily, 1956, p.113), whose base is 6m above the uppermost occurrence of B. curvus sp. nov.. The interval between the disconformity and the base of the Parara Limestone has been discussed in Chapter 3.

Remarks concerning Regulares not found in Faunal Assemblage I and II.

No representatives of the Suborder Monocyathina have been found at Wilkawillina Gorge. Some small one walled cups were collected from Upper Faunal Assemblage II at the Mount Scott Range but these could be juvenile stages of other Archaeocyatha and have not been described herein. No species belonging to the Suborders Capsulocyathina and Putapacyathina have been found in the stratigraphic interval studied. Specimens of genus Alphacyathus in the Suborder Putapacyathina have been found by the writer above Faunal Assemblage II in the upper parts of the Wilkawillina Limestone near Wirrealpa but these belong in much younger faunal assemblages.

In the Ajacicyathina, rare specimens of species belonging to the genus Aldanocyathus have been found in Faunal Assemblage II at the Mount Scott Range. They have not been described herein owing to the lack of material. No species in the genus Ajacicyathus have been found, nor any species belonging to the genus Robustocyathus.

With the exception of Ajacicyathus, which appears at the base of the Sanashtykgol Horizon in the Altay-Sayan region of the USSR, Aldanocyathus and Robustocyathus are known overseas from the stratigraphic interval which correlates with Faunal Assemblages I and II. Their apparent absence from the two localities studied strongly suggests that the species described in this chapter form only a proportion of the total number of species of Regulares yet to be found in Faunal Assemblages I and II from South Australia.

CHAPTER 7.

SYSTEMATIC DESCRIPTIONS CLASS IRREGULARES VOLOGDIN, 1937.

CLASS IRREGULARES Vologdin, 1937

ORDER ARCHAEOCYATHIDA Okulitch, 1935.

SUBORDER ARCHAEOCYATHINA Okulitch, 1935.

FAMILY DICTYOCYATHIDAE Taylor, 1910.

DIAGNOSIS. Two walled cups, Intervallum composed of an orthogonal scaffold of cylindrical rods. Outer and inner walls rudimentary or simple.

Genus AULISCOCYATHUS Debrenne, 1974.

Type species. Spirocyathus multifidus Bedford R. and W.R., 1936.

DIAGNOSIS. Solitary cups with minor transverse undulations affecting especially the outer wall. Intervallum composed of a scaffolding of rods forming an arched lattice with openings quadratic in cross-section. Outer wall rudimentary, inner wall may be simple or rudimentary.

Auliscocyathus arcuatus sp. nov.

(Plate 13, Figs. 1 to 3; Plate 44, Figs. 1, 2)

NAME. From Latin arcuatus = curved.

HOLOTYPE. P21539-3 (three thin sections).

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary cylindro-conical cup. Outer wall with transverse undulations, inner wall relatively smooth. Outer and inner walls rudimentary with some minor thickening of the intervallum elements at their outer and inner extremities. The intervallum consists of an orthogonal system of linked cylindrical rods arranged to form an arched lattice, convex-upward in longitudinal section with the axis of curvature in the mid-line of the intervallum. Each lattice opening is quadratic in cross-section.

DIMENSIONS (mm) Holotype P21539-3

Diameter 22; intervallum width 7; lattice aperture dimensions in the intervallum (side, top and bottom apertures) 0.29-0.41; lattice apertures through the outer wall 0.29-0.41; lattice apertures through the inner wall 0.17-0.19; diameter of rods 0.05-0.09.

COMPARISON AND REMARKS. The intervallum lattice of *A.arcuatus* sp.nov. differs from that of *A.multifidus* (Bedford R. and W.R.) by its non-staggered arrangement of apertures and by its lattice curvature, which is horizontal in the middle of the intervallum for *A.arcuatus* and horizontal at the outer wall for *A.multifidus*. The inner wall of *A.multifidus* ap~~pears to~~ consists of simple pores. that of *A.arcuatus* is rudimentary. The strongly arched tabulae of *Archaeosycon* Taylor and *Sphinctocyathus* Zhuravleva, closely resemble the curvature of the lattice of *A.arcuatus*, but there is no resemblance of the lattice in the latter to tabulae. Dissepiments are always present in *Sphinctocyathus* according to Zhuravleva (1960b, p.305) but have not been seen in *A.arcuatus*, although the base of the only known specimen is missing.

NO!

Auliscocyathus irregularis (Taylor, 1910)

(Plate 44, Figs. 3 to 5)

1910 *Spirocyathus irregularis* Taylor; p.148, Pl.16, Figs. 93, 94.

1936 *Spirocyathus irregularis* Taylor; Bedford R. and W.R., p.14, Pl.13, Fig. 64.

1937 Flindersicyathus irregularis (Taylor); Bedford R. and J.,p.28.
1960 Archaeocyathus irregularis (Taylor); Debrenne F. and M.,p.702, Pl.20, Fig. 5.
1969 Flindersicyathus (Flindersicyathus) irregularis (Taylor); Debrenne, p.348, Pl.14, Fig. 4.
1974 Pycnoidocyathus ? irregularis (Taylor); Debrenne, p.214, Fig.18.

HOLOTYPE. T1604-A, B and C, which are three fragments of a single specimen. (30 Ajax).

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

TYPE LOCALITY. Ajax Hill.

DISCUSSION. Recent examination of the holotype has shed new light on the affinities of the species originally described by Taylor (1910). R. and W.R. Bedford (1936) included under Spirocyathus irregularis Taylor specimens which are in fact representatives of Pycnoidocyathus and ? Flindersicoscinus. These are in the Bedford collection housed in the Palaeontology Section, South Australian Museum numbered P948. One of these specimens (P948-76) a species of ? Flindersicoscinus was subsequently figured by Debrenne (1974a, Fig.18) as Pycnoidocyathus ? irregularis (Taylor). The structure of the walls and intervallum of the holotype is quite different from that of Pycnoidocyathus and much more closely resembles the structure of Auliscocyathus. In a comparison of Flindersicyathus decipiens with Spirocyathus irregularis, R. and J. Bedford (1937, p.28) noted for the latter that "there is no defined porous plate forming the outer wall, the pores being merely the interstices between the elements of the superficial maze of rods." Their diagrams (Plate 27, Fig. 108a, b) are not those of specimens illustrated by R. and W.R. Bedford (1936, P.13, Fig. 64.) and are presumably of the holotype.

DIAGNOSIS. As for the genus.

REDESCRIPTION OF HOLOTYPE. Solitary cup, cylindro-conical, transverse section oval. Outer and inner walls smooth. The outer wall is rudimentary consisting of the outer openings of the intervallum lattice with some additional oblique lintels. The intervallum contains an orthogonal system of cylindrical rods which form an arched lattice with apertures quadratic in cross-section. The apertures appear to be side by side rather than in alternating rows. In longitudinal section the lattice slopes obliquely upward and curves away from the inner wall to become horizontal at the outer wall. The inner wall is not well preserved but appears to be composed of simple pores, one to each intervallum lattice opening.

DIMENSIONS (mm)

Dimensions of transverse section 23 by 20; height (partial) 60; intervallum width 6.25; intervallum lattice apertures (sides, top and bottom) 0.36-0.53; lattice apertures outer wall 0.44-0.61; inner wall pore diameter 0.48-0.61; inner wall lintels approx.0.15; diameter of rods 0.05-0.10.

COMPARISON AND REMARKS. The curvature of the intervallum lattice of A.irregularis (Taylor) is identical to that found in A.multifidus (Bedford R. and W.R.) but different from that of A.arcuatus sp.nov. The lattice aperture dimensions of A.irregularis are 2-3 times the size of those in A.multifidus and almost twice the size of those found in A.arcuatus. The species Dictyocyathus translucidus Zhuravleva, judging by its original description (Zhuravleva, 1960b, p.275) has a very similar intervallum and wall structure, and may belong in the genus Auliscocyathus Debrenne.

in my scholar english I should have written belong to.

Genus AGASTROCYATHUS Debrenne, 1964.

Type species. Protopharetra gregaria Debrenne, 1961, p.21.

DIAGNOSIS. Colonial, rarely solitary cups. Outer wall partly lined by dissepimental tissue. Intervallum with rods in regular longitudinal rows but without a marked radial disposition; horizontal or oblique rods less common. Central cavity may be partly free or replaced by an axial zone extending from the intervallar mesh. Vesicular tissue is present.

Agastrocyathus araneosus sp.nov.

(Plate 44, Fig. 6; Plate 45, Figs. 1 to 4)

NAME. From Latin araneosus = full of spider webs.
HOLOTYPE. P21483-2 (one thin section).
PARATYPES. P21659; P21660; P21663-3.
TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.
TYPE LOCALITY. Wilkawillina Gorge. Section I.
MATERIAL. Fifteen specimens from Wilkawillina Gorge, sections E, G, H and I. Holotype and paratypes as above. Additional specimens: P21483-3 to -6;P21597-2;P21661;P21662;P21663-1 to -3;P21664;P21665.

DIAGNOSIS. As for the genus.

DESCRIPTION. Colonial forms in which individual cups are difficult or sometimes impossible to distinguish. Individuals radiate from a common base with the lower cups almost prostrate. General form of the colony is compact with a hemispherical upper surface in longitudinal section. In transverse section colonies are more or less circular with rarely empty central cavities, or one or more central zones replacing the central cavities. The intervallum contains radially distributed vertical rows of platelets or flattened bars, the rows diverge slightly both vertically and radially with new vertical rows frequently added. Each vertical row is linked to its neighbours by a series of evenly spaced tangential horizontal bars with rounded junctions, resulting in a porous lattice with circular and oval openings. The vertical and horizontal tangential bars form an orthogonal lattice in the outermost part of the intervallum, in the inner part the horizontal bars are oblique, forming a hexagonal lattice. The outer wall appears to be rudimentary but is often covered by an imperforate, seemingly discontinuous pellis obscuring the porosity. The central cavity where present is bounded by a rudimentary inner wall, opening directly into the hexagonal intervallum lattice. More often the central cavity is partly filled by a system of oblique to vertical rods bearing tufts of spinules, connected by dissepiments. Dissepiments are present in the intervallum and central cavity, they are not abundant or complex, and tend to form concentric zones arched upwards in longitudinal section.

DIMENSIONS (mm) Holotype P21483-2

Width and height of colony usually less than 13mm.

Vertical platelets: length 0.06-0.09; width 0.04; separation of rows 0.15-0.36.

Horizontal bars: length 0.09-0.12; width 0.05; separation 0.09-0.10.

Lattice pores: diameter 0.09-0.12.

COMPARISON AND REMARKS. This is the first occurrence of Agastrocyathus from South Australia. Other species in the genus are widespread in southern Morocco and are also known from Sardinia (Debrenne, 1964, 1978). A.araneosus differs from other species by its more compact colonial form, and smaller vertical platelets in the intervallum with a more marked radial arrangement. Transverse sections through colonies give the impression of highly porous radial septa similar to those found in *Prismocyathus* Fonin. This is a false picture owing to the fact that individuals in a colony grow outward, some almost horizontally, from a common centre; the sections are in fact almost longitudinal but through prostrate cups. Fonin (1960) described the axial zone of *Prismocyathus* as a honeycomb of porous prisms. The hexagonal inner zone of the intervallum of *Agastrocyathus* is composed of a scaffolding of rods or bars, not of prismatic pore tubes.

Genus DICTYOFAVUS gen.nov.

NAME. From *Dictyocyathus* and Latin *favus* = honeycomb.

Type species. *Dictyofavus obtusus* sp.nov.

DIAGNOSIS. Solitary or colonial cups, individual central cavities are well defined in colonial forms. The outer wall is rudimentary consisting of the outer edges of the intervallum mesh, usually covered in the lower part of the cup by a film of dissepimental tissue; finger-like outgrowths of intervallum elements are common. The intervallum contains a scaffolding of linked rods arranged to form a hexagonal-prismatic lattice. Sparse dissepiments are present. The central cavity is well defined and empty except at early growth stages. The inner wall is rudimentary. Short spines project into the central cavity from the inner edges of the intervallum elements. Earliest stages of growth before the formation of a central cavity have an irregular network of rods and sparse dissepiments within the space bounded by the outer wall.

DISCUSSION. *Dictyofavus* gen.nov. has been created to accommodate new forms found at Wilkawillina Gorge. The genus is similar to *Dictyocyathus* Bornemann, which however, has an orthogonal lattice of rods in the intervallum. The scaffolding of rods in *Dictyofavus* form a more or less regular hexagonal-prismatic lattice, with vertical prism sides and horizontal hexagonal openings. The latter are clearly seen in transverse sections. Dictyofavus gen.nov. differs from Protopharetra Bornemann by the absence of septa and from Agastrocyathus Debrenne by the lattice arrangement and the presence of well defined central cavities.

Dictyofavus obtusus sp.nov.

(Plate 45, Figs. 5, 6; Plate 46, Figs. 1, 2)

1967 ? Archaeocyathidae gen.nov., Walter, p.144, Table 1.

NAME. From Latin obtusus - obtuse.

HOLOTYPE. P21666 (two thin sections).

PARATYPES. P21667; P21668; P21669; P21670.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section I.

MATERIAL. University of Adelaide OA1582F-2; OA1600F-9, 12 (Walter collection). Seventeen specimens from Wilkawillina Gorge, sections E, F, G, H and I. Holotype and paratypes as above. Additional specimens: P21671 to P21673; P21674-1; P21675 to P21682.

DIAGNOSIS. As for the genus.

DESCRIPTION. Small solitary or colonial cups, colonial forms massive, consisting of 2 or 3 linked cups. Individuals in a colony have well defined separate central cavities. The outer wall is rudimentary or simple, some addition of skeletal material to the outer edges of the intervallum elements poorly defines circular pores. In early growth stages the outer wall is covered by a smooth or puckered pellis of dissepimental tissue. The intervallum contains a scaffolding of linked cylindrical vertical rods, horizontal oblique rods and horizontal radial rods, which form a hexagonal-prismatic lattice. Horizontal tangential rods (synapticulae) are rare. Openings in transverse section are hexagonal to rounded, with larger openings mainly in the middle of the intervallum. The openings in the prism sides are quadrate to rounded in longitudinal section. Their sizes generally increase with cup growth. The inner wall is rudimentary with small spines projecting into the central cavity from the inner edges of the intervallum elements. The central cavity forms early, in one specimen at a cup diameter of 0.75mm. In small cups, sparse dissepiments cross the intervallum and central cavity. In larger cups the central cavity is circular and empty. although sometimes bordered by a film of dissepimental tissue. Finger-like outgrowths from the outer wall are common and are filled with linked rods and sparse dissepiments.

DIMENSIONS (mm) Holotype P21666

Cup diameter 4.5-6.0; intervallum width 1.5-2.5; outer wall pores where present 0.07-0.10; inner wall openings 0.10-0.15; dimensions of hexagonal openings (transverse section) 0.12-0.53; dimensions of rectangular openings (longitudinal section) 0.07-0.22; rod diameter 0.04-0.07.

COMPARISON AND REMARKS. Several specimens listed by Walter (1967, p.144, Table 1) as ? Archaeocyathidae gen.nov. belong to the species *Dictyofavus obtusus* sp.nov.. R. and J. Bedford (1937, p.27, Pl.27, Fig. 106a-c) described a younger species from the "Paint Mine", which they named *Protopharetra furca*. Its colonial form, well defined central cavities and hexagonal intervallum lattice are strikingly similar to those of *Dictyofavus*. However, the Bedfords described and illustrated a clearly defined simple inner wall for *P.furca*. The inner wall of *D.obtusus* is rudimentary. In all probability this belongs to a different genus, which in the classification proposed in Chapter 4 may belong to a separate family. As has already been stated, no new families have been proposed for species having a lattice of rods in the intervallum.

Perejon (in Perejon, Moreno and Vegas, 1976, p.39) assigned two specimens to the species Dictyocyathus ? c.f. irregularis Taylor. Their specimens have an intervallum of rods oriented in three directions to form hexagonal cells in transverse section (op.cit. Pl.1, Fig.2). Although the specimens might belong to the genus Dictyofavus gen.nov., they bear no resemblance to Dictyocyathus irregularis Taylor (redescribed on p.335).

SUPERFAMILY METACYATHACEA superfam.nov.

DIAGNOSIS. Two walled cups. Intervallum with septa. No tabulae. Outer wall basic and simply porous or compound with subdivided pore openings. Wall attached directly to septa. Outer wall pores in vertical rows.

FAMILY METACYATHIDAE Bedford R. and W.R., 1934.

1934 Metacyathidae Bedford R. and W.R., p.5.
1937 Cambrocyathidae Okulitch, p.251.
1937 Copleicyathidae Bedford R. and J., p.29.
1964 Cambrocyathinae Debrenne, p.218.
1964 Metaldetinae Debrenne, p.218.
1970 Paranacyathidae Debrenne, p.38.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall basic and simply porous or compound with subdivided pore openings. Wall attached directly to septa. Inner wall pores in vertical rows.

Genus PARANACYATHUS Bedford R. and J., 1937.

1936 Paracyathus Bedford R. and W.R., p.17.
1937 Paranacyathus Bedford R. and J., p.34. Nom.subst.pro. Paracyathus Bedford R. and W.R., 1936, p.17., non Paracyathus Edwards and Haime, 1848 (a coelenterate).

Type species. *Paracyathus parvus* Bedford R. and W.R., 1936.

DIAGNOSIS. Two walled conical cups, solitary or colonial. The outer wall is basic with one or two vertical rows of simple pores, pores may vary in size and shape. Intervallum with radial septa, usually having pores more widely separated than their diameter. Inner wall basic with simple circular or oval pores in one or two rows per intersept. The lower part of the cup before the formation of the central cavity contains irregularly curving, interweaving plates and vesicular tissue.

DISCUSSION. The generic diagnoses of R. and W.R. Bedford (1936,p.17) and R. and J. Bedford (1937, p.34) did not mention the number of outer and inner wall pores per intersept. Zhuravleva's diagnosis (1960b, p.288) stated that the outer and inner walls are both pierced by a single row of pores per intersept. However, she described *Paranacyathus subartus* Zhuravleva with two rows on the outer wall and one or two rows per intersept on the inner (*op.cit.*, p.291). Debrenne (1970b, p.38; 1974c, p.170) diagnosed *Paranacyathus* with an outer wall of two pore rows which may join, and an inner wall with one pore row per intersept.

A recent examination of the holotype of *P.parvus* (Bedford R. and W.R.) showed that some inner wall intersepts have two rows of pores, others only one. A new species found in the Mount Scott Range has one or two rows of pores per intersept on both walls. The generic diagnosis given above differs from previous diagnoses by allowing the presence of one or two rows of pores per intersept on both walls.

Paranacyathus spinosus sp.nov.

(Plate 13, Figs. 4, 5; Plate 46, Figs. 3 to 5)

HOLOTYPE. P21552-5 (six thin sections).

PARATYPES. P21425-3; P21466-4; P21540-2; P21683.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Six specimens from the Mount Scott Range, section N. Holotype and paratypes as above. One additional specimen P21435-2.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary two walled cylindro-conical cups reaching a large size, intervallum relatively narrow. Outer wall basic, simply porous with 1-2 rows of small circular and larger elliptical to angular pores per intersept. Pores funnel shaped, widening outwards. The intervallum is crossed by straight or slightly wavy septa sometimes bifurcating near the outer wall. Septal pores are in 4-6 near vertical rows across the intervallum, outer rows curve slightly to the outer wall, inner rows curve in the opposite sense. Septal pores are circular or oval in quincunx, with smaller pores close to the walls. The inner wall is basic, simply porous with 1-2 rows of circular or oval pores per intersept in quincunx. Sparse sharp spines are directed upwards into the central cavity from the inner wall lintels. Earliest growth stages unknown, the smallest cup 5.8mm diameter has a well defined central cavity, inner wall and septa. Dissepiments are present in the lower parts of the central cavity and intervallum. They occur sporadically at higher levels in some cups.

DIMENSIONS (mm)	Holotype P21552-5	Paratype P21540-2	Paratype P21683
Diameter	28.2	9.7	9.7
Intervallum width	1.43-3.15	1.62	1.63-1.87
N	146	-	approx.50
ds	0.36-0.73	0.32-0.49	0.41-0.51
IK	0.05-0.11	0.17	0.17-0.19
RK	5.18	-	approx.5.2
Loculi	1/2.0-1/8.7	1/3.3-1/5.2	1/3.2-1/4.6

Outer wall:			
n	1-2	1-2	1-2
d	0.12-0.36x0.24	0.24-0.51x0.39	0.19-0.26
l	0.03-0.10	0.07-0.24	0.07-0.12
t	0.15	0.12-0.15	0.10-0.17
Inner wall:			
n	1-2	1-2	1-2
d	0.24-0.26	0.18-0.29	0.11-0.19
l	0.10-0.12	0.06-0.11	0.07-0.12
t	av.0.10	av.0.07	0.05-0.09
Septa:			
n	6 approx.	4-?6	5
d	0.29x0.44	0.15-0.26x0.37	0.26x0.41
l	0.12-0.22	0.10-0.15	0.12-0.17
t	0.09-0.12	0.07	0.07
Spine length	0.15-0.29	-	0.19

COMPARISON AND REMARKS. Paranacyathus spinosus sp.nov. has a similar outer wall to P.parvus (Bedford R. and W.R.) described by Debrenne (1974c, p.170), but differs by the presence of spines on the inner wall, larger and more frequent septal pores and a higher radial coefficient. Other species of Paranacyathus have more regularly distributed outer wall pores.

Genus COPLEICYATHUS Bedford R. and J., 1937.

Type species. Copleicyathus confertus Bedford R. and J., 1937.

DIAGNOSIS. Colonial cups increasing by opposed indentation of the intervallum or by budding. Inner wall and central cavity appear late above a base containing disoriented rods, plates and dissepiments. Outer wall compound, consisting of a simple carcass of rounded pores, subdivided to form a system of circular micropores. Septa with net-like porosity linked by sparse oblique synapticulae. Inner wall with a simple carcass of several pores per intersept, pores surrounded by a zone of branching spines growing obliquely upward at a low angle into the central cavity.

DISCUSSION. R. and J. Bedford (1937, p.29) originally described the inner wall as "a thick, felted mass of curved anastomosing rods continuous outwardly with the septal mesh. .... The form appears to be sufficiently distinctive to require a new family." Their description and subsequent revisions by Debrenne (1970b, 1974a) and Hill (1965) were based on a fragment of a single silicified specimen from the "Paint Mine". New specimens of C.confertus and specimens of two new species, all well preserved, from Wilkawillina Gorge and the Mount Scott Range, have clarified the morphology of this genus. The diagnosis given above and the following species descriptions are based on entirely new material.

Copleicyathus confertus Bedford R. and J., 1937.

(Plate 46, Figs. 6 to 8;Plate 47, Figs. 1 to 4)

1937 Copleicyathus confertus Bedford R. and J., p.29,Pl.28;Fig.116A-D.
1965 Copleicyathus confertus Bedford R. and J.; Hill, p.128, Pl.10, Fig. 4a-c, Fig.23, 8a-b.
1970 Copleicyathus confertus Bedford R. and J.; Debrenne, p.31.
1972 Copleicyathus confertus Bedford R. and J.;Hill, p.E117,Fig.84-2.
1974 Copleicyathus confertus Bedford R. and J.;Debrenne, p.233,Fig.17.

HOLOTYPE. 86741-283, Princeton University.

TYPE FORMATION. Ajax Limestone. Faunal Assemblage II.

TYPE LOCALITY. "Paint Mine".

MATERIAL. Four specimens from the Mount Scott Range, section N. Two specimens from Wilkawillina Gorge, section G. P21488-2; P21551-2; P21558-2; P21684 to P21686.

DIAGNOSIS. As for the genus.

DESCRIPTION. Colonial cups increasing by opposed indentation of the intervallum, each new cup more or less parallel to its neighbours. Outer wall with minor transverse undulations. The compound outer wall is composed of a simple carcass with 2-3 circular pores per intersept, each subdivided into approximately 3 micropores. Micropores are circular and oval formed by skeletal projections across the carcass pore openings. Septa are straight, radial with netlike porosity. Pore rows in the centre of the intervallum are vertical, neighbouring rows curve slightly towards the inner and outer walls. Septal pores are circular, elliptical and subrectangular, the largest ones occur most often along the mid-line of the intervallum. Synapticulae are sparse, usually found near the outer wall; very short oblique synapticulae link some septa with the outer wall. The inner wall has a simple carcass with 2-4 rows of circular pores per intersept. Attached to the lintels surrounding each pore is a series of close-set, more or less parallel spines extending obliquely upwards into the central cavity. Each spine has a short stem which forks into a series of branches tipped with fine featherlike tufts. The spines are very close together and line and margin of the central cavity.

DIMENSIONS (mm)	P21684	P21588-2	P21488-2
Diameter	9.6	8.3	9.2
Intervallum width	1.7-2.4	1.9	1.7
N	67	approx.46	approx.72
ds	0.24-0.34	0.36	0.24-0.32
IK	0.18-0.25	0.23	0.18
RK	7.0	5.5	7.8
Loculi	1/5-1/9.8	1/5.3	1/5.3-1/6.9
Outer wall carcass:			
n	3-4	3	2-4
d	0.11-0.15	approx.0.17	0.12-0.15
l	0.05-0.06	-	-
t	0.10-0.15	0.12	0.10-0.15

Outer wall subdivided pores:			
n	3	3	-
d	0.07-0.09	0.05-0.07	0.05-0.07
l	approx.0.05	-	approx.0.05
t	0.03	0.03-0.05	0.05
Inner wall:			
n	3-4	3	2-3
d	0.07-0.11	0.07-0.10	0.07-0.10
l	0.05	0.03-0.05	-
t	0.05-0.07	approx.0.05	approx.0.05
Septa:			
n	6-9	5-7	6-7
d	0.15-0.39x0.22	0.10-0.48x0.41	0.24x0.29
l	0.07-0.11	0.07-0.12	0.06-0.10
t	0.07	0.07	0.07
Width of spinose lining	0.07-0.19	0.15-0.22	0.12

ONTOGENY. At the smallest known cup diameter of 3.22mm the outer wall is well defined and may have subdivided outer wall pores. The space enclosed by the outer wall contains short disoriented plates linked by numerous dissepiments. The inner wall and central cavity appear at a cup diameter of 4.9mm. The inner wall is spinose from its first appearance. Septa with netlike porosity appear together with the inner wall and central cavity. The latter remains largely free from skeletal material but one or two dissepiments occur near its base.

COMPARISON AND REMARKS. The holotype (not seen by the writer) is a fragment of a larger cup (diameter 15mm) than those described above. According to R. and J. Bedford (1937, p.29) the width of the inner wall and spinose lining is 1.5mm, five times greater than the maximum width seen in the specimens described above. However, the Bedfords appear to have overestimated this width, since from measurements of photographs of the holotype (in Hill, 1965, Pl.10, Figs. 4a, b) the width of the spinose lining varies from 20 to 30 percent of the intervallum width. In the specimens measured above, this width is 10 percent. The differences between the holotype and the specimens described above are thought to be due to the larger cup size and silicification of the holotype.

Copleicyathus scottensis sp.nov.

(Plate 47, Figs. 5 to 9; Plate 48, Fig. 1)

NAME. After Mount Scott.

HOLOTYPE. P21423-1 (six thin sections).

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus.

DESCRIPTION. Colonial cup increasing by opposed indentation of the intervallum, new cups grow erect and parallel. Both walls are affected by minor transverse undulations. The compound outer wall is composed of a simple carcass with 2-3 rows of rounded pores per intersept frequently anastomosing laterally. Each carcass pore is partly or completely subdivided into 2-4 micropores. The intervallum is crossed by straight radial septa with netlike porosity; pore rows curve away from the mid-line of the intervallum towards both walls. Septal pores are oval to slit-like with the largest and most elongate in the middle of the intervallum. Synapticulae are sparse. Inner wall simple with 2-3 rows of quincunxial circular pores per intersept, occasionally anastomosing. Interpore lintels bear a series of tufts of very short spines which radiate into the central cavity and partly obscure the inner wall pore openings. Dissepiments are absent but the specimen is broken well above the base so that early growth stages are not known.

DIMENSIONS (mm)

Diameter 12.5; height (partial) 50; intervallum width 2.17; N 93; ds 0.31-0.36; intervallum coefficient 0.17; radial coefficient 7.45; loculi 1/6-1/7.

Outer wall carcass: n 2-3; d 0.10-0.15; l 0.06-0.07; t 0.12-0.15.

Outer wall subdivided pores: n 2-4; d 0.03-0.05; l 0.03; t 0.03-0.05.

Inner wall: n 2-3; d 0.07-0.12; l 0.06-0.07; t 0.05-0.07.

Septa: n 6-9; d 0.12x0.17-0.53x0.17; l 0.07; t 0.06-0.09; width of spinose lining 0.03-0.05.

COMPARISON AND REMARKS. Copleicyathus scottensis sp.nov. has a spinose inner wall lining which is 2 percent of the intervallum width for a cup 12.5mm in diameter. This is significantly less than that measured for smaller cups of C.confertus. In addition C.scottensis has a slightly narrower intervallum and more elongate septal pores.

Copleicyathus cymosus sp.nov.

(Plate 48, Figs. 2 to 7)

NAME. From Latin cymosus = full of shoots.

HOLOTYPE. P21687-1 (three thin sections).

PARATYPES. P21687-2; P21688; P21689.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section E.

MATERIAL. Eighteen specimens from Wilkawillina Gorge. Sections E, G and I. Holotype and paratypes as above. Additional specimens: P21690; P21691-1,-2; P21692 to P21696; P21697-1, -2; P21698; P21699; P21700-1; P21701.

DIAGNOSIS. Colonial two walled cups increasing by budding from the intervallum. Outer wall compound with carcass pores subdivided to form a microporous system. Intervallum with highly porous septa which are straight near the inner wall but bend near the outer so that crests are opposite for adjacent septa. These are linked by frequent oblique and tangential synapticulae. Inner wall simple with several pores per intersept. Spines of varying length grow from the lintels subhorizontally into the central cavity, resulting in a spinose lining of irregular shape. Dissepiments in the intervallum and outgrowths from the outer wall are abundant.

DESCRIPTION. Colonial cups increase by budding from the intervallum to produce an extensive dendritic growth. The compound outer wall has 2-3 rows of circular or irregular pores per intersept, each subdivided into approximately 4 micropores. Septa in the intervallum are straight near the inner wall, then bend in a zig-zag fashion towards the outer wall, crests and troughs of adjacent septa are opposite. Septal pores are abundant, inner rows curve towards the inner wall, central and outer rows curve in the opposite direction. Where septa are wavy 1-2 pore rows are formed on each crest and trough, pores are oval with the long axis in the direction of curvature of the rows. Opposing septal crests are linked by synapticulae or porous tangential partitions especially in the outer part of the intervallum. Inner wall simply porous with several rows of rounded pores per intersept in quincunx. Growing inward from the interpore lintels is a series of delicate branching spines with fine tufted tips, their lengths are variable, either up to half the width of the central cavity or totally absent in the same specimen. Spines are subhorizontal. Intervallum with abundant dissepiments, especially around newly forming cups. Outgrowths from the outer wall are common, particularly where adjacent cups are close. They usually form a repetition of the outer wall and intervallum structure beyond the original cup boundary.

DIMENSIONS (mm)	Holotype P21687-1	Paratype P21689	Paratype P21688
Diameter	13.3	10.7	13.3-14.5
Intervallum width	3-4	3.0-3.4	3.4
N	-	38	64
ds	0.50	0.30-0.56	0.32-0.78
IK	0.25	0.28-0.32	av.0.25
RK	-	3.6	4.8
Loculi	1/6.7	1/5.3-1/11.6	av.1/5.4
Outer wall carcass:			
n	2	3	3
d	0.15-0.19	-	0.15-0.22
l	-	-	0.05
t	0.15-0.19	0.12-0.17	0.15-0.17
Outer wall subdivided pores:			
n	?4	-	?4
d	0.06-0.07	0.07-0.08	0.04-0.05
l	0.05	-	0.03-0.05
t	-	0.05-0.10	0.05-0.07
Inner wall:			
n	2-3	1-3	2-3
d	0.12-0.15	0.12-0.15	0.10-0.17
l	-	0.05-0.07	0.05-0.07
t	approx.0.05	0.05-0.12	0.07
Width of spinose lining	0.0-2.2	-	0.0 -0.34
Septa:			
n	8-?	6-?	8
d	0.15x0.24-0.34x0.41	0.17x0.12-0.65x0.34	0.22x0.39
l	0.10-0.15	0.07-0.15	0.12-0.15
t	0.07-0.09	0.07-0.11	0.06-0.07

COMPARISON AND REMARKS. Copleicyathus cymosus sp.nov. differs from other species in the genus by the irregularity of its spinose lining on the inner wall; lower radial coefficient; higher intervallum coefficient and larger wall pores. In addition septa are more wavy and linked by numerous synapticulae. The type of colonial cup growth is also different.

Genus METALDETES Taylor, 1910.

1910 Metaldetes Taylor,p.151
1957 Bedfordcyathus Vologdin, p.182, 205.
1964 Bedfordcyathus Vologdin; Hill, p.144.
1970 Metaldetes Taylor; Debrenne, p.36.
1972 Metaldetes Taylor; Hill, p.E111.
1974 Metaldetes Taylor; Debrenne, p.217.
1974 Praefungia Debrenne, p.227.

Type species. Metaldetes cylindricus Taylor, 1910.

DIAGNOSIS. Solitary or colonial two walled cups. Outer wall compound with several pore rows per intersept, each subdivided by skeletal protrusions from the lintels to form a rudimentary or well developed microporous system. Intervallum with straight porous septa; netlike porosity may form but septal pores are not usually sufficiently close. Synapticulae are present in early stages of growth but are often lost in adult cups. The inner wall is compound similar to the outer wall. Inner wall and central cavity are developed late in ontogeny above a base containing vertical and horizontal tangential rods and numerous dissepiments.

DISCUSSION. Considerable debate has centred around the question of synonymy between Metacyathus Bedford R. and W.R. and Metaldetes Taylor. The type species of Metacyathus is Metacyathus taylori by original designation by R. and W.R. Bedford (1934, p.5, Fig. 20). Okulitch (1955, p.E16); Debrenne (1964, p.218; 1969a, p.335; 1970b, p.36; 1974a, p.217) and Hill (1972, p.E109) considered Metacyathus and Metaldetes to be synonymous. Three fragments of the holotype of Metacyathus taylori are in the British Museum of Natural History and have not been examined by the writer. However, three other fragments labelled as being part of the holotype are housed in the South Australian Museum (Bedford collection, P970-151, 152, 153). An examination of these shows that the inner wall has two rows of simple pores per intersept, corresponding with the original observations of R. and W.R. Bedford (1934, p.6) and with those of Debrenne (1969a, p.361). The inner wall of Metaldetes is compound, consisting of a basic carcass with subdivided pores. Because of the simpler construction of the inner wall of the holotype of Metacyathus taylori, which is the type species of Metacyathus the genera Metacyathus and Metaldetes are not considered to be synonymous. Vologdin (1957) created a genus Bedfordcyathus whose type species by monotypy is Metacyathus irregularis Bedford R. and W.R., the second species described by the Bedfords (1934, p.6). Hill (1964b, p.144; 1965, p.118) considered Bedfordcyathus to be a distinct genus from both Metaldetes and Metacyathus, whereas Debrenne (1969a, 1970b, 1974a) considered all three genera to be synonymous. The type specimens of Metacyathus irregularis are all kept at the British Museum and have not been seen by the writer but judging by Debrenne's description (1969a, p.360) the inner wall appears to be compound, with subdivided pores. It is considered herein that Bedfordcyathus is synonymous with Metaldetes, but Metacyathus is not. Debrenne (1974a, p.227) separated a new genus Praefungia from Metaldetes based on the presence of synapticulae and absence of dissepiments in the former. These two genera are placed in synonymy in this work because it is considered that the presence or absence of synapticulae and dissepiments constitute specific and not generic criteria.

Metaldetes dissepimentalis (Taylor, 1910)

(Plate 16, Fig. 1; Plate 49, Figs. 1 to 4)

1910 Archaeocyathus dissepimentalis Taylor, p.128,Pl.1m,Pl.9,Fig.53.
1934 Metaldetes conicus Bedford R. and W.R., p.5,Pl.4,Fig.26,Pl.5, Figs.28, 31.
1934 Metacyathus irregularis Bedford R. and W.R., p.6,Pl.5,Fig.29.

1936 Metaldetes conicus Bedford R. and W.R., p.18, Pl.18, Fig.77.
1957 Bedfordcyathus irregularis (Bedford R. and W.R.); Vologdin, p.43.
1964 Bedfordcyathus irregularis (Bedford R. and W.R.); Debrenne, p.231.
1965 Bedfordcyathus irregularis (Bedford R. and W.R.); Hill, p.118, Pl.10, Fig.1, Fig.22-9a-c.
1969 Metaldetes dissepimentalis (Taylor); Debrenne, p.358, Pl.16, Figs.1-3.
1969 Metaldetes irregularis (Bedford R. and W.R.); Debrenne, p.359, Pl.16, Fig.4.
1974 Metaldetes dissepimentalis (Taylor); Debrenne, p.221, Fig.22.

HOLOTYPE. T1550M-Z8

TYPE FORMATION. Ajax Limestone. Faunal Assemblage not known.

TYPE LOCALITY. Ajax Hill.

MATERIAL. Seventeen specimens from Wilkawillina Gorge. Sections E, G, H and I. P21451-2; P21447-2, -3; P21648-2, -3; P21545-2; P21642-1; P21702-1, -2; P21703-1, -2; P21704 to P21706, P21707-1, -2; P21708.

DIAGNOSIS. Two walled cups with compound outer and inner walls. Intervallum with straight or curving septa, frequently bifurcating and linked by sparse synapticulae in small cups. Septa are porous but not enough to produce netlike porosity. The inner wall bears small spines projecting into the central cavity. Dissepiments are abundant in the intervallum especially when near outgrowths from the outer wall; in rare cases dissepiments are absent in the upper parts of the intervallum.

DESCRIPTION. Cups solitary, roughly conical. The compound outer wall consists of a simply porous basic carcass with 2-3 rows of pores per intersept each subdivided into a cluster of 4-6 micropores. The skeletal protrusions subdividing the carcass pores bear a series of very fine spinules which project partly across the micropore openings. The intervallum is crossed by straight and gently curving septa which bifurcate frequently. New septa are added from the outer and inner walls. Septa are porous with vertical rows in the mid-line of the intervallum, and flanking rows which curve gradually towards the inner and outer walls. Septal pores are circular and oval. Sparse tangential and oblique synapticulae are present in cups up to approximately 12mm diameter. At larger diameters they are absent. The compound inner wall has a simply porous carcass with 1-3 rows of circular pores per intersept; each pore is partly subdivided into 2-4 lobes. The inner wall lintels support a nap of fine spinules which project into the central cavity and border the pore openings. Dissepiments are usually abundant particularly where outgrowths are formed on the outer wall and to a lesser extent the inner wall. They may be absent from some parts of the intervallum. The central cavity is normally empty from the moment of its first appearance, but is sometimes partially blocked by films of dissepimental tissue which envelop growths from the inner wall.

DIMENSIONS (mm)	P21702-1	P21702-2	P21703-1
Diameter	14.2	8.2	12.3
Intervallum width	2.5-2.7	2.0	2.1-2.3
N	approx.68	-	approx.80
ds	0.44-0.74	approx.0.40	0.36-0.44
IK	0.16-0.18	0.24	0.17-0.19
RK	4.2	-	6.5
Loculi	1/3.4-1/5.7	-	1/4.9-1/6.4
Outer wall carcass:			
n	2-3	2	2
d	-	0.17-0.24	0.17-0.22
l	-	0.07-0.12	-
t	0.15-0.17	0.10-0.15	0.14
Outer wall subdivided pores:			
n	-	4-6	-
d	-	0.09	-
l	-	0.03	-
t	-	0.03	-
Inner wall carcass:			
n	2-3	2-3	2-3

d	0.12	0.10-0.17	0.12-0.19
l	-	0.05-0.07	-
t	0.12	0.10	0.12
Inner wall subdivided pores:			
n	approx.4	3-?6	-
d	0.05	0.05	approx.0.07
l	-	approx.0.01	-
t	approx.0.025	-	-
Septa:			
n	6-7	7	6-7
d	0.12-0.27	0.12-0.15x0.31	0.12-0.19x0.26
l	0.10-0.17	0.09-0.16	0.07-0.17
t	0.07-0.10	0.05-0.07	0.06-0.07
Outer wall spine length	approx.0.02		
Inner wall spine length	0.05-0.07		

ONTOGENY. The inner wall and central cavity appear at a cup diameter of 4.5-5.5mm. The central cavity is normally empty once a cup diameter of 7.5mm is attained, but may contain short disoriented rods and dissepiments to 12mm cup diameter. Before the inner wall appears, the base of the cup contains vertical and horizontal tangential short rods and numerous dissepiments. When the inner wall appears it has one pore row per intersept and the lintels are spinose. The first appearance of inner wall subdivided pores is uncertain but they are present at a cup diameter of 6.7mm. The origin of the outer wall is not clear but it is well developed with subdivided pores at 6mm cup diameter. The first appearance of porous septa is obscured by abundant dissepiments but septa are evident once the inner wall is defined. Sparse synapticulae link adjacent septa at cup diameters less than 12mm. It is not certain whether synapticulae are a continued development of the tangential rods at the base of the cup or whether they arise separately after the formation of septa.

COMPARISON AND REMARKS. The major difference between the holotype and the specimens described above is in the value of the radial coefficient which is 2.2 at a cup diameter of 26mm for the holotype. The largest specimen from Wilkawillina Gorge has a radial coefficient of 4.2 at a cup diameter of 16.3mm. The specimens described above show a considerable increase in septal separation with cup growth, with a corresponding decrease in radial coefficient. The difference between the holotype and specimens described above are consistent with their differences in size.

The descriptions of Metacyathus irregularis and Metaldetes conicus by Debrenne (1969a, p.358-360) indicate that these species are synonymous with Metaldetes dissepimentalis, a view held by Debrenne (1974a, p.221) and by the present writer. As stated above, the species Metacyathus taylori is not considered to be synonymous with Metaldetes dissepimentalis.

Metaldetes ferulae sp.nov.

(Plate 49, Figs. 5 to 8; Plate 50, Figs. 1, 2)

NAME. From Latin ferula = rod.

HOLOTYPE. P21498-1 (three thin sections).

PARATYPE. P21709.

TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section G.

MATERIAL. Two specimens, one each from Wilkawillina Gorge, section G, and the Mount Scott Range, section N.

DIAGNOSIS. Solitary conical cups with a wide central cavity. Outer and inner walls compound with subdivided pores. Rods extend outwards from the interpore lintels of the outer wall. The inner wall is thickened by lintel projections into the central cavity. Intervallum with robust porous septa which are linked by sparse synapticulae. Dissepiments abundant. Inner wall and central cavity appear late in ontogeny above a base containing vertical rods or platelets linked by dissepiments.

DESCRIPTION. Solitary conical cups with a wide central cavity. The outer wall supports an extensive growth of exothecal tissue with a ramifying and encrusting habit. The compound outer wall has a simply porous carcass with 2-3 rows of circular pores per intersept, often anastomosing laterally. The carcass pores are partly subdivided by skeletal protrusions across their openings to form a series of three or more lobes. Cylindrical rods or fingerlike projections extend outward from the interpore lintels. Septa in the intervallum are straight or slightly wavy, pores are circular or oval in rows curving gently from the inner to the outer wall. Some septal pores are closed by films of dissepimental tissue. Sparse synapticulae occur chiefly close to the outer wall. The inner wall is thick with triangular projections extending into the central cavity from the septa and from lintels between adjacent septa. Inner wall pores are in 2-3 rows per intersept, circular in shape and frequently anastomosing to form hourglass-like or cloverleaf-like openings. These openings are subdivided on the intervallum side of the inner wall to form 3 or more micropores per carcass pore. Dissepiments are abundant throughout the intervallum. Often they extend beyond the outer wall to fill exothecal outgrowths.

DIMENSIONS (mm)	Paratype P21709	Holotype P21498-1
Diameter	approx.13.5	19.5
Intervallum width	3.2-3.5	3.3-4.1
N	approx.40	56
ds	0.51-0.72	0.53-0.78
IK	0.24-0.26	0.17-0.21
RK	approx.4.0	approx.2.9
Loculi	1/4.5-1/6.8	1/4.2-1/7.8
Outer wall carcass:		
n	?2	3

d	-	0.15-0.29
l	-	0.07-0.17
t	0.24	0.17
Outer wall subdivided pores:		
n	-	3-4
d	0.05-0.10	0.09-0.11
l	0.07 max.	0.07max.
t	0.05	0.05
Inner wall carcass:		
n	2-3	2-3
d	0.12-0.19	0.15-0.19
l	0.12	-
t	0.10-0.15	0.12
Inner wall subdivided pores:		
n	4	-
d	0.03-0.07	approx.0.02
l	approx.0.02	-
t	0.05	approx.0.06
Septa:		
n	8	10-12
d	0.20-0.48	0.24x0.15-0.22x0.65
l	0.15-0.27	0.15-0.19
t	0.12-0.15	0.11-0.17

Outer wall rods, length 0.27-0.41; diameter 0.05-0.07.
Inner wall projections 0.41-0.60.

COMPARISON AND REMARKS. Metaldetes ferulae sp.nov. differs from other species in the genus by the presence of rodlike projections from the outer wall and a robust inner wall. Because of its thickness the inner wall pores are subdivided on the side of the intervallum. In other species the inner wall pores are subdivided on the side of the central cavity.

Metaldetes incohatus sp.nov.

(Plate 3, Fig. 3; Plate 15, Fig.4; Plate 50, Figs. 3 to 6)

NAME. From Latin incohatus = rudimentary.

HOLOTYPE. P21710 (five thin sections).

PARATYPES. P21711; P21712-1; P21713.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Five specimens from the Mount Scott Range, sections K and N; one specimen from Wilkawillina Gorge, section G. Holotype and paratypes as above. Additional specimens: P21714-1; P21715.

DIAGNOSIS. Solitary or colonial cups. Solitary cups vary from narrow pipe-like to widely expanding bowl shaped forms. The intervallum remains narrow throughout cup growth. The compound outer wall carcass has anastomosing pores subdivided to a very rudimentary degree. Septa are straight and radial with oval pores. Synapticulae are rare to absent. The simply porous inner wall carcass has several pore rows per intersept, each subdivided to a greater extent than the outer wall carcass pores. Dissepiments are usually restricted to the base of the cup.

DESCRIPTION. Pipe or bowl-like forms, solitary or colonial. Outer wall with 1-3 rows of rounded pores per intersept, frequently anastomosing laterally and vertically to form cloverleaf, hourglass and meandering slit-like openings. Some, but not all openings are partly subdivided by very short skeletal projections from the lintels. Septa are straight, radial, occasionally bifurcating, with pore rows curving gently from the inner to the outer wall. Septal pores are circular and oval. Synapticulae are rare to absent in the upper parts of cups more abundant near the base. Inner wall pores circular and oval in 2-3 rows per intersept, each pore partly or completely subdivided to form microporous openings. Close, fine short spines extend from the lintels into the central cavity. Dissepiments are normally restricted to the base of the cup. Where present at higher cup levels they are associated with outgrowths from the cup.

DIMENSIONS (mm)	Holotype P21710	Paratype P21711	Paratype P21712
Diameter	est.max.108	11.6	11.4
Intervallum width	2.8-3.2	1.5-2.1	1.7-2.2
N	approx.153 at D=40	60	est.40
ds	0.58-0.68	0.48-0.61	0.63-0.75
IK	0.07-0.23	0.13-0.18	0.15-0.19
RK	approx.4.5	5.2	est.3.5
Loculi	1/4.5	1/2.5-1/4.3	1/2.3-1/3.5
Outer wall carcass:			
n	2	2	2-3
d	0.10-0.30	0.15-0.46x0.22	0.17-0.27
l	0.05-0.18	0.07-0.12	0.12-0.19
t	0.17-0.20	0.10	0.15
Outer wall subdivided pores:			
	rudimentary	rudimentary	rudimentary
Inner wall carcass:			
n	2-3	2-3	2-3
d	0.22-0.29	0.17	0.17-0.24
l	0.07-0.12	0.05-0.09	0.06-0.12
t	0.12-0.15	0.05-0.10	0.12-0.15
Inner wall subdivided pores:			
n	2-4	-	2-4
d	0.07-0.12	approx.0.10	0.08-0.10
l	0.03	-	0.03
t	0.05-0.07	-	0.07
Septa:			
n	6	4-5	5
d	0.17-0.34x0.44	0.14x0.22	0.05-0.32
l	0.10-0.15	0.08-0.19	0.13-0.20
t	0.06-0.11	0.07-0.09	0.07

COMPARISON AND REMARKS. *Metaldetes incohatus* sp.nov. has the most rudimentary subdivision of the outer wall pores of any known species of the genus.

Metaldetes gracilis sp.nov.

(Plate 50, Figs. 7, 8; Plate 51, Figs. 1, 2)

NAME. From Latin *gracilis* = slender.

HOLOTYPE. P21716 (four thin sections).

PARATYPE. P21717.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Two specimens from the Mount Scott Range, section N.

DIAGNOSIS. Colonial and ? solitary cups. Outer and inner wall pores subdivided. Septa with netlike porosity,sporadic synapticulae. Dissepiments may be present or absent in adult cups. Early growth stages are not known.

DESCRIPTION. Cylindro-conical colonial and possibly solitary cups. Outer wall carcass with 2-3 rows of rounded pores per intersept, each subdivided to form a microporous system. Intervallum with straight radial septa pierced by pores in near vertical rows which diverge gradually from the inner to the outer wall. Septal porosity netlike, with large oval pores in the centre of the intervallum and smaller pores close to the walls. Synapticulae are sparse,usually only one is seen in the intervallum in transverse section. Inner wall carcass compound with 2-3 rows of rounded pores per intersept, each subdivided to form a microporous system. Dissepiments are absent from one specimen, the other has dissepiments in the intervallum only where encrusting outgrowths are present on the walls. Both specimens are broken above the base.

DIMENSIONS (mm)	Holotype P21716	Paratype P21717
Diameter	12.0	11.6
Intervallum width	1.38-1.92	1.48-1.78
N	85	approx.63
ds	0.29-0.36	0.32-0.41
IK	0.12-0.16	0.13-0.15
RK	7.1	approx.5.4
Loculi	1/3.8-1/6.6	1/3.6-1/5.7

Outer wall carcass:		
n	2-3	2-3
d	0.15-0.15x0.22	0.16-0.24
l	0.05-0.10	0.07-0.12
t	0.12	0.10-0.17
Outer wall subdivided pores:		
n	2-4	2-5
d	0.03-0.07	0.06
l	0.01-0.03	approx.0.02
t	0.03	0.02-0.03
Inner wall carcass:		
n	2	2-3
d	0.10-0.15	0.07-0.15
l	0.05	0.05-0.07
t	0.10-0.12	0.10-0.12
Inner wall subdivided pores:		
n	2-3	3
d	0.05-0.07	approx.0.07
l	0.03	-
t	0.05	-
Septa:		
n	6-7	4-7
d	0.09-0.39x0.48	0.12x0.20-0.48x0.32
l	0.06-0.08	0.06-0.012
t	0.07	0.07

COMPARISON AND REMARKS. Metaldetes gracilis sp.nov. differs from other known species in the genus by its netlike septal porosity and lack of spines on either wall.

FAMILY ARDROSSACYATHIDAE fam.nov.

DIAGNOSIS. Outer wall basic with simple pores in vertical rows. Inner wall with pore tubes in several rows per intersept.

Genus ARDROSSACYATHUS Bedford R. and J.,1937.

Type species. Ardrossacyathus endotheca Bedford R. and J., 1937

DIAGNOSIS. Solitary conical two walled cups. Outer wall thick composed of a simple carcass pierced by pores of varying size and shape, pore openings not subdivided. Intervallum with septa having netlike porosity. Sparse synapticulae link septa at early stages of growth, but are absent from large cups. Inner wall consists of several (rarely one) rows of short oblique pore tubes per intersept, opening upwards into the central cavity. The inner wall and central cavity appear late in ontogeny over a base containing short plates and rods connected by numerous dissepiments. Dissepiments may be present or absent from the intervallum and central cavity at large cup diameters.

DISCUSSION. The holotype of the genotype (Princeton University 86 766), not seen by the writer, is a fragment of a cup 13mm in diameter. Judging by the original description and illustrations of the holotype, which is the only known specimen, the outer wall is composed of irregular pores and the inner wall of oblique pore tubes. Septa are straight and composed of a delicate mesh surrounding large irregularly shaped pores (Bedford R. and J., 1937, p.31, Pl.30, Fig.125A, Pl.31, Fig. 125B). Numerous specimens of a new species described below, have the same skeletal characteristics, the chief difference being that in the new species dissepiments are confined to small cups whereas they are present throughout the intervallum and central cavity of the type species, which is comparatively small cup.

<u>Ardrossacyathus grandis</u> sp.nov.

(Plate 3, Fig. 1; Plate 14, Fig. 2; Plate 51, Figs. 3 to 9)

HOLOTYPE. P21718(three thin sections).

PARATYPES. P21719; P21720; P21722; P21725.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Twenty three specimens from the Mount Scott Range, sections

J, K and N. Eight specimens from Wilkawillina Gorge, sections H and I. Holotype and paratypes as above. Additional specimens: P21714-2; P21721; P21723-1, -2; P21724-1, -2; P21725; P21726; P21727-1, -2; P21728; P21729; P21730-1, -2;P21731-1, -2; P21732 to P21739.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary conical cups with smooth outer and inner walls. Outer wall thick and simply porous, with 1-4 irregular rows of rounded pores per intersept. Intervallum with straight radial, sometimes bifurcating septa, new septa are frequently added from the outer wall. Septa have netlike porosity. Synapticulae are sparse, usually restricted to cups less than 14mm diameter. The inner wall is composed of short oblique pore tubes in 2-4 (more rarely 1-4) rows per intersept, tubes open upward into the central cavity. Carcass pores at the base of the tubes may anastomose laterally. The inner wall and central cavity appear late above a base containing disoriented short plates and rods connected by numerous dissepiments. Dissepiments may persist in the intervallum after the inner wall and central cavity appear, but are usually absent in large cups.

DIMENSIONS (mm)	Holotype P21718	Paratype P21720	Paratype P21725
Diameter	26	14.2	21.9
Intervallum width	4.0	3.1	3.8-4.9
N	73+17 partial	39+5 partial	approx.58+14partial
ds	0.61-0.97	0.57-0.85	0.73-0.97
IK	0.15	0.22	0.17-0.23
RK	2.8	2.8	approx.2.7
Loculi	1/4.1-1/6.6	1/3.6-1/5.4	1/3.9-1/6.8
Outer wall carcass:			
n	3	1-3	2-3
d	0.10-0.22x0.48	0.10-0.44	0.12-0.36
l	0.07-0.15	0.05-0.24	0.12-0.31
t	0.17-0.36	0.15-0.36	0.17-0.36

Inner wall pore tubes:

n	3	1-3	1-3
d	0.15-0.36	0.24-0.29	0.24-0.36
Tube length (oblique)	0.44	0.46	max.0.46
Tube wall thickness	0.10	0.10-0.15	0.12
Septa:			
n	7	6	11
d	0.24x0.36-0.53x1.0	0.22-0.56	0.19-0.48x1.2
l	0.17	0.12-0.22	0.10-0.17
t	0.10-0.15	0.10-0.12	0.12

ONTOGENY. The inner wall and central cavity appear at 5-6mm cup diameter, above a base containing short plates, rods, and dissepiments. The outer wall is usually visible within the dissepiment zone at smaller cup diameters. One specimen with very little dissepimental tissue at the base shows an inner wall and central cavity well defined at a cup diameter of approximately 4.4mm, its inner wall is initially simple but pore tubes develop rapidly at a cup diameter of 6mm. Septa are well defined from the moment of the first appearance of the inner wall and central cavity, the first pores are oval and up to 0.48mm in size. Synapticulae are present but sparse between 7.5mm and 14mm cup diameter. They are rare to absent in larger cups.

COMPARISON AND REMARKS. Lack of knowledge of the detailed structure of the outer wall of A.endotheca makes comparison of this feature impossible, but A.grandis differs by having septa with oval and not irregular pores.

SUPERFAMILY SPIRILLICYATHACEA superfam.nov.

DIAGNOSIS. Outer wall initially simply porous. The wall becomes compound with subdivided pores later in ontogeny. Pores are in vertical rows. Outer wall attached to septa by paired oblique struts. Septa only reach the outer wall between successive vertical pairs of struts.

FAMILY SPIRILLICYATHIDAE fam.nov.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with a simply porous carcass attached directly to the septa. Pores are in vertical rows.

Genus SPIRILLICYATHUS Bedford R. and J., 1937.

Type species. Spirillicyathus tenuis Bedford R. and J., 1937.

DIAGNOSIS. Two walled cups, initially conical with circular cross-section. With cup growth transverse sections become oval and increasingly elongate. Outer wall with a simply porous carcass attached indirectly to the septa by paired oblique struts. Septa only reach the outer wall between successive pairs of struts. An additional outer wall pore is formed between each pair of struts. Outer wall pores are subdivided to form a microporous system. The intervallum contains porous septa perpendicular to the walls. Septa may be wavy and linked by synapticulae, or straight without synapticulae. The inner wall has a simply porous carcass attached directly to the septa. Pores are in one or two vertical rows per intersept. Initial stages are characterized by the early appearance of the inner wall, central cavity and porous septa. No dissepiments have been seen.

DISCUSSION. The discovery of several well preserved specimens of S.pigmentum and one of S.tenuis has contributed to a greater understanding of the morphology and ontogenetic development of these species. The fragmentary nature and small size of the only two specimens in the Bedford collection prevented any clarification of the affinities of the genus, consequently Debrenne (1970b, p.43) and Hill (1972, p.E111) placed Spirillicyathus doubtfully in the Metacyathidae. Earlier Hill(1965, p.118) referred the genus doubtfully to the Dictyocyathidae and more recently Debrenne (1974a,p.202) regarded the genus as incertae familiae.

Spirillicyathus tenuis Bedford R. and J., 1937.

(Plate 52, Figs. 1 to 5)

1937 Spirillicyathus tenuis Bedford R. and J., p.30,Pl.29,Fig.118.
1939 Spirillicyathus tenuis Bedford R. and J., p.73.
1970 Spirillicyathus tenuis Bedford R. and J.; Debrenne, p.43.
1972 ? Spirillicyathus tenuis Bedford R. and J.;Hill, p.E111,Fig.77-1.
1974 ? Spirillicyathus tenuis Bedford R. and J.;Debrenne, p.202,Fig.10.

HOLOTYPE. Princeton University, 86752-179.

TYPE FORMATION. Ajax Limestone. Faunal Assemblage II.

TYPE LOCALITY. "Paint Mine".

MATERIAL. Three specimens from the Mount Scott Range, section N. One specimen from Wilkawillina Gorge, section E. P21411-2; P21535-3; P21614-4; P21741.

DIAGNOSIS. As for the genus. This species has wavy septa linked by synapticulae.

DESCRIPTION. Two walled solitary cups initially conical and circular in transverse section. With increasing growth, cups develop an elongate shape in transverse section. The compound outer wall consists of a simple carcass attached to oblique struts from the septa, carcass pores between struts and opposite each septum are shared by adjacent intersepts. An additional row of carcass pores is present at the centre of each intersept, pores frequently anastomose vertically. Each carcass pore is subdivided into two or more micropores. The intervallum contains porous septa perpendicular to both walls, septa are regularly wavy with opposing crests linked by synapticulae. Synapticulae are regularly spaced in transverse and longitudinal sections. Septa are pierced by oval pores in vertical rows curving gently from the inner to the outer wall, pores are more distant vertically than horizontally.

The inner wall consists of a simply porous carcass linked directly to the septa, with one vertical pore row per intersept.

DIMENSIONS (mm) Specimen P21411-2.

Length of major axis 25; width of minor axis at the same level 5.8 (minimum); intervallum width 2.0; N 58; intervallum coefficient 0.34; radial coefficient 2.3; ds 0.64-0.74; loculi 1/2.7-1/3.1.

Outer wall carcass: n 2; d 0.15-0.27; l 0.10; t 0.12.

Outer wall subdivided pores: n 2-?;d 0.07-0.10; l 0.05-0.07; t 0.03-0.05.

Inner wall carcass: n 1; d 0.24-0.29; l 0.15-0.22; t 0.10-0.12.

Septa: n ?5; d 0.15-0.29x0.41; l (between rows) 0.08; l (between pores in one row) 0.15-0.22; t 0.10-0.12.

Synapticulae: horizontal separation 0.34-0.64; vertical separation 0.34-0.59.

ONTOGENY. Earliest stages of growth are not known. Below a cup diameter of approximately 6mm the outer wall is simply porous, with up to 4 rows of circular pores per intersept. At this stage the carcass is linked directly to the septa. At approximately 6mm cup diameter, struts from septa to the outer wall are formed, but the carcass pores are still not subdivided. Rudimentary outer wall subdivisions appear at a cup diameter of approximately 9mm. The early development of septa and synapticulae is not known.

COMPARISON AND REMARKS. Debrenne (1974a, p.202) was unable to find a microporous system on the outer wall. This is not surprising since the holotype is only 6mm in diameter. S.tenuis differs from S.pigmentum by the presence of wavy septa linked by synapticulae in the intervallum, and by the closer spacing of septal pores.

Spirillicyathus pigmentum Bedford R. and J., 1937.

(Plate 16, Figs. 2 to 4; Plate 52, Figs. 6 to 11)

1937 Spirillicyathus pigmentum Bedford R. and J., p.30,Pl.29,Fig.117.
1974 ? Spirillicyathus pigmentum Bedford R. and J.;Debrenne, p.203,Fig.11.

HOLOTYPE. Princeton University 86761-182.

TYPE FORMATION. Ajax Limestone. Faunal Assemblage II.

TYPE LOCALITY. "Paint Mine".

MATERIAL. Ten specimens from the Mount Scott Range, section N.
P21507-3; P21509-3; P21423-2; P21590-3; P21742 to P21745; P21746-2, -3.

DIAGNOSIS. As for the genus. This species has straight septa with no synapticulae.

DESCRIPTION. Solitary two walled conical cups initially with circular cross-section. With increasing cup size transverse sections have a progressive elongation in one direction with a steadily increasing major axis and a more or less constant minor axis. The compound outer wall consists of a simple carcass attached to struts from the outer edges of the septa, pores between struts opposite a septum are shared between adjacent intersepts; one or two additional pore rows are formed between adjacent septa. Each carcass pore is completely subdivided to form a microporous system. Sometimes these are further subdivided to form a second series of micropores. Septa are straight, perpendicular to the walls, pierced by rows of elliptical pores which curve gently from the inner to the outer wall, septa not sufficiently porous to form netlike porosity. The inner wall has a simple carcass attached directly to the septa, carcass pores are in one or two rows per intersept in irregular quincunx.

DIMENSIONS (mm)	P21742	P21423-2	P21507-3
Major axis	10	24.8	oblique
Minor axis	5.1	8.0	-
Intervallum width	1.7	2.4-2.9	2.0
N	27+2	66+8	-
ds	0.61-0.73	0.54-0.94	0.69-0.96
IK	0.34	0.30-0.36	0.31
RK (=N/Major axis)	2.70	2.66	-
Loculi	1/2.4-1/2.9	1/2.6-1/5.3	1/2.1-1/2.9
Outer wall carcass:			
n	$2+\frac{1}{2}+\frac{1}{2}$	$2-?3+\frac{1}{2}+\frac{1}{2}$	$1-2+\frac{1}{2}+\frac{1}{2}$
d	approx.0.20	approx.0.24	0.31-0.39
l	-	0.05-0.07	0.06-0.12
t	0.07-0.12	0.05-0.10	0.10
Outer wall subdivided pores:			
n	-	-	3-?5
d	0.12	0.07-0.10	0.10-0.15
l	-	0.05-0.07	0.03-0.05
t	0.04	0.05	-
Inner wall carcass:			
n	1-2	1-2	1-2
d	approx.0.19	0.24x0.19-0.44x0.34	0.22-0.39
l	-	0.11-0.19	0.15-0.24
t	0.10-0.12	0.07	0.10-0.12
Septa:			
n	3-?4	4-6	?4
d	0.36x0.22	0.10x0.17-0.53x0.24	0.35x0.17
l	av.0.24	0.24-0.53	0.15-0.34
t	0.06	0.05-0.08	0.04-0.06

ONTOGENY. Diameter of smallest specimen is 0.29mm. The cup is single-walled to a diameter of 0.48mm, porosity if present is obscured by secondary thickening. The inner wall appears at 0.48mm cup diameter when it has one pore row per intersept, pore diameter approx.0.08mm. Sparse horizontal ? rods may be present in the intervallum before the first appearance of septa at 1.06mm cup diameter. Dissepiments have not been seen. Outer wall pores are visible at 2.6mm cup diameter, when the attachment of carcass to the septa is simple. Struts attach septa to the outer wall from 3.5mm cup diameter. Outer wall pores are subdivided at about 4.5mm cup diameter. Development of an oval shape in transverse section begins at cup diameter of 5-6mm.

COMPARISON AND REMARKS. S.pigmentum differs from S.tenuis by its straight septa and lack of synapticulae. Outer wall struts and subdivided pores appear at an earlier growth stage for S.pigmentum. A specimen of S.pigmentum is present in the matrix surrounding the holotype of Beltanacyathus wirrialpensis (Taylor) from Wirrealpa. The reported discovery of S.pigmentum from Bunyeroo Gorge (Walter, 1967, p.146) remains unconfirmed as no specimens are present in the Walter collection.

FAMILY JUGALICYATHIDAE fam.nov.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with one row of oblique pore tubes per intersept, opening upwards into the central cavity.

Genus JUGALICYATHUS gen.nov.

NAME. From Latin jugalis = yoked together.

Type species. Jugalicyathus tardus sp.nov.

DIAGNOSIS. Two walled conical cups whose transverse sections remain circular with increasing growth. Outer wall carcass attached to the septa by oblique struts, carcass pores partly subdivided to form a rudimentary microporous system. Intervallum with straight, sparsely porous septa, no synapticulae. Inner wall of pore tubes, one row per intersept, tubes open obliquely upward into the central cavity.

Jugalicyathus tardus sp.nov.

(Plate 4, Fig. 1; Plate 53, Figs. 1 to 5)

NAME. From Latin tardus = late.

HOLOTYPE. P21747 (three thin sections).

PARATYPES. P21748; P21749.

TYPE FORMATION. Ajax Limestone. Upper Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Fifteen specimens from the Mount Scott Range, sections J, K and N. Sixteen specimens from Wilkawillina Gorge, sections E, G, H and I. Holotype and paratypes as above. Additional specimens: P21750; P21751; P21752-1, -2; P21753 to P21756; P21757-1, -2; P21758 to P21760; P21761-1; P21762 to P21772; P21727-3; P21520-2; P21641-2.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary conical cups showing no change in shape with cup growth. Septa are attached to the compound outer wall carcass by paired oblique struts, and directly to the outer wall between successive pairs of struts. There are 2-3 rows of outer wall pores per intersept; pores are rounded, occasionally anastomosing. One or two outer wall pores occur between struts, opposite each septum. Outer wall lintels are secondarily thickened in large cups, giving a false impression of pore-tubes. The outer wall pores are partly subdivided into lobes by blunt protrusions into the openings from the surrounding lintels. The intervallum contains sparsely porous septa, 2-3 pore rows are confined to the outer part of each septum but their exact distribution is not known. New septa are frequently added from the outer wall. Synapticulae are absent. The inner wall consists of a carcass of circular pores with one row per intersept. These develop into oblique pore tubes at a fairly late stage in ontogeny. In large cups the tubes are long with a wide upper opening into the central cavity.

DIMENSIONS (mm)	Holotype P21747	Paratype P21748	Paratype P21749
Diameter	15.4	14.3	4.7
Intervallum width	3.5	3-7	1.18
N	-	26+6	19+2
ds	approx.1.3	0.9-1.4	0.4-0.5
IK	0.23	0.26	0.25
RK	-	1.82	approx.4
Loculi	approx.1/5	1/2.7-1/4.2	1/2.3-1/3.0
Outer wall carcass:			
n	2-3	2-3	2-3
d	0.29-0.36	0.24-0.41	approx.0.27
l	0.12-0.19	0.07-0.15	-
t	0.19	0.11	0.07-0.10
Outer wall subdivided pores:			
	Rudimentary	Rudimentary	Not formed
Inner wall pore tubes:			
n	1	1	1
d	0.4-1.1	1.0x0.6	0.17-0.24
Tube length (oblique)	1.1	2.3	Not formed
Tube wall thickness	0.12	0.1-0.17	-
Septa:			
n	?2	2-3	2
d	0.4x0.7	approx.0.4	0.10-0.29x0.22
l	-	0.2-1.0	0.2-0.3
t	0.07	0.05-0.07	0.05-0.06

ONTOGENY. The smallest known cup is 2.38mm in diameter in which the inner wall central cavity and septa are already formed. The outer wall carcass is simply porous and is attached directly to septa. The inner wall has one row of simple pores per intersept, diameter 0.17mm. Septa have 2 rows of circular pores of diameter 0.18mm, separation 0.12-0.17mm. Struts attach septa to the outer wall at 3mm cup diameter. The inner wall is simply porous up to a cup diameter of 6.5mm after which pore tubes are formed. In some cups the formation of pore tubes is delayed to cup diameters up to 13.5mm. The moment of the first appearance of partly subdivided pores on the outer wall is not precisely known, cups appear to have simple pore openings at diameter 11.0mm. Cups 17mm in diameter have subdivided pore openings.

COMPARISON AND REMARKS. Jugalicyathus gen.nov. has the same type of outer wall attachment to the septa seen in Spirillicyathus. The presence of late but well formed pore tubes on the inner wall places the new genus in a different family from Spirillicyathus which has simple inner wall pores. Large cups are required for accurate specific diagnosis. When the outer walls of specimens of Jugalicyathus tardus are thickened by secondary tissue the cups superficially resemble species of Beltanacyathus. Small cups of Jugalicyathus tardus (6mm diameter or less) are very similar to small cups of Spirillicyathus pigmentum.

SUPERFAMILY FLINDERSICYATHACEA superfam.nov.

DIAGNOSIS. The outer wall consists of a porous membrane covering the outer edges of adjacent septa and successive horizontal lintels. Pores have a peripheral distribution. Early growth stages are seemingly imperforate; pores, if present, are presumably very sparse.

FAMILY HAWKERCYATHIDAE fam.nov.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with one row of simple pores per intersept.

Genus HAWKERCYATHUS gen.nov.

NAME. From the town of Hawker, southern Flinders Ranges.

Type species. Hawkercyathus insculptus sp.nov.

DIAGNOSIS. Solitary two walled conical cups. After a prolonged early seemingly imperforate stage the outer wall is transformed abruptly into a delicate mesh of circular pores with a peripheral distribution, stretched between the openings formed by the outer edges of adjacent septa and successive horizontal lintels. The intervallum contains straight, radial porous septa linked by regularly arranged synapticulae. The inner wall is simply porous with one row of pores per intersept. Dissepiments are absent. Initial stages of development are characterized by an early formed inner wall and central cavity, and septa with netlike porosity developed very rapidly from a series of horizontal rods which link the two walls.

Hawkercyathus insculptus sp.nov.

(Plate 1, Fig.4;Plate 14, Fig.4;Plate 15, Fig.1; Plate 53, Figs. 6, 7; Plate 54, Figs. 1 to 6)

1967 Spirocyathella sp. Walter, p.144, Table 1, Pl.7, Fig.7.

NAME. From Latin insculpto = to carve or engrave.

HOLOTYPE. P21773 (five thin sections).

PARATYPES. P21697-3; P21774; P21775.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section F.

MATERIAL. F17227 (Walter collection). Six well preserved but incomplete specimens, plus numerous fragments from Wilkawillina Gorge; sections E, F, G, H and I. Holotype and paratypes as above. Additional specimens: P21674-2, -3; P21697-4; P21700-2; P21776 to P21789.

DIAGNOSIS. As for the genus.

DESCRIPTION. The species is described in two parts, each corresponding to the contrasting stages of development. Dimensions (mm) are included in the first stage description, separately for the second stage.

Stage 1. Presumed rarely perforate or imperforate outer wall stage (up to 6-10mm cup diameter).

The cup is initially a slender cone which widens rapidly above 3mm diameter. The outer wall is constructed of successive seemingly imperforate laminae each 0.02-0.05mm thick, total thickness of wall composed of adjacent laminae up to 0.24mm. The outermost initial lamina is connected to the intervallum elements. Subsequent laminae are added on the intervallum side of the cup. At the smallest known cup diameter of 0.85mm a central cavity is present. The intervallum contains radial rods which extend inwards from the outermost lamina of the outer wall. Dissepiments are absent. At about 1.2mm cup diameter an inner wall is formed by the addition of horizontal tangential lintels to the inner edges of the intervallum rods; vertical lintels appear to be formed at about the same time or possibly slightly earlier. Successive radial rods in the intervallum are coplanar in longitudinal section, their junctions with both walls are rounded and the space they enclose appears as a subrectangular pore with dimensions 0.36x0.48mm, rod thickness 0.09mm, inner wall thickness 0.05mm. Vertical lintels linking radial rods in the centre of the intervallum at 1.35mm cup diameter form the first beginnings of septa with 2 rows of rounded rectangular and oval pores, their sizes increase together with the intervallum width as the cup grows. A third row of septal pores, initially of small diameter is formed between the first two rows of pores; successive new pore rows are similarly added between earlier rows as the cup grows, so that a constant lintel width of 0.07-0.10mm is maintained between the septal pores. The inner wall has a single row of simple pores per intersept from its first appearance. The moment of the first appearance of synapticulae is not known, they are present in sparse numbers from about 4mm cup diameter.

Stage 2. Porous outer wall stage (above 6-10mm cup diameter).

Attached to the top circular rim of the apparently imperforate outer wall of the earlier stage is a saucer-like depression. The outer wall contracts rapidly, then renews its growth to form a smooth conical cup; the inner wall remains smooth and unaffected by the change in shape of the outer wall. From the saucer-like depression to the top of the cup the outer wall consists of a framework formed from the outer edges of adjacent septa and successive horizontal lintels, the enclosed openings, one row per intersept are circular to rectangular in shape. Stretched across each opening is a mesh of six or seven closely spaced circular and oval pores with a dominantly peripheral distribution, usually surrounding one or two central pores. The peripheral pores are notched into the enclosing framework and the whole mesh forms a continuous sheet over the outer surface of the cup. The intervallum contains straight septa with netlike porosity; pore rows curve gently from the inner to the outer wall. Septal pores are oval and large, the first pores in newly added rows are smaller than those in existing rows. Septa are linked by fairly regularly spaced tangential or slightly oblique synapticulae. The inner wall is simple with one row of circular pores per intersept.

DIMENSIONS (mm) Cup diameter above 6-10mm.

	Holotype P21773	Paratype P21774
Diameter	8.7-16	7.6(set in imperforate rim of diameter 10.4)
Intervallum width	1.2-2.8(Diam.=8.7)	1.7-2.2(Diam.=7.6)
N	38 (Diam.=8.7)	approx.28(Diam.=7.6)
ds	0.41-0.61	0.44-0.53
IK	0.24-0.32	0.23-0.29
RK	4.4(Diam.=8.7)	approx.3.7(Diam.=7.6)
Loculi	1/4.8	1/4.1

Outer wall framework:		
n	1	1
d	0.41-0.63	0.32-0.53
l	0.08-0.12	0.05-0.07
t	0.10	0.05-0.07
Outer wall mesh:		
n	?7	7
d	0.10-0.12	0.10-0.12
l	0.03-0.05	0.03-0.05
t	0.07-0.10	0.07
Inner wall:		
n	1	1
d	0.24-0.29	approx.0.24
l	0.10	-
t	0.07-0.10	0.07-0.10
Septa:		
n	4-7	-
d	0.31-0.46	0.29-0.58
l	0.10-0.17	0.17-0.19
t	0.05-0.07	0.05-0.07
Synapticulae:		
d	0.07-0.10	0.05-0.07
Horizontal separation	0.31-0.53	0.46-0.53
Vertical separation	0.41-0.53	0.44-0.65

COMPARISON AND REMARKS. The outer wall mesh of H.insculptus is similar to that found on Pycnoidocyathus cribrus sp.nov. (described on p.326). but the latter has more angular pores with a less regular peripheral distribution. The specimen listed by Walter (1967, p.144, Table 1) as Spirocyathella sp. from his Collection 1, is a specimen of Hawkercyathus insculptus sp.nov. The possible occurrence of Spirocyathella from Walter's Collection 2 cannot be confirmed because of a lack of specimens.

FAMILY FLINDERSICYATHIDAE Bedford R. and J., 1939.

1939 Flindersicyathidae Bedford R. and J., p.78.

1943 Cambrocyathidae Okulitch, p.53.

1950 Pycnoidocyathidae Okulitch, p.394.
1964 Metacyathidae (Cambrocyathinae) Debrenne, p.218.
1969 Flindersicyathidae Bedford R. and J.;Debrenne, p.344.
1972 Flindersicyathidae Bedford R. and J.;Hill, p.E116.
1974 Flindersicyathidae Bedford R. and J.;Debrenne, p.206.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with one row of short, steep pore tubes per intersept.

Genus PYCNOIDOCYATHUS Taylor, 1910.

1910 Pycnoidocyathus Taylor, p.131.
1936 Pycnoidocyathus Taylor; Bedford R. and W.R.,p.15.
1937 Flindersicyathus Bedford R. and J., p.28.
1955 Archaeocyathus Billings;Okulitch, p.E14 (pars).
1955 Pycnoidocyathus (Pycnoidocyathus) Taylor;Okulitch, p.E16.
1960 Archaeocyathus Billings;Zhuravleva, p.296 (pars).
1965 Flindersicyathus Bedford R. and J.;Hill, p.123.
1965 Pycnoidocyathus Taylor;Hill, p.128.
1966 Flindersicyathus Bedford R. and J.;Yaroshevitch, p.23.
1969 Flindersicyathus (Flindersicyathus) Bedford R. and J.;Debrenne, p.344.
1969 Flindersicyathus (Pycnoidocyathus) (Taylor); Debrenne, p.350.
1970 Pycnoidocyathus Taylor; Debrenne, p.40.
1972 Pycnoidocyathus Taylor;Hill, p.E116.
1974 Pycnoidocyathus Taylor; Debrenne, p.206.

Type species. Pycnoidocyathus synapticulosus Taylor, 1910.

DIAGNOSIS. Two walled conical cups, outer wall may be smooth or transversely corrugated to varying degrees, the inner wall remains smooth. After a prolonged early seemingly imperforate stage the outer wall is abruptly transformed into a delicate mesh of peripherally distributed pores, stretched across the outer edges of adjacent septa and horizontal lintels. The intervallum contains septa which may be straight or wavy. Synapticulae are sparse, or abundant and linking opposing septal crests. The septal pore area is either greater or less than the area of the surrounding lintels. The inner wall consists of short, steep pore tubes in one row per intersept; tubes directed obliquely upward into the central cavity. Early stages of growth are characterized by a seemingly imperforate outer wall, early formed simple inner wall and central cavity, and septa with netlike porosity. Inner wall pore tubes appear together with or slightly before the transformation of the outer wall from an imperforate or rarely perforate early stage, to a later stage with peripherally distributed pores.

DISCUSSION. Species of the genus Pycnoidocyathus have an inner wall composed of short, steep pore tubes in one row per intersept opening upwards into the central cavity. Often the pore tubes are quite rudimentary, consisting of little more than louvre-like lintels, surrounding the pores, e.g. in Pycnoidocyathus cribrus sp.nov. (described below). The presence of inner wall pore tubes separates the Family Flindersicyathidae from the Hawkercyathidae which is characterized by a simple inner wall with one pore row per intersept. The Superfamily Flindersicyathacea is characterized by an outer wall with peripheral porosity covering the openings leading to the exterior of adult cups. Juvenile cups are either imperforate, or pores are so sparse as to normally escape detection in thin section. Species placed in the genus Flindersicyathus by workers in the USSR (e.g. Yaroshevitch, 1966; Zhuravleva et al, 1967) usually have a rudimentary or simple inner wall and an outer wall with pores in vertical rows, but apparently not with peripheral distribution. These species may belong to the genus Graphoscyphia Debrenne, rather than to Pycnoidocyathus Taylor. The genus Andalusicyathus Perejon has outer and inner walls with several pore rows per intersept and may also be more closely related to Graphoscyphia than to Pycnoidocyathus. The genus Syringsella Krasnopeeva has an outer wall of funnel shaped pore canals covered by a microporous membrane (Krasnopeeva, 1961, p.248). This structure is quite different from that seen on the outer wall of Pycnoidocyathus Taylor.

Pycnoidocyathus synapticulosus Taylor, 1910.

(Plate 55, Figs. 1 to 5)

1910 *Pycnoidocyathus synapticulosus* Taylor, p.132,Pl.12,Figs.68-69.

1910 *Pycnoidocyathus ptychophragma* Taylor, p.132,Pl.12,Figs.70-71, Text-fig. 32.

1936 *Pycnoidocyathus synapticulosus* Taylor;Bedford R. and W.R.,p.15, Pl.15,Fig.69.

1969 *Flindersicyathus (Pycnoidocyathus) synapticulosus* Taylor;Debrenne, p.351,Pl.15

1972 *Pycnoidocyathus synapticulosus* Taylor;Hill,p.E116,Fig.84,1c.

1974 *Pycnoidocyathus synapticulosus* Taylor;Debrenne,p.208,Fig.13a-d.

HOLOTYPE. T1587A-C. Three fragments of a single specimen.

TYPE FORMATION. Ajax Limestone. Faunal Assemblage ? V.

TYPE LOCALITY. Ajax Hill.

MATERIAL. T1587A-C; T1588A, B (ex.*P.ptychophragma*); P953; three specimens from the Mount Scott Range, section M. P21790 to P21792.

DIAGNOSIS. Two walled cups reaching a large size. Outer wall with strongly pronounced transverse corrugations, inner wall smooth. The outer wall carcass consists of the outer edges of adjacent vertical septa and successive horizontal lintels, sometimes with a vertical lintel between the septa. The resulting one or two large openings per intersept are covered with a mesh of small circular pores, apparently with a peripheral distribution. Intervallum with wavy porous septa, opposing crests regularly linked by synapticulae. In longitudinal section, the septal crest and troughlines are nearly vertical adjacent to the inner wall and curve outward to become nearly horizontal in the transverse corrugations. The inner wall consists of short pore tubes, one row per intersept directed steeply upwards into the central cavity.

DESCRIPTION. Solitary conical cups. Outer wall corrugated. The outer wall consists of a basic carcass having 1 or 2 openings per intersept, with a fine mesh of circular pores stretched across them. Pores appear to be peripherally distributed across each opening. Intervallum contains radial septa which are slightly but regularly wavy with opposing crests linked by synapticulae. Septal pore rows are nearly vertical close to the inner wall and curve outward to become nearly horizontal in the transverse corrugations. There is usually a pore row on each septal flank between a crest and trough,and an additional row in the midline of each trough. Pore rows appear to be absent from crests. Pores are circular and oval, stretched in the direction of curvature of the rows, their area is less than that occupied by interpore skeletal material. Synapticulae occur as flattened bars distributed quite evenly, but more numerous near the outer wall. In some places adjacent synapticulae broaden and unite to form porous sheets, apparently where some new septa are added from the outer wall. The inner wall is composed of short steep pore tubes, one row per intersept in irregular quincunx; tubes open upward into the central cavity. Early growth stages are not known.

DIMENSIONS (mm)	Holotype SAM.T1587	(ex.P.ptychophragma) SAM.T1588	P21790
Diameter	75x90	70-80	52
Intervallum width	8-23(in bulges)	8-30(in bulges)	8.9-10.0
N	approx.160	approx.150	approx.130
ds	1.06-1.45	0.87-1.25	0.95-1.20
IK	0.10-0.28	0.11-0.43	approx.0.18
RK	approx.2.0	approx.2.0	approx.2.0
Loculi	1/6.4-1/18.4	1/7.5-1/28	1/7.4-1/10.5
Outer wall framework:			
n	1-2	1-2	1-2

d	0.4-0.6	-	approx.0.5
l	approx.0.17	approx.0.17	0.12-0.15
t	-	-	0.12-0.15
Outer wall mesh:			
n	approx. 6	-	?4-8
d	0.15-0.24	0.17-0.19	0.12-0.24
l	0.05-0.15	0.07-0.13	-
t	0.07-0.20	approx.0.12	0.07-0.12
Inner wall pore tubes:			
n	1	1	1
d	0.61-0.85	0.85-0.97	0.97-1.09
Tube length	1.15-1.95	-	1.10-1.80
Tube wall thickness	-	approx.0.17	0.12
Septa:			
n	12	?11	?18
d	0.20-0.58x0.73	0.17-0.40x0.78	0.24-0.41x0.58
l	variable 0.10-1.0	0.22-0.56	-
t	0.10-0.15	-	0.08-0.11
Synapticulae:			
d	0.17-0.73	0.17	0.10-0.15
Horizontal separation	av.1.26	1.26-1.64	1.06-1.74
Vertical separation	1.16-1.93	-	0.97-1.84

COMPARISON AND REMARKS. Debrenne (1974a,p.109) placed P.synapticulosus Taylor and P.ptychophragma Taylor in synonymy. Her opinion is confirmed herein after a study of the holotypes. Other specimens from the Bedford collection included by Debrenne in P.synapticulosus are considered to belong to different species with the exception of specimen P953. The differences relate mainly to septal porosity and the length of inner wall pore tubes; in most of Bedford's specimens these are not typical of P.synapticulosus.

Pycnoidocyathus amplus sp.nov.

(Plate 55, Figs. 6, 7; Plate 56, Figs. 1 to 3)

NAME. From Latin amplus = spacious.

HOLOTYPE. P21793 (three thin sections).

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary cup, outer wall with slight regular transverse corrugations. Inner wall with very slight uneven undulations which do not follow those of the outer wall. The central cavity is wide. The outer wall appears to consist of a network of large rounded pores in groups of three or more, over each opening between adjacent septa and successive horizontal lintels. Septa in the intervallum are flat to slightly undulating, with opposing crests linked by synapticulae. Septal pore rows are vertical near the inner wall and curve outwards towards the outer wall, reaching an angle of 55° from the vertical in the widest transverse corrugation. Septal pores are large, subrounded to circular and oval in shape. Synapticulae regularly link opposing septal crests and are evenly spaced in longitudinal section. The inner wall is composed of short, steep pore tubes in one row per intersept, directed obliquely upwards into the central cavity. Early growth stages are unknown, the smallest available cup diameter is 16mm.

DIMENSIONS (mm) Holotype P21793.

Cup diameter 35; partial height 65; intervallum width 3.5-8.2; N approx. 115; ds 0.49-0.74; IK 0.10; RK 3.3; loculi 1/4.7-1/7.1.

Outer wall framework: n 1; d 0.73x0.97; l 0.07-0.12; t 0.10-0.12.

Outer wall mesh: n 3-?4; d 0.24-0.36x0.44; l 0.03-0.07; t 0.05.

Inner wall pore tubes: n 1; d 0.17x0.34; tube length 0.24-0.36; tube wall thickness 0.12-0.15.

Septa: n 4-8; d 0.34x0.48-0.63x0.95; l 0.09-0.17; t 0.07-0.15.

Synapticulae: d 0.07; horizontal separation 0.77-1.26; vertical separation 0.77-1.16.

COMPARISON AND REMARKS. Pycnoidocyathus amplus sp.nov. differs from other species in the genus by its larger outer wall pores and septal pores. The peripheral outer wall pore distribution is difficult to see in the only known specimen.

Pycnoidocyathus cribrus sp.nov.

(Plate 15, Fig. 2; Plate 56, Figs. 4 to 8)

NAME. From Latin cribrus = sieve.

HOLOTYPE. P21794-1 (four thin sections).

PARATYPES. P21794-2; P21466-5; P21632-2; P21796.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage II.

TYPE LOCALITY. Wilkawillina Gorge. Section G.

MATERIAL. Seven specimens from Wilkawillina Gorge, sections E and G. Three specimens from the Mount Scott Range, sections J and N. Holotype and paratypes as above. Additional specimens: P21761-2; P21695-1, -2; P21797; P21798.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary two walled cups, outer wall with regular asymmetric transverse corrugations, inner wall smooth. The outer wall consists of a fine mesh of subrounded pores stretched across the opening between adjacent septa and successive horizontal lintels, pore distribution is more or less peripheral. Septa in the intervallum are straight to slightly wavy with netlike porosity, pore rows curve gently from the inner to the outer wall. Pores are circular and subrectangular, becoming oval near the outer wall. Synapticulae are abundant but variable in spacing. The inner wall consists of one row of short steep pore tubes per intersept, opening obliquely upwards into the central cavity.

DIMENSIONS (mm)	Holotype P21794-1	Paratype P21466-5	Paratype P21632-2
Diameter	18.1	36	16.4
Intervallum width	2.4-5.8	3.1-6.7	6.2
N	approx.50	165	-
ds	0.44-0.61	0.39-0.48	0.65
IK	0.21	0.09-0.19	0.29
RK	approx.4.0	approx.4.6	-
Loculi	1/4-1/5.6	1/6.4-1/8.8	-
Outer wall framework:			
n	1	1	1
d	0.39-0.56	0.41-0.56	0.39-0.53
l	0.09-0.12	0.12	0.10
t	0.10-0.12	0.12-0.15	0.10
Outer wall mesh:			
n	?8	?12	-
d	0.10-0.12	0.07-0.12	0.07-0.12
l	0.03-0.05	0.02-0.04	0.03
t	0.03-0.05	0.05	0.05
Inner wall pore tubes:			
n	1	1	1
d	approx.0.36	0.36x0.17	0.24-0.29
Tube length	-	0.34	0.46
Tube wall thickness	-	0.07	0.10
Septa:			
n	4-6	5-8	4-10
d	0.29-0.48	0.26-0.55	0.48-0.72
l	0.10-0.12	0.12-0.17	0.10-0.12
t	0.05-0.07	0.05-0.07	0.10
Synapticulae:			
d	0.07	0.10	0.10
Horizontal separation	approx.0.78	0.36-0.58	-
Vertical separation	-	approx.0.4	-

ONTOGENY. The smallest known cup diameter is 1.57mm at which stage the inner wall and central cavity are already present. The inner wall has one row of simple pores per intersept; pore diameter is 0.12mm. The outer wall is seemingly imperforate. Septa in the intervallum are straight, radial, pierced by 2 rows of large pores. At a cup diameter of 3.2mm septa have 3 rows of pores with diameter up to 0.39mm, lintels 0.05-0.07mm. Synapticulae occur sporadically at a cup diameter of 3.0mm and are more numerous and regularly arranged at 6.0mm cup diameter. The outer wall remains apparently imperforate up to 7-10mm cup diameter, then abruptly forms a finely porous mesh stretched across the outer edges of adjacent septa and successive horizontal lintels. The asymmetric transverse corrugations of the outer wall also appear at this stage of development. At about the same growth stage the inner wall pore tubes are formed.

COMPARISON AND REMARKS. Early stages of growth of P.cribrus sp.nov. are very similar to those shown by Hawkercyathus insculptus gen.et sp.nov. P.cribrus differs from other described species of Pycnoidocyathus by its netlike septal porosity and asymmetric outer wall transverse corrugations. To be also compared with P. vicini-septa (Bedf)

? Pycnoidocyathus strictus sp.nov.

(Plate 15, Fig. 3; Plate 57, Figs. 1 to 4)

NAME. From Latin strictus = narrow.

HOLOTYPE. P21799 (seven thin sections).

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section J.

MATERIAL. One specimen.

DIAGNOSIS. Solitary cup with marked periodic transverse corrugations of the outer wall. The outer wall appears to be a simple carcass of irregular pores, some partly closed by skeletal protrusions across their openings. Intervallum with flat porous septa linked by sparse synapticulae. Inner wall with one or two rows of short pore tubes per intersept directed obliquely upwards into the central cavity.

DESCRIPTION. Solitary cup. Outer wall with strongly pronounced symmetrical transverse corrugations. The intervallum is very narrow between the corrugations. The outer wall carcass appears to consist of 1-2 rows of irregular or polygonal shaped pores per intersept, some of these are partly subdivided into lobes by small blunt protrusions of skeletal material. Septa are radial, flat and porous with pore rows vertical close to the inner wall and curving outwards to become nearly horizontal in the transverse corrugations; pores are mainly circular in shape. Synapticulae are sparse, details of their distribution are not known. The inner wall consists of one or sometimes two rows of pore tubes per intersept, opening obliquely upwards into the central cavity.

DIMENSIONS (mm)   Holotype P21799.

Max. diameter 46; partial height 100. The remaining dimensions are for a cup diameter of 26mm; intervallum width 3.2-8.3; N 128; ds 0.49-0.61; IK 0.12; RK 5.0; loculi 1/5.8-1/15.

Outer wall carcass: n 1-2; d 0.24-0.48; l 0.12; t 0.12.

Outer wall subdivided pores: n 2-4; d 0.07-0.12; l 0.03; t -.

Inner wall pore tubes: n 1-2; d 0.24-0.48; tube length 0.24-0.34; tube wall thickness 0.08-0.17.

Septa: n 3-8; d 0.22-0.46; l 0.12-0.19; t 0.10.

COMPARISON AND REMARKS. The outer wall of ? P.strictus appears to be a simple carcass with subdivided pores rather than a finely porous mesh with peripheral distribution. Using the classification proposed earlier this species might more properly be placed in the Superfamily Metacyathacea rather than the Flindersicyathacea. The outer wall of the only known specimen is difficult to see clearly because the fossil is embedded in a matrix of red micrite. Early stages of growth are not known. The species is reluctantly placed in the genus Pycnoidocyathus until new specimens can clarify its systematic position.

Early growth stages of Pycnoidocyathus Taylor, 1910.

(Plate 57, Figs. 5 to 9)

DISCUSSION. More than 40 cups with a diameter of 10mm or less have been found throughout Faunal Assemblage II at both the Mount Scott Range and Wilkawillina Gorge. These are believed to be incomplete or juvenile representatives of the genus Pycnoidocyathus Taylor. They are all characterized by the early development of an inner wall, central cavity, and septa with netlike porosity. In all cups less than 7mm diameter the outer wall is apparently imperforate or rarely perforate and in all known instances the abrupt change to a simply porous outer wall can be seen in cups 7-10mm diameter.

The striking similarity of ontogenetic development of these cups with early stages of growth of Pycnoidocyathus cribrus sp.nov., strongly suggests that they are small forms of Pycnoidocyathus. However, their development is also very similar to that known for early stages of Hawkercyathus gen.nov. and although the latter is known only from Faunal Assemblage I, the possibility of its presence at higher stratigraphic levels cannot be discounted at present.

It is evident from the spacing and porosity of the skeletal elements of the small cups that they represent more than one species of Pycnoidocyathus, but no attempt is made here to separate them because of a lack of data for later stages of growth. A description of the morphological features of the best preserved specimens is given below.

MATERIAL. Four selected specimens from the Mount Scott Range, sections K and N. Specimen numbers: P21800 to P21803. Other specimens are listed under P21804.

DESCRIPTION AND DIMENSIONS.

Small conical cups up to 10mm diameter, smallest cup diameter 1.45mm. The outer wall, which has minute transverse wrinkles on the outer surface, is constructed of several parallel laminae each 0.02-0.05mm thick. Intervallum elements are connected to the first deposited outermost lamina whilst succeeding laminae are deposited on the side of the intervallum. Total thickness of all laminae forming the outer wall may reach 0.40mm giving the small cups a very robust wall structure. All of the laminae appear to be non-porous. However, the outermost lamina cannot be followed around the entire outer surface and gaps up to 0.30mm across break its continuity. Most of the gaps are sealed by later deposited laminae but some are left open so that the intervallum can communicate with the exterior. It is not known whether the gaps are the result of post-mortem abrasion or constitute a series of rare, large pores. If the gaps are pores, they are so sparse that they are not often intersected in thin section. Some of those gaps may be seen in specimens illustrated in Plate 57, Figs. 5 and 9.

The central cavity and inner wall have been formed at the smallest known cup diameter. No dissepiments have been found in the central cavity or intervallum, except in one case where they appear to be associated with an encrustation on the outer surface of the cup (Plate 57, Fig. 9). The inner wall is simple with one row of circular pores per intersept, pore diameter varies from 0.10mm to 0.33mm in different cups. The first known intervallum elements are radial septa with initially one, then two and more rows of rounded pores with a netlike arrangement. Diameters of the first formed pores are 0.10-0.36mm, pores formed later are oval and rectangular, up to 0.68mm long.

Nothing is known of the intervallum elements before the formation of septa. The first synapticulae appear sporadically at 1.57-2.1mm cup diameter. They increase rapidly in abundance and are fairly regularly distributed at 4.0mm cup diameter.

At 7-10mm cup diameter (in 2 cases at 5.0mm cup diameter) the smooth conical outer wall expands rapidly and is then surmounted abruptly by an outer wall with a fine porous mesh stretched across the openings formed by adjacent septa and successive horizontal lintels. This change coincides with the first development of regular transverse corrugations of the outer wall. The inner wall remains smooth but pore tubes develop rapidly at this stage, although in some cups they appear slightly earlier.

REMARKS. The early stages of growth described above are considered to be typical for species in the genus *Pycnoidocyathus* Taylor. The abrupt transformation at 7-10mm cup diameter from a seemingly non-porous outer wall possibly represents a point of post-mortem mechanical weakness in the cup structure which explains why so few specimens have been found with both the upper part and the lower part intact. As a result, the small cups have been considered by previous investigators as being representatives of other genera, notably *Dictyocyathus* Bornemann. A revision of specimens from the collections of Taylor and the Bedfords housed in the South Australian Museum is given below.

A revision of South Australian species formerly placed in the genus *Dictyocyathus* Bornemann, 1891.

DISCUSSION. Debrenne (1974a) has rightly questioned the validity of the systematic position of species placed by Taylor and the Bedfords in the genus *Dictyocyathus* Bornemann, and new data concerning the early ontogenetic development of the genus *Pycnoidocyathus* Taylor makes it quite clear that not one species described by early Australian workers can be assigned with certainty to the genus Dictyocyathus. On the contrary, most species can be related with greater justification to other genera.

The original diagnosis of the genus Dictyocyathus given by Bornemann (1891, p.500) is as follows:

Cup with a finely porous outer wall and an inner wall of larger sieve-like pores. The space between the outer and inner wall is without continuous septa and they are only joined by a very delicate framework of rounded rodlike struts.

The holotype of the genotype D.tenerrimus Bornemann is lost and no neotype has yet been chosen from the type locality in Sardinia. Consequently, considerable doubt has been expressed by many authors concerning the precise concept of the genus. However, many species of Dictyocyathus have been described from the Soviet Union based on a generic definition given by Zhuravleva (1960b, p.273), as follows:

Solitary and colonial Archaeocyatha. Cups conical, cylindrical, not uncommonly with repetitions, indentations, outgrowths. Outer wall with small simple pores easily destroyed; often replaced by films of vesicular tissue. Intervallum filled by radial rows of vertical and horizontal rods, not uncommonly with a clear inclination towards the outer wall, and rare horizontal cross-links (synapticulae) distributed in tangential planes. Vesicular tissue abundant. Inner wall practically absent, its pores replaced by openings into the inner rows of radial and horizontal rods. At the junctions of the rods there may be spines directed into the central cavity. Central cavity narrow at first and relatively wide at mature stages.
(Translated from Russian by the present writer).

The specimens from the Taylor and Bedford collections are redescribed below for comparison with Zhuravleva's diagnosis of Dictyocyathus translated above and the preceding description of early growth stages of Pycnoidocyathus. The redescriptions given below are based on an examination of the type material in its original state. It is considered imperative to suitably cut and re-etch these specimens so that a more accurate appraisal of their structure can be made.

Dictyocyathus simplex Taylor (1910).

1910 Dictyocyathus simplex Taylor, p.144, Text-fig. 34.
1974 Chouberticyathus ? simplex (Taylor); Debrenne, p.193.

HOLOTYPE. T1598 A-E (72 Ajax, not Type 51 Ajax as stated by Taylor, p.145).

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

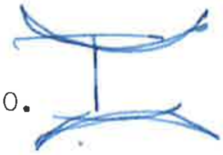
TYPE LOCALITY. Ajax Hill.

REDESCRIPTION. Cylindro-conical cup. Outer wall with 2-4 rows of ? simple pores between adjacent rods. Inner wall more robust with 1-2 rows of simple pores between adjacent rods. Both walls linked by radial horizontal rods which are sufficiently closely spaced in longitudinal section to give the impression of septa with a single row of horizontally stretched oval pores across the intervallum. Sparse vertical and tangential rods link the radial rods. No dissepiments.

DISCUSSION. Debrenne (1974a, p.193) doubtfully included this species in the genus Chouberticyathus, based on the presence in the intervallum of radial rods linking the two walls. Chouberticyathus however, has a non-porous outer wall (Debrenne, 1964, p.208). The species is probably a Regulare in the Suborder Dokidocyathina.

Unfortunate setting!

REVISED DESIGNATION. Class Regulares, Suborder Dokidocyathina, *incertae familiae*.



Dictyocyathus irregularis Taylor, 1910.

1910 *Dictyocyathus irregularis* Taylor, p.145. Pl.12, Fig.66.

1936 *Dictyocyathus irregularis* Taylor; Bedford R. and W.R., p.13, Pl.11, Fig. 56.

1964 *Dictyocyathus irregularis* Taylor; Debrenne, p. 201.

1974 *Dictyocyathus ? irregularis* Taylor; Debrenne, p.197, Figs. 5a, b.

HOLOTYPE. T1590 (Type 51 Ajax, on a fragment with the paratype of *Syringocnema favus* Taylor).

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

TYPE LOCALITY. Ajax Hill.

MATERIAL. T1590 Taylor collection. P939 Bedford collection.

REDESCRIPTION OF HOLOTYPE. Deeply etched fragment of an oblique longitudinal section. The outer wall porosity is masked by silicification but may have been originally imperforate; wall with transverse wrinkles. Inner wall with a single row of simple circular pores between adjacent intervallum elements. The oblique section of the fragment makes interpretation of the intervallum structures difficult, but it appears to have contained a crudely orthogonal scaffold of radial, vertical and tangential rods. Sparse dissepiments cross the intervallum at a steep angle. Also crossing the intervallum are the remains of 2 oblique porous partitions strongly resembling tabulae.

DISCUSSION. The presence of a well formed inner wall with a single row of circular pores between adjacent intervallum elements removes this species from the genus *Dictyocyathus*, *sensu* Zhuravleva. The intervallum appears to be composed of a scaffolding of rods, rather than of septa with netlike porosity. A careful examination of Taylor's illustration (1910, Pl.12, Fig.66) clearly shows the fragments of one porous tabula just below and to the left of the obliquely cut central cavity.

The specimens described as Dictyocyathus irregularis by R. and W.R. Bedford (1936, p.13, Pl.11, Fig. 56) have an intervallum filled by septa with netlike porosity, linked by synapticulae. As far as is known, the specimens lack tabulae.

REVISED DESIGNATION. The holotype is possibly a juvenile cup of Flindersicoscinus Debrenne. Bedford's specimens are probably juvenile cups of Pycnoidocyathus Taylor.

Dictyocyathus fragilis Bedford R. and W.R., 1936.

1936 Dictyocyathus fragilis Bedford R. and W.R.,p.13,Pl.11,Fig.57.
1964 Chouberticyathus fragilis (Bedford R. and W.R.);Debrenne, p.208.
1974 Chouberticyathus ? fragilis (Bedford R. and W.R.);Debrenne, p.192, Fig.2.

HOLOTYPE. P945-59.
TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.
TYPE LOCALITY. Ajax Hill.

REDESCRIPTION. Outer wall apparently imperforate and transversely wrinkled. Inner wall with one row of simple pores per intersept. The intervallum structure is poorly preserved but appears to consist of sparse radial septa with netlike porosity. Synapticulae not seen. Sparse dissepiments cross the intervallum.

DISCUSSION. Debrenne (1974a, p.193) doubtfully included this species in the genus Chouberticyathus because of the difficulty of interpreting the intervallum structure.

REVISED DESIGNATION. Possibly Chouberticyathus Debrenne, or fragments of a juvenile cup of Pycnoidocyathus Taylor.

Dictyocyathus robustus Bedford R. and W.R., 1936.

1936 Dictyocyathus robustus Bedford R. and W.R., p.13, Pl.12, Fig.58.
1964 Alphacyathus robustus (Bedford R. and W.R.); Zhuravleva et al., p.90, Fig. 54.
1974 Chouberticyathus robustus (Bedford R. and W.R.); Debrenne, p.192, Fig.1.

HOLOTYPE. P941.

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

TYPE LOCALITY. Ajax Hill.

REDESCRIPTION. Outer wall seemingly imperforate on available evidence, and transversely wrinkled. Inner wall with simple pores, or possibly rudimentary pore tubes between adjacent intervallum elements. One vertical rod connects two successive radial rods near the top of the fragment. No synapticulae or dissepiments seen.

DISCUSSION. R. and W.R. Bedford (1936, p.13, Pl.58c) described and illustrated a single tangential rod (synapticula) which is no longer preserved on the holotype. The intervallum rods certainly do not constitute septa with netlike porosity below a cup diameter of 6.0mm, which is the largest diameter known. Alphacyathus has a simply porous outer wall and no vertical rods.

REVISED DESIGNATION. ? Chouberticyathus Debrenne.

Dictyocyathus quadruplex Bedford R. and W.R., 1936.

1936 Dictyocyathus quadruplex Bedford R. and W.R., p.13, Pl.12, Figs.59,60.
1964 Chouberticyathus quadruplex (Bedford R. and W.R.); Debrenne, p.208.
1974 Dictyocyathus ? quadruplex Bedford R. and W.R.; Debrenne, p.198, Fig. 6.

HOLOTYPE. P943-63.

TYPE FORMATION. Ajax Limestone. Stratigraphic position not known.

TYPE LOCALITY. Ajax Hill.

MATERIAL. P943-63; P944-64; P970-153.

REDESCRIPTION. Outer wall apparently imperforate but poorly preserved. Inner wall with a single row of circular pores per intersept. Intervallum occupied by radial septa with netlike porosity, septa linked by sparse tangential synapticulae.

DISCUSSION. Present observations agree with those of Debrenne (1974a, p.198) who stated that specimen P970-153 shows a pseudo-septum and not an assemblage of rods. These specimens more closely resemble fragments of small cups of Pycnoidocyathus than any others in the collections of Taylor and the Bedfords.

REVISED DESIGNATION. Juvenile cups of Pycnoidocyathus Taylor.

Dictyocyathus macdonnelli Bedford R. and W.R., 1936.

1936 Dictyocyathus macdonnelli Bedford R. and W.R.,p.14,Pl.12,Fig.61.
1964 ? Alphacyathus macdonnelli (Bedford R. and W.R.);Zhuravleva et al., p.91, Fig.55.
1974 "Dictyocyathus" macdonnelli Bedford R. and W.R.;Debrenne, p.196, Fig. 4.
1979 ; Nitecki and Debrenne p. 5-27 -

HOLOTYPE. P940.

TYPE FORMATION. Not known.

TYPE LOCALITY. Macdonnell Ranges, Northern Territory.

MATERIAL. One specimen.

REDESCRIPTION. Roughly conical, sack shaped cup. Both walls heavily silicified, central cavity filled with silica. Intervallum relatively wide with irregularly spaced, thin radial rods. No other intervallum links evident.

DISCUSSION. The cup shape and rod distribution suggest that this specimen is a poorly preserved radiocyathid.

REVISED DESIGNATION. ? *Radiocyathus* Okulitch. already revised and published

SUPERFAMILY BELTANACYATHACEA superfam.nov.

DIAGNOSIS. Outer wall constructed of oblique pore tubes whose outer openings may be simple or subdivided.

FAMILY BELTANACYATHIDAE Debrenne, 1970.

1970 *Beltanacyathidae* Debrenne, p.30.
1974 *Beltanacyathidae* Debrenne, p.243.

DIAGNOSIS. Outer wall as for the superfamily. Inner wall with one row of pore tubes per intersept directed steeply upwards into the central cavity.

DISCUSSION. Debrenne (1970b, 1974a) stated that in her opinion the genus *Archaeofungia* Taylor is an Irregulare. After an examination of the holotype the present writer agrees with her view. Hill (1972, p.E112). placed the genus *Beltanacyathus* into the Family Archaeofungiidae Vologdin, 1962. However, Vologdin (1962a, p.90) created this family to accommodate Regulares in the Superfamily Ajacicyathacea, whose septa are linked by synapticulae. In his remarks about the genus *Archaeofungia*, Vologdin states: OK

> Forms in the genus *Archaeofungia* isolated by Taylor in Australian material, by the construction of their cup walls and septa are generally very close to Ajacicyathids. In any case they cannot be related to irregular Archaeocyatha. (*op.cit.*,p.91).

(Translated by the author from Russian).

Workers in the USSR now place ajacicyathids with simple outer and inner walls and synapticulae into the genus *Sibirecyathus* Vologdin, in the Family Ajacicyathidae, (see Voronin, 1974, p.126). The holotype of *Archaeofungia ajax* Taylor is not suitably well preserved to enable its precise affinities to be established. It is considered herein that this species might belong to the Flindersicyathacea superfam.nov..

It does not resemble *Beltanacyathus* in any way.

Genus WARRIOOTACYATHUS gen.nov.

NAME. From Warrioota Creek near Beltana.

Type species. *Warriootacyathus wilkawillinensis* sp.nov.

DIAGNOSIS. Two walled conical cups. Outer wall may be smooth or vertically fluted, position of flute crests and their amplitude is variable and not related to the positioning of septa. The outer wall consists of short oblique pore tubes in several rows per intersept directed obliquely upward to the exterior. Pore tube openings may be rounded or irregular in shape, there is no subdivision of the openings to form any kind of microporous system. The intervallum is wide and contains straight or broadly undulating septa pierced by large oval pores. Synapticulae and dissepiments are absent. The inner wall is composed of very long straight or elongated S-shaped pore tubes in one row per intersept, directed steeply upwards into the central cavity.

Warriootacyathus wilkawillinensis sp.nov.

(Plate 14, Fig. 3; Plate 58, Figs. 1 to 6)

1967 *Ethmophyllidae gen.nov.1*. Walter, p.155, Table 1.

NAME. From Wilkawillina Gorge.

HOLOTYPE. P21806-1 (nine thin sections).

PARATYPES. P21806-2; P21806-3.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. OA1582F-1; OA1600F-1,-10 (Walter's Collection 1, Univ. of Adelaide); twelve specimens from Wilkawillina Gorge, sections E, F, G, H and I. Holotype and paratypes as above. Additional specimens: P21807 to P21815.

DIAGNOSIS. As for the genus.

DESCRIPTION. Solitary conical cups reaching a large size. Outer wall may be smooth, faceted, or vertically fluted; flute crests or facets bear no relation to the position of septa. The outer wall consists of short straight pore tubes directed obliquely upwards to the exterior at a low angle. The number of rows of pore tubes between adjacent complete septa varies from 8 to 13, but only 2-3 pore tubes are present between any two adjacent radial elements (complete septa, partial septa or pillars). Pore tubes are in quincunx, openings are circular or oval with no subdivision of the openings to form smaller pores or lobes; secondary concentric laminae of skeletal material may reduce the pore diameter. The intervallum is wide and contains complete radial or undulating septa. Partial septa coming from the outer wall rarely extend inward more than 25% of the intervallum width; vertical pillars rarely extend inward from the outer wall more than 10% of the intervallum width. Complete septa are pierced by 2-4 rows of very large elliptical pores in irregular quincunx; interpore area equals or exceeds pore area. Porosity of partial septa unknown, pillars are imperforate. The inner wall consists of very long oblique pore tubes, one row per intersept opening upwards into the central cavity. The pore tubes are built on a rectangular or rhombic lattice infilled by secondary skeletal material to form circular or irregular oval openings from the intervallum.

The upper openings of the pore tubes into the central cavity are elliptical with their long axes parallel to the inner wall. In longitudinal section the wall of each pore tube has a bulbous base and a stem which tapers gradually to a sharp tip, pore tubes are an elongated S-shape, the upper free edges of the pore tube walls are notched. The central cavity is empty.

DIMENSIONS (mm)	Holotype P21806-1	Paratype P21806-2	Paratype P21806-3
Diameter	40	21	25
Intervallum width	7.4-9.3	3.2-6.1	approx.6.5
N (complete septa)	36	approx.20	approx.19
ds (complete septa)	2.2-2.5	1.8-2.7	1.6-3.9
IK	0.18-0.23	0.15-0.29	approx.0.26
RK	0.90	approx.0.95	approx.0.76
Loculi	1/2.9-1/4.2	-	1/1.7-1/4.0
Outer wall pore tubes:			
n	8-13	7-13	7-12
d	0.34-0.53x0.30	0.24-0.34	0.29
Tube length	0.68	0.39-0.68	-
Tube wall thickness	0.10	0.07-0.12	0.10
Inner wall pore tubes:			
n	1	1	1
d	1.7x1.1	approx.1.1	approx.0.8
Tube length	2.7-3.4	approx.2.4	-
Tube wall thickness	0.12	0.15	-
Septa:			
n	3	2-3	3
d	2.8x1.0	0.80x0.60	-
l	1.2-2.5	-	-
t	0.07-0.15	0.12-0.15	0.07-0.11

Note. Thicknesses of skeletal elements given above do not include secondary thickening which may more than double some dimensions.

ONTOGENY. Diameter of smallest known cup 1.33mm, the inner wall and central cavity have been formed, diameter of central cavity 0.15mm. The inner wall is simple with one pore row per intersept. Six septa cross the intervallum, their porosity and that of the outer wall is hidden by secondary material. Dissepiments are absent. Outer wall pore tubes are formed between 2.4mm and 4.8mm cup diameter. Well developed inner wall pore tubes form at about 12.5mm cup diameter, rudimentary pore tubes may form slightly earlier.

COMPARISON AND REMARKS. Warriootacyathus gen.nov. differs from Beltanacyathus Bedford by the absence of any kind of subdivision over the mouths of the outer wall pore tubes. The species Warriootacyathus wilkawillinensis has larger septal pores than those found in other species in the genera which constitute the Beltanacyathidae. An examination of the specimens listed by Walter (1967, p.144, Table 1) as Ethmophyllidae gen.nov.1, shows that they belong to the species Warriootacyathus wilkawillinensis.

Warriootacyathus irregularis sp.nov.

(Plate 59, Figs. 1 to 6)

NAME. From Latin irregularis = irregular.

HOLOTYPE. P21515-2 (five thin sections).

PARATYPES. P21816; P21817; P21818; P21819.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage 1.

TYPE LOCALITY. Wilkawillina Gorge. Section F.

MATERIAL. Five specimens from Wilkawillina Gorge, sections F, H, and I, as above.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups. Outer wall smooth or slightly fluted. The wall consists of short straight oblique pore tubes opening upwards to the exterior. Pore tube openings are variable in size and circular, elliptical or polygonal in shape. There are up to 6 rows of pore tubes between adjacent complete septa, with usually 2 rows between adjacent radial elements (complete or partial septa). The intervallum contains numerous complete and partial septa which undulate slightly. Close to the outer wall septa frequently bifurcate and form oblique links with the outer wall to form an outer branching zone. Septa are sparsely porous with several pore rows close to the outer wall. The exact size and distribution of the septal pores is unknown. Synapticulae are absent. The inner wall consists of short pore tubes, one row per intersept directed steeply upwards into the central cavity. The upper openings of the pore tubes are elliptical with their long axes parallel to the inner wall. The intervallum at the top of the largest specimen is covered by a perforated cap, only part of which is preserved. Pores piercing the cap are circular or oval and quite regular in size and distribution. Early growth stages are not known. The smallest cup (7.0mm in diameter) has an outer wall of pore tubes and possibly a simple inner wall; septa are sparsely perforate.

DIMENSIONS (mm) Holotype P21515-2.

Diameter 25; partial height 80; intervallum width 4.8-7.7; N approx.46; ds 0.65-1.1; IK 0.19-0.31; RK approx.1.8; loculi 1/5-1/8.

Outer wall pore tubes: n 2-6; d 0.17-0.36; tube length 0.39-0.65; tube wall thickness 0.07-0.12.

Inner wall pore tubes: n 1; d 0.6x0.8; tube length 0.97-1.33; tube wall thickness 0.12.

Septa: n 2-3+?2-3; d approx.0.3-0.5; l ?; t 0.04-0.08.

COMPARISON AND REMARKS. Warriootacyathus irregularis sp.nov. differs from W.wilkawillinensis by the irregular size and shape of its outer wall pore tube openings; more frequent and more irregular septa and by its shorter inner wall pore tubes.

Warriootacyathus lucidus sp.nov.

(Plate 59, Figs. 7, 8; Plate 60, Figs. 1 to 3)

NAME. From Latin lucidus = clear.

HOLOTYPE. P21820 (nine thin sections).

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. One specimen.

DIAGNOSIS. Two walled cup. Outer wall smooth to slightly undulating, intervallum and central cavity wide. Outer wall with several rows of S-shaped pore tubes per intersept opening upwards to the exterior. Intervallum with numerous slightly undulating septa pierced by frequent pores; new septa are added very frequently. No synapticulae or dissepiments. The inner wall is composed of long S-shaped pore tubes, one row per intersept opening opwards into the central cavity.

DESCRIPTION. Solitary two walled cup presumably conical in shape. The outer wall is smooth or slightly undulating, composed of short S-shaped pore tubes in 4-7 quincunxial rows per intersept. Pore tubes open upwards to the exterior, their openings are circular to hexagonal in shape with no development of any kind of microporous system. The intervallum is crossed by numerous slightly undulating septa, new septa are frequently added from the outer wall and less commonly from the inner wall. Septal pores are in closely spaced ? vertical rows, pores are oval and slit-like in shape with the long axes vertical. No synapticulae or dissepiments are seen. The inner wall is composed of very long pore tubes in one row per intersept opening upwards into the central cavity.

The upper openings of the tubes are oval or rectangular with their long axes parallel to the inner wall. In longitudinal section the tubes have a stretched S-shape, the tube walls have a bulbous base, and a stem which tapers upwards to a fine tip. The intervallum at the top of the cup is covered by an oblique porous cap which does not cover the central cavity or inner wall pore tubes. Early growth stages are unknown, the specimen consists of only the upper 35mm of a very large cup.

DIMENSIONS (mm)   Holotype P21820.

Diameter 72-76; intervallum width 12-15.5; N 73 complete septa;
ds 1.84-3.29; IK 0.17-0.22; RK 1.0; loculi 1/6.5-1/8.4.
Outer wall pore tubes: n 4-7; d 0.17-0.32; tube length 0.56-0.61;
tube wall thickness 0.05-0.07.
Inner wall pore tubes: n 1; d 0.8x1.3-1.0x2.3; tube length 3.7-5.3;
tube wall thickness 0.10.
Septa: n 19-25; d 0.22x0.73-0.41x1.33; l 0.12-0.56; t 0.10-0.15.
Porous cap: d 0.08-0.22; l 0.07-0.19; t 0.85.

COMPARISON AND REMARKS. Warriootacyathus lucidus sp.nov. differs from the type species by the distribution and porosity of the septa. The construction of the outer and inner walls is basically similar. The species described above is placed provisionally in the genus Warriootacyathus because of a lack of knowledge of earlier stages of growth.

Genus BELTANACYATHUS Bedford R. and J., 1936.

Type species. Archaeocyathus wirrialpensis Taylor, 1910.

DIAGNOSIS. Two walled conical cups. The outer wall may be smooth or vertically fluted; flute crests bear no relation to the positioning of septa. The outer wall consists of several rows of short pore tubes per intersept opening obliquely upwards to the exterior. The upper opening of each pore tube is partly subdivided into lobes by protrusions of skeletal material from the lintels. The intervallum contains infrequent porous septa, partial septa and pillars on the intervallum side of the outer wall. Partial septa and pillars are not always well developed between complete septa. Synapticulae and dissepiments are absent. The inner wall consists of one row of very long pore tubes per intersept directed steeply upwards into the central cavity.

DISCUSSION. Three thin sections of the holotype of B.wirrialpensis (Taylor) have been prepared by the writer. One thin section grazing the outer wall shows that the outer wall pore tubes are partly subdivided into lobes to form a quite rudimentary microporous system. Separate micropores are not formed. Debrenne (1974a, p.243) placed B.ionicus Bedford R. and J. in synonymy with B.wirrialpensis (Taylor). Unfortunately the only specimen of B.ionicus housed in the South Australian Museum (P962) is a fragment of a very large silicified cup. The outer wall is not clear; part of the intervallum and all of the inner wall and central cavity are missing. However, a portion of a septum is preserved and it is evident that the septal pores are smaller and more numerous than those found in the holotype of B.wirrialpensis. All of the remaining specimens are at Princeton University and have not been seen by the writer. Why did'nt you ask me for the photographs?

It is considered herein that B.wirrialpensis and B.ionicus are probably two different species, but this cannot be confirmed until the specimens at Princeton University have been revised. Thank you! I thought I've done that (74) You might think it is not enough but don't say it that way Four specimens undoubtedly belonging to B.wirrialpensis have been found in the Mount Scott Range, but these are as fragmentary as the holotype and yield no additional information. If B.ionicus is a valid species as suggested above, then this will become the genotype of Beltanacyathus, and not B.wirrialpensis as revised by Debrenne (1974a) and indicated above.

Beltanacyathus wirrialpensis (Taylor, 1910)

(Plate 15, Figs. 5, 6; Plate 60, Figs. 4, 5)

1910 Archaeocyathus wirrialpensis Taylor, p.124,Pl.8,Figs.43,44, Text-fig.30.

1936 Beltanacyathus ionicus Bedford R. and J.,p.23,Pl.23,Fig.95, Pl.24, Fig. 96.

1939 Beltanacyathus ionicus Bedford R. and J., p.79.

1965 Beltanacyathus ionicus Bedford R. and J.; Hill, p.89, Pl.6, Fig.3a-e, Text-fig.18-3a to d.

1970 Beltanacyathus ionicus Bedford R. and J.;Debrenne, p.30.

1972 Beltanacyathus ionicus Bedford R. and J.;Hill, p.E114,Fig.83.

1974 Beltanacyathus wirrialpensis (Taylor);Debrenne, p.244,Fig.33a to f.

HOLOTYPE. T1581A, B, C, D, E. Five fragments of a single specimen.

TYPE FORMATION. Wilkawillina Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Wirrealpa.

MATERIAL. T1581A, B, C, D, E; T1596B, C; P962; four fragmentary specimens from the Mount Scott Range, section N. P21476-1; P21615-4; P21821; P21822.

DIAGNOSIS. As for the genus.

DISCUSSION. The holotypes of Beltanacyathus wirrialpensis and Somphocyathus coralloides Taylor were originally together on the same hand specimen. Portions of transverse sections of B.wirrialpensis are present with the holotype of S.coralloides. These (T1596B, C) have been studied together with the fragments which comprise the holotype of B.wirrialpensis and are enumerated above. Portions of the exothecal tissue surrounding S.coralloides are present on two fragments with the holotype of B.wirrialpensis (T1581C, E).

DESCRIPTION. Cups with a smooth or very slightly fluted outer wall. The outer wall consists of 4-8 rows of short straight pore tubes, directed obliquely upwards to the exterior at a low angle. The pore tube openings are irregularly rounded. Each opening is partly subdivided into lobes by short, blunt protrusions from the lintels. The intervallum contains sparse, straight to slightly undulating septa pierced by evenly spaced rows of large oval pores. Partial septa are usually situated midway between complete septa. Additional narrow vertical pillars between septa and partial septa are rare. The inner wall consists of one row of very long pore tubes per intersept directed steeply upwards into the central cavity. The upper openings of the pore tubes are oval in cross-section with their long axes parallel to the inner wall. The upper edges of the pore tube walls are notched. Early stages of growth are unknown.

DIMENSIONS (mm)	Holotype T1581	P21822	P21476-1
Diameter	approx. 40	approx.50	60
Intervallum width	7.15	8.9	8.7-14.5
N (complete septa)	approx.37	approx.54	approx.72
ds (complete septa)	2.3-3.1	2.2-2.6	1.6-2.1
IK	approx.0.18	approx.0.18	0.15-0.24
RK	approx.0.9	approx.1.1	approx.1.2
Loculi	1/3.7	1/3.7	1/4.1-1/9.4
Outer wall pore tubes:			
n	5-7	5-7	4-8
d	0.41x0.65-0.73x0.65	0.48-0.61	0.48-0.73
Tube length	0.48-0.61	0.48-0.65	-
Tube wall thickness	0.07	0.10	0.12
Outer wall subdivided pores:			
n	4-6	4	4-?6
d	0.17-0.34	0.17-0.29	0.17-0.24
l	0.05-0.10	0.05-0.07	0.05-0.07
t	approx.0.10	-	0.07
Inner wall pore tubes:			
n	1	1	1
d	2.30x1.45	approx.1.8	approx.1.7-2.4

Tube length	approx.5	-	-
Tube wall thickness	0.07	0.10	0.10-0.20
Septa:			
n	7-9	?8	?12
d	approx.0.7x1.5	approx.0.5x1.0	-
l	approx.0.34	-	-
t	0.07-0.10	0.10	0.05-0.10

Note. The above dimensions do not include secondary thickening.

COMPARISON AND REMARKS. The only available fragment of B.ionicus Bedford (P962) has septal pores with dimensions 0.48x0.73mm and pore separation 0.36-0.61mm. It is not known whether the differences in septal pore size and spacing between this specimen and the holotype of B.wirrialpensis are due to differences in cup size and preservation. A new species B.digitus described below, differs from B.wirrialpensis by having a more variable number of outer wall pore tubes per intersept. The outer wall pore tubes of B.digitus are circular and oval in cross-section and quite regular in shape; its septal pores are more variable in size and distribution. The inner wall pore tubes of B.digitus are smaller, both in length and in area of opening.

Beltanacyathus digitus sp.nov.

(Plate 15, Fig. 7; Plate 60, Figs. 6, 7)

NAME. From Latin digitus = a finger.

HOLOTYPE. P21823 (two thin sections).

PARATYPES. P21515-1; P21824; P21825.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. Four specimens from Wilkawillina Gorge, sections F, H, and I; as above.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups with vertically fluted outer walls and smooth inner walls. The position of flutes is not related to the position of septa. The compound outer wall consists of several rows of short pore tubes per intersept, directed obliquely upward to the exterior. The outer opening of each pore tube is partly subdivided by digitate protrusions from the interpore lintels. The number of pore tubes per intersept varies from 3 to 13 depending on the amplitude of the outer wall fluting. Pore tubes are circular and oval in cross-section, occasionally anastomosing. The intervallum contains slightly wavy porous septa pierced by large and small oval pores. Partial septa are situated midway between complete septa. Short vertical pillars extend inward from the outer wall and are more numerous where fluting of the outer wall is most pronounced. Synapticulae and dissepiments are absent. The inner wall consists of one row of long pore tubes per intersept directed steeply upwards into the central cavity. In longitudinal section each pore tube wall has a bulbous base and a slender stem which tapers upwards to a sharp tip. Secondary thickening frequently obscures these details. Inner wall pore tubes are oval in cross-section with their long axes parallel to the inner wall.

DIMENSIONS (mm)	Holotype P21823	Paratype P21824	Paratype P21825
Diameter	approx.40	24	34
Intervallum width	6.8-11.6	4.4-5.6	6.3-7.6
N (complete septa)	approx.45	21	approx.29
ds (complete septa)	1.7-2.4	1.6-2.5	1.7-2.5
IK	approx.0.17-0.30	0.18-0.23	0.19-0.22
RK	-	0.88	approx.0.85
Loculi	1/2.8-1/8.7	1/1.7-1/3.6	1/2.5-1/4.4

Outer wall pore tubes:			
n	4-11	5-13	3-13
d	0.36-0.41	0.31-0.46	0.25-0.34
Tube length	-	0.36-0.48	av.0.73
Tube wall thickness	0.07-0.12	0.05-0.07	0.07-0.12
Outer wall subdivided pores:			
n	4-5	2-?7	2-4
d	0.12-0.27	0.07-0.20	0.10-0.19
l	0.05-0.06	0.03-0.05	0.04
t	-	0.07	0.12
Inner wall pore tubes:			
n	1	1	1
d	1.2-1.7x?	approx.1.0x0.7	1.2x0.7
Tube length	-	2.5-3.1	1.9-2.5
Tube wall thickness	0.12	0.10	0.05-0.12
Septa:			
n	4-5	?3-4	5-8
d	1.3x?2.6	-	0.73x0.36
l	-	-	0.40-0.50
t	0.09-0.15	0.10	0.07-0.10

Note. Thickness of skeletal elements may be considerably increased by secondary thickening.

COMPARISON AND REMARKS. A comparison with B.wirrialpensis (Taylor) has been given above. B.digitus sp.nov. differs from Warriootacyathus wilkawillinensis by the presence of subdivided outer wall pore tube openings in the former. In addition, B.digitus has smaller, more numerous septal pores.

Genus FRIDAYCYATHUS gen.nov.

NAME. From Mt. Friday Well, 8.6km south of Mt. Scott.

Type species. Fridaycyathus biserialis sp.nov.

DIAGNOSIS. Two walled conical cups. Outer wall smooth in large cups and slightly furrowed at junctions with the septa in small cups. The outer wall consists of a basic carcass with several rows of pores per intersept. Attached to the carcass is a series of S-shaped pore tubes opening upwards to the exterior, arranged so that each carcass pore opens into two pore tubes. The outer opening of each pore tube is partly or completely subdivided into 2-3 circular pores, this occurs late in ontogeny. The intervallum contains porous septa, partial septa are infrequent. Pillars strengthening the outer wall are absent. No synapticulae or dissepiments. The inner wall consists of very long pore tubes of stretched S-shape, one row per intersept opening upwards into the central cavity.

<u>Fridaycyathus biserialis</u> sp.nov.

(Plate 15, Fig.8; Plate 61, Figs. 1 to 8; Plate 62, Figs. 1 to 3)

NAME. From Latin <u>bis</u> = twice, <u>serialis</u> = forming a series.

HOLOTYPE. P21465-1 (nine thin sections).

PARATYPES. P21746-1; P21826.

TYPE FORMATION. Ajax Limestone. Lower Faunal Assemblage II.

TYPE LOCALITY. Mount Scott Range. Section N.

MATERIAL. Four specimens from the Mount Scott Range, section N. Four specimens from Wilkawillina Gorge, section H. Holotype and paratypes as above. Additional specimens: P21482-1; P21484-2; P21827 to P21829.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled conical cups. The outer wall of large cups is usually smooth but minor vertical fluting may be present. The outer wall of small cups is slightly furrowed at junctions with the septa. The outer wall carcass has 4-6 rows of circular pores per intersept in irregular quincunx. The pore tubes attached to the carcass are of a stretched S-shape opening upwards to the exterior, their number per intersept varies from 8 to 12 (two pore tubes for each carcass pore) in regular quincunxial rows. Pore tubes have a hexagonal cross-section in their mid-parts and are circular or oval at each extremity. The upper openings of the pore tubes in large cups are partly or completely subdivided into 2 or 3 circular pores. The intervallum contains straight, radial septa pierced by evenly distributed rows of circular and oval pores. Synapticulae and dissepiments are absent. The inner wall consists of very long pore tubes, one row per intersept in quincunx directed steeply upwards into the central cavity. In transverse section the pore tube openings are oval to sub-rectangular with their long axes parallel to the inner wall. In longitudinal section each pore tube wall has a bulbous base and a stem which tapers upwards to a fine tip, pore tubes have a stretched S-shape. Secondary skeletal tissue may be present at the base of the central cavity and in the intervallum of small cups. At the top of the holotype a porous cap covers the intervallum but leaves the central cavity and inner wall pore tubes open. Pores in the cap are circular and oval.

DIMENSIONS (mm)	Holotype P21465-1	Paratype P21746-1	Paratype P21826
Diameter	57	12.8	60
Intervallum width	13.5-14.5	3.2-4.3	13.1
N	approx.52	11	approx.56
ds	2.3-3.6	1.9-2.4	2.2-2.7
IK	0.25	0.25-0.34	0.22
RK	approx.0.9	approx.0.9	approx.0.93
Loculi	1/3.8-1/6.3	1/1.3-1/2.2	1/4.9-1/6.0
Outer wall carcass:			
n	4-5	-	4-6
d	0.36-0.51	0.29-0.34	0.36-0.44

l	0.12-0.15	-	0.15-0.20
t	0.12	0.12	0.12-0.15
Outer wall pore tubes:			
n	8-10	10	8-12
d	0.24-0.29	0.19-0.27	0.22-0.37
Tube length	0.61-1.1	0.48-0.53	av.0.10
Tube wall thickness	0.05-0.07	0.05-0.07	0.07
Outer wall subdivided pore tubes:			
n	2-?3 (partly subdivided)	Not developed	2-3 (fully subdivided)
d	0.15-0.18	-	0.17-0.20
l	0.05-0.07	-	0.03-0.05
t	0.05	-	0.05-0.10
Inner wall pore tubes:			
n	1	1	1
d	2.5x0.90	0.90x0.73	2.1x1.1
Tube length	2.9-4.8	1.5-2.2	3.9-5.0
Tube wall thickness	0.15	0.07	0.12-0.15
Septa:			
n	10-12	5-6	13
d	0.22-1.20x0.73	0.36-0.57x0.75	0.41x0.19-1.5x0.48
l	0.34-0.68	0.12-0.29	0.48-0.78
t	0.09	0.09	0.07-0.12
Perforated cap:			
d	0.17-0.29	Not present	Not present
l	0.06-0.36	-	-

ONTOGENY. The inner wall and central cavity are present in the smallest known cup 5.2mm in diameter. Between cup diameters of 5.6mm and 16mm the outer wall is slightly furrowed at junctions with septa and smoothly bulging between them. Below cup diameters of 5.6mm the outer wall is simple. At 5.6mm cup diameter strongly curved S-shaped pore tubes are formed on the outer wall, by 10mm cup diameter the pore tubes are stretched with a less pronounced curvature. The outer openings of the pore tubes are apparently not subdivided until cups reach a diameter of approximately 19mm. Inner wall rudimentary pore tubes are present at

5.6mm cup diameter, these lengthen rapidly with cup growth and are well developed at a cup diameter of 8mm. Earliest stages of growth of septa are not known, the inner wall, central cavity and septa are already formed in the smallest cup examined.

COMPARISON AND REMARKS. Fridaycyathus gen.nov. differs from Beltanacyathus Bedford R. and J., by the distribution of its outer wall pore tubes which are arranged in pairs opposite each underlying carcass pore. In addition, the outer wall pore tubes of Fridaycyathus are hexagonal in cross-section, those of Beltanacyathus digitus are rounded; in B.wirrialpensis they are irregular in shape.

Genus BAYLEICYATHUS gen.nov.

NAME. From Mt. Bayley, 8km. north of Beltana.

Type species. Bayleicyathus bowmani sp.nov.

DIAGNOSIS. Two walled conical cups with a smooth outer wall comprised of short pore tubes inclined upwards to the exterior. The outer openings of the pore tubes are partly or completely subdivided into smaller pores or lobes. The intervallum contains porous septa which branch close to the outer wall. Sparse synapticulae may be present. The inner wall consists of very short pore tubes in one row per intersept, directed obliquely upwards into the central cavity.

DISCUSSION. Bayleicyathus gen.nov. differs from Beltanacyathus and Fridaycyathus by the much shorter length of its inner wall pore tubes, which are scarcely longer than those of the outer wall.

<u>Bayleicyathus bowmani</u> sp.nov.

(Plate 62, Figs. 4 to 6; Plate 63, Figs. 1, 2)

NAME. After B.Bowman of the Department of Geology and Mineralogy, University of Adelaide.

HOLOTYPE. P21830 (five thin sections).

PARATYPES. P21831; P21832.

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. Three specimens from Wilkawillina Gorge, sections E, F, and H; as above.

DIAGNOSIS. As for the genus.

DESCRIPTION. Two walled slender conical cups with smooth outer and inner walls. The outer wall consists of a basic carcass of large rounded apertures which open into a series of short pore tubes inclined upwards to the exterior. There are possibly 2 pore tubes over each underlying aperture but their precise arrangement is not known. The outer opening of each pore tube is partly or completely subdivided into a series of lobes or smaller circular pores by inward radiating protuberances from the lintels. Additional small circular pores pierce the outer surface of the cup between adjacent pore tubes. The intervallum contains septa pierced by circular and oval pores whose dimensions increase with cup growth. Septa branch close to the outer wall to form oblique links of varying complexity. Some septa attach directly to the outer wall. Synapticulae are not seen. The inner wall consists of pore tubes in one row per intersept directed obliquely upwards into the central cavity. Pore tubes are very short, their openings are circular in cross-section. The lower part of the central cavity in some specimens contains secondary skeletal material added to the interpore lintels as fingerlike protrusions. Sparse dissepiments are present in the intervallum and central cavity near the base, which is usually surrounded by tersioid outgrowths.

DIMENSIONS (mm)	Holotype P21830	Paratype P21831	Paratype P21832
Diameter	11.8	12.6	9.2
Intervallum width	3.0-3.7	2.6-2.9	2.0-2.4
N	34+8partial	-	34+4partial
ds	0.7-1.0	0.6-0.9	0.5-0.6
IK	0.25-0.31	0.20-0.23	0.22-0.26
RK	2.9	-	3.7
Loculi	1/2.9-1/5.4	1/3.7-1/5.4	1/3.6-1/4.9
Outer wall pore tubes:			
n	2-4	2-?4	2-4
d	0.24-0.36	-	approx.0.24
Tube length	0.24-0.53	0.34-0.48	0.36
Tube wall thickness	0.07-0.12	0.10	0.10
Outer wall subdivided pores:			
n	4-?6	-	-
d	0.07-0.12	-	approx.0.12
l	0.03	-	0.02-0.03
t	0.10	0.07-0.10	approx.0.10
Inner wall pore tubes:			
n	1	1	1
d	0.41	0.39-0.46	0.24-0.34
Tube length	0.48-0.61	0.39-0.56	0.29-0.36
Tube wall thickness	0.17-0.19	0.15	0.12
Septa:			
n	3-4	3-?	4
d	0.24x0.36	0.24-0.32	0.15-0.36
l	0.24-0.29	0.17-0.36	0.24
t	0.05-0.07	0.08-0.10	0.05-0.07

ONTOGENY. At the smallest known cup diameter of 2.9mm the inner wall and central cavity are present. The outer wall is simple, without pore tubes but secondary thickening obscures details. The inner wall has a single row of simple pores per intersept. Septa have 2 pore rows across the intervallum. Outer wall pore tubes form at a cup diameter of 3.7mm. Subdivided pores on the outer wall pore tube openings may form as early as 7.5mm cup diameter; they are certainly present at 9.0mm cup diameter. Short pore tubes on the inner wall appear at 6.0to6.5mm cup diameter. These lengthen slightly with cup growth.

COMPARISON AND REMARKS. See Bayleicyathus diversus sp.nov. described below.

Bayleicyathus diversus sp.nov.

(Plate 63, Figs. 3 to 7)

NAME. From Latin diversus = facing different ways.

HOLOTYPE. P21833 (three thin sections).

TYPE FORMATION. Wilkawillina Limestone. Faunal Assemblage I.

TYPE LOCALITY. Wilkawillina Gorge. Section H.

MATERIAL. One specimen.

DIAGNOSIS. As for the genus.

DESCRIPTION. Slender cylindro-conical cup with smooth outer and inner walls. The outer wall consists of 2 rows of short or rudimentary pore tubes directed obliquely upwards to the exterior. In places the outer wall appears to be simply porous. The outer wall pore tubes are subdivided into a system of smaller circular pores or lobes. It is not known whether the simply porous openings to the exterior are also subdivided. The intervallum contains straight radial septa pierced by 2-3 rows of circular and oval pores. The pore rows are widely spaced and diverge gradually from the inner to the outer wall. Sparse synapticulae link adjacent septa, their distribution in the intervallum is not known. The inner wall consists of one row of very short pore tubes per intersept directed steeply upwards into the central cavity. The shape of the pore openings is not known.

DIMENSIONS (mm) Holotype P21833.

Diameter 11.4; intervallum width 3.3; N approx.37; ds 0.61; IK 0.29; RK 3.25; loculi 1/5.4.
Outer wall pore tubes: n 2; d 0.29-0.34; tube length 0.24-0.61; tube wall thickness 0.10.
Outer wall subdivided pores: n 3-?6; d 0.07-0.08; l 0.03; t 0.05.
Inner wall pore tubes: n 1; d ?; tube length 0.24-0.46; tube wall thickness 0.05-0.12.
Septa: n 2-3; d 0.34x0.24; vertical separation 0.24-0.31; horizontal separation 0.30-1.0; t 0.06.

ONTOGENY. At the smallest known cup diameter of 4.54mm the inner wall and central cavity are present. The outer wall consists of short pore tubes or of simple pores whose openings are not subdivided. The inner wall has rudimentary pore tubes. Septa have 3 closely spaced rows of pores across the intervallum. The timing of the subdivision of the outer wall pore tube openings is not known, but subdivisions are apparent at a cup diameter of 5.4mm. Septal pore rows begin to separate widely at approximately 6.3mm cup diameter. The first formation of synapticulae is not known.

COMPARISON AND REMARKS. Bayleicyathus diversus sp.nov. differs from B.bowmani described above by the sparseness of the septal pores and their more uniform size. The outer wall of B.diversus appears to have intervals which lack pore tubes but have only simple pores; B.bowmani has pore tubes over the entire outer wall as far as is known. *B.diversus* has sparse synapticulae which are not known from *B.bowmani*, but this may be due to a lack of well preserved material.

Other Irregulares from the Mount Scott Range.

Apart from the species described in this chapter, there are several other genera of Irregulares which are worthy of mention although at present the material is too sparse to allow accurate species determinations to be made.

In Faunal Assemblage II, several fragments of ? *Flindersicoscinus* Debrenne have been found. These are the only known specimens of tabulate Irregulares from this stratigraphic level. It is clear from one specimen at least that tabulae are present in very small cups at a stage when the outer wall is still seemingly either imperforate or has rare, large pores (Plate 57, Figs. 10, 11). The discovery of this specimen raises the possibility that species in the genus *Dictyocoscinus* Bedford R. and W.R. may prove to be juvenile forms of *Flindersicoscinus* Debrenne, or of some similar tabulate genus.

In the uppermost parts of the Ajax Limestone (? Faunal Assemblage V) fragments belonging to the genera *Sigmofungia* Bedford R. and W.R. and *Syringocnema* Taylor have been found. The latter genus appears to be restricted to the uppermost parts of the Ajax Limestone and Wilkawillina Limestone.

One very poorly preserved specimen of ? *Uranosphaera* Bedford R. and W.R. was found in Lower Faunal Assemblage II (Section N) at the Mount Scott Range. The specimen is 30mm in diameter and has traces of star-like nesasters on part of its surface. Its very poor preservation precludes an accurate description at present. Dolomitized specimens of species of this genus have been seen in outcrop in Lower Faunal

Assemblage II at Ajax Hill. In section N at the Mount Scott Range there are numerous circular voids now filled with calcite spar. Many of these voids contain circular aggregates of micrite which may have originally filled central cavities of species of Radiocyatha. If this is the case, the preferential replacement of radiocyathid skeletons compared with archaeocyathid skeletons (which are very well preserved in this section), may indicate a different skeletal composition.

CHAPTER 8.

SUMMARY AND CONCLUSIONS.

Seventy three species of Archaeocyatha have been described herein, including forty four species of Regulares belonging to twenty two genera, and twenty nine species of Irregulares belonging to fifteen genera. Of these, forty one species and six genera of Regulares are new, and twenty two species and six genera of Irregulares are new.

Archaeocyatha from Faunal Assemblages I and II appear to correlate with the Bazaikhian Horizon or Atdabanian of Siberia, USSR. Unfossiliferous oolitic and stromatolitic dolomites which precede the first Archaeocyatha in the Flinders Ranges may be basal Atdabanian in age. It is not yet possible to precisely define the upper limits of Faunal Assemblage II in relation to the USSR stratigraphic scheme, but Archaeocyatha typical of the Sanashtykgol Horizon (Botomian) occur only in younger faunal assemblages in South Australia.

Rapid lateral and vertical facies changes in the Mount Scott Range and breaks in the sequence at Wilkawillina Gorge, have limited the stratigraphic ranges of many of the species described herein. Studies of other localities will not only improve local biostratigraphic resolution but will also aid in reconstructing the palaeogeography of the Early Cambrian and may provide explanations for the observed concentration of species of Archaeocyatha in particular localities.

Detailed studies of the more complex outer wall structures of Regulares have confirmed the early appearance in ontogeny of pore diaphragms first outlined by Zhuravleva and Elkina (1974). At the same time however, the present studies have revealed that drastic revision of constituent genera of the Cyclocyathellidae, Stillicidocyathidae and other families in the Suborders Ajacicyathina and Nochoroicyathina is urgently required. The morphology of non-independent microporous sheaths of species of the tabulate Superfamily

Anaptyctocyathacea is quite variable and more complex than previously imagined. Different micropore shapes and distributions are very similar to those observed by Kashina (1979) for species of the non-tabulate Superfamily Erbocyathacea; however it is not possible to demonstrate reduction in the number of sheath micropores with time for the Superfamily Anaptyctocyathacea on the present evidence.

Studies of the outer walls of Irregulares have shown that there is a gradation in morphological complexity which has no counterpart in the Regulares. The present studies have enabled a new classification of Irregulares based on the definition of certain wall structural types and types of porosity. Subdivided outer wall pores, which are considered to be analogous to microporous sheaths of Regulares, display gradations in complexity often between species of the same genus. A new Superfamily classification, following the same principle used for Regulares, is proposed for non-tabulate Irregulares. The same classification should equally apply to tabulate Irregulares.

It was found that the main wall structure or carcass always reached its final degree of complexity before that of the inner wall, consequently outer wall carcass structures were assigned super-family rank and inner wall carcass structures were assigned family rank. In contrast to the microporous sheaths of Regulares the formation of subdivided outer wall pores of Irregulares developed either simultaneously with, or later than that of the inner wall carcass. In general, subdivided pores were formed earlier over outer wall carcasses of simple construction than those of complex construction. This has led to the assignment of generic rank to the presence of subdivided pores in the proposed new classification, resulting in the grouping into families of those genera which are morphologically similar in most other respects. For instance in the Family Beltanacyathidae, the species <u>Beltanacyathus digitus</u> sp.nov. differs from the species

Warriootacyathus wilkawillinensis sp.nov. only by the presence of minor protrusions across the mouths of the outer wall pore-tubes, and by somewhat smaller and more numerous septal pores. These species would be placed in separate superfamilies if subdivided outer wall pores were assigned the same taxonomic rank as microporous sheaths in the Regulares.

This raises the question of which morphological characters acquired during ontogenetic development are the most important in a scheme of classification. All modern workers regard the ontogenetic development of outer and inner wall structures to be the basis of the present classification of Regulares. However, the present work suggests strongly that the development of septal porosity, which has hitherto been insufficiently studied, should be used in conjunction with the progressive development of wall structures. Recent work by Rozanov (1973), Zhuravleva and Elkina (1974), Kashina (1979) and others have greatly contributed to an understanding of the ontogenetic development of the outer and inner walls, and to some extent of the septal porosity. The study of Siberian Archaeocyatha by Zhuravleva (1960b) laid the foundations for much of this recent development.

The fundamental importance of septa in subordinal classification in all but the most simply constructed Regulares and Irregulares has long been known, but relatively little systematic study has been applied to the ontogenetic development of septa. A new method of measuring septal porosity outlined herein has revealed the possibility of two patterns of ontogenetic change where only one had previously been considered likely. At present, this alternative "arrested" development of septal porosity appears to occur only in the Suborder Ajacicyathina. This suborder, however, embraces a considerable proportion of known species of Regulares.

The alternative pathway raises the question of whether such apparently dissimilar genera as Leptosocyathus Vologdin, Joanaecyathus gen.nov. and possibly others such as Prethmophyllum Debrenne, Stapicyathus Debrenne, Ussuricyathus Okuneva and species placed in the genus Archaeocyathellus Ford by workers in the USSR, might be related by having this type of septal development in common. On the other hand there is a possibility that the "arrested" pathway of septal development occurred independently in different taxa at different times.

There is evidently a link between the change in septal porosity and the rate at which new septa were added, which can be traced by changes in the radial coefficient with cup growth. Seemingly random changes in the radial coefficient can be explained mathematically if septa were added as a straight line function of cup growth. In these cases straight lines representing septal addition at a relatively slow rate have low gradients and hence low radial coefficients which decrease gently with cup growth. The septal porosity in these cases is relatively high. Rapid septal addition results in straight line functions of high gradient with correspondingly high radial coefficients, which decrease rapidly with cup growth. The septal porosity is lower in these cases. In some species a point is reached where the gradient is high and the straight line function when extended downwards, intersects the vertical axis at negative values. Under these conditions the radial coefficient rises with cup growth and the present very sparse data suggests that the septal porosity may also rise. Although these processes are at present little understood mainly due to a lack of data, they indicate complex ontogenetic changes in septal development which had not previously been predicted. The present writer suspects that very low septal porosity is not found in species of the Suborder Coscinocyathina because the presence of tabulae in some way offsets or compensates for the processes causing the loss of septal porosity in the other septate suborders. There is as yet no firm evidence to support this idea.

A brief study of exothecal tissue surrounding the cups of some Regulares has yielded interesting results, connected with the outer wall microporous structure. In a study of Erugatocyathus krusei sp.nov. it was found that the non-independent microporous sheath was continuous where no exothecal tissue was present, but discontinuous where buttresses of exothecal tissue had been added to the outer wall. The knife-sharp lintels below the continuous sheath were too narrow to provide a firm foundation for the addition of the buttresses, and so it appeared necessary to modify the outer wall in order to add them. This modification took the form of resorption of the continuous sheath and strengthening of the underlying lintels. Once the buttresses were formed a new microporous sheath was subsequently added. This may have been the case for several other species having exothecal tissue of this type.

It was demonstrated that exothecal tissue added as radial extensions to the outer wall lintels and septal extremities served as an anchoring device for Somphocyathus coralloides Taylor. The different zones of exothecal tissue were formed at different stages of cup growth. The number of buttresses in a given zone correspond quite closely to the number of lintels and septa present on the outer wall at the time when the zone was formed. The illustrated straight-line relationship showed this clearly and also indicated that for this species, the number of septa and lintels were added as a straight line function of cup growth. The maximum diameter of exothecal tissue observed surrounding the holotype indicates the cup diameter achieved on cessation of growth. Large expanses of exothecal tissue near the base of the cup were not connected with its functioning at that growth stage, but were added later.

The ability of the species E.krusei sp.nov. and S.coralloides

Taylor to modify their outer wall structures in response to changing requirements (in the latter case at least, additional stability required due to larger cup size), suggests that possibly a number of other species may do the same. If modifications of the outer wall sheath were to arise as a result of adaptation to changing circumstances, then a species showing such modifications might be classified as two distinct species, even when other morphological characteristics are identical at all stages of cup growth.

The present studies have opened new avenues of investigation, which if pursued, may provide important information about evolutionary trends and how they may be distinguished from trends in response to changing conditions. It is hoped that they will contribute to a better understanding of the phylogeny of Archaeocyatha, particularly of the septate Regulares,and provide an insight into the physiological processes of the organisms that gave rise to such diverse and delicate ancient cups - the Archaeocyatha.

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