GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

BULLETIN 202

CONTRIBUTIONS TO CANADIAN PALEONTOLOGY

Fossils of the Ordovician Red River Formation (Cat Head Member), Manitoba

D. C. McGregor, F. H. Cramer, Rousseau H. Flower, and J. Keith Rigby

Ottawa, Canada 1971

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Part I — Palynomorphs
D. C. McGregor and F. H. Cramer

Part II — Cephalopods
Rousseau H. Flower

Part III — Sponges
J. Keith Rigby

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PREFACE

The Red River Formation of Manitoba has yielded a rich and varied Ordovician fauna which represents an important phase in the geological history of the Lower Paleozoic, recognizable in one form or another from Greenland to New Mexico. The faunas have attracted the interest of geologists for many years, from the time of J. F. Whiteaves at the end of the last century. It is thus appropriate that the Geological Survey should attempt a modern definitive study of these faunas from their type region.

Aside from their continent-wide correlative and biological interest the fossils offer a means of solving the many problems of age relationship within the sequence of the Ordovician rocks in Manitoba; rocks which are perhaps more obvious to the layman than any other limestones in Canada, as it is from the quarries of Manitoba that the mottled fossiliferous building stones, so widely used in public buildings are obtained.

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

Ottawa, May 27, 1970

BULLETIN 202 — Beiträge zur kanadischen Paläontologie

Die Faunen der Cat-Head-Schichten in der ordovizischen Red-River-Formation (Manitoba)

Die Palynomorphen der ordovizischen Cat-Head-Schichten, (Lake Winnipeg, Manitoba)
Von D. C. McGregor und F. H. Cramer
Die Cephalopoden der ordovizischen Cat-Head-Schichten, (Lake Winnipeg, Manitoba)
Von Rousseau H. Flower
Die Schwämme der ordovizischen Cat-Head-Schichten (Lake Winnipeg, Manitoba)
Von J. Keith Rigby

БЮЛЛЕТЕНЬ 202 — МАТЕРИАЛЫ ПО ПАЛЕОНТОЛОГИИ КАНАДЫ

Фауны ордовикской формации р. Ред-Ривер, Манитоба (пачка Кэт-Хед)

Палиноморфы ордовикской пачки Кэт-Хед, оз. Виннипег, Манитоба.
Д. К. Мак-Грегор и Ф. Г. Крамер
Цефалоподы ордовикской пачки Кэт-Хед, оз. Виннипег, Манитоба
Руссо Г. Флоуэр
Губки ордовикской пачки Кэт-Хед, оз. Виннипег, Манитоба
Дж. К. Ригби

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PART I

PALYNOMORPHS OF THE ORDOVICIAN CAT HEAD MEMBER, LAKE WINNIPEG, MANITOBA

D. C. McGregor and F. H. Cramer[1]

ABSTRACT

Gloeocapsomorpha prisca Zalessky, acritarchs, and chitinozoans have been recovered from the Cat Head Member of the Red River Formation of Ordovician age, Lake Winnipeg. *G. prisca*, the most abundant microfossil, is of little zonal significance because of its long stratigraphic range. However, its presence suggests that the Cat Head sea, although marine, may have had little exchange with the open sea, and that it may have been relatively shallow and in a region with tropic or temperate climate. There are fewer species of both acritarchs and chitinozoa than are commonly encountered in Ordovician marine sediments. Some characteristic Ordovician forms are present, but the assemblages are of little use at present for more refined dating.

RÉSUMÉ

On a retrouvé dans le niveau de Cat Head de la formation de Red River d'âge ordovicien, aux environs du lac Winnipeg, le *Gloeocapsomorpha prisca* Zalessky, des acritarches et des chitinozoaires. Le *G. prisca*, le plus abondant des microfossiles, est peu utile dans la répartition zonale en raison de sa vaste portée stratigraphique. Sa présence laisse toutefois entrevoir que la mer de Cat Head, bien que salée, n'a eu que peu de contacts avec l'océan, qu'elle était peut-être peu profonde et située dans une région tropicale ou tempérée. Les acritarches et chitinozoaires sont moins nombreux que d'ordinaire dans les dépôts marins de l'Ordovicien. Il y a bien quelques espèces caractéristiques de cet âge, mais les assemblages sont peu prometteurs pour servir à une datation plus précise.

[1]Department of Geology, Florida State University, Tallahassee, Florida.

INTRODUCTION

The occurrence of several morphological forms of megafossil algae in the Cat Head Member of the Red River Formation of Manitoba, recorded by Whiteaves (1897) and Fry (1960), prompted the suggestion that the rock might contain abundant palynomorphs. Records of microflora in association with megascopic algae are rare, and demonstration of such an association would have paleoecological significance. Moreover, one microfossil group, the chitinozoans, already has been used with some success in subsurface zonation of the Red River Formation and in correlation between surface and subsurface sections, according to Jodry and Campau (1960). Other palynomorphs, if present, might also eventually be applicable to zonation and assessment of age and environment.

A specimen of rock from the Cat Head Member, collected by G.W. Sinclair from GSC Plant Fossil Locality 5235, between McBeth Point and Cat Head, Lake Winnipeg, Manitoba, was selected for study. On its surface was a specimen of the alga Chondrites cuneatus Whiteaves. A preparation was run using dilute HCl followed by concentrated HF, the resulting residue subsequently being heated in 30% HCl and finally macerated in concentrated nitric acid for 30 minutes.

The second author (Cramer) processed, without oxidation, another sample of rock from the Cat Head Member, collected by G.W. Sinclair at GSC Invertebrate Fossil Locality 40148, McBeth Point, Lake Winnipeg. He also examined the preparations from loc. 5235, photographed the specimens illustrated on Plate I, figures 25, 26, and Plate II, figures 3, 12, 13, 15, 16, 17 and 19, and is responsible for the identifications of the acritarchs and chitinozoans.

Gloeocapsomorpha

The most abundant microfossil in both samples was Gloeocapsomorpha prisca Zalessky (Plate I, figs. 1-4). This species occurs in the maceration residues in masses of from 10µ (one or two cells) to about 150µ in diameter. Comparison with Gloeocapsomorpha in a preparation from the kuckersite of Estonia[1] (Plate I, figs. 5 and 6) aided in identification of the Cat Head specimens.

Gloeocapsomorpha prisca is very similar to, if not identical with, the living Botryococcus braunii Kützing. Some workers (e.g. Adamczak, 1963) have expressed caution in identifying the Ordovician forms with Tertiary ones and with B. braunii, but Cookson (1953, p. 108) has remarked,

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[1] Supplied to McGregor by the late Prof. Paul W. Thomson, Bonn.

Manuscript received: February, 1970.

"... it is now generally believed that an alga [Gloeocapsomorpha prisca] identical with the living Botryococcus braunii has existed from the Ordovician onwards."

Leiospherid acritarchs

Numerous smooth, punctate, granulose, or apiculate ahaptotypic palynomorphs which have no polarity spot, are present in both samples (Plate I, figs. 7-20 and 33). Two of them, the thin-walled, punctate types shown in Plate I, figures 19 and 20 are small specimens of Tasmanites. The thick-walled specimen of Plate I, figure 33, is a typical Tasmanites. Others could on cursory examination be mistaken for trilete spores (e.g. Plate I, figs. 8, 9 and 10), but their triradiate pattern is accidental, caused either by folding or splitting of the wall. They, and the specimens figured in Plate I, figures 7 and 11-14, are assignable to Leiosphaeridia (Eisenack) Downie and Sarjeant, or Protoleiosphaeridium Timofeev.

The three specimens illustrated on Plate I, figures 15-18 have single subcircular openings. A pore or pylome of similar appearance is present in the wall of some species of Leiosphaeridia and of Schismatosphaeridium Staplin, Jansonius and Pocock. However, the rent or slit that is a diagnostic feature of Schismatosphaeridium was not observed.

Records of Leiosphaeridia-like fossils are abundant in the literature, and there have been various interpretations given as to their affinities. There is a tendency to regard them as algal spores. As applied to the Cat Head leiospheres this suggestion seems reasonable, because the microfossil association does seem to be predominantly planktonic, and marine algae are locally abundant in the Cat Head. Judging from variations in size and ornamentation represented by the Cat Head leiospheres, there were numerous contributing species; perhaps some were reproductive bodies of thalli similar to those described by Whiteaves. Convincing evidence is still lacking, however, that they are algal spores, or that they are even of plant origin (see commentary in Schopf, 1957). On the other hand, Wall (1962) has provided strong evidence that Tasmanites was a planktonic green alga.

Other acritarchs

The number of species of non-leiosphaerid acritarchs is very low in both samples. All species recorded have simple, hollow, sharp-pointed spines, a feature that is prevalent among lower Paleozoic acritarchs. Veryhachium of the V. trispinosum (Eisenack) Deunff - Micrhystridium vulgare Stockmans and Willière transition series is the most abundant type. Also present are Lophosphaeridium cf. L. citrinum Downie, V. irroratum Loeblich and Tappan, a new species, Veryhachium sp. II, that also occurs in the Ordovician of Tunisia, Algeria, Libya, and Saudi Arabia (Cramer, unpublished), Veryhachium sp. I, a species of the Veryhachium - Micrhystridium complex with filose ectoderm sculpture, B. brevifurcatum (Eisenack) Downie and Sarjeant, Dactylofusa sp., similar to a species from the Silurian Neahga shale of the Niagara Peninsula and from Libya and Saudi Arabia, described by Cramer (in press), but with thicker, less curved sculpture, and Leiofusa sp. of a wall thickness and general outline similar to that of Eupoikilofusa striatifera (Cramer) Cramer but without its characteristic longitudinal striae and/or ridges. This form of Leiofusa is also present in the Ordovician of the Iberian Peninsula, of the Sahara, and in the Elkhorn Formation of Ohio.

Chitinozoans

The chitinozoan assemblage of the samples comprises five taxa: a simple form of (=Sphaerochitina Angochitina, Hercochitina, or Ancyrochitina), two species of Conochitina, Hercochitina sp., and Hoegisphaera acollaris (Eisenack) Jansonius. Sphaerochitina and Conochitina are the most abundant. No species of Cyathochitina, which are abundant in strata of approximately the same age in Florida, Oklahoma, and Iowa were found. Of the striate or filose forms, e.g. Belonechitina and Hercochitina crickmayi Jansonius, only one specimen of Hercochitina was encountered. Cyathochitina, Hercochitina, and Belonechitina are known to occur in the Upper Ordovician of Anticosti Island (Jansonius, 1964, 1967) and in the Middle and Upper Ordovician of Iowa and Ohio (Taugourdeau, 1965; Cramer's unpublished data).

Although they are fairly well preserved, the chitinozoans are crushed and cracked, evidently by diagenesis rather than by laboratory processing. As a result they tend to break up during preparation. They consist of the endoderre only and are dark brown and of a preservation characteristic of limestones in a rather stable area, opaque to visible light but transparent to infrared (Xe light source).

Stratigraphic Significance of the Fossils

Gloeocapsomorpha prisca has been reported and discussed in many papers from deposits as old as Lower Ordovician (e.g. Eisenack, 1958; Bachmann, 1967) and as young as Tertiary (e.g. Traverse, 1955). Eisenack (1958) suspected that it appeared even before the Ordovician, and a report by Nagappa (1957) of a Cambrian or Precambrian fossil that he called Botryococcus may support Eisenack's suggestion. Timofeev (1962) has also mentioned Gloeocapsomorpha from the late Precambrian. G. prisca may be of some use as an accessory for local correlation, but because it is long-ranging it is not applicable as an age indicator.

There has not been any convincing demonstration of the stratigraphic value of leiosphaerid acritarchs, but further investigation may reveal their usefulness for this purpose. The non-leiosphaerid acritarchs, on the other hand, have achieved undoubted biostratigraphic value, and are especially significant for early Paleozoic rocks where miospores are rare.

The non-leiosphaerid acritarch assemblage of the Cat Head Member unfortunately is like the chitinozoan assemblage, poor in species, and most of the species are stratigraphically long-ranging. This is rather unusual, as Ordovician assemblages tend to be rich in species, some of which have restricted range. In the Cat Head, Veryhachium irroratum and the other species of Veryhachium with filose sculpture are typically Ordovician; their range within the Ordovician has not been established, but provisionally they appear not to range into the latest Ordovician. Dactylofusa n. sp. is of Ordovician aspect. None of the large forms, e.g. Baltisphaeridium

(Goniosphaeridium) described by Eisenack (1958, 1965, 1968, 1969) from the Baltic, and none of the species from Canada referred to by Staplin, et al. (1965) are present.

The chitinozoan assemblage has a definite Ordovician aspect, characterized by the presence of Hercochitina, but is of little use yet for more refined dating.

Jodry and Campau (1961, p. 1390) concluded that "... Chitinozoa and Tasmanites give promise of becoming the most useful [fossils] to the subsurface geologist working with Williston basin Paleozoic rocks." They were able to distinguish the Dog Head, Cat Head, and Selkirk "formations" on the basis of chitinozoa. However, their published work did not include either details of their zonations nor identifications of the fossils.

Conclusions on paleoecology

One can infer something of the environment of deposition of the Cat Head specimens of the alga Gloeocapsomorpha by referring to the habitat of the present-day Botryococcus braunii. According to Blackburn (1936), B. braunii occurs as a plankton in tropic and temperate zones, usually in fresh water but occasionally in brackish or salt water. Dulhunty (1944) and Traverse (1955) conclude that Permian and Tertiary Botryococcus lived in relatively shallow open water which was far enough from quantities of decaying vascular vegetation to be low in humic concentration.

In the early Paleozoic rocks (i.e. in the kuckersite) Gloeocapsomorpha (? = B. braunii) sometimes occurs in high concentrations comparable to those of some younger deposits, but it is in much less concentration in the two samples studied from Cat Head Member.

It would seem that Gloeocapsomorpha colonies probably lived at the surface in low concentrations at the site of deposition of the Cat Head, or if they were not in low concentrations, deposition was rapid enough to dilute the algal deposit, or bottom scavengers drastically reduced the numbers that were finally preserved. They were adapted to life in quiet surface waters, and their biocoenosis would likely include acritarchs and chitinozoans, such as we do find associated with them in the Cat Head.

The Cat Head sea was marine or brackish; acritarchs appear to have been part of the marine plankton, although little else is known of their ecology or of the groups of organisms (plant and/or animal) they represent. The fact that the acritarch assemblage is poor in species is difficult to explain. Perhaps the acritarchs lived in an environment that, although marine, had very little exchange with the open sea, so that a restricted assemblage developed. They may have been eaten selectively by scavengers, and some species may have been destroyed selectively during the process of fossilization.

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Plate I

Gloeocapsomorpha prisca Zalessky.

Figures 1-4. Hypotypes, GSC Nos. 26259-26262, GSC loc. 5235; x500.
Figures 5-6. Hypotypes, GSC Nos. 26263, 26264, Estonian kuckersite; x500.

Leiosphaeridia spp. or Protoleiosphaeridium spp.

Figures 7-14. Hypotypes, GSC Nos. 26265-26272, GSC loc. 5235; x500.

Leiosphaeridia spp.

Figures 15-18. Specimens with pylome visible; hypotypes, GSC Nos. 26273-26275, GSC loc. 5235; x500.

Tasmanites spp.

Figures 19, 20. Hypotypes, GSC Nos. 26276, 26277, GSC loc. 5235; x500.
Figure 33. Hypotype, GSC No. 26278, GSC loc. 40148; x200.

? Baltisphaeridium sp. I

Figures 21, 22. Hypotype, GSC No. 26279, GSC loc. 5235; 21, x500; 22, x1000.

Veryhachium irroratum Loeblich and Tappan

Figures 23, 24. Hypotype, GSC No. 26280, GSC loc. 5235; 23, x1000; 24, x500.

Leiofusa sp.

Figure 25. Hypotype, GSC No. 26281, GSC loc. 40148; x500.

Dactylofusa n. sp.

Figure 26. Hypotype, GSC No. 26282, GSC loc. 40148; x500.

Veryhachium-Micrhystridium complex

Figures 27, 28. Hypotype, GSC No. 26283, GSC loc. 5235; x500.

Baltisphaeridium sp. II

Figures 29, 30, 32. Hypotypes, GSC Nos. 26284-26286, GSC loc. 5235; x500.

Lophosphaeridium cf. L. citrinum Downie

Figure 31. Hypotype, GSC No. 26287, GSC loc. 5235; x500.

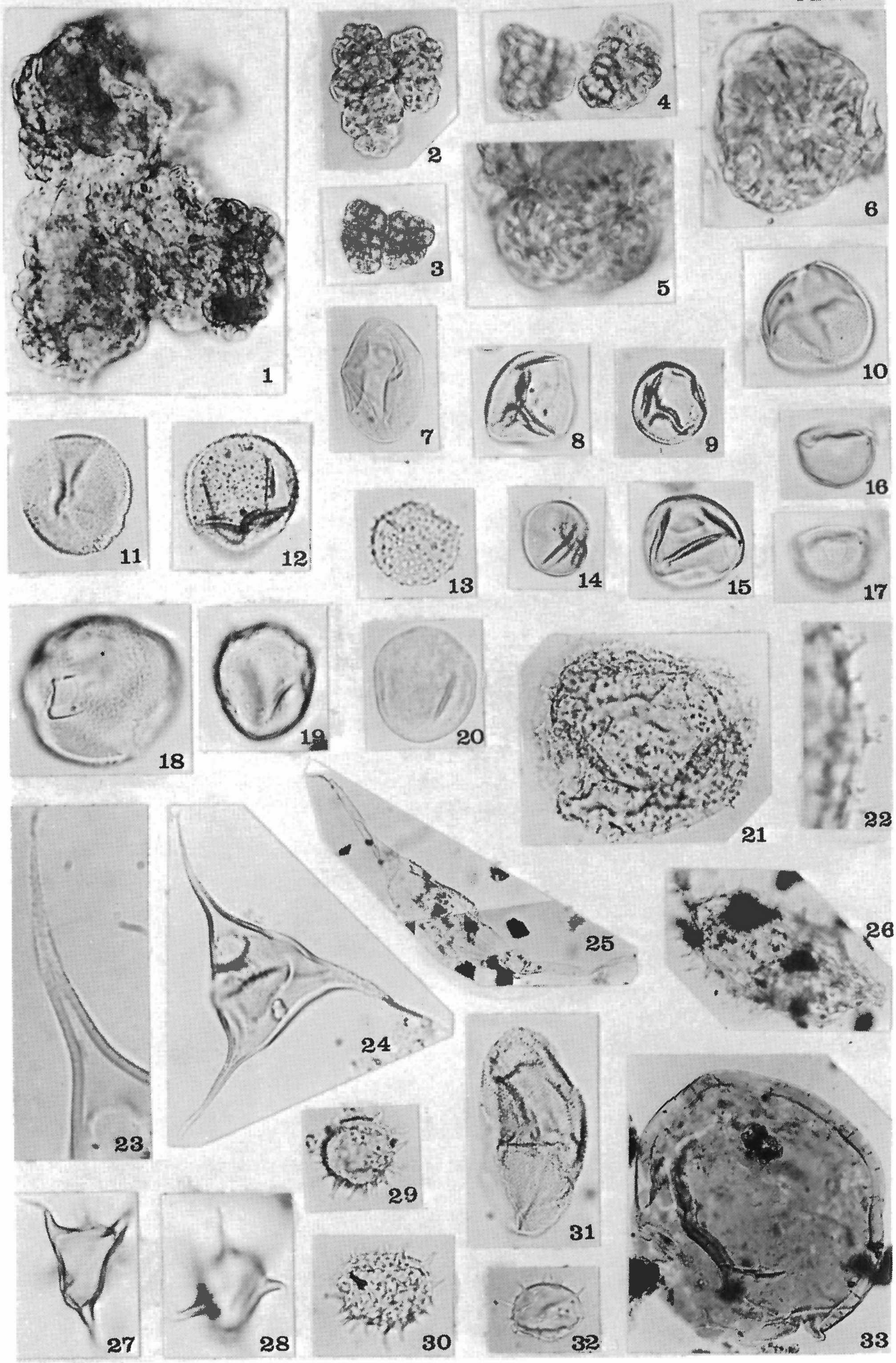
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Plate II

Veryhachium-Micrhystridium complex

Figures 1, 2, 4, 6, 8, 9. Hypotypes, GSC Nos. 26288-26293, GSC loc. 5235, showing variation in number, thickness and length of processes; x500.

Veryhachium sp. I

Figure 3. Hypotype, GSC No. 26294, GSC loc. 40148; x500.

Veryhachium sp. II

Figure 5. Hypotype, GSC No. 26295, GSC loc. 5235; x500.

Baltisphaeridium sp. III

Figure 7. Hypotype, GSC No. 26296, GSC loc. 5235; x500.

Hoegisphaera acollaris (Eisenack) Jansonius

Figures 10, 18, 19. Hypotypes, GSC Nos. 26297, 26298, GSC loc. 40148; x200.

? Angochitina sp.

Figures 11, 12. Hypotype, GSC No. 26299, GSC loc. 40148; x200.

Hercochitina sp.

Figures 13, 17. Hypotype, GSC No. 26300, GSC loc. 40148; 13, x200; 17, x500.

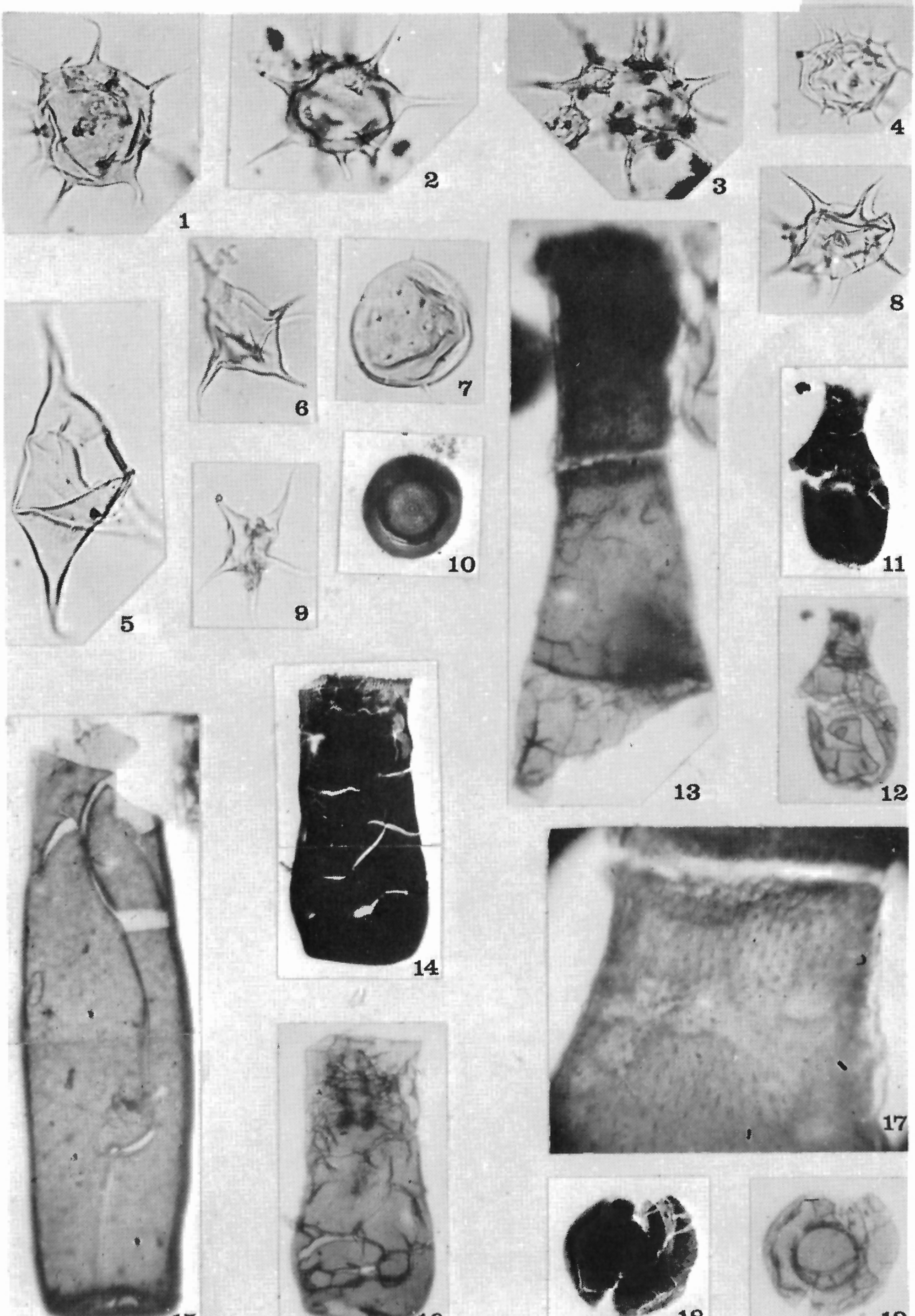
Conochitina sp. I

Figures 14, 16. Hypotype, GSC No. 26301, GSC loc. 40148; x200.

Conochitina sp. II

Figure 15. Hypotype, GSC No. 26302, GSC loc. 40148; x200.

PLATE II



PART II

CEPHALOPODS OF THE ORDOVICIAN CAT HEAD MEMBER, LAKE WINNIPEG, MANITOBA

Rousseau H. Flower[1]

ABSTRACT

Most cephalopods of the Cat Head limestone are crushed and their internal structure is destroyed. This leaves some generic assignments doubtful, but it is possible to recognize twenty-two specific forms. Not all of these are represented by material well enough preserved to permit proper definition or to justify the erection of species names. The brevicones show affinities in general with Red River faunas as developed broadly from Greenland to New Mexico, with some allied forms in the late Trenton, Richmond, and the Whitehead Formation of eastern North America.

RÉSUMÉ

La plupart des céphalopodes des calcaires de Cat Head sont écrasés et leur structure interne détruite, ce qui jette le doute sur certaines classifications génériques. Il est cependant possible d'en distinguer 22 formes particulières, dont toutes ne sont pas représentées par des restes suffisamment bien conservés pour permettre une définition ou pour justifier l'attribution d'un nom d'espèce. En général, les brévicones sont apparentés aux faunes de Red River dans leur extension du Groenland au Nouveau-Mexique, quelques formes étant liées aux formations du Trenton récent, de Richmond, et de Whitehead de l'est de l'Amérique du Nord.

[1] New Mexico State Bureau of Mines and Mineral Resources, Socorro, New Mexico.

INTRODUCTION

The Cat Head limestone is the upper member of the Red River Formation (Sinclair, 1959); the underlying Dog Head limestone changes at the south end of Lake Winnipeg to the Selkirk facies. The Cat Head has yielded about sixty specimens of cephalopods. More than half of these are indeterminable, being mere scraps of orthocones and brevicones. The better specimens are somewhat flattened in the limestone, and ordinarily only one side of the shell is preserved. Septa and siphuncles have been destroyed. Such specimens commonly fail to supply the evidence necessary for proper assignment of species to presently accepted genera. However, the species themselves are in a large part recognizable, and permit significant comparison with cephalopods in other Ordovician faunas. It is significant that the species of the Cat Head limestone are not identical either with those of the underlying Dog Head Member or the overlying Stony Mountain Formation. In a broader sense, however, the species are comparable with others which have been described from "Red River" faunas from Colorado to Greenland, and some forms also have relatives in the late Trenton of Quebec, the Whitehead Formation of Gaspé, and the Richmond of eastern North America.

The most curious group of shells consists of brevicones which are strongly humped, usually over the anterior part of the phragmocone, and then taper gently to the aperture. Such shells are compressed, fusiform; some have the two ends of the shell nearly equal in length and diameter; when the cephalopodium was extended beyond the aperture, the symmetry was probably more perfect, and the resultant complete animal was boomerang-shaped. It is an odd fact that this type of shell is peculiar to the later Ordovician faunas, but is achieved in two orders, three families and four known genera. Cyrtogomphoceras has such a shell; it is endogastric, and a member of the Cyrtogomphoceratidae of the Discosorida (Flower and Teichert, 1957). The allied genera Westonoceras and Winnipegoceras are exogastric, and members of the Westonoceratidae of the same order. Some question surrounds the structure of the type species of Neumatoceras Foerste (1935), and Foerste figured the allied N. nutans as having a rather large tubular siphuncle. Re-examination of the type has failed to support this conclusion. However, there are shells of the aspect and general size of Neumatoceras in the late Trenton of Quebec and in the Richmond of the Cincinnati, Ohio region which have moderately slender fusiform siphuncles typical of the Oncoceratidae. Indeed, there is some gradation between typical Neumatoceras and the oncoceroid genera Beloitoceras and Oncoceras (Flower, 1946), and we here considered Neumatoceras as a member of the Oncoceratidae.

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Without knowledge of the position of the siphuncle, one cannot certainly distinguish Cyrtogomphoceras from these other exogastric genera by shell form alone. There are, however, some secondary characters which permit the reference of two of the species here described to Cyrtogomphoceras with some assurance. Likewise, using such affinities among species as are apparent, distinction among the exogastric genera Westonoceras, Winnipegoceras and Neumatoceras is attempted. Probably it has not been perfectly successful, but similar confusion has long existed even when better preserved material was available. Miller, Youngquist, and Collinson (1954) employed Westonoceras very broadly, including in it not only Neumatoceras, but also some species belonging to other oncoceroid genera. This matter has been rectified as far as the evidence permits (Flower and Teichert, 1957).

The odd thing is that even with confusion surrounding the correct separation of these four genera from the present poorly preserved material, these forms are nevertheless stratigraphically useful, being diagnostic of the Red River faunas in a broad geographical sense. The Silurian lacks such shells; the closest approach to a similar shell form is found again in the genera Archiacoceras, known only from the Eifel Middle Devonian, and Mecynoceras, a rare genus, common to the Upper Devonian of Europe and North America.

Doubtless there is some facies control of the types of cephalopods in the chalky limestone of the Cat Head. The specimens are mainly small, contrasting markedly in this respect with those of the Dog Head Member, and only the orders Michelinoceratida, Oncoceratida, and Discosorida are represented. Narthecoceras has not been found. No endoceroids have been recognized; there is one piece of a big, flat orthocone of endoceroid dimensions, but the endosiphuncle, which is the most commonly preserved part of an endoceroid has not been found. There are no actinoceroids. Coiled genera are lacking, though Discoceras, Apsidoceras, Antiplectoceras, Charactoceras, and Bickmorites have been found either in Red River or Richmond faunas, or in both.

It is of some interest to note that the Surprise Creek Formation on the west side of Hudson Bay, which, as Nelson (1963) notes is by position a reasonable equivalent of the Cat Head limestone, has yielded a completely different cephalopod fauna. Nelson lists a Narthecoceras, Lambeoceras walkeri Nelson, and Whiteavesites procteri Nelson.

Fortunately, Red River cephalopods have been quite extensively described mainly in the several works of Foerste, Miller and various coworkers, and Troedsson, cited in our bibliography.

The species here described and illustrated are: Michelinoceras sp. 1, Michelinoceras? sp. 2, Polygrammoceras? sp., "Spyroceras" (possibly Gorbyoceras) sp. 1, "Spyroceras" sp. 2, Ephippiorthoceras? sp., Diestoceras crater n. sp., Diestoceras sp., Manitoulinoceras? lenticontractum n. sp., Oncoceras pupa n. sp., Beloitoceras? productum n. sp., Beloitoceras sp. 1, Beloitoceras? sp. 2, Neumatoceras? foerstei n. sp., Neumatoceras? gracile n. sp., Neumatoceras? sp., Cyrtogomphoceras tuber n. sp., Cyrtogomphoceras minore n sp., Cyrtogomphoceras? sp. cf. C. baffinense Foerste, Westonoceras? sp. 1, Westonoceras? sp. 2, and Winnipegoceras simplicem n. sp.

In addition, Narthecoceras simpsoni (Billings) is from the Cat Head limestone. The type specimen cannot be located, no other Cat Head specimens have been found even pertaining to this genus. The species has been discussed previously (Flower, 1968, p. 62).

The two small species assigned (one questionably) to Michelinoceras are generalized and in a broad sense too nondescript to be diagnostic, it is nevertheless significant that no similar shells have been found in the underlying Dog Head Member or in the overlying Stony Mountain Formation. Orthocones with annuli and longitudinal ornament have long been referred broadly to Spyroceras, though that genus belongs to the Pseudorthoceratidae and is unknown before the Devonian. Genera of this aspect in the Ordovician are Anaspyroceras, in which the siphuncle is tubular, and Gorbyoceras, in which the siphuncle segments are expanded. Many Ordovician species of this group have not been investigated as to internal structure; it may be noted, however, that one of our species suggests, by spacing of annuli and finer markings, species which are certainly assignable to Gorbyoceras; Spyroceras fritzi Foerste of the Selkirk limestone is a true Gorbyoceras. Our one orthoconic fragment showing the fine longitudinal lirae of Polygrammoceras is not very significant. In the Silurian, Polygrammoceras is certainly allied to true Kionoceras, being similar in internal structure. The same may well be true of a group of later Ordovician species from Anticosti Island which include the type species (P. twenhofeli Foerste, 1928b), but it is doubtful whether the same lineage is represented by smaller species from older Ordovician strata in northern Europe.

For the brevicones, results are more satisfactory. The species here assigned to Cyrtogomphoceras, Westonoceras, Winnipegoceras, and Neumatoceras have comparable forms in many of the Red River faunas and some also have comparable forms in eastern North America in the late Trenton of Quebec, the Richmond of the Cincinnati arch, and the Whitehead Formation of Gaspé. Although Manitoulinoceras is related to Upper Ordovician species rather than to those of the early Trenton or Black River, the simpler Oncoceratidae are mostly rather long ranging genera in the Ordovician, and the affinities which the proportions of the species suggest seem to be of little value in making very precise correlations.

In the following descriptions the affinities of the species are discussed, and also it is noted where and why generic assignments seem questionable. Some species, e.g., Cyrtogomphoceras? sp. cf. C. baffinense Foerste, cannot be assigned certainly and suggest possible relationships with Oncoceras and Westonoceras as well as with Cyrtogomphoceras.

Most of the material here described was collected and submitted for study by G. Winston Sinclair. A few specimens were from the collections of the University of Manitoba. Most specimens bear locality data; a few do not, but the Cat Head limestone is known only from one rather small area midway on the western shore of Lake Winnipeg, and the lack of information is probably not serious. A few specimens were collected by the writer and contributed to the collection of the Geological Survey of Canada.

SYSTEMATIC DESCRIPTIONS

Michelinoceras sp. 1

Plate I, figures 1, 2

The specimen is an internal mold of a very small smooth orthocone. It shows an apical length of 13 mm in which there is apparently a break through a tubular siphuncle and the shell enlarges from 2.5 to 5.0 mm; a

19 mm length of phragmocone showing straight transverse sutures and increasing to a width of 7 mm; the anterior part shows four camerae in 7 mm, the anterior camera is not shortened. The living chamber, with a broken aperture, is 20 mm long, increasing to a width of 9 mm.

Type. Figured specimen GSC No. 22834; Cat Head limestone, Kinwow Bay Island (Inmost Island), Lake Winnipeg.

Michelinoceras? sp. 2

Plate I, figure 3

This is a tiny smooth internal mold of one side of an orthocone. A posterior part 13 mm long expands from 1.4 to 3.5 mm, and shows transverse septa with 13 camerae ranging in length from 0.9 to 1.4 mm; there is an anterior part which is either another camera or the base of the living chamber. The specimen is probably immature, and shows no contraction of the anterior camerae. There is in addition a crushed apical part 3 mm long containing parts of an additional five camerae; these have calcitic margins, and show elongate dark rectilinear surfaces which are probably portions of the crushed shell wall; one is widened apically, and the alternate interpretation, that they represent fillings within camerae with deposits, is most unlikely.

Discussion. This tiny acicular shell is noteworthy as such early stages of Michelinoceratida are rare. This is either a specimen of a tiny species or an immature shell, or both. It could be an earlier growth stage of Michelinoceras sp. 1 but close comparison of the two available specimens is not possible.

Type. Figured specimen GSC No. 22835; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Polygrammoceras? sp.

Plate I, figures 4, 5

This is a flattened part of an orthocone 25 mm long and 22 mm wide, showing four complete camerae ranging irregularly from 5.5 to 7.0 mm in length. The surface bears fine closely spaced longitudinal ridges, subequal in width and elevation, such as are considered characteristic of Polygrammoceras. Relief is very faint, and the ridges are spaced between 0.8 and 1.0 mm apart. The specimen shows a surface on which dark grey accentuates the ridges. It seems unlikely, however, that the ridges were originally colour bands; no colour bands as narrow or as closely spaced as these, are known in cephalopods, though it is true that in some orthocones the colour bands, protecting the shell from solution or weathering or both, may produce some relief.

Type. Figured specimen GSC No. 22836; the Cat Head limestone, locality unknown.

"Spyroceras" (possibly Gorbyoceras) sp. 1

Plate I, figure 6

This species is represented by the impression of a small part of a shell of the aspect of "Spyroceras" with annuli rounded, merging into interspaces spaced with crests 3 mm apart, where the shell is 12 mm wide; there are fine raised longitudinal lirae a little more than 1 mm apart; on the sides, secondary lirae nearly as strong lie between them. The surface is similar to that of Cincinnatian species of Gorbyoceras, but without the siphuncle generic determination is a guess.

Type. Figured specimen GSC No. 22837; Cat Head limestone, McBeth Point, Lake Winnipeg. Collected by the writer.

"Spyroceras" sp. 2

Plate I, figure 9

A fragment of an annulated cephalopod 27 mm long and expanding from 4.5 to 6.5 mm in the anterior 20 mm shows narrow closely spaced annuli, six in a length of 5 mm adorally and seven in the same length apically. Interspaces are broader than the annuli, only faintly concave; annuli are low and well rounded. The surface shows traces of faint longitudinal markings.

This form is worth noting as there is no closely comparable form of Ordovician age in North America. The nearest are some species from the Middle Ordovician, such as "Spyroceras" cf. lesueuri (Clarke) (Foerste, 1932, Pl. 12, fig. 9), which are unknown internally.

Type. Figured specimen GSC No. 22190; Cat Head limestone, locality unknown.

Ephippiorthoceras? sp.

Plate II, figure 6

This is a part of a crushed shell, evidently straight or nearly so, slender, 35 mm across adorally, showing one camera 6 mm long, and another of 5 mm, suggesting that this fragment is close to the base of a mature or nearly mature living chamber. There is a basal 14 mm of a living chamber. The sutures show a broad lobe on the right side, and a somewhat narrower rounded crest, the left limb of which descends into another lobe at the margin of the specimen. This fragment would not be worth noting except that the suture pattern suggests the genus Ephippiorthoceras, a genus occurring in Red River faunas at least from Colorado to the Arctic. Oddly, most american specimens are not only fragments, but are poorly preserved internally, and it remained for Teichert and Glenister (1953) to publish an adequate interior, which shows the pattern of the Proteoceratidae. Anomalously, this specimen is from the Gordon River area of Tasmania, is without a precise locality, and its authors ascribe it, from cephalopods from the same region, to the Silurian. While such wishful thinking may be excused, it cannot be accepted as good evidence of the extension of the genus into the Silurian.

Of the North American occurrences, we must discount as inadequately known that in the early Trenton, which rests upon the identification of Cyrtoceras subarcuatum d'Orbigny from the lower Trenton (Rockland) of Middleville, N.Y. as an Ephippiorthoceras. More typical but poorly preserved specimens occur in the Cobourg of northwestern New York and Ontario. In Anticosti Island the Vauréal Formation has yielded E. formosum, E. alticameratum, E. sieboldi, and the anomalous E. plicatum, which should probably have a separate genus for itself. The overlying Ellis Bay Formation has yielded E. schucherti. E. ekwanense (Whiteaves) from the Silurian Attawapiskat limestone of Hudson Bay Lowland is inadequately known, and is based on fragments which, while not a true member of the genus, cannot be assigned elsewhere. Foerste and Savage did what they could with the material at hand.

Though the genus may, as do many Red River genera, extend into the Richmond, it has not been recognized in the Richmond of Cincinnati, southern Ontario, or western New York.

Type. Figured specimen GSC No. 22838; Cat Head limestone, between Cat Head and McBeth Point, Lake Winnipeg.

Genus DIESTOCERAS Foerste, 1924

Diestoceras contains slightly compressed essentially straight brevicones typically with straight sutures, a ventral siphuncle known in large forms to have expanded segments and actinosiphonate structure, and a living chamber which contracts gently to the aperture. Species are included in which the shell attains its greatest cross section before the living chamber, but others are largest beyond the base of the living chamber. The forms recognized here are all flattened shells, and no other generic assignment is suggested by the material.

Diestoceras crater n. sp.

Plate II, figure 7

This shows one side of a crushed shell, in which there is expansion to the aperture; sides are gently convex over the living chamber and the rate of expansion is reduced adorally. Sutures describe broad saddles on the exposed surface. Both the saddles and the adoral continuity of expansion may be the result of crushing.

The specimen shows a phragmocone 19 mm long increasing from 19 to 33 mm, in which there are apparent six camerae, increasing from 2.5 to 4.0 mm; the last camera is not shortened, and the specimen may not be quite mature. The living chamber expands from 33 mm to an estimated 45 mm, one side being incomplete adorally. The aperture shows a broad crest, parallel with the last septum. This may have been transverse originally.

Diestoceras curtum Foerste (1935) is comparable in form, but is more expanded and the camerae are materially longer.

Type. Holotype GSC No. 22839; Cat Head limestone, between Cat Head and McBeth Point, Lake Winnipeg.

Diestoceras sp.

Plate I, figure 13

This is a crushed shell, with only one side preserved. The two camerae are 4 mm long, show sutures with broad gentle lobes; in the length of the phragmocone the shell increases from 24 to 26 mm. The living chamber is abraded anteriorly, but a length of 21 mm is preserved which is reasonably close to the total length. In the first 10 mm the living chamber becomes 28 mm across; the sides are gently convex, and more curved on the left than on the right of the specimen; the aperture is reasonably restored as being about 26 mm across, showing slight adoral contraction of the shell.

Discussion. This species is not named being both crushed and incomplete. There are several species of Diestoceras of about this size and aspect, including D. Kirki Foerste (1935, Pl. 11, fig. 2) of the Big Horn Group, and D. occidentale Foerste (1935, Pl. 12, figs. 3, 4) of the Fremont limestone of Colorado. D. subglobosum Foerste (1936) of the Whitehead Formation of Gaspé is also similar to our present form in size and general aspect.

Type. Figured specimen GSC No. 22840; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Manitoulinoceras? lenticontractum n. sp.

Plate I, figure 14

We have of this form a lateral portion of a somewhat flattened cyrtocone, nearly tubular apically, gently expanding to the base of the living chamber, and then most gently contracting to the aperture. In the 14 mm of the phragmocone the shell increases in height from 14 to 16 mm, shows straight transverse sutures, and camerae, most of which are 4 mm long, the length gently decreasing in the adoral third, the last camerae 3 mm. The living chamber is 25 mm long, and decreases in height gently from 16 to 12 mm, though this may be a slight exaggeration as the true dorsum is not clearly evident adorally. None of the internal structure is known.

Discussion. Generic position without knowledge of the siphuncle and the original section is, of course, hazardous, but less so in this species than in some associated forms; we know no genus other than Manitoulinoceras which combines such slender form with straight transverse sutures; known species of Kentlandoceras are more rapidly expanding and Staufferoceras which is more slender but has a circular section, shows lateral lobes of the sutures which are clearly wanting here.

Type. Figured specimen GSC No. 22841; Cat Head limestone, Kinwow Bay Island (Inmost Island), Lake Winnipeg.

Oncoceras pupa n. sp.

Plate I, figures 7, 8

This is a small, slender Oncoceras, belonging to a group of species which seemingly merge into the more slender Beloitoceras. The holotype shows one side of a somewhat flattened shell, in which the venter is gently convex over the phragmocone but straight or nearly so on the anterior part of the living chamber where it approaches the dorsum. The dorsum is gently convex over the phragmocone, becoming straight and then faintly concave on the living chamber, the concavity lying shortly before the aperture. The phragmocone, 12 mm long on the venter, expands vertically from 8 to 13 mm, and contains seven camerae which average 1.5 mm long except the last, which is shortened. Sutures are faintly sinuate, nearly transverse, but rise forming a low saddle at the extreme ventral part and indicate a lower fainter saddle on the dorsum. The living chamber 12 mm long is 13 mm high at the base and 12 mm high at the apertural end which is obscure. The shell shows a maximum height of 14 mm slightly before the anterior end of the phragmocone.

The paratype shows the dorsal surface of a crushed individual similar in proportion to the holotype.

Types. Holotype GSC No. 22842; paratype GSC No. 22843; Cat Head limestone, McBeth Point (holotype) and between Cat Head and McBeth Point (paratype), Lake Winnipeg.

Beloitoceras? productum n. sp.

Plate II, figures 3, 4

This is a small slender brevicone of the general shape of Beloitoceras, distinctive in the long anterior camerae, the deep lateral lobes, and the oddly extended anterior end of the living chamber. The specimen is 33 mm long, showing only one lateral surface, expanding in height from an estimated 15 mm to 17 mm in the first 12 mm, contracting gently to 11 mm in the next 19 mm, beyond which the living chamber contracts, and bends abruptly dorsad to an apparent aperture only 7 mm high. Lateral lobes are deep, the three camerae are subequal, 4 mm long on the venter. The living chamber is 17 mm high across its oblique base with a maximum length of 16 mm. The dorsum is uniformly and gently concave to near the aperture, where it is strongly concave, almost angular, then straight. The venter, which is not quite complete, seems gently convex, curvature slightly greater over the anterior end of the phragmocone, and then bent abruptly dorsad near the anterior end.

The aperture is difficult to interpret. It appears to be small and turned toward the dorsal side. The specimen suggests the possibility that this might be only the main dorsal part of the aperture, and that there might be a linear hyponomic sinus as in the Trimeroceratidae and Hemiphragmoceratidae. If so, this species would require a new genus; we know of no other shells with such apertures in the Ordovician.

Though this form has the general profile of a Beloitoceras, the long anterior camerae and deep lateral lobes are not typical of the genus; this might be a diminutive member of the Discosorida, possibly allied instead to Westonoceras and Winnipegoceras.

Type. Holotype GSC No. 22844; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Beloitoceras sp. 1

Plate II, figure 9

The phragmocone shows parts of six camerae, sutures with only faint lateral lobes, sloping progressively forward on the venter, last two camerae progressively shortened. Camerae on the dorsum - the venter is incomplete - occupy 12 mm, and are 2 mm long, shortening to 1 mm. We have in addition 15 mm of a nearly complete length of a living chamber. Where before the dorsum was straight, here it is gently convex. The venter is evidently more convex than the dorsum; the height at the base is estimated at 16 mm along the last septum, and at 12 mm at the aperture. There is no preoral constriction.

Type. Figured specimen GSC No. 22845; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Beloitoceras? sp. 2

Plate II, figure 10

This brevicone is rather like Cyrtogomphoceras? sp. cf. C. baffinense Foerste, but is smaller, sutures fail to develop lateral lobes or to slope progressively forward on the convex side. The specimen is crushed, showing a maximum of 23 mm of a phragmocone with an adoral height of 30 mm, and 20 mm of a living chamber. Both are incomplete. The supposed ventral profile, the more convex side, is gently convex where preserved over the adoral end of the phragmocone and most of the living chamber, but becomes faintly concave, and then flares slightly just before the aperture. The dorsal profile is largely wanting but the shell appears to contract over the living chamber, though it may share the concavity of the venter just before the aperture. The phragmocone contains six camerae averaging 3.5 to 4 mm and the last camera is 2 mm long. The parallel condition of the sutures suggests that the phragmocone was essentially straight rather than curved. Without the dorsum, one cannot determine certainly where the shell is largest in diameter, but it is in the vicinity of the base of the living chamber.

There is no species known to me which is similar to this in size, general contour of the shell, and the nearly straight subparallel stuures; perhaps the closest is the considerably smaller Beloitoceras cummingsi Flower, but the present form is clearly a distinct species. It could be interpreted also as a smaller species allied to our Cyrtogomphoceras? sp. cf. C. baffinense Foerste.

Type. Figured specimen GSC No. 22846; Cat Head limestone, Cat Head, Lake Winnipeg.

Neumatoceras? foerstei n. sp.

Plate II, figure 8

Winnipegoceras sp. Foerste, 1929, p. 217, Pl. 16, fig. 6.

This specimen shows a lateral half of a shell, retaining a living chamber and two camerae, contracting gently forward and gently curved from just before the base of the living chamber. The more convex side, the assumed venter, is curved over the phragmocone, becoming nearly straight over the anterior two thirds of the living chamber; the concave side is faintly convex, nearly straight over the anterior part of the phragmocone, gently concave over most of the living chamber. The two sutures show lateral lobes, and slope farther forward on the venter than on the dorsum. The shell retains faint costae or growth lines. The specimen expands from a height of 24 to 25 mm and contracts to 16 mm at the aperture in a length of 34 mm. The two camerae measure 5 mm and 4 mm on the venter, the last being slightly shortened. The living chamber has a ventral length of 24 mm and a dorsal length of 19 mm.

Discussion. The form of this species is distinctive, but its generic position is dubious. Foerste first referred it to Winnipegoceras, but later (1935) noted that it could as easily be placed in Neumatoceras. Without internal structure, form is the only basis for comparison of the species. Winnipegoceras royi Miller, Youngquist, and Collinson (1954, Pl. 32, figs. 1, 2) is rather similar in shape, but is a much larger shell, with less marked adoral contraction, and their Winnipegoceras aff. W. laticurvatum (Whiteaves), though smaller than W. royi, is still larger than our present form and less contracted adorally. Troedsson's (1926) Maelonoceras? reclinatum, which from both shape and the elongate subquadrate siphuncle segments seems a good Winnipegoceras, is also comparable, though it is again larger and less contracted. Miller, Youngquist, and Collinson (1954) have figured (Pl. 47, figs. 1-8; Pl. 48, figs. 1-3, and particularly Pl. 49, figs. 1, 2) Westonoceras cornulum and also comparable is their Westonoceras? cf. W.? breviposticum (Pl. 48, figs. 4, 5) but in that work some oncoceroids were included in Westonoceras. Westonoceras? contractum Foerste and Savage (1927, Pl. 16, fig. 2), is somewhat comparable, but larger, and more strongly bent anteriorly.

Foerste (1935) has figured and described several species of Neumatoceras which have the general shape of our specimen. While this applies in general to all of the species of Neumatoceras in that work, the resemblance is particularly close for Neumatoceras sp. (Pl. 5, figs. 1-3) of the Fremont limestone of Colorado and N. sp. (Pl. 5, fig. 4), from the Lander sandstone of the Big Horn Group. Similar species have been assigned to Neumatoceras by Foerste (1936) from the Whitehead Formation of Gaspé.

While affinities with Cyrtogomphoceras cannot be ruled out completely, species of that genus have living chambers which are considerably shorter.

Type. Holotype GSC No. 22847; Cat Head limestone, bay between Cat Head and McBeth Point, Lake Winnipeg.

Neumatoceras? gracile n. sp.

Plate I, figure 15

This is a specimen similar to the preceding one, but smaller, more slender, less curved, and less markedly contracted adorally. The living chamber contracts from a height of 20 mm at the base to 15 mm at the aperture, and is 27 mm long on the convex side, 17 mm on the concave side.

Traces of four camerae are preserved only on the concave side of the specimen, occupying a length of 4 mm; the last is markedly shorter than the others.

Discussion. The remarks on similarities of *N.? foerstei* n. sp. apply almost as well to this species. The sutures here describe a shallower lateral lobe, and are less markedly inclined forward on the convex side of the shell.

Type. Holotype GSC No. 22848; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Neumatoceras? sp.

Plate II, figure 1

This is an odd, tiny brevicone showing a living chamber almost conically contracting from the base to the aperture. It is 12 mm across at the base, 7 mm across at the aperture, which is slightly inclined forward on the more convex side of the shell, and 10 mm long. At the base of the living chamber there are vestiges of three subequal camerae occupying together a length of 2.1 mm. The suture, as far as it is preserved, is transverse and without development of a lateral lobe.

Discussion. We have no other small shells of strictly comparable aspect, but the living chamber is close to that of *Neumatoceras* in form than to that of any other described genus. No comparably small species assignable to *Westonoceras*, *Winnipegoceras*, or *Cyrtogomphoceras* are known.

Type. Figured specimen GSC No. 22849; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Cyrtogomphoceras tuber n. sp.

Plate II, figure 5

The type and only known specimen shows one side of a somewhat crushed shell with the assumed venter straight, the dorsum convex, and strongly humped over the anterior part of the phragmocone. The specimen is 41 mm long, expanding from 19 to 25 mm in a length 25 mm on the dorsum, and 5 mm on the venter, then contracting adorally for a dorsal length of 14 mm to a height of 19 mm. Camerae are rather long, increasing from 4 to 7 mm on the venter, with the last shortened to 4 mm. Sutures slope progressively forward on the dorsum, but lack more than vestiges of lateral lobes. The dorsum shows 6 mm of shell anterior to the last septum, which may be part of the living chamber.

Discussion. Though internal structure is wanting, and thus either orientation of this specimen cannot be proved, its form and particularly the absence of lateral lobes and the length of the camerae, are features found in *Cyrtogomphoceras* but not known in anything of comparable form in *Westonoceras*, *Winnipegoceras*, or *Neumatoceras*. The species is small for *Cyrtogomphoceras*, and there is no described species which is close to it in proportions.

Type. Holotype GSC No. 22850; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Cyrtogomphoceras minore n. sp.

Plate II, figures 12, 13

The type and only known specimen shows a dorsolateral surface of a considerably flattened shell. Both dorsal and ventral profiles are convex, the dorsal one the more strongly curved, and the living chamber contracts from a height of 21 mm to 9 mm, in a ventral length of 18 and a dorsal length of 20 mm. There is part of a suture at the base which is straight and transverse as far as it is preserved. A small prominent hyponomic sinus occurs on the aperture, which is otherwise only slightly inclined forward from venter to dorsum.

Discussion. The essentially transverse suture, the presence of a hyponomic sinus on the less convex side of the living chamber and general proportions support assignment of this species to Cyrtogomphoceras rather than to any of the exogastric breviconic genera of similar general shape. The specimen shows some colour, and is illustrated both whitened and in its natural state. Colour bands are not indicated, but aside from the colour in two cracks, there is a suggestion of original dark organic material near the aperture as previously noted by the writer in some Trenton oncoceroids (Flower, 1964, p. 10, Pl. 1, figs. 6-11).

Type. Holotype GSC No. 22851; Cat Head limestone, McBeth Point, Lake Winnipeg.

Cyrtogomphoceras? sp. cf. C. baffinense Foerste

Plate II, figure 11

Cf. Cyrtogomphoceras baffinense Foerste, 1928a, p. 63, Pl. 4, fig. 1; Pl. 11, fig. 4.

This is a big brevicone, preserving only parts of one side showing a convex (dorsal?) surface which is gently convex over the living chamber, a ventral outline gently convex over the anterior end of the phragmocone, but nearly straight basally. The living chamber is incomplete here, but the outline must have been nearly straight or faintly concave.

Sutures show curved lateral lobes, and slope forward progressively on the convex side. The phragmocone increases in length from 20 mm ventrally to 37 mm dorsally, and retains seven camerae, which are nearly straight and transverse to the shell axis in the earliest preserved part. The penultimate camera is 6 mm on the dorsum, the last shortened to 4 mm. The living chamber has a dorsal length of 20 mm, an estimated ventral length of 19 mm. The shell expands in height from an estimated 39 mm basally to a maximum of 45 mm, and contracts to an estimated 34 mm at the aperture.

Discussion. This is a rather puzzling species as to affinities when the only evidence is part of a surface of an internal mold. In proportions it is not unlike Cyrtogomphoceras baffinense, but is slightly smaller and camerae are definitely shorter. However, it must be noted that less similar but also comparable are the specimens which Miller, Youngquist, and Collinson (1954) describe as Westonoceras thompsoni and W. wilsoni. The shape and general aspect of the shell would be duplicated also rather closely in an unusually large species of the genus Oncoceras.

Type. Figured specimen GSC No. 22852; Cat Head limestone, between Cat Head and McBeth Point, Lake Winnipeg.

Westonoceras? sp. 1

Plate I, figures 10, 11

This specimen preserves one side of a nearly straight living chamber and three camerae, in all 27 mm long. Dorsal and ventral outlines are nearly symmetrical on the living chamber, approaching each other and gently convex, so that the living chamber contracts from 23 to 14 mm in 11 mm. Most of the aperture is preserved; it is straight, very slightly inclined forward on the more convex side of the shell. Sutures describe deep lateral lobes, so that the living chamber increases from the venter to mid-height from 11 to 15.5 mm. There are parts of three camerae which are longer on the more convex side of the shell, that side being definitely convex over the anterior part of the phragmocone, while the other side is more nearly straight. The two camerae preceding the last one are 5 mm long on the venter, the last is 4 mm. The surface of the specimen shows some colouring, but the pattern, of faint lines strongly inclined forward from venter to dorsum, may well be adventitious. There is again a suggestion of darker material at the aperture, probably indicating a concentration of black organic material in the shell there.

Discussion. The deep lateral lobes and the short living chamber suggest Westonoceras; the camerae suggests that the earlier part of the shell may have been humped, rather abruptly on the ventral side, and certainly suggest marked curvature in the earlier part of the shell.

Type. Figured specimen GSC No. 22853; Cat Head limestone, Kinwow Bay Island, Lake Winnipeg.

Westonoceras? sp. 2

Plate II, figure 2

This is a very small brevicone, of which we have only an anterior part of a phragmocone 24 mm long, somewhat crushed, widening from 15 to 21 mm in the first three-fourths of its length, then contracting to 20 mm. The seven camerae preserved increase in length from 3 to 5 mm. Sutures rise to a saddle on the venter; owing to crushing, they appear nearly transverse over most of the surface shown, but the ventral saddle marks a point beyond which, at the left side of the specimen, sutures turn strongly apicad.

Discussion. The similarity of the suture pattern between this form and the much larger Westonoceras nelsonense Foerste (1929, Pl. 38, fig. 1), is responsible for the reference of this fragment to Westonoceras. This form is the smallest Westonoceras known.

Type. Figured specimen GSC No. 22854; Cat Head limestone. There is no locality record.

Winnipegoceras simplicem n. sp.

Plate I, figure 12

This is an internal mould of an anterior part of a shell which is essentially straight, very faintly curved, and decreases gently adorally in height. Parts of six camerae occupy 12 mm on the apparent dorsum. The anterior four camerae occupy 9 mm on the venter, in which length the shell height contracts from 30 to 28.5 mm; the first three camerae average 2 mm in maximum (ventral) length; the last is slightly less than 1 mm. The living chamber shows a length of 16 mm, and has an estimated height at the aperture, which is incomplete, of 24 mm. The dorsal profile is slightly concave on the living chamber, the venter most faintly convex, though faintly concave just before the aperture.

Discussion. This species has the aspect of the group of species of Winnipegoceras with rather short living chambers, and in which lateral lobes are greatly reduced, for example W. reclinatum (Troedsson) and W. royi Miller (see Flower in Flower and Teichert, 1957). The present form is smaller, shows even more complete obliteration of the lateral lobes, and has closer septa.

Type. Holotype GSC No. 22855; Cat Head limestone, McBeth Point, Lake Winnipeg. R.H. Flower, collector.

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Plate I

Figures 1, 2. Michelinoceras sp. 1. Only surface preserved, X2; (1) whitened, showing sutures; (2) unwhitened, showing a trace of a tubular siphuncle apically. GSC No. 22834, Kinwow Bay Island (Page 16).

Figure 3. Michelinoceras? sp. 2. A tiny shell, X3, with a crushed apical part showing peculiar rectilinear bits of shell material. GSC No. 22835, Kinwow Bay Island (Page 17).

Figures 4, 5 Polygrammoceras? sp. A flattened orthocone with the surface of Polygrammoceras. (4) whitened; (5) unwhitened. GSC No. 22836, locality uncertain (Page 17).

Figure 6. "Spyroceras" (possibly Gorbyoceras) sp. 1. An impression of a small part of the shell surface. GSC No. 22837, McBeth Point (Page 18).

Figures 7, 8. Oncoceras pupa n. sp. (7) holotype, showing a lateral surface, GSC No. 22842; (8) paratype, showing a dorsolateral surface, GSC No. 22843, between Cat Head and McBeth Point (Page 21).

Figure 9. "Spyroceras" sp. 2. A small shell with unusually close annuli. GSC No. 22190, precise locality unknown (Page 18).

Figures 10, 11. Westonoceras? sp. 1. Figured specimen (10) whitened and unwhitened, showing oblique staining of surface and darkened aperture. GSC No. 22853, Kinwow Bay Island (Page 26).

Figure 12. Winnipegoceras simplicem n. sp. Holotype, a lateral surface, venter at left. GSC No. 22855, McBeth Point (Page 27).

Figure 13. Diestoceras sp. A crushed shell; venter probably on the right. GSC No. 22840, Kinwow Bay Island (Page 20).

Figure 14. Manitoulinoceras? lenticontractum n. sp. Holotype, showing a lateral surface, dorsum on left, photographed unwhitened. GSC No. 22841, Kinwow Bay Island (Page 20).

Figure 15. Neumatoceras? gracile n. sp. Holotype, showing a lateral surface venter on right. GSC No. 22848, Kinwow Bay Island (Page 23).

All specimens are from the Cat Head Member, Red River Formation, and unless otherwise indicated are shown natural size.

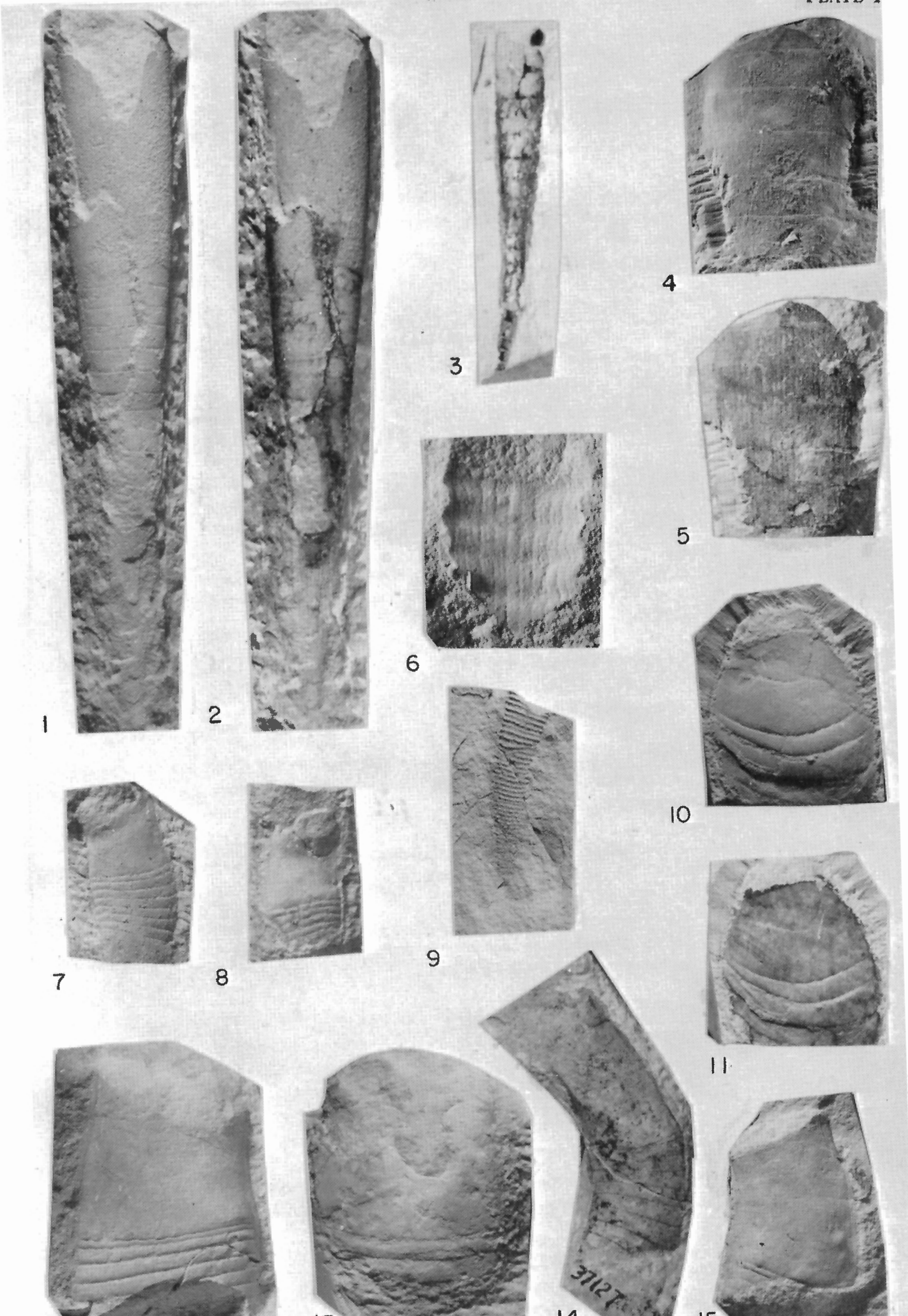
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Plate II

Figure 1. Neumatoceras? sp. Lateral surface, presumed venter on left, of tiny species, X2. GSC No. 22849, Kinwow Bay Island (Page 24).

Figure 2. Westonoceras? sp. 2. A small bit of phragmocone with the suture pattern of the genus; the midventral region is just to the right of the left margin. GSC No. 22854, locality unknown (Page 26).

Figures 3, 4. Beloitoceras? productum n. sp. Holotype, a lateral surface, dorsum on left; (3) unwhitened; (4) whitened. GSC No. 22844, Kinwow Bay Island (Page 21).

Figure 5. Cyrtogomphoceras tuber n. sp. Holotype, a lateral surface, dorsum on left. GSC No. 22850, Kinwow Bay Island (Page 24).

Figure 6. Ephippiorthoceras? sp. A fragment of an orthocone showing the suture pattern of the genus. GSC No. 22838, between Cat Head and McBeth Point (Page 18).

Figure 7. Diestoceras crater n. sp. Holotype, a flattened shell, orientation uncertain. GSC No. 22839, between Cat Head and McBeth Point (Page 19).

Figure 8. Neumatoceras? foerstei n. sp. Holotype, venter on left. GSC No. 22847, bay between Cat Head and McBeth Point (Page 22).

Figure 9. Beloitoceras sp. 1. A specimen showing a lateral surface of a slender brevicone. GSC No. 22845, Kinwow Bay Island (Page 22).

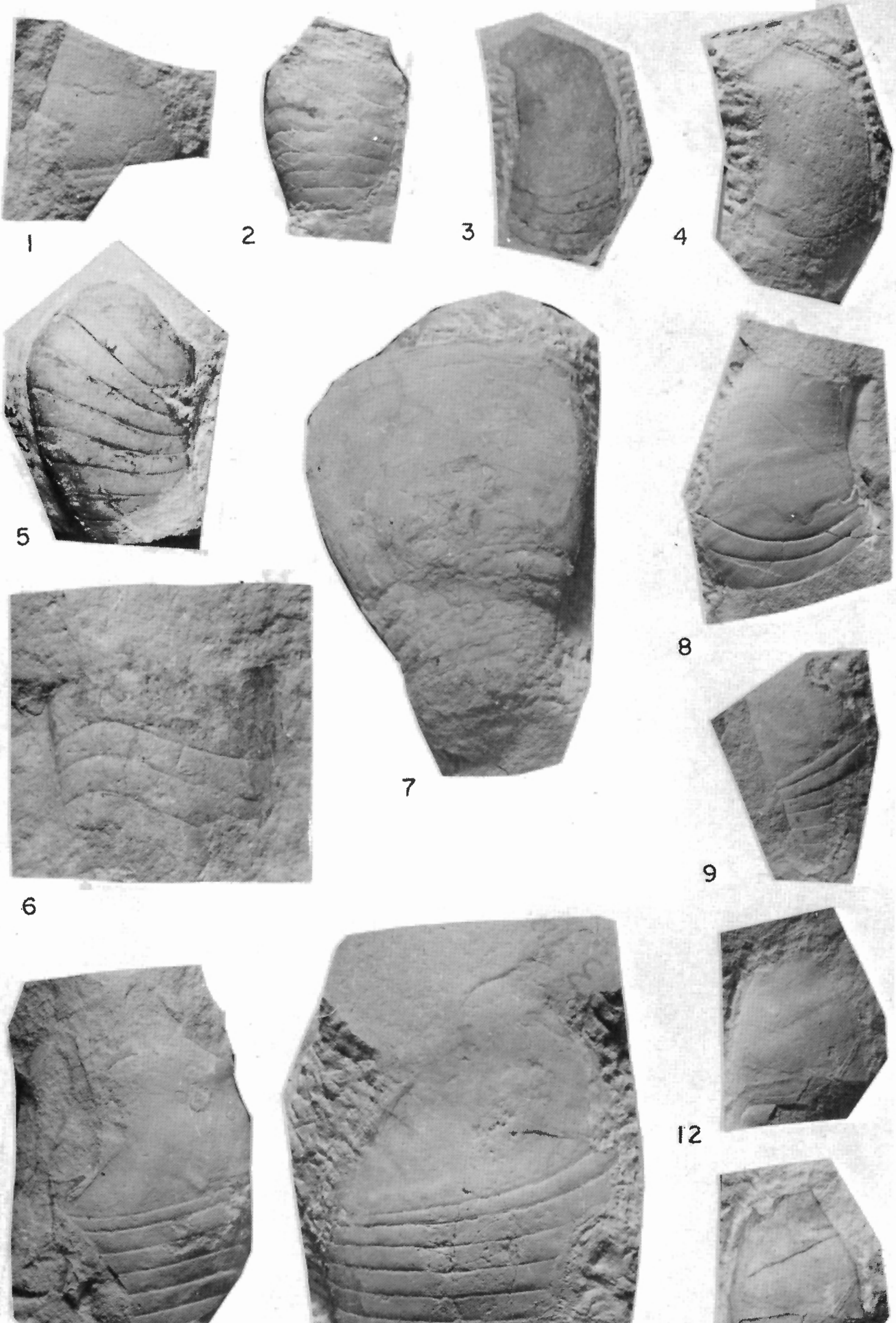
Figure 10. Beloitoceras? sp. 2. A lateral surface of a larger form. GSC No. 22846, Cat Head (Page 22).

Figure 11. Cyrtogomphoceras? sp. cf. C. baffinense Foerste. A specimen showing an incomplete lateral surface. GSC No. 22852, between Cat Head and McBeth Point (Page 25).

Figures 12, 13. Cyrtogomphoceras minore n. sp. Holotype, showing a slightly oblique ventrolateral surface, venter just to the right of the left edge, marked by the hyponomic sinus. (12) whitened, showing form more clearly; (13) unwhitened, showing darker coloration near aperture. GSC No. 22851, McBeth Point (Page 25).

All specimens are from the Cat Head limestone of Lake Winnipeg, and are shown natural size where not otherwise indicated.

Plate II



PART III

SPONGES OF THE ORDOVICIAN CAT HEAD MEMBER, LAKE WINNIPEG, MANITOBA

J. Keith Rigby [1]

ABSTRACT

The sponges: Brachiospongia digitata (Owen), Hudsonospongia irregularis Raymond and Okulitch, (?) Anthaspidella mammulata Ulrich and Everett, (?) Edriospongia basalis Ulrich and Everett, (?) Cyathophycus reticulatus Walcott and Patellispongia sp. are reported and described from the Ordovician Cat Head Member of the Red River Formation for the first time. Hydnodictya acantha, n. gen. and n. sp., Pyruspongia ruga, n. gen. and n. sp., and Pyruspongia camella, n. sp., are described from the same unit, from outcrops along the western shore of Lake Winnipeg, Manitoba. Type material of Aulocopella winnipegensis Rauff, and Trichospongia hystrix, the latter being placed in the new genus Trichospongiella, are redescribed.

Specimens of Hudsonospongia, Aulocopella, Patellispongia, and (?) Edriospongia are preserved as chert nodules or coarse chalcedonic replacements. Hydnodictya, Pyruspongia, Trichospongiella, and (?) Cyathophycus are now mainly limonite-stained moulds in light yellow-grey dolomite, having been altered from a former probable pyritic condition. Brachiospongia, (?) Anthaspidella, and a specimen of Pyruspongia are preserved, in large part, as dolomite ghosts or casts with little except surface sculpture remaining.

Pyruspongia is a pear-shaped to bowl-shaped sponge which is the basis of the new superfamily Pyruspongioidea and the new family Pyruspongiidae. Hydnodictya is a conical form and is the basis for the new family Hydnodictyidae, which appears to be an off-shoot of the Protospongiidae. Trichospongiella is interpreted to be an erect spinose epipolasid.

RÉSUMÉ

Les éponges suivantes ont été relevées pour la première fois dans le niveau de Cat Head de la formation de Red River, d'âge ordovicien: Brachiospongia digitata (Owen), Hudsonospongia irregularis Raymond et Okulitch, (?) Anthaspidella mammulata Ulrich et Everett, (?) Edriospongia basalis Ulrich et Everett, (?) Cyathophycus reticulatus Walcott et Patellispongia sp. De la même unité, soit des affleurements de la côte occidentale du lac Winnipeg (Man.) sont décrits: Hydnodictya acantha, n. gen. et n. sp., Pyruspongia ruga, n. gen. et n. sp. et Pyruspongia camella, n. sp. Le rapport fait une nouvelle description du matériau type Aulocopella winnipegensis Rauff et Trichospongia hystrix, ce dernier type faisant partie du nouveau genre Trichospongiella.

Les spécimens Hudsonospongia, Aulocopella, Patellispongia et (?) Edriospongia se présentent sous forme de nodules de silex ou de substitutions chalcédoniques grossières. Hydnodictya, Pyruspongia, Trichospongiella et (?) Cyathophycus sont principalement des moules entachés de limonite dans de la dolomie gris-jaunâtre et ont probablement subi une altération à partir d'une condition pyritique. Brachiospongia, (?) Anthaspidella et un

[1] Department of Geology, Brigham Young University, Provo, Utah.

spécimen, Pyruspongia, sont principalement conservés sous forme de moules ou d'empreintes dans la dolomie, la forme superficielle seulement étant conservée.

Pyruspongia est une éponge dont la forme varie entre celle de la poire et celle d'un bol et constitue la base d'une supra-famille de Pyruspongioidea et de la nouvelle famille des Pyruspongidés. De forme conique, Hydnodictya constitue la base de la nouvelle famille des Hydnodictyidae, qui semble être une branche des Protospongidés. On croit que Trichospongiella est un épipolasidé à épines vertical.

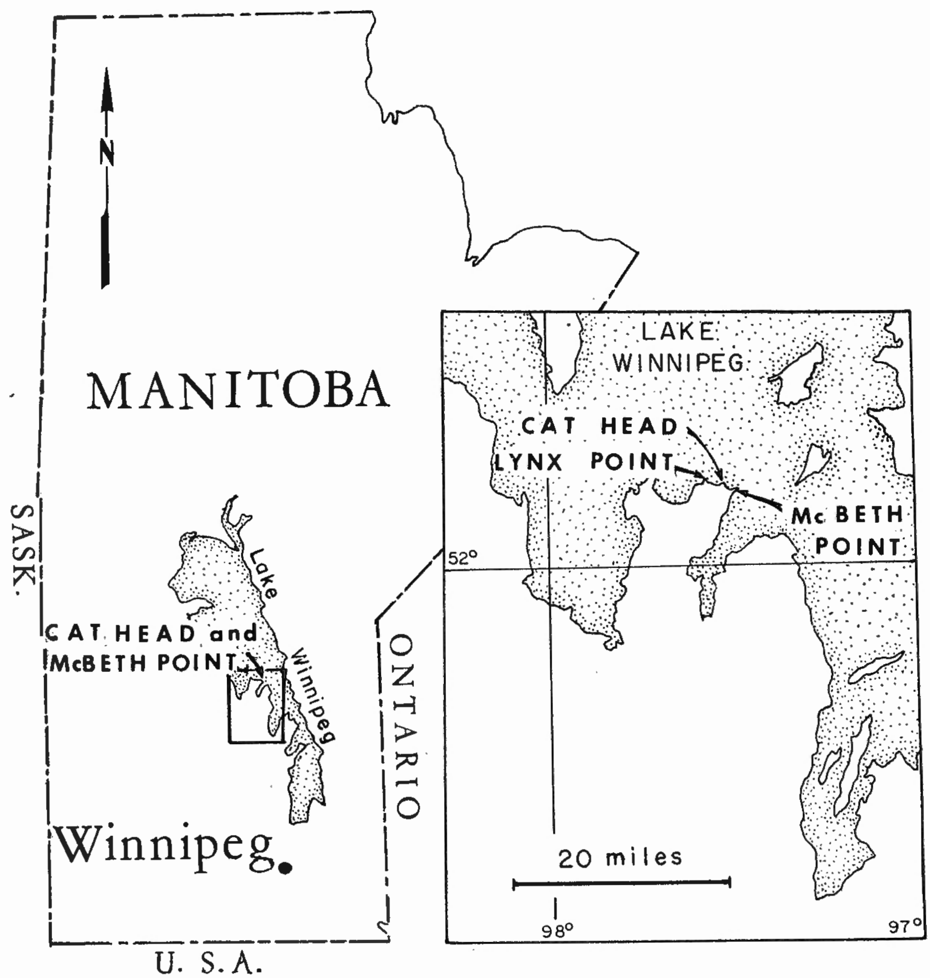


Figure 1. Index map of sponge localities of the Cat Head Member, Lake Winnipeg, Manitoba.

INTRODUCTION

Sponges were first reported from the Cat Head dolomite by Rauff (1895, p. 269) who described Aulocopella winnipegensis from Cat Head Fig. 1), 150 miles north of Winnipeg. Later, Whiteaves (1897, pp. 147-148, Pl. 17, fig. 3) described Trichospongia hystrix from the same locality. The present sponge fauna is the most extensive thus far described from the region; it was collected by G. W. Sinclair of the Geological Survey of Canada in the vicinity of Cat Head and McBeth Point on Lake Winnipeg (Fig. 1).

Sponges occur in three distinctive preservations within the characteristic cream-coloured finely crystalline dolomite of the member. Two specimens of Hudsonospongia, for example, are in light grey, dense chert, in which the canal system and spicule net are moderately well preserved in the original three-dimensional pattern. Other genera, such as Aulocopella and Patellispongia, have been replaced with chalcedony in which the botryoidal structure has obscured much of the fine skeletal detail but has retained the structure in three dimensions.

Specimens of Hydnodictya and (?) Cyathophycus, for example, are preserved as limonite-stained impressions or moulds, in which only a few spicules are preserved, either as silica or limonite. Much of the original structure must have been pyritic and is now limonitic because of weathering. There is some distortion in each of the sponges preserved in this manner, and in some, the specimens have been completely flattened.

Specimens of Brachiospongia and (?) Anthaspidella are preserved in still a different manner, for in neither are spicules preserved. They are preserved as casts or ghosts of dolomite in which there is no trace of the internal structure of the sponge, but only the gross form, with surface sculpture locally preserved in great detail.

The collection records the northwesternmost known occurrence of Brachiospongia digitata (Owen), Hudsonospongia irregularis Raymond and Okulitch, and Cyathophycus reticulatus Walcott, forms which were known only from the eastern United States and Canada.

The new genus Hydnodictya is superficially similar to Hydnoceras and is significant in being morphologically transitional from Early Paleozoic protosponges to Middle Paleozoic dictyosponges in spicule character. Both stauractine and hexactine spicules are present, but in an arrangement less regular than in either group. For the present the genus is included with the protosponges because of lack of fasiculation in the spicule net.

Little can be concluded from the sponge collection concerning paleoecology, and stratigraphic value of the sponges described has yet to be determined although they have much in common with Middle and Upper Ordovician faunas from eastern Canada and various localities in the United States.

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SYSTEMATIC PALEONTOLOGY

Class DEMOSPONGIA Sollas, 1875

Order EPIPOLASIDA Sollas, 1888

Family SOLLASELLIDAE Lendenfield, 1888

Genus TRICHOSPONGIELLA Rigby, n. gen.

Type species. *Trichospongia hystrix* Whiteaves.

Diagnosis. An elongate, probably erect, ribbed sponge with pronounced prostalia occurring in vertical rows. Prostalia, marginalia, and basalia of oxeas. Spiculation of body unknown; the only specimen known is preserved as a limonite stain.

Trichospongiella hystrix (Whiteaves)

Plate III, figures 2, 3; Figure 2

Trichospongia hystrix Whiteaves, 1897, pp. 147-148, Pl. 17, fig. 3; Bassler, 1915, p. 1289; Bolton, 1960, vol. I, p. 11.

Description. This species is known from a single specimen. It is preserved as a limonite-stained impression of spicules and a central body in finely crystalline dolomite. The specimen is an elongate impression, 45.4 mm long, rounded both top and bottom, and with an average width of 6.2 to 6.3 mm in upper and lower parts, but a maximum width of 8.5 mm near the middle. The surface is marked with pronounced marginal impressions of inclined spicules and two vertical ribs, one in the centre of the body throughout the length, and the other at the margin where few spicules are developed or preserved.

The central rib is evenly developed throughout its length, but is most pronounced in the middle and upper part of the sponge. It is traceable without difficulty to within 1 mm of the upper margin of the impression. In the upper part it is smooth, weakly rounded, approximately 1.2 to 1.3 mm wide and 0.3 to 0.4 mm high. It is evenly rounded and rises from the nearly flat impression along either side. Toward the middle of the sponge, the rib is 1.6 to 1.75 mm wide and slightly higher than at the upper margin, as much as 0.5 mm above the slightly impressed border. The rib is widest, 2.3 to 2.4 mm, 11 to 13 mm above the base, and then tapers slightly to where it is flattened and merges with the densely stained part of the base. It is weakly defined at the base by a lighter, less stained, presumably somewhat eroded crest of the rib, standing against the denser marginal flat area at the rounded base.

The rib is not evenly crested, but has culminations and depressions along it. These do not seem to be regularly spaced or have a rhythmic pattern, but are from 1.5 to 2.0 mm apart and affect the upper half of the rib. Some of this variation is related to the method of preservation, but there may have been weak nodes along the crest.

The marginal rib, as now seen, can be traced to within 1 mm of the top of the sponge where it is 0.7 to 1.0 mm wide and separated from the medial rib by a flattened surface, 1.2 to 1.4 mm across, which is stained a darker colour than the ribs on either flank. At mid-height the marginal rib is well defined, rounded, and 1.2 to 1.3 mm across and as high as 0.4 mm above the margin. At maximum width of the specimen, the marginal rib is separated from the medial one by 1.8 to 1.9 mm of densely stained surface and is 1.5 to 1.6 mm across and 0.3 mm high. Below maximum width, the separation between ribs decreases and the intervening surface forms a rounded trough so that 10 mm above the base it is difficult to draw limits, but the ribs are still 0.5 mm apart and the marginal rib at least 1.7 mm across. The lowermost 2.5 mm of the marginal rib is buried beneath matrix. There is some slight suggestion of nodes on the marginal rib, but it is less pronounced than on the medial one. It leaves the impression that the irregularities may have been the result of collapse rather than original growth.

Prostalia are visible around one margin, the left side as preserved in the slab, the upper part, and along the uppermost margin of the right side. There are also some spicules evident at the base of the sponge which are now considered to be root tufts or basalia.

At first glance there appears to be two lengths of prostalia along the margin of the specimen. One of these forms a thick felt approximately 3 mm beyond the sponge body margin and the other extends slightly over 6 mm from the margin. These spicules are now preserved as limonite-stained smooth surfaces on the dolomite matrix, in the main, but a few still have obloid-sectioned spicules of limonite preserved.

The longer set of spicules ranges up to a maximum observed length of 11 mm, and appears as relatively smooth impressions with diameters of up to 0.16 mm, but most are of 0.10 to 0.08 mm diameter. They are diactinal, with maximum diameters approximately mid-length, if the longer spicules originate near the sponge margin and shorter ones near the left margin of the central rib, as they seem to do. Most appear as gently tapering oxeas, but the tips are not preserved. One can follow individual spicules to where the impression suggests a diameter of approximately 0.02 mm, but beyond that the impression is too vague to be certain.

More completely outlined spicules along the margin have their maximum diameter 2.0 to 4.5 mm distance from the sponge wall, and taper both toward and away from the sponge body. In one instance a diameter of 0.06 mm was maintained up to 11 mm from the sponge wall, but in most spicules the diameters range from 0.06 to 0.08 mm at their broken tips, 5 or 6 mm from the sponge wall. These same spicules taper toward the sponge and have diameters of approximately 0.05 mm where detail is lost at the sponge margin.

Shorter-appearing spicules along the margin can be traced across the surface of the sponge to the near flank of the medial rib. In general, those spicules with diameters approaching 0.08 mm at the margin of the body are the ones which are traceable to their origin at the base or flank of the medial rib. There is no similar felt of spicules arising from the base of the next rib at its inner margin, but some do show near the edge of the body in the upper part which may have their origin on the lower part of the impression, below the lateral rib.

Those prostalia around the upper margin and upper right of the holotype (Pl. III, fig. 3) are less well preserved than those along the left margin, but seem of the same general pattern and size. They are inclined upward, away from the flattened sponge surface and are preserved only in their proximal portions. Lower along the right margin, the impression is below that where the prostalia are preserved, and hence free of marginal spicules. Only the upper right part of the sponge is high enough that impressions of even proximal parts of prostalia are preserved.

Prostalia, where preserved, are inclined outward and upward along the sides of the sponge, but have a radiating pattern at the upper end of the specimen. Near the base, prostalia are inclined 75 to 77 degrees away from the sponge margin, but are only inclined 65 degrees at mid-height, and approximately 45 degrees near the upper end of the specimen, on both sides of the impression.

Impressions of at least twelve spicules are clustered below the base of the specimen. These converge toward an irregular limonitic-stained area which is apparently attached to the lower right of the specimen. These twelve spicules are interpreted as basalia and form a root tuft. They are elongate oxeas with a maximum diameter of 0.08 to 0.10 mm and appear identical to prostalia of the main sponge body, except that they converge toward a point outside the sponge body. They are not in contact with the main impression, but there seems little probability that they are not an integral part of the sponge.

Body spicules are not preserved in the limonitic-stained surface, but if thickness of the limonite-stained film is any indication, the sponge was very thin-walled.

An osculum may be present in the upper part of the specimen. One can interpret the ribbed part of the impression as separated from the more densely-stained part of the rounded crest by a lenticular mass of matrix, possibly representing filling and flattening of the spongocoel. There is a suggestion that the radiating prostalia may be marginalia around an osculum for they continue into the upper part of the sponge, as though ringing an osculum. Evidence of a double layered specimen and of the presence of an osculum and spongocoel is not conclusive, however.

Discussion. When originally described by Whiteaves (1897, pp. 147-148) the specimen was interpreted as a more horizontal sponge, with the pronounced fringe of prostalia marking the upper surface, and the now apparently spicule-free margin marking the base. If the prostalia occur in rows, as their distribution at the base of the medial rib suggests, it is possible to visualize their apparent absence along one margin, particularly since they are present at both sides toward one end of the impression, with the spicule-free portion depressed below the spiculed portion. It seems more probable that the impression is of an erect sponge, armoured with prostalia arranged in rows along the body of the sponge, but forming a radiating tuft at the upper end, and with a well defined basal tuft. Because of ribbing and prostalia distribution the form may have appeared more quadrangular than cylindrical in transverse outline, but this is now impossible to conclusively show since the specimen is flattened (Fig. 2).

Whiteaves included this species in the genus Trichospongia, presumably because of its low profile and abundant prostalia, but there is some question about this placement if the specimen represents an erect form. Billings (1865, p. 357) proposed the genus Trichospongia for rudely

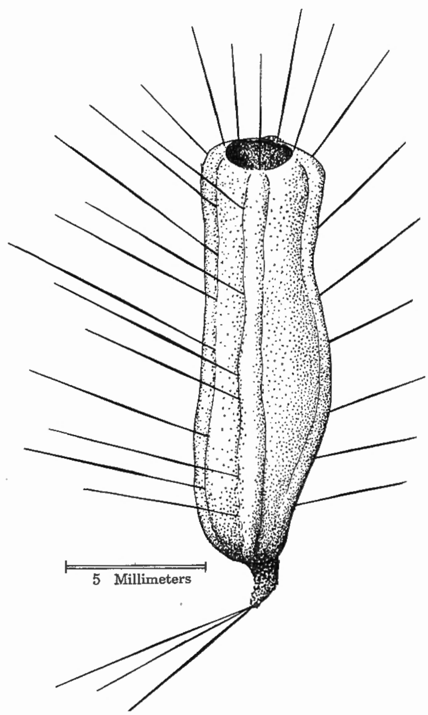


Figure 2. A possible restoration of Trichospongiella hystrix (Whiteaves). Only a few of the abundant prostalia are shown. The sponge may have been more cylindrical and have had a more rounded upper margin than shown. The holotype and only known specimen is flattened and shows only two ribs and adjacent side areas, along with abundant marginal spicules.

hemispherical masses full of cylindrical spicules and with numerous branching canals. The type species, T. sericea Billings, is apparently a thick-walled form markedly unlike the present specimen. Because of the difference in shape, growth pattern and position, and wall thickness the present specimen is placed in the new genus, Trichospongiella. There are few erect spinose Paleozoic sponges with which the present species might be confused. Pirania muricata Walcott (1920, pp. 298-300, Pl. 79, figs. 1, a-c) is a spinose Cambrian form, but it is uniformly and irregularly covered with prostalia which are chiefly tylostyles. Prostalia of Trichospongiella are mainly oxeas and are uniformly distributed in rows, as presently interpreted.

Type. Holotype, GSC No. 6864; Cat Head Member, Cat Head western shore of Lake Winnipeg; collected by D. B. Dowling and L. M. Lambe, 1890.

Order LITHISTIDA Schmidt, 1870

Suborder TETRACLADINA Zittel, 1878

Family ANTHASPIDELLIDAE Miller, 1889

Genus HUDSONOSPONGIA Raymond and Okulitch, 1940

Hudsonospongia irregularis Raymond and Okulitch

Plate I, figures 1, 3-5

Hudsonospongia irregularis Raymond and Okulitch, 1940, p. 207, Pl. 4, figs. 6, 7.

Description. Two specimens are in the collection, both preserved as light grey chert nodules in light yellow-grey, fine-grained dolomite. The larger specimen has been etched free of matrix, but the smaller, and more fragmentary specimen, is still embedded.

The larger specimen (GSC No. 25404) is low, gently expanding and conical, the lower part has been weathered away, with a maximum diameter of 10.2 cm, and a thickness of 3.2 cm. It would be at least an additional centimetre thick if complete, judging from the canal system and curve of the basal part of the fragment.

The upper surface is nearly flat, but with several large depressions within it, some of which are probably the result of irregular growth. One large depression in the centre is immediately above the radiating canals visible in the broken base. Outlines of canals rim one margin, and a mound surmounted by two canal openings occurs in the bottom of the depression. The large depression may have been a central spongocoel region for the sponge.

Many isolated ostia are present on the upper surface of the sponge and are openings for the radiating apochetes obvious throughout the specimen. Ostia range from 1.0 to 1.5 mm in diameter and are separated by nearly the same distance with spicular material. Individual openings are circular and expressed as weak depressions in the sponge surface.

Canals are closely crowded in the basal central part of the sponge where they comprise nearly half the volume, but are more widely spaced toward the exterior. Apochetes in the basal region are from 1.0 to 1.2 mm in diameter where they first radiate from the base. They range from 0.80 to 1.50 mm in the outer part of the sponge, but average 1.1 mm in diameter. Individual canals are nearly circular and show little variation throughout their visible length. There is little evidence of intertwining, even though most of the canals are not straight. The entire system is one of gradual upward radiation and expansion, but the canals themselves are irregularly placed throughout the sponge, except at the base where they are side by side.

Spicules are dendroclones, typical of the family. They are relatively smooth except at the complex ray tips which intermesh with tips of adjacent spicules. In a few areas on the large specimen spicules have been weathered into relief.

Rhabs range from 0.30 to 0.40 mm long and form the well defined rungs in the ladder-like spicule structure. They are from 0.04 to 0.06 mm in diameter, but average approximately 0.05 mm. Some rays appear thickened by secondary silica and are much thicker.

Clads of the spicules are much shorter than the rhabs and range from 0.02 to 0.10 mm in length, but are of about the same diameter. They split from the rhab at 60 to 70 degrees. Ray tips are not clearly preserved where they intertwine to form the complex columns that are the most prominent part of the spicule net. These compound columns average 0.15 mm thick, but may range to twice that thickness. As many as eight rows of spicules converge on a single column, like spokes of a wheel, but most columns are formed of five or six rows of spicules.

Spacing of spicules in a single vertical row varies from 0.01 to 0.08 mm. There seems little pattern or regularity, except when two are closely spaced, the third is usually spaced a greater than average distance.

Skeletal pores are usually triangular, but may be quadrangular or pentagonal in some instances. These openings between vertical rows of spicules range up to 0.45 mm across, and follow the course of the complex rods.

A smaller, unfigured specimen (GSC No. 25405) of the species is preserved in a chert nodule and could not be etched free. It is 62 mm in diameter and 30 mm high on the fractured surface of the nodule, where it forms a gently expanding cone, nearly flat across the upper surface and tapered toward a rounded base. It extends into the block a maximum of 21 mm in a transverse section 25 mm above the base. Less than half the original sponge is preserved.

Canals in the smaller specimen are similar to those of the larger one and form a gently radiating ascending system; a few bifurcate. They range from 0.7 to 1.3 mm in diameter near the top of the specimen, but average 1.0 to 1.1 mm as seen in the following table. Diameters were measured across the shortest diameter of the ellipses where the canals are cut diagonal to their main trend.

TABLE I

Canal Diameter at the Upper Surface of the Sponge

Diameter (Millimetres)	Number of Observations
1.4	0
1.3	4
1.2	5
1.1	11
1.0	11
0.9	4
0.8	0
0.7	4
0.6	0

In vertical section the canals rise nearly vertically and gently fan out toward the top of the sponge. They do not branch in the visible section, but do branch in a transverse section cut near the top, particularly near the sponge margin. There are approximately ten ostia per square centimetre at the upper surface.

There is no readily apparent evidence of cross connecting canals, but there may be some of small size where gaps in spicules occur.

Spicules are typical of the Anthaspidellidae, but are not well preserved in spite of the fine-grained silicification. Thin sections do not show appreciably better detail than weathered surfaces. Ladder-like spicule patterns result from the merging of the essentially horizontal dendroclones at their tips. Rhabs are from 0.10 to 0.15 mm long and terminal arborescents are from one-half to two-thirds as long, although indistinct and difficult to isolate in thin sections. Cladomes unite to form the vertical complex columns which form the large elements of the ladder-like structure. These columns are usually spaced four or five per millimetre in vertical sections, and range up to 0.10 mm in diameter. Rhabs radiate from the complex rods like spokes of a wheel, usually five or six in a cycle. There are approximately twenty spicules per millimetre in a typical vertical series as "rungs" in the structure.

Skeletal pores are usually triangular but may be quadrangular or pentagonal. Openings range up to 0.15 mm across and are vertical, parallel the complex rods.

Discussion. Both specimens have the canal system and spicule pattern typical of the genus, a form intermediate between Zittelella and Streptosolen. They lack the meandering canal pattern of the latter and the regularity of the former. The present specimens lack the clustered canal system of Anthaspidella.

Although the spicule arrangement is somewhat similar to Aulocopella and Aulocopium, the regular canal system of the two latter genera is wanting in the present specimens.

Assignment of the specimens to H. irregularis Raymond and Okulitch is done with some reservation for the spongocoel depression of the types is not evident in the Cat Head material. The canal system, size, and broad shape are similar to the types, however, and suggest a relationship here.

Types. Hypotypes, GSC Nos. 25404, 25405; Cat Head Member, between McBeth Point and Cat Head, and between Cat Head and Lynx Point, Lake Winnipeg; collected by G. W. Sinclair, 1959.

Genus AULOCOPELLA Rauff, 1895

Rauff (1895, p. 268) originally designated Aulocopella as a subgenus of Aulocopium, differentiating it on the basis of the position of the point from which the skeletal structure radiates. In Aulocopella the point of radiation is within the sponge body rather than at the base of the sponge as it is in Aulocopium.

Rauff (1895, pp. 268-271) included the previously described species Aulocopium cepa Roemer (1861, p. 7, Pl. 2, figs. 2a, b) and the new species Aulocopium (Aulocopella) winnipegensis in the subgenus. Bassler (1915, p. 96) recognized Aulocopella as a separate genus and lists A. winnipegensis as the type species, as does De Laubenfels (1955, p. E53). However, since Aulocopella cepa (Roemer) was first described and then included, it should be considered as the type species of the genus.

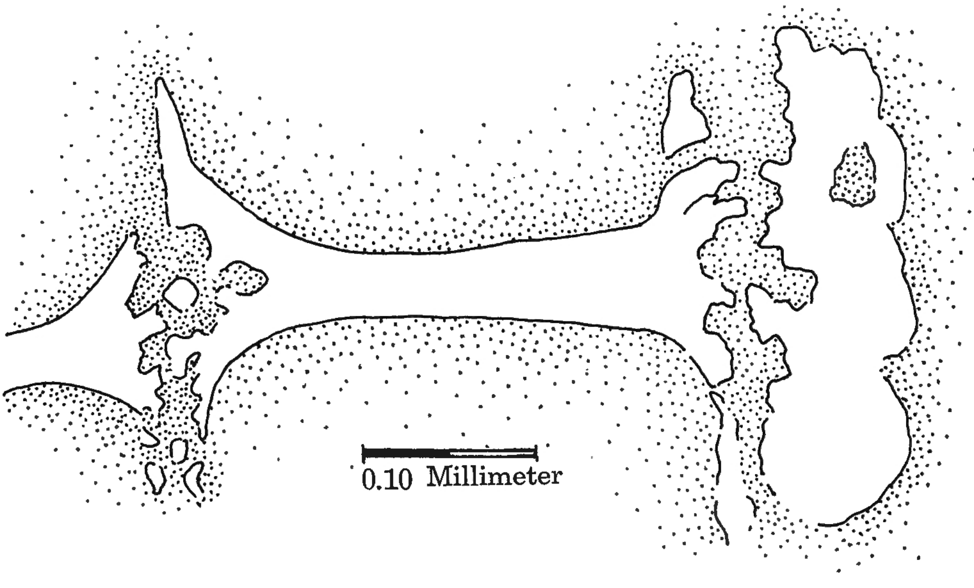


Figure 3. Sketch of a single spicule of Aulocopella winnipegensis Rauff as seen outlined by matrix along the margin of one of the radiating fins. Stippled areas are matrix, clear areas are skeletal material. The gently tapered smooth shaft divides into two clads at the left, both of which develop characteristic complex terminations which interlock with adjacent spicules to form complex vertical rods. These complex rods at either end of the spicule are formed by union of three or more rows of spicules and are the dominant and most easily preserved part of the skeletal structure.

Aulocopella Winnipegensis Rauff

Plate IV, figures 1, 2; Plate V, figures 1, 2, 4; Figures 3, 4

Aulocopium (Aulocopella) winnipegensis Rauff, 1895, pp. 269-271, text-fig. 124, Pl. 24, figs. 4-6.

Aulacopella winnipegensis, Whiteaves, 1897, pp. 145-146, text-fig. 9, Pl. 16, figs. 1-3; Bolton, 1960, p. 8.

Aulocopella winnipegensis, Bassler, 1915, p. 96; De Laubenfels, 1955, p. E53.

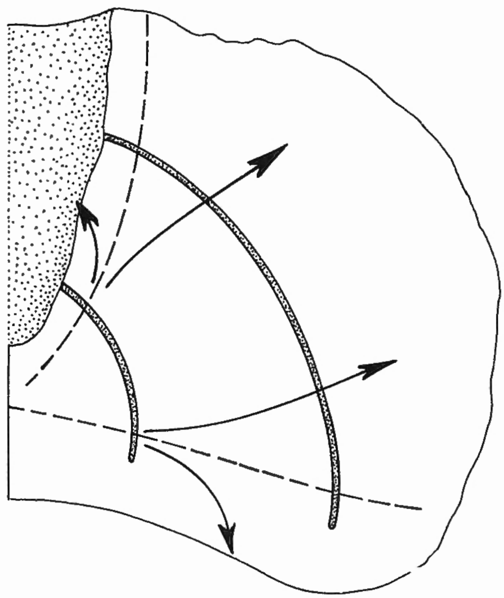


Figure 4. A vertical cross-section in a median plane through the spongocoel and one of the radiating fins or digitations of Aulocopella winnipegensis Rauff. The large stippled area in the upper left is the spongocoel, and the two arcuate densely stippled areas represent two of many similarly oriented excurrent canals which are concentrated in the medial plane of the fin. Arrows show the orientation and divergence of the complex rods of the skeletal net away from two surfaces. One of these is conical and surrounds the spongocoel, and the other is a line a short distance above the base of the blade. Both are shown as dashed lines. The complex rods of the spicule structure maintain a position approximately normal to the sponge surface, except at the spongocoel margin and at the base of the fins where the rods meet the surface at a high angle. Approximately natural size.

Description. The holotype and an unfigured fragmentary specimen are in the collections. The following description is of the holotype, which occurs as a chalcedonic replacement within a chert nodule.

The specimen, as presently preserved, consists of five radially arranged fins or digitations, of a probable eight when complete, branching from a central moderately thick-walled spongocoel area. It has been sectioned in a horizontal plane to show internal structure and one vertical section has been polished as well. Assuming a moderately thin slice was taken, the sponge originally was approximately 69 mm high with a radius from the centre of the spongocoel to the tip of the most complete ray or fin of 65 to 66 mm. It is obloid in vertical section, with a slightly invaginated base but uniformly rounded profile of the fins or digitations.

Individual digitations or fins are up to 52 mm long from the margin of the central wall and somewhat irregular in thickness. In general they thicken upward in the immediate vicinity of the central cone and thicken upward and outward in their distal portions. Proximal parts of the digitations are covered on the base of the specimen, but are exposed at mid-height where one complete and two incomplete fins are 9 to 10 mm thick. Mid-height thickness increases irregularly distally to a maximum of approximately 19 mm at three-quarters distance, beyond there it thins slightly and then thickens at the distal margin to 18.5 mm. Two of the fins show an abrupt thinning at the margin to form a bullet-shaped outline when seen in horizontal section and are completely enclosed in matrix, presumably preserving the growth form.

Fins are thick at their upper margins throughout their length. The single complete one has a thickness of approximately 18 mm throughout its length. Thickness of other fins cannot be determined, but appear of the same magnitude.

A simple spongocoel is centrally located and surrounded by a conical wall from which the fins radiate. The spongocoel wall is 6 to 8 mm thick near the base, thickening to 10 or 11 mm near the top of the specimen at the oscular rim. Base of the sponge is thicker than the walls, with a thickness of at least 21 mm immediately below the spongocoel. As seen in vertical section the central region is invaginated 5 or 6 mm from the lowermost points on the radiating fins.

The centrally located spongocoel is distinctly conical, 44 to 45 mm deep, with straight sides but a rounded hemispherical base. It is approximately 15 mm in diameter at the base, but gradually expands to 21 mm at mid-height, and to 34 mm at the oscular margin. Coarse organic debris fills the lower part of the spongocoel and fine-grained silicified sediment the upper part. There is no conclusive evidence, however, that any of the organisms now preserved in the spongocoel lived there during the life of the sponge.

Canal openings into the spongocoel are arranged in vertical series which are spaced five or six per centimetre near the base and four or five per centimetre around the periphery at the top of the spongocoel. They are spaced three or four per centimetre within a single vertical series.

Most prominent canals are the strongly arched ones visible in vertical sections through the medial part of the radiating fins. The canals are arranged in a concentric pattern, originating near the base of the fin, then arching upward through the fin to meet the spongocoel surface at right angles. Outer canals are longest, as much as 9 or 10 cm from their origin in the lower 10 to 15 mm of the fins to their terminus at the spongocoel. They range in diameter from 1.4 to 1.75 mm, with most approximately 1.50 mm, and are uniformly cylindrical as presently preserved, although some are partially filled with drussy quartz or chalcedony. Inner lowermost and shortest canals are of the same diameter as outer longer ones. These large canals are concentrated in the medial part of the fin and have formed a plane of weakness along which the blades have parted. As measured across their trend, parallel to the axial rods of the skeletal structure, these large canals are spaced six in 2 cm in the medial plane of one of the blades.

Intermediate-size canals occur outside the medial area of the radiating fins and converge upward and inward toward the larger medial ones. Intermediate canals range from 0.85 to 1.30 mm in diameter, but most are 1.20 to 1.25 mm in diameter. They are relatively uniform throughout their short course, and are spaced four to five per centimetre normal to their trend as measured in a vertical line close to the spongocoel wall.

Smallest canals occur along the margin of the radiating fins and most are oriented nearly normal to the medial excurrent system. These small canals range from 0.45 to 0.80 mm in diameter, but most are from 0.65 to 0.75 mm across. These canals follow the skeletal pores but are larger than these openings and are nearly normal to the sponge surface. They arch inward and downward to meet the intermediate-size canals within a few millimetres of the surface. A few small canals were observed in the interior of the blade as well, but most are concentrated in the outer part of the radiating structures. Where most evident along the margin of one of the blades, they are inclined gently downward and proximally and join intermediate canals which rise proximally to join the large medial canals. Where measured parallel to the surface of one of the blades, near its base, the small canals are spaced siz to eight per centimetre in a vertical line.

The small canals are interpreted as incurrent ones, connecting through the intermediate canals to the large medial ones which are interpreted as excurrent. Perhaps the shorter intermediate canals represent elongate flagellate chambers.

Skeletal pores are arcuate, generally normal to the major canal pattern, and parallel the major ladder-and-rung elements of the skeleton. They are relatively uniformly spaced and sized throughout the sponge. They are spaced twenty-eight to thirty-two per centimetre in horizontal sections at the upper margin of the blades. In the interior of the wall of the central cone they are spaced thirty to thirty-two per centimetre and along the lateral margin of the blades they range from thirty-two to thirty-six per centimetre as measured in a horizontal line. Openings are obscured by coarse chalcedonic preservation, original shapes of pores have been modified as skeletal elements were enlarged and rounded during fossilization. In general, however, they appear triangular and range from 0.20 to 0.24 mm across.

The skeletal net is typical of the family, but not well preserved in detail because of the coarse silicification. Individual spicules are poorly preserved within the body of the sponge, but a few can be isolated along the margin where they were nearly surrounded with fine matrix (Fig. 3). Individual spicules have shafts up to 0.21 mm long which bifurcate into clads of 0.025 to 0.035 mm, which in turn branch into complex ray tips that merge with adjacent ray tips to form the major complex rods. The rods are irregularly shaped like rough-barked twigs and range up to 0.22 mm in diameter, but are frequently traceable through much of the height of a blade where seen in vertical medial section, even though individual spicules have been destroyed. Where best preserved, individual spicules are spaced five or six per millimetre in a single vertical series.

Position of the complex rods outlines the general pattern of the skeleton, even though details are obscure. The skeleton radiates from a point 4 or 5 mm below the base of the spongocoel, with rods arranged in pinnate fashion within each of the radiating blades and the spongocoel wall. In a vertical section through the spongocoel wall and the medial part of a radiating blade, there are two surfaces from which the skeletal rods diverge (Fig. 4). One of these is essentially conical and surrounds the spongocoel, 4 to 5 mm away from the spongocoel surface, or approximately in the middle of the wall. From this surface, rods gently arch upward and away from the midline so to meet the exterior and spongocoel margin at high angles. The other surface is more a nearly horizontal line 10 to 15 mm above the base of the radiating blade. From this line, complex rods curve downward to meet the base of the sponge at right angles, and above the line, they curve upward, maintaining a position normal to the major canal systems and to the outer surface.

Skeletal rods are also pinnately arranged as seen in either a horizontal or vertical transverse section of the radiating blades. The rods arch outward and upward from a medial plane through the blade maintaining a position approximately normal to the sponge surface.

Rods were not seen to branch, but are inserted to keep spicule length relatively constant. Rod spacing is moderately uniform, whether in the pinnate axes or near the sponge surface.

Each of the inserted matrix wedges between the radiating digitations is rounded at the apex but with straight sides. Each of the wedges are 4 to 5 mm across at their apices and expand to 33 to 45 mm wide at mid-height, at their outer preserved edges. Fine sediment of the wedge is concretionarily banded parallel the outer surface and is now a light yellowish grey-brown. Few fossils are preserved in the matrix, but isolated fragments of poorly preserved bryozoans and ostracodes occur in some wedges. In local areas matrix has filtered into openings within the sponge and outlined the skeletal elements, but elsewhere the sponge is veneered with a thin chalcedonic layer, sharply isolating the specimen from matrix as now preserved.

Matrix covers the base of the sponge and there is no evidence of attachment spicules.

Types. Holotype, GSC No. 6863, Cat Head Member, Cat Head, Lake Winnipeg; collected by D. B. Dowling and L. M. Lambe, 1890; hypotype, same locality, GSC No. 25406; collected by G. W. Sinclair, 1959.

Genus PATELLISPONGIA Bassler, 1927

Patellispongia sp.

Plate VI, figures 5, 6

Description. A single fragment of a rapidly expanding cone is preserved as a silicified specimen in a chert nodule. The fragment is roughly triangular, with a rounded lower portion in what was near the base of the conical sponge, and an upper broader part of the fragment including some of the original rounded margin of the cone. The sponge fragment is approximately 53 mm high, with a maximum width of 43 mm near the preserved sponge margin. It is a relatively thin-walled specimen, with thickest walls near the base where it is 10.0 to 11.0 mm thick, thinning upward gradually so that at mid-height it is 5 mm thick, and at the upper rounded to bullet-shaped margin it is slightly over 3 mm thick. The lower, or outer, part of the wall converges in a gentle curve to meet the more nearly straight inner or upper margin of the wall.

Most prominent canals are those oriented normal to the upper and lower surfaces of the sponge, and range from 0.60 to 0.80 mm in diameter. They are spaced in rows which radiate from the base of the conical specimen, and occur 5.6 to 6.8 mm apart within rows. Rows of canals are spaced 7.8 to 8.4 rows per centimetre where seen on the upper surface. Individual canals are circular but have elliptical outlines when seen on the upper surface because they swing from a trend normal to the surface in the interior of the sponge to a slightly oblique attitude at both the upper and lower surfaces. Openings on the surface are nearly twice as long as wide as a result of this relationship. There is no grouping into complex patterns as in Anthaspidella.

The spicule pattern is typical of the family, but not well preserved because of the chalcedonic replacement of the net. The major complex rods of the ladder-and-rung pattern are evident, however, and are arranged normal to the lower surface, but swing tangentially to the upper surface near the base of the conical fragment. Growth appears to have been radially, but with the individual spicules paralleling the margin of growth. Where best exposed along the margin, these complex rods are spaced sixteen to eighteen per millimetre. Individual spicules are almost impossible to isolate, but shafts of the spicules can be seen spaced approximately six per millimetre near the base of the specimen. Shapes of individual spicules have been obscured by the manner of preservation.

Discussion. Bassler (1927; 1941) differentiated several species of *Patellispongia* in collections from the Pogonip Group in central Nevada. These were based upon size and spacing of ostia on the upper surfaces of thin plate-like fragments. Such openings are not preserved on the specimen at hand, and since Bassler did little with internal structures, specific identification of the Cat Head specimen must await review of the Nevada material, although on the basis of thickness and general character the Cat Head specimen might fit into either *P. oculata* Bassler or *P. clintoni* Bassler.

Type. Figured specimen GSC No. 25407, Cat Head Member, between McBeth Point and Cat Head, Lake Winnipeg collected by G. W. Sinclair, 1957.

Genus ANTHASPIDELLA Ulrich and Everett, *in* Miller, 1889

(?) *Anthaspidella mammulata* Ulrich and Everett

Plate III, figure 1

Anthaspidella mammulata Ulrich and Everett 1890, pp. 258-259, Pl. 1, figs. 1, 1 a-d; Bassler, 1915, p. 52; DeLaubenfels, 1955, p. E64.

Description. A poorly preserved specimen of what is interpreted as a questionable *Anthaspidella mammulata* Ulrich and Everett occurs in the collection. It is now a completely recrystallized semi-circular fragment, with a long dimension of 98 mm and a short radius of 54 mm. It is a nearly flat impression, with minor irregularly spaced mounds on the upper surface, some of which have obscure radiating patterns associated with them. The broken edge of the specimen is nearly straight and shows a thickness of 8 to 12 mm, with a slightly greater thickness in an off-centre position below the main sponge mass, but this cannot be certainly related to the main part of the sponge. The unbroken margin of the specimen is rounded, with a smooth margin, marked by very weak radial lines.

The small mounds on the upper surface may represent oscular mounds but because of the poor preservation, internal structure, and canal patterns are not evident. The mounds are somewhat irregular, rounded on top, roughly circular, but with much variation in plan outline. They range from 3 to 9 mm across, and are spaced somewhat irregularly. With the broken margin of the sponge down, those on the left of the specimen and in the centre are smallest and most pronounced. Those on the right are less prominent, but slightly larger. Mounds range up to 2 mm high, but most are less than 1 mm above the general surface. They range from five to thirteen per square inch and are spaced from 6 to 15 mm apart, from crest to crest. They do not form either concentric or radial rows, but appear irregularly placed. Oscular pits or the distinctive radiating canals typical of the genus are not evident, even though on some there is a faint suggestion of a radial pattern on the sponge surface.

The outer 7 to 10 mm of the margin of the specimen is free of mounds and is separated from the remainder of the surface by a weak linear depression parallel to the margin. There are a few faint radiating lines and ridges within this smooth area which are approximately 1 mm wide and are traceable from the inner mounded area onto the smooth area, but are not well defined beyond the immediate boundary.

There is no trace of spicules, although on the broken edge, an alignment of dolomite grains parallel to the upper and lower surface of the plate-like fragment can be seen. These could be ghosts of the now removed anthaspidellid complex rods, preserved in much the fashion of spicules in the associated Brachiospongia digitata (Owen).

A foreign silicified mass occurs on the base of the sponge. It appears much like the massive sponge Eridospongia basalis Ulrich and Everett which encrusts an Anthaspidella in Trentonian rocks of Illinois. The siliceous material seems independent of the present fragment.

Discussion. The single specimen at hand cannot be certainly identified as a sponge, much less as Anthaspidella mammulata Ulrich and Everett, but the faint upper markings on some mounds and the distinctive rounded smooth margin are known to me only in the Anthaspidellidae, and the spacing of the mounds and their variation in shape and spacing seem distinctive of the above species.

Type. Hypotype, GSC No. 25408, Cat Head Member, Kinwow Bay Island, Lake Winnipeg; collected by G. W. Sinclair, 1959.

Genus EDRIOSPONGIA Ulrich and Everett in Miller, 1889

(?) Edriospongia basalis Ulrich and Everett

Plate III, figure 1; Plate V, figure 3

Edriospongia basalis Ulrich and Everett, 1890, pp. 272-273, Pl. 6, figs. 1 a-c; Bassler, 1915, p. 474; DeLaubenfels, 1955, p. E64.

Description. Two fragments, questionably identified as this species, occur as silicified encrustation on the base of the previously described specimen of (?) Anthaspidella mammulata Ulrich and Everett. One (GSC No. 25408a) occurs as a curved irregular mass, approximately 50 mm long across the curved arc, 20 mm high, and 5 or 6 mm thick, curved around the pedicle-like base of the larger sponge. A probably related impression can be traced an additional 45 mm to the broken edge of the specimen. The impression is marked by distinctive pits and a curved semi-cylindrical surface.

The second fragment consists of a ribbed specimen showing parts of four ribs and three intervening troughs. It is 29 mm long, parallel the ribbing, and 32 mm wide. The ribs are 3 or 4 mm wide with relatively steep walls but rounded crests, as preserved. They rise as much as 3 mm above the rounded troughs, and are spaced 9 to 11 mm apart.

Canals are visible in both fragments, but show better in the larger. They are oriented normal to the sponge surface and range from 0.7 to 1.0 mm in diameter. They appear to be short, nearly straight, and nearly cylindrical, although their course within the body cannot always be determined. They are frequently filled with light grey dense silica.

The specimens are replaced with coarse chalcedony which has destroyed most of the skeletal net. Enough remains, however, to be certain that the specimens belong in the Anthaspidellidae, for the ladder-and-rung pattern of the family is evident even though individual spicules are poorly preserved. Where most evident, the complex rods are spaced three or four per millimetre and are oriented parallel to the major canals.

Discussion. The growth habit of these fragments suggests their placement in Edriospongia for they are encrusting the base of another sponge and have a ribbed or pillared appearance, judging from the fragments available. There is little question that the fragments should be included in the Anthaspidellidae, largely because of the skeletal net, as poorly preserved as it is, but as to whether these are conspecific or congeneric with the Illinois form is questionable because of poor preservation.

Types. Hypotypes, GSC Nos. 25408a, b, Cat Head Member, Kinwow Bay Island, Lake Winnipeg; collected by G. W. Sinclair, 1959.

Class HEXACTINELLIDA Schmidt, 1870

Order LYSSAKIDA Zittel, 1877

Superfamily PROTOSPONGIOIDEA Finks, 1960

HYDNODICTYIDAE, Rigby new family

Type genus. Hydnodictya n. gen.

Diagnosis. Thin-walled, vasiform sponges whose skeletal net is composed of at least two intertwining systems of approximately quadrately-arranged stauract and hexact spicules. The layers or systems are arranged at an angle to one another and contain additional irregularly oriented spicules. Fasciculation of spicule rays not common. Prostalia may be present but parietal gaps are wanting.

Discussion. Irregularity of spiculation characterizes the Teganiidae and this suggests relatively close relationships between it and the Hydnodictyidae. The two can be differentiated relatively easily, however, for the Teganiidae have numerous parietal gaps, and in addition lack even the roughly quadrate skeletal arrangement seen in the Hydnodictyidae. Dictyospongiidae, Stereodictyidae, and Hyphantaeniidae all have strap-like bundles of spicules and appear quite distinct from the Hydnodictyidae. The Protospongiidae and the recently defined Mattaspongiidae (Rigby, 1970) differ in having a regularly arranged skeletal pattern.

At present, the only genus included in the family is Hydnodictya n. gen.

Genus HYDNODICTYA Rigby, n. gen.

Type species. Hydnodictya acantha n. gen. and n. sp.

Diagnosis. A hydnoceroid-shaped protosponge with relatively sharp-crested, ridge-like nodes capped by tuft of prostalia. Spiculation is irregular, although grossly of two intertwining quadrate systems of stauract and hexact spicules, one horizontal-vertical, and the other at acute angles of 45 to 60 degrees from vertical. Parietal gaps not developed. Base and osculum unknown.

Hydnodictya acantha n. gen. and n. sp.

Plate I, figure 2; Plate II, figures 2, 3; Figures 5, 6

Description. A single fragmental specimen is available, approximately 55 mm long and 99 mm high, preserved mostly as limonite-stained spicule moulds in a fine-grained, light yellow-grey dolomite. The fragment appears as part of a gently expanding conical form, somewhat like Hydnoceras tuberosum Conrad. Both the base and oscular regions have been broken away, so that only the central 10 cm of the sponge body have been preserved. The upper part is 58 mm wide, and the lower is 42 mm wide.

Two somewhat irregular rows of vertically elongate nodes are preserved, with an impression of a lower third row shown only in profile against the matrix. The upper row is the most pronounced, with nodes from 15 to 22 mm long, up to 10 mm wide, and at least 3 mm high, although the crest of each of the three visible nodes has been broken away. The nodes are from 13 to 18 mm apart.

The middle row of nodes is centred approximately 3 cm below the upper row. Four nodes are visible in the specimen and form vertical ridges 8 to 13 mm long above the generally smooth sponge surface. The nodes are up to 5 mm wide and at least 2 mm high. The tufted crest of one node is preserved in profile at the margin of the sponge. The tuft is up to 2 mm long, 4.5 mm wide, and has a triangular shaped pattern.

The third series of nodes is visible only as a single impression in the margin of the sponge. It is approximately 2.5 cm below the middle row. The specimen is broken across where the third row would project.

Spiculation is more irregular than in most genera of the Dictyospongidae or Protospongiidae but the net consists of two irregularly rectangular, interwoven systems plus additional nearly randomly directioned spicules. Smaller unoriented spicules add to the apparent confusion. One of the rectangular systems is essentially horizontal-vertical, and the other is diagonal to it by 30 or 40 degrees (Fig. 5).

Individual spicules are rarely preserved, but a few small siliceous hexactines are preserved along the flanks of the nodes (Fig. 6). Most of the spicules have been pyritized and are now shown as limonite traceries and shallow impressions on the sponge surface. Moulds of individual spicules are difficult to differentiate, but long limonite-stained lines suggest individual rays several millimetres long, with basal diameters of up to 0.1 mm.

Rays of the small siliceous hexactines range up to 0.85 mm long, but are invariably broken at the tips. They range from 0.10 to 0.15 mm in diameter at the base and are smooth, gently tapering forms. In some, the

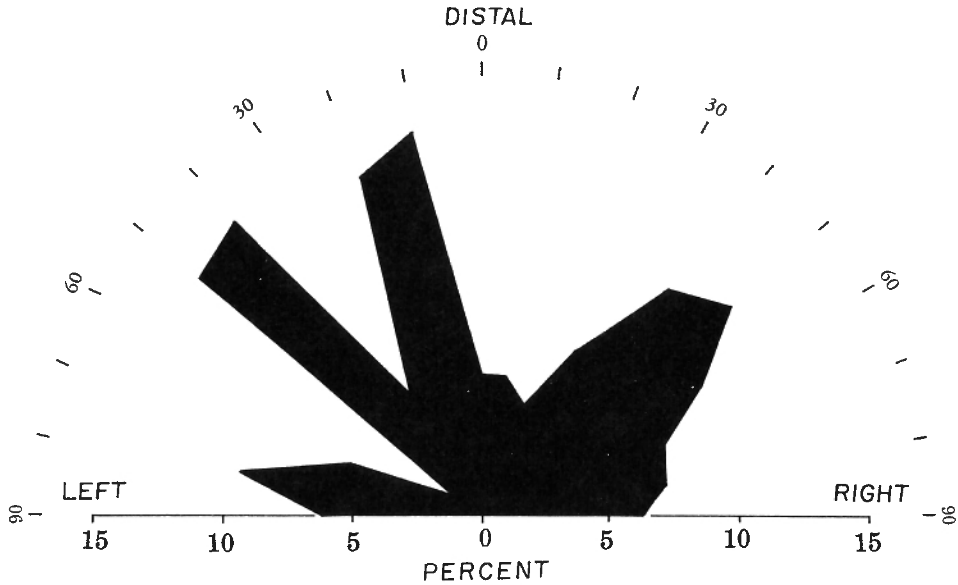


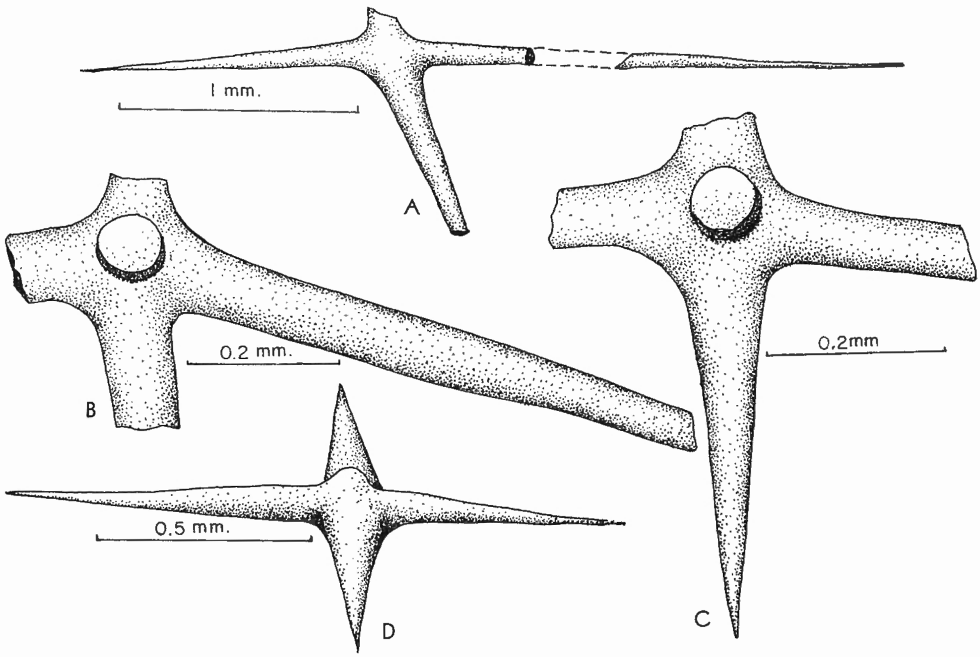
Figure 5. Spicule orientation in the middle part of Hydnodictya acantha n. sp. Orientation was measured on a projected image. The two relatively obscure rectangular grids show as peaks in the left part of the diagram. Irregularity of many minor spicules obscure the rectangular pattern apparent in particular areas of the sponge.

fifth rays are expressed as small nodes and in others as more elongate rays, consistently broken. The fifth rays are of the same diameter as the four preserved rays. Proximal rays are not seen, but have left an impression where similar-size spicules have been removed by weathering.

There is a rough ranking into quadrules, with at least three sizes of spicules. The largest are preserved as limonite-stained moulds. These spicules have individual rays over 3 mm long and range up to 0.12 mm in diameter, but average 0.06 mm in diameter at their base. This size spicule forms the major subdivision in each of the two rectangular grids. The next smaller spicules have rays from 1.3 to 1.5 mm long and 0.04 mm in diameter. These are usually subparallel to the larger spicules. The smallest preserved hexactines are locally three dimensional limonite ghosts. They have ray lengths from 0.05 to 0.06 mm long and are from 0.01 to 0.02 mm in diameter at their base.

In some areas, smaller spicules are seen to underlie the coarser forms. Over most of the preserved fragment it is impossible to determine the manner of lamination or interweaving of individual spicules.

Prostalia form a tapering tuft at the crests of nodes. One excellent tuft is preserved along the margin of the sponge. It forms a spicule mass 4.8 mm wide at the base and 4.7 mm high. Spicules seem to be monactines of 0.01 mm or less in diameter and up to at least one millimetre long. Individual spicules are difficult to isolate because of the coarse limonite preservation, but some could be as much as 2 mm long. Tips of individual spicules



A. The largest spicule identified with certainty as a single skeletal element. The central area is not well preserved and could have a vertical ray, not shown.
B. An intermediate size spicule which shows rays varying from the typical right-angle development.
C. A small spicule showing one complete ray and the rapid taper typical of small rays.
D. A relatively complete spicule in which a distal ray is aborted to a node. In most preserved spicules, the vertical or distal ray is broken.

Figure 6. Small siliceous spicules of Hydnodictya acantha n. sp.

are broken and buried within the mass. The basal part of the tuft is poorly preserved, consequently the manner of insertion of prostalia into the body net is not known.

Discussion. Irregular spiculation of Hydnodictya appears somewhat similar to Actinodictya placenta Hall (Hall and Clarke, 1898, Pl. 30, figs. 1-3; Pl. 31, figs. 1, 2) and to the upper oscular region of Cyathophycus reticulatus Walcott (1879; 1920). The present specimen, however, does not show the marked variation in primary spicule size characteristic of Actinodictya and is immediately differentiated from the latter form by the distinctive tufted nodes. Rauff (1894, Pl. 3, fig. 1) shows an enlarged view of the upper margin of Cyathophycus with a pattern very similar to the body net of Hydnodictya. Such irregularity is distinctive of only the upper 5 to 10 mm of Cyathophycus, however, and is common throughout the entire principal net in the present specimen. In addition, Cyathophycus lacks the tufted nodes and has a much more regular reticulation, commonly with fasciculation of spicules.

Hydnodictya lacks parietal gaps and has a more regularly arranged skeletal network than the conico-cylindrical lyssakid Ratcliffespongia (Rigby, 1969).

The present specimen resembles Hydnoceras tuberosum Conrad in general shape, but lacks the regular reticulation of that species. Nodes in Hydnoceras are tufted, as in Hydnodictya, and are connected by low ridges to one another. Nodes in the present specimen arise from a relatively smooth surface and are not connected by ridges.

There is no known Early or Middle Paleozoic sponge with which the present species might be confused because of its distinctive spiculation and shape.

Hall and Clarke (1898, pp. 31-32) were of the opinion that the outer hexactine spicules of some dictyosponges were gastrally underlain by larger elements. This is also probably true for the present specimen, for in a few areas large spicules overlie smaller ones. There is no evidence, however, of bundles of spicules on inner layers as in the specimens described by Hall and Clarke.

Type. Holotype GSC No. 25907, Cat Head Member, McBeth Point, Lake Winnipeg.

Family PROTOSPONGIIDAE Hinde, 1887

Genus CYATHOPHYCUS Walcott, 1879

(?) Cyathophycus reticulatus Walcott

Plate III, figures 4, 5

Cyathophycus reticulatus Walcott, 1879, p. 18, Pl. 2, figs. 16, a-d; 1881, p. 395; Hall, 1884, p. 468, Pl. 18, fig. 1; Dawson, 1888, pp. 55-58; Hinde, 1888, pp. 65-67; Rauff, 1894, p. 252, Pl. 2, fig. 1; DeLaubenfels, 1955, p. E69.

Cyathophycus reticulatum, Bassler, 1915, p. 318.

Cyathospongia reticulatus, Dawson and Hinde, 1889, p. 46.

Cyathodictya reticulata, Hall and Clarke, 1898, pp. 24, 200, Pl. 1, figs. 1-13; Ruedemann, 1925, pp. 35-36; 1925a, pp. 14-18, Pl. 4, figs. 1-3; Kilfoyle, 1954, p. 46; DeLaubenfels, 1955, p. E72.

Description. Two impressions of sponges occur on the surface of cream-coloured, finely crystalline dolomite, typical of the formation. One is a nearly complete conical, but flattened, impression, and the other is less well exposed, with the lower half buried beneath the upper more completely exposed specimen.

The better exposed impression is 40 mm high and gradually expands upward from a nearly pointed base to a maximum diameter of 22 mm approximately 10 mm below the upper rim. At the maximum diameter the profile is gently rounded, and above this the specimen narrows to a diameter of 14.5 mm at the oscular margin. The oscular margin is slightly tilted with respect to the long axis of the impression so that one side is 3 to 4 mm higher than the other. Some of this might have been distortion during burial.

Surface of the impressions are relatively smooth, lacking both ribs and nodes. There is some irregularity of the surface, but this is apparently related to flattening and the manner of preservation.

The spongocoel is filled with crystalline dolomite between the enclosing limonite-stained walls. Walls were very thin, possibly only a single spicule thick, but their spicular character is vague. The spongocoel filling, at the osculum, is lenticular with maximum thickness of 0.8 mm medially, thinning laterally to a feather-edge. Where the spongocoel filling is thick, the impression of stained dolomite is medium grey-brown, but along the margins it is dark grey-brown, probably because of superposition of the two flattened walls.

The lower sponge is approximately 10 mm wide at the osculum and expands downward so that 8 mm below the margin, the impression is 20 mm wide. The lower part of the specimen is matrix-covered, but at least part of the upper 24 mm is exposed, and suggests a taper like that in the overlying, more completely exposed specimen.

Spicule patterns are vague in both impressions, but there are areas on both where linear stains suggest a quadrate reticulation. In the lower partial specimen, a few vertical rays are spaced 1.25 to 1.5 mm apart where measured 5 to 6 mm below the osculum. In the same vicinity, horizontal rays are spaced approximately 1 mm apart. Only limonite stains remain, no spicules have been preserved, and the stains are not without question. Smaller grids are suggested in the same area, but are too vague to measure. In the upper specimen an ill defined quadrate reticulation is suggested by stains in the middle and lower part of the sponge.

Prostalia and basalia are not evident on either specimen, although the extreme tips are matrix covered.

Discussion. The sponge origin of these impressions is indicated by their outline, hollow nature, and vague reticulation of stains which suggests a spicule pattern often seen in *Cyathophycus*. The reticulation is less well defined than in *Protospongia* and related genera and lacks fasciculation such as characterizes various dictyospongid forms. The specimens at hand are included, with some question, in *Cyathophycus reticulatus* Walcott because of their similar shape, somewhat similar skeletal patterns, and a preservation somewhat like specimens of this species in the type area, although details of the skeleton are missing, making placement within this genus and species uncertain.

Generic designation of this form has had a complex history. Walcott (1879) originally defined the genus, based on material from the Utica Shale in New York, and named it *Cyathophycus*, thinking that it represented an alga. He subsequently discovered its sponge nature and published a note in 1881. Dawson concluded that it should be renamed, since the root ending suggested a plant origin, and consequently Dawson and Hinde (1889, pp. 44-47) proposed changing the name to *Cyathospongia*. This name was preoccupied, however, and Hall and Clarke (1898, p. 24) proposed *Cyathodictya* in its stead. More recently DeLaubenfels (1955, pp. E69, E72) used both names, placing *Cyathodictya* in the Dictyospongiidae and *Cyathophycus* in the Protospongiidae. He separated two forms which should have generic rank, but should have proposed a new name for the spinose Quebec species. In spite of the original misunderstanding on the nature of the organisms, Walcott's name has priority and is used here.

Type. Hypotypes, GSC Nos. 25908, a, Cat Head Member, west shore of Lake Winnipeg.

Superfamily BRACHIOSPONGIOIDEA Finks, 1960

Family BRACHIOSPONGIIDAE Beecher, 1889

Genus BRACHIOSPONGIA Marsh, 1867

Brachiospongia digitata (Owen)

Plate II, figure 1

Scyphia digitata Owen, 1858, p. 111.
Syphonia digitata, Owen, 1862, pp. 362-363, fig. 1.
Brachiospongia digitata, James, 1887, p. 248; Beecher, 1889, pp. 19-26, figs. 1-4, Pl. 1, figs. 1, 2; Pl. 2, figs. 1-7; Pl. 3, figs. 1, 2; Pl. 4, figs. 1-8. (For a more complete synonomy see Bassler, 1915, p. 131.)

Description. A single specimen, preserved as a fragmentary mould in finely crystalline dolomite, is an impression of the upper surface of the radially lobate lower part of a Brachiospongia, probably B. digitata (Owen). The impression consists of ten radiating digitations, spanning a diameter of 10 to 11 cm, in a block approximately 13 by 15 cm. The collared upper part of the sponge is probably within the block, and the lower part has been removed by erosion.

Outlines of the various digitations or arms are triangular. One of the most completely outlined is 39 mm long and 18 mm wide at the widest point, immediately distal to the point of separation of the digitations. Common walls are shared between arms for 12 to 14 mm within the central disc, but beyond this point, walls diverge at angles of 55 to 65 degrees, curving to 75 degrees near the tips of the arms, to produce the triangular impression.

Most of the digitations are initiated in the central part of the disc as ridges, but diverge at the edge of the central disc as distinct arms. There is no marked separation of digitations in the Cat Head specimen. Most specimens from Kentucky show marked separation, commonly from 5 to 10 mm between arms, at the margin of the central disc.

On some specimens of B. digitata from Kentucky, individual digitations are uparched at the margin of the central disc, like swollen knuckles, and then descend abruptly. Other specimens have digitations which descend in a more or less smooth arc, without the uparched proximal part. The present specimen suggests the latter pattern but is inconclusive because of the manner of preservation.

Surface of the Cat Head specimen is covered with small pits, now stained brownish grey, which would have represented small mounds on the surface of the original. Pits range from less than 0.1 mm to over 0.5 mm in diameter, but average approximately 0.3 mm. They are randomly distributed, although some, by the nature of packing, seem to fall in short linear series. They occupy approximately one-third of the surface and are commonly less than 1 mm apart.

Beecher (1889, p. 23) noted small mounds on the surface of better preserved specimens from Kentucky, elevations that were formed by the abrupt termination of thick-rayed pentactine spicules at the surface of the sponge. The small mounds were capped by a central node and four radial nodes, each formed by an individual ray of the large spicule. Although small mounds are preserved on the present specimen, individual small cones capping the mounds were not seen anywhere on the specimen. It is assumed that the mounds have the same origin as described by Beecher (1889) for the Kentucky specimens.

Discussion. The Cat Head specimen is similar to B. digitata (Owen) in form and size, and probably in spicule arrangement, if the small surficial mounds are evidence of large free pentactines like those described by Beecher (1889, p. 23). It differs from typical specimens in having less well separated and more triangular-shaped arms. It is similar to B. hullensis Wilson (1948) in this respect, but is different in spicule pattern if interpretation of the two species is correct.

Because of the preservation, the Cat Head specimen is questionably referred to B. digitata (owen), although there seems little doubt that it is closely related, if not conspecific.

Type. Hypotype, GSC No. 25409, Cat Head Member, between McBeth Point and Cat Head, Lake Winnipeg; collected by G. W. Sinclair, 1959.

PYRUSPONGIOIDEA Rigby, new superfamily

Diagnosis. Moderately thin-walled vasiform sponges which lack parietal gaps and which have unoriented simple hexactines and derivatives of hexactines of various sizes as body spicules and which have an outer layer of larger simple hexactines and derivatives arranged with four rays roughly parallel to the sponge surface.

Discussion. The Brachiospongioidea (Finks, 1960, pp. 115-118) differ from the Pyruspongioidea in being thick-walled, possessing large parietal gaps, and in having large dermal spicules whose rays are somewhat modified. The Pyruspongioidea lack parietal gaps that are characteristic also of the Malumispongioidea (Rigby, 1967, p. 769) and contrast with these latter sponges in having large, though simple, hexactine and pentactine spicules as dermal spicules. The Protospongioidea (Finks, 1960, pp. 101-103) are more regularly arranged, in the main, and are characterized by thin walls that lack the distinctive large armouring spicules which are present in the Pyruspongioidea and Brachiospongioidea.

Included family. At present only the Pyruspongiidae are included in the superfamily.

PYRUSPONGIIDAE Rigby, new family

Type genus. Pyruspongia Rigby, n. gen.

Diagnosis. Bowl- to vase-shaped, moderately thin-walled sponges whose walls are composed of an inner layer of irregularly arranged hexactines armoured with a dermal layer of hexactines and derivatives of hexactines.

Discussion. Only the genus Pyruspongia is currently included in the family but other Early Paleozoic forms might be expected to occur, for these sponges are almost ideally transitional between the more complex brachiospongids and the probable protosponge stem-group.

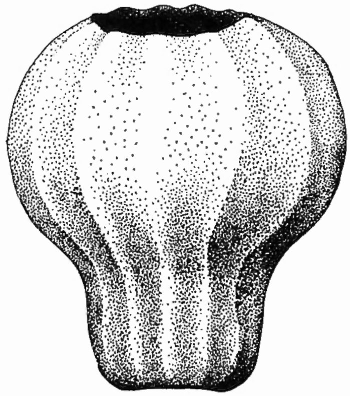


Figure 7. A restoration of Pyruspongia ruga n. sp., based upon the holotype. The upper oscular margin is not preserved on the specimen and is conjectural, but is suggested by comparison with P. camella n. sp. Approximately natural size.

Genus PYRUSPONGIA Rigby, n. gen.

Type species. Pyruspongia ruga n. gen. and n. sp.

Diagnosis. A moderately thin-walled, pear-shaped to bowl-shaped sponge with prominent vertical ribbing which persists from the smooth margin of a flat base to near the oscular margin. Hexactine body spicules arranged irregularly or with major rays approximately parallel or at right angles to the main dimension of the sponge, or at angles of approximately 45 degrees; with dermal layer of simple, stubby pentactines or hexactines.

Discussion. The relatively simple dermal pentacts and hexacts and the lack of a well-organized skeletal net are features in common with some genera of Paleozoic sponges, but the lack of parietal gaps and growth form differentiate the genus.

Pyruspongia ruga n. sp.

Plate I, figure 6; Figure 7

Description. The single specimen at hand consists of the impression of a longitudinally ribbed, pear-shaped sponge, preserved, in large part, as limonite-stained spicule impressions in a fine-grained, light yellow-grey dolomite. The impression consists of an upper ribbed circular part, outlined by six brown longitudinal ribs, and a lower cylindrical, ribbed neck. It has the overall appearance of a ribbed light globe or a short-necked Erhlenmeyr flask, 44 mm in diameter and 47 mm high (Fig. 7).

The globose part of the sponge forms an impression 44 mm wide and 30 mm high. It consists of four nearly complete, arcuate ribs and two less complete impressions. Individual ribs are approximately 1 cm apart at the maximum width of the impression and converge toward each other in the polar regions, although the actual junction is incomplete. Two shorter ribs are only half as long as the other more complete impressions. The ribs are approximately 3 mm high in the central part of the specimen, where the external surface of the sponge is preserved. They have a rounded profile which decreases in height from the equatorial maximum toward the polar regions where they are less than 1 mm high at the junction with the neck. Individual ribs appear relatively smooth in the globose part of the specimen.

The necked part of the impression is 27 mm wide and 17 mm high. It has parallel margins in the upper part, but a rounded profile in the lower half, where the width gradually decreases to 17 mm at the tip of the impression. Five vertical ribs are preserved, each 1.2 to 2.0 mm wide and 3.0 to 4.0 mm apart. They have a rounded profile with approximately 1 mm of relief, although they are flattened along the margin and asymmetrically compressed toward the centre in lateral ribs, presumably by flattening during fossilization. These ribs are continuous with those of the globose part of the sponge.

Individual spicules are preserved as limonite replacements, where intact, or as limonite-stained moulds where removed. A single siliceous spicule is preserved in the widest rib of the flobose part of the sponge. Hexactine spicules dominate, with major rays parallel to the main fabric of the sponge. Others are roughly arranged at 45 degrees to the main dimensions of the sponge. Spacing appears random, although orientation is fairly systematic.

Largest spicules are preserved in the neck part of the sponge, particularly in the immediately lowermost part and in some of the lower part of the ribs. Smaller spicules are developed in the globose part of the sponge.

Parallel, or dermal, rays of the spicules range up to 0.7 mm long and 0.07 to 0.15 mm in diameter at their base. All rays seem to taper quickly to a sharp point where the tips are preserved. Distal rays penetrate the matrix and length is difficult to determine, but most appear short where moulds are evidently complete and define the rays. In some spicules, distal rays of limonite are still intact and of unknown length, but of the same general diameter as the dermal rays. Proximal rays are unknown except for a short fragment on a single siliceous spicule. The distal rays apparently extended directly inward, roughly at right angles to the sponge surface.

There is some suggestion of slight swelling of the distal ray in some spicules. In other spicules the distal ray is not clearly developed. Details of the shape of the distal rays and of the surface of the parallel rays is not well shown for the enclosing dolomite crystals are approximately the same diameter as the spicule rays. It is impossible to be certain of either presence or absence of surface modifications of spicules such as seen in Brachiospongia digitata (Owen).

Manner of articulation of various spicules is not evident, but they are certainly not joined tip to tip, nor is there much evidence of rays lying closely parallel to one another.

Discussion. Two sponges, Oncosella and Colpospongia, are similar to at least part of the specimen. Oncosella Rauff (1894, pp. 264-267, Pl. 8, figs. 5-10) is a ribbed cylindrical form with a broad flat base. It is superficially similar to the lower part of the specimen at hand, but lacks the bulbous part, and also has spiny hexact spicules, not seen in the Cat Head specimen.

Colpospongia Lamont (1935, p. 307, fig. 1-c) from the Ordovician of Scotland, is a bowl-shaped sponge but is ribbed and appears similar to the bulbous part of the specimen at hand. It lacks the constricted neck, but is similarly ribbed. Spicules of Colpospongia are unknown, but there is a trace of quadrate reticulation.

Type. Holotype, GSC No. 25410, Cat Head Member, between McBeth Point and Cat Head, Lake Winnipeg; collected by G. W. Sinclair, 1957.

Pyruspongia camella n. sp.

Plate VI, figures 1-4; Figure 8

Description. Two fragmentary and two nearly complete side impressions of sponges represent this species. The most complete of these (holotype, GSC No. 7203a) is a somewhat flattened impression of an unbranched sponge which is a gently tapering, vertically ribbed, flat-bottomed bowl-shaped individual (Fig. 8). The other nearly complete individual (paratype, GSC No. 7203) is similarly shaped, but part of one margin is missing, and it represents a slightly smaller individual.

The large holotype (GSC No. 7203a) is flattened obliquely so the partially matrix-covered flat base can be seen grading through a rounded margin into the ribbed walls. One fragment is missing, but as presently exposed the impression is 70 mm high, with a maximum width of 61 mm one-third distance below the oscular margin, and with a minimum width of 37 mm, with perhaps 3 or 4 mm missing, at the nearly complete base. From the flattened base, the specimen gradually expands upward to approximately 55 mm at mid-height. Because of distortion in oblique flattening, the

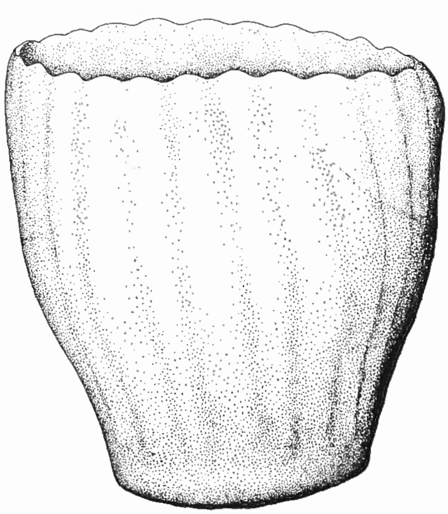


Figure 8. A restoration of Pyruspongia camella n. sp., based upon holotype and paratypes. Approximately natural size.

maximum width, which was probably near the upper margin, appears low in the body of the sponge. There may have been some constriction of the upper margin, but this would have affected only the upper few millimetres of the sponge.

There are nine vertical ribs shown in the impression, which may have represented approximately half those of the complete sponge. Those near the left margin (Pl. VI, fig. 1) are less obvious than those near the right. The ribs are best defined in the centre of the specimen and here show as smoothly rounded troughs and crests. The ribs appear at the upper limit of the rounded smooth margin of the base and range from 3.4 to 5.1 mm apart there. At 13 to 14 mm above the base, both troughs and crests have expanded slightly and are spaced from 5.2 to 6.1 mm apart, and are 0.6 to 0.7 mm high. Toward the upper margin they are more widely spaced, from 7.2 to 9.5 mm, but are less marked, so that the oscular rim is only weakly ribbed for the upper 3 to 4 mm of the wall. The central rib, which is considered typical and least distorted, widens from 4.5 mm where first evident near the rounded base, to 6.5 mm halfway up the wall, and to 8.8 mm near the upper margin where ribbing becomes vague.

Wall appears to have been thin, for where seen in cross section on the edge of one of the fragments, it ranges from 0.6 to 1.3 mm thick. Elsewhere on this specimen the wall appears as a thin film of spicules or limonite traceries, with a thickness of less than 0.5 mm as preserved.

The holotype is generally a cast of dolomite and only locally are more than isolated spicules preserved, in contrast to the other nearly complete paratype side impression (GSC No. 7203) where spicules are abundantly preserved.

The smaller paratype (GSC No. 7203) is nearly complete from a flattened base to a slightly scalloped upper oscular margin which is only partially preserved. The right margin (Pl. VI, fig. 4) is incomplete, but the left margin is well delineated against the light yellow-grey dolomite matrix by limonitic stained spicules. The impression is 63 mm high, as presently preserved, and is 34.5 mm wide across the base, but the remainder is incomplete. It gradually expands to a nearly complete maximum width of 56.5 mm, 10 to 14 mm below the upper margin.

Eight more or less complete vertical, slightly fanning ribs are preserved. These first appear here, as in the other specimen, immediately above the rounded margin of the base and are spaced 3.8 to 5.6 mm apart, except for a marginal rib which appears distorted and is 7.0 mm from the next one. Half way up the sponge wall, equally well defined ribs are spaced from 5.8 to 9.6 mm apart, and near the top, at the edge of the fragment in part, the ribs are spaced from 8.3 to 13.0 mm apart. Near the base of the specimen, ribs and troughs are nearly equally wide, but the ribs expand upward less rapidly than the intervening areas. For example, the medial rib is 2.3, 2.8, and 3.9 mm wide at the base, mid-height, and top, where an adjacent trough is 2.2, 3.1, and 5.2 mm across. Ribs rise above troughs 0.3 to 0.4 mm where first well developed near the base, but gradually rise to 0.9 to 1.0 mm above in the upper part of the sponge.

On the larger holotype isolated siliceous pentacts occur here and there on the surface, but are particularly evident around the sides and upper margin of the sponge. Elsewhere they are less common and usually indicated only by circular white siliceous knobs normal to the sponge surface. On the smaller paratype, GSC No. 7203, siliceous pentacts are preserved over the entire surface, but locally many are also limonite replacements. On neither specimen is there a readily apparent pattern to the spicule arrangement, but in both some spicules are oriented with dermal rays horizontal-vertical and at an angle of 40 to 50 degrees to the ribbing. Most spicules are at an angle to the prominent ribs.

In the holotype, individual spicules have dermal rays up to at least 2 mm long, but most rays are usually broken at shorter lengths, usually less than 1 mm from their origin. Rays are smooth and evenly tapering from a maximum diameter of 0.16 to 0.20 mm at their base to 0.08 to 0.12 mm at 1 mm distance. They are 0.03 to 0.04 mm in diameter at 1.75 mm, and only rarely are rays preserved beyond this point.

On the paratype (GSC No. 7203) dermal rays are parallel to the sponge surface and proximal rays show well as broken rays normal to the surface. Various rays range from 0.15 to 0.16 mm in diameter at their base, thinning abruptly to 0.10 to 0.12 mm away from the junction and then to 0.05 mm to 0.06 mm approximately 0.8 mm from the base. Only rare rays are preserved at greater distances, but the taper seems to continue relatively abruptly to form moderately robust pentacts. Other smaller spicules must be present but they are ill-defined because of the nature of preservation.

Both these specimens show mainly the outer surface or the outer part of the skeletal net. One of the smaller fragments (GSC No. 25411) is the filling of a spongocoel and preserves impressions of spicules near the gastral surface, along with remnants of the outer coarser net. The fragment is of the upper 34 mm of the specimen and shows six slightly divergent ribs, spaced 9.4 to 13.7 mm apart at the upper margin. This fragment shows a finer textured skeleton inside the large pentact layer for many of the limonitic spicules are less than 0.04 mm in diameter near the intersection of the rays. Unfortunately the preservation is poor, but impressions of different sizes of spicules suggest an irregular pattern and distribution, particularly for interior parts of the skeleton, except for a series of linear belts of vertical rays at the junction of ribs and troughs, suggested by limonite-stained impressions.

Vague shallow pits and low mounds are present on the same fragment and are most apparent in tangential light. They are gently rounded. from 0.5 to 1 mm in diameter, but less than 0.1 mm high or deep. They occur two or three per 5 mm measured in either a horizontal or vertical direction, but are irregularly spaced. Spicules arch over or into them so they probably represent small irregularities on the surface of the spongocoel, rather than parietal gaps or canals.

There is no evidence of prostalia or basalia in any of the specimens.

The spongocoel is filled with matrix identical to the country rock on both the larger specimens. As seen in cross section in the larger one, it is approximately 3.2 to 3.5 mm thick near the centre, but thins to a feather edge at the margin of the flattened specimen. Only the filling of the basal part of the spongocoel is preserved on the smaller nearly complete specimen.

Discussion. The present species is differentiated from Pyruspongia ruga n. sp. by lacking the globose upper development, but in many other respects it is similar. It superficially resembles Colpospongia lineata Lamont (1935, p. 307, fig. 1-c) in being bowl-shaped and vertically ribbed, but is different in lacking the pronounced vertical and horizontal spicule development that is suggested by linear impressions on the cast of the European form. Absence of spinose hexactines differentiates the present species from Oncosella catinus Rauff (1894, pp. 264-267, Pl. 8, figs. 5-10), along with development of a much thicker wall in the latter form.

Types. Holotype, GSC No. 7203a; paratypes, GSC Nos. 7203, b, 25411, Cat Head Member, Cat Head and Kinwow Bay Island, Lake Winnipeg; collected by D. B. Dowling and L. M. Lambe, 1890, and G. W. Sinclair, 1959.

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Plate I

Figures 1, 3-5. Hudsonospongia irregularis Raymond and Okulitch (Page 42).

1. Nearly vertical face through fragmentary silicified specimen. Irregularly radiating canals show as grey areas, x1. Hypotype, GSC No. 25405.

3. Upper surface of silicified specimen, after removal from matrix. Ostia show as small pits over the surface. The central depression may represent an oscular region, xl.
4. Exposed spicules, along the margins of an apochete. "Ladder-and-rung" character of anthaspidellid spicules is apparent, x10.
5. Lower surface of the sponge as originally imbedded in dolomite matrix. Radiating apochetes show in the upper right and the closely crowded central canals show near the middle of the photograph, xl. Hypotype, GSC No. 25404.

Figure 2. Hydnodictya acantha n. sp. Prostalia as preserved capping one node along the margin of the holotype, x10. GSC No. 25907 (Page 53).

Figure 6. Pyruspongia ruga n. sp. Holotype preserved as limonite mould in dolomite. The ribbed, pear-shape is distinctive, xl. GSC No. 25410 (Page 60).

PLATE I

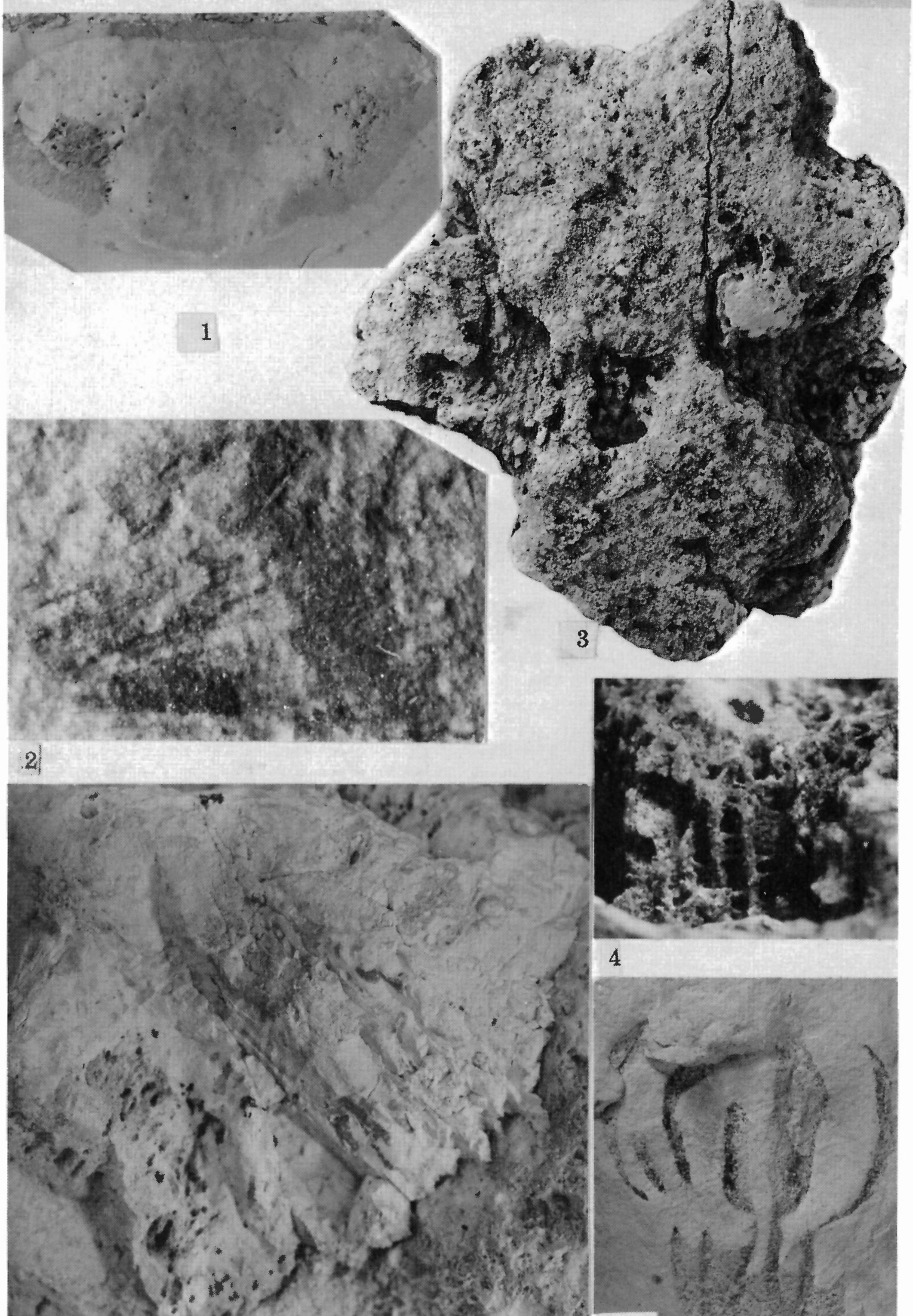
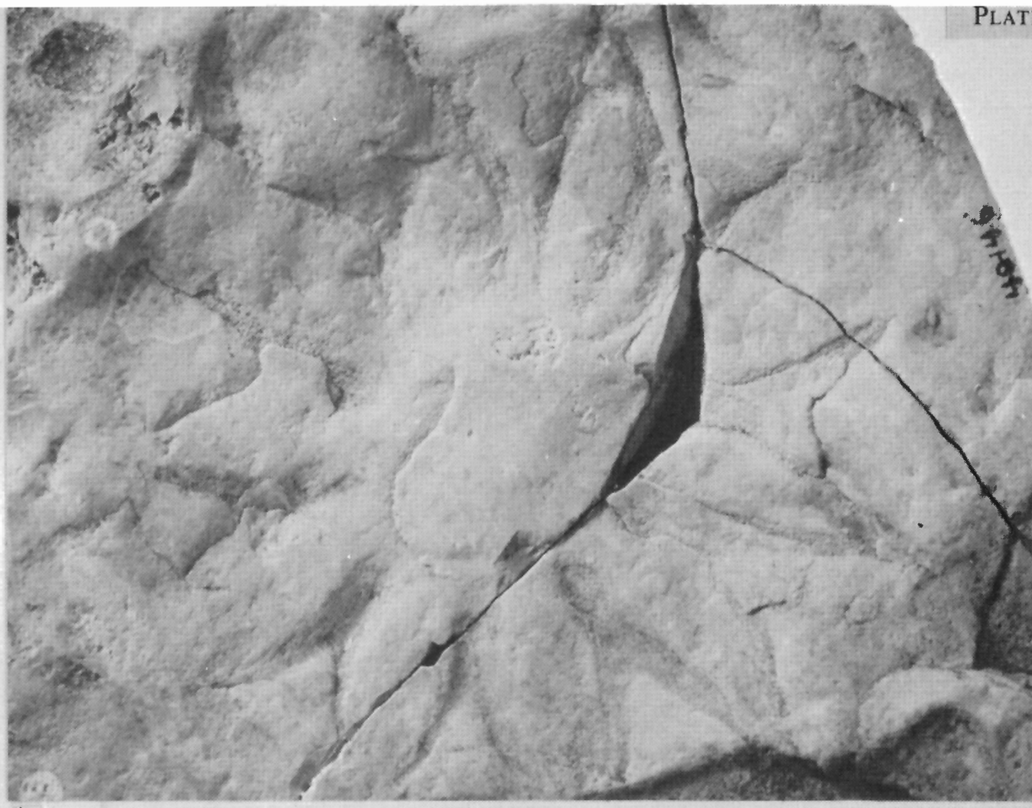


Plate II

Figure 1. Brachiospongia digitata (Owen). An external mould of the central ring and radiating digitations, x1. Hypotype, GSC No. 25409 (Page 58).

Figures 2, 3. Hydnodictya acantha n. sp. 2, Enlarged view of the sponge surface of the holotype. The rectangular net is most evident in the upper part of the photograph. The dark area in the left centre corresponds to the dark area at the base of the third node in the middle row of nodes. Small siliceous hexactines form light grey crosses to the right of the crest of the node, x5. 3, Holotype; prostalia show well along the right margin on the middle row of nodes. The grossly quadrate spicule pattern shows in the upper part of the specimen, x1. GSC No. 25907 (Page 53).



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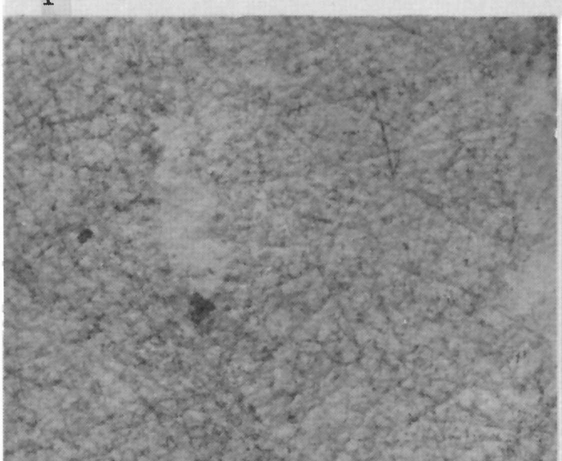

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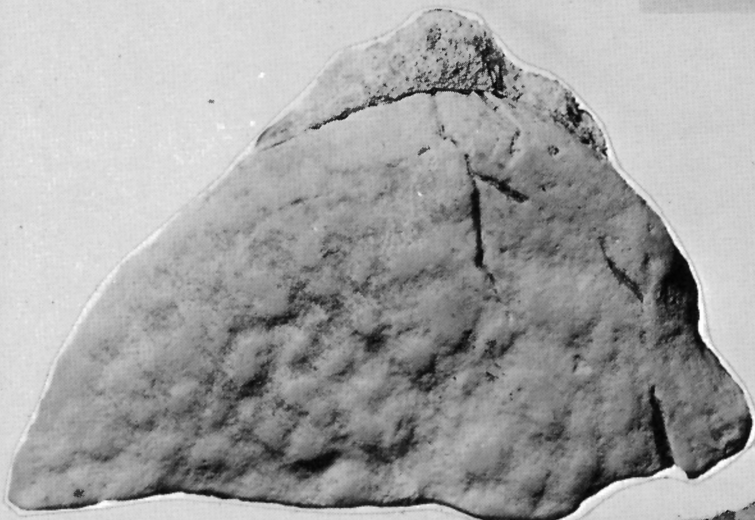
Plate III

Figure 1. (?) Anthaspidella mammulata Ulrich and Everett. The upper surface of the poorly preserved sponge showing the small oscular (?) mounds and the smooth margin of the specimen. An attached silicified fragment (Hypotype, GSC No. 25408a) of a sponge like Edriospongia basalis Ulrich and Everett shows at the top of the specimen. No spicules are present in the Anthaspidella nor are canals well defined, x1. Hypotype, GSC No. 25408 (Page 50).

Figures 2, 3. Trichospongiella hystrix (Whiteaves). 2, Part of the holotype showing prominent prostalia and their development into two series, one overlapping onto the sponge surface and the other beneath the margin. The overlapping series terminates at the near margin of the medial rib, x5. 3, The holotype preserved as a flattened limonite-stained impression with abundant prostalia. A possible basal tuft shows in the lower part of the picture, x1. GSC No. 6864 (Page 38).

Figures 4, 5. (?) Cyathophycus reticulatus Walcott. 4, Upper left part of the lower incomplete specimen shown in fig. 5 on which horizontal and vertical stains of spicule reticulation show as a vague pattern in the central part of the photograph, x5. 5, Two specimens preserved as limonite-stained impressions on finely crystalline dolomite. Spongocoel filling and osculum shown in the upper part of the more completely exposed specimen, x1. Hypotypes, GSC Nos. 25908, a (Page 56).

PLATE III



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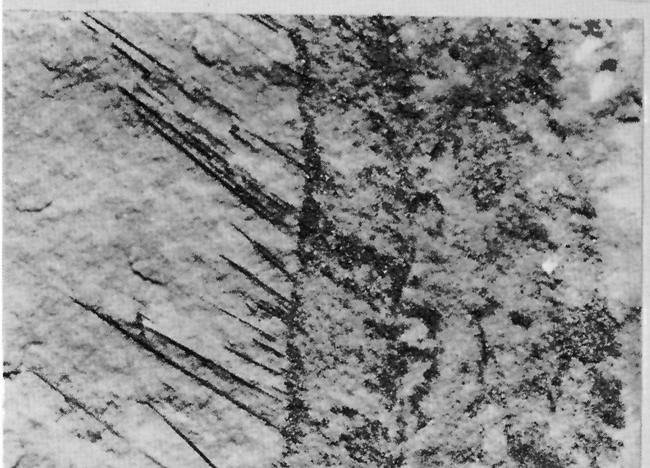

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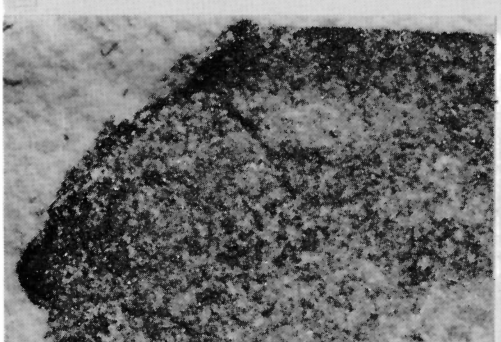

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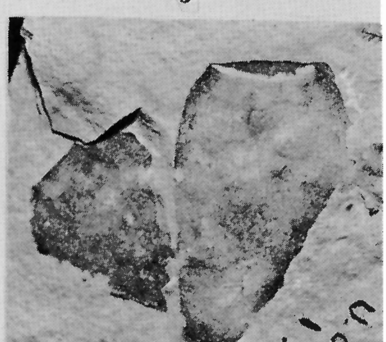

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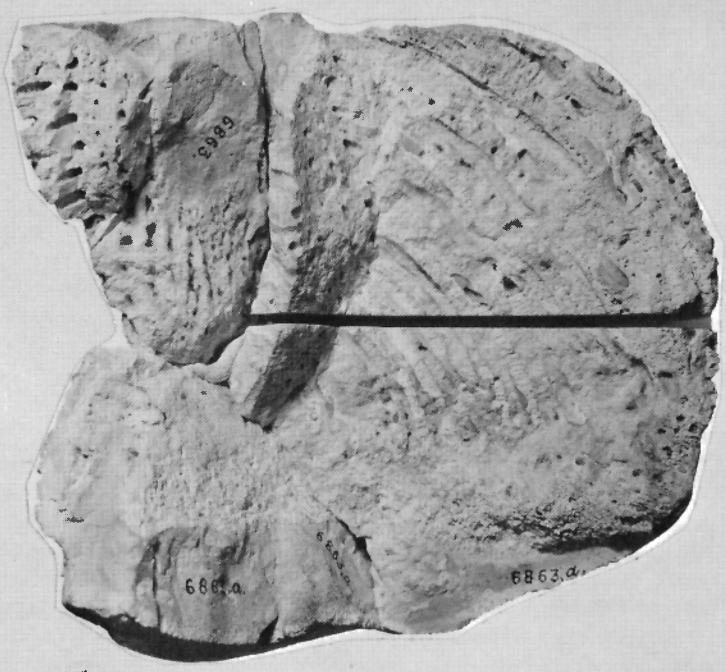
Plate IV

Figures 1, 2. Aulocopella winnipegensis Rauff. 1, A side view of the holotype showing the spongocoel margin and a vertical medial section of one of the radiating blades or fins. The pattern of arcuate excurrent canals and radiating skeletal rods is typical of the genus. Canals originate in the basal part of the blade and terminate at the spongocoel. The invaginated base is seen in profile where partially covered with matrix, xl. 2, A side view of the holotype showing a median section of the matrix-filled spongocoel and the arcuate excurrent canals in the medial plane of one of the radiation blades, xl. GSC No. 6863 (Page 45).

PLATE IV



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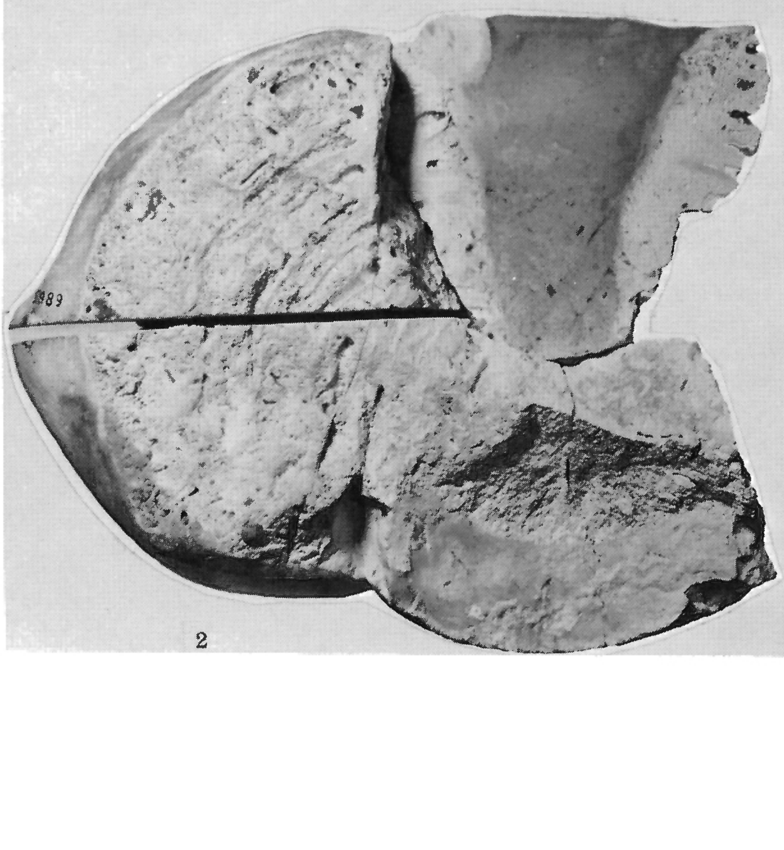

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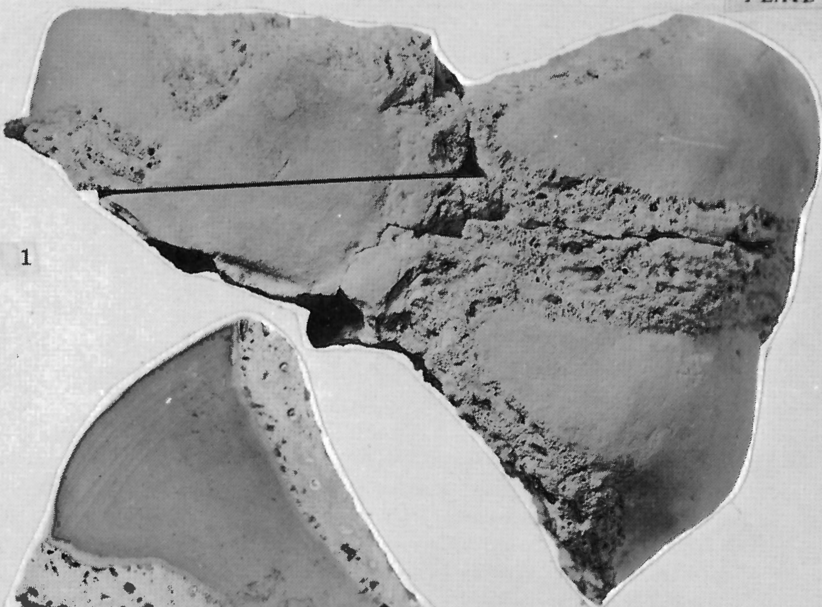
Plate V

Figures 1, 2, 4. Aulocopella winnipegensis Rauff. 1, Upper surface of the holotype showing the central matrix-filled spongocoel and at least parts of five of the presumed eight radiating fins or blades and two relatively complete matrix-filled wedges between the blades. Most prominent medial canals in the blades are upper ends of arched excurrent canals, xl. 2, Polished horizontal section through the holotype at approximately mid-height. Canal arrangements within the blades and the variation in blade thickness shows between the silicified fine-grained matrix-filled wedges, xl. 4, Sawed surface of the margin of one of the radiating blades. Relationships between small, downward inclined, incurrent canals, intermediate upward inclined canals, and the large medial excurrent canals is shown by their interconnection. Dark material at right is silicified matrix, and bordering light layer is massive chalcedony which veneers the sponge, x5. GSC No. 6863 (Page 45).

Figure 3. (?) Edriospongia basalis Ulrich and Everett. Two fragments of the species encrusting the lower part of (?) Anthaspidella mammulata Ulrich and Everett. The ribbed or pillared surface shows in the lower fragment. The rounded impression at the lower right is where a large fragment has been removed that at one time connected to the fragment at the upper left. The upper fragment is the one which shows in Plate III, fig. 1, xl. Hypotypes, GSC Nos. 25408 a, b (Page 51).



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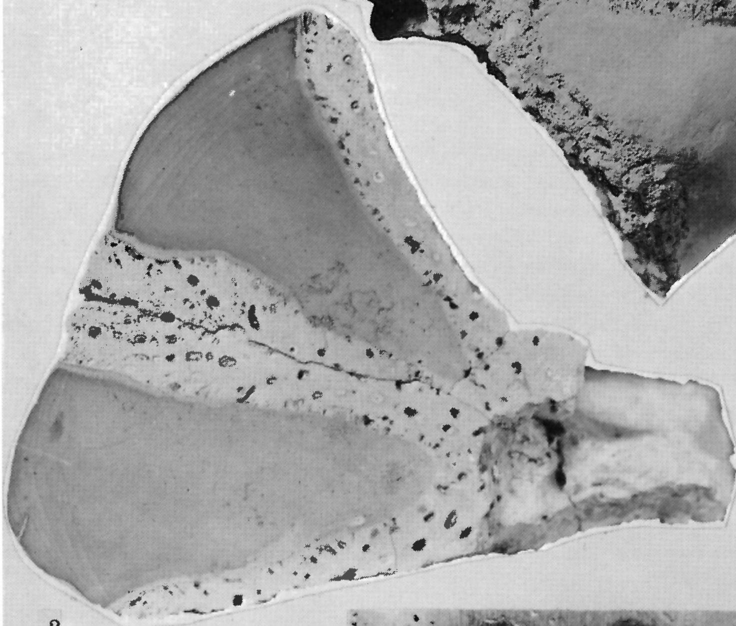

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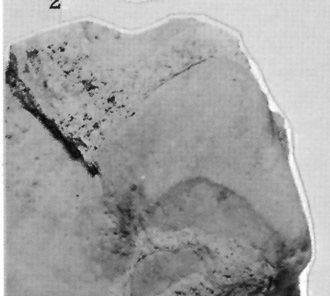

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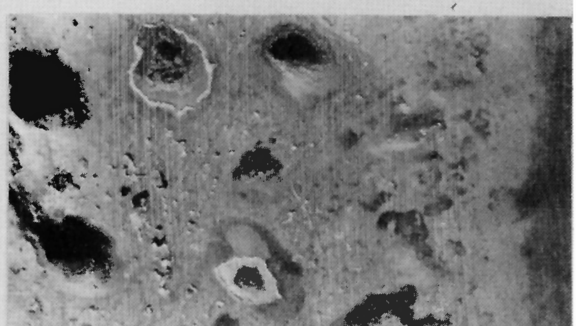

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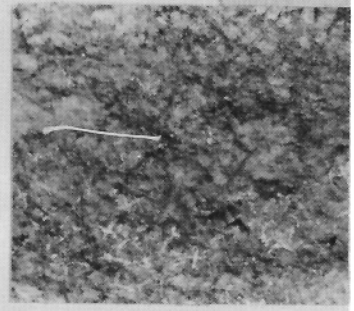
Plate VI

Figures 1-4. Pyruspongia camella n. sp. 1, Holotype, showing general form of the species. The flattened base and gently expanding bowl-like shape is evident. A weakly scalloped upper margin may be the result of moderate vertical ribbing, xl. GSC No. 7203a. 2, Details of spicule arrangement and manner of preservation on paratype. Small siliceous hexactines, or pentactines, are typical of the outer layer of the sponge and are most apparent near the bottom of the picture, x5. Paratype, GSC No. 25411. 3, Intricate pattern of limonite impressions of spicules within the sponge wall showing size of spicules and relatively poor definition of skeletal patterns, x5. Paratype, GSC No. 25411. 4, Surface of paratype, a relatively well preserved specimen, as viewed from the spongocoel surface. The flat base and ribbed character show well. Individual spicules show as minute white crosses over the entire surface of the sponge, xl. GSC No. 7203 (Page 62).

Figures 5, 6. Patellispongia sp. 5, Silicified fragment of the sponge as part of a chert nodule. The matrix appears slightly lighter grey and outlines the sponge margin, xl. 6, Details of the central upper part of the same specimen as figure 5, showing details of a radiating spicule structure and canal system characteristic of the uppermost interior of the sponge, x5. Figured specimen, GSC No. 25407 (Page 49).

PLATE VI

1



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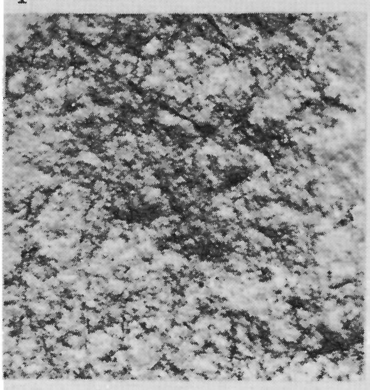

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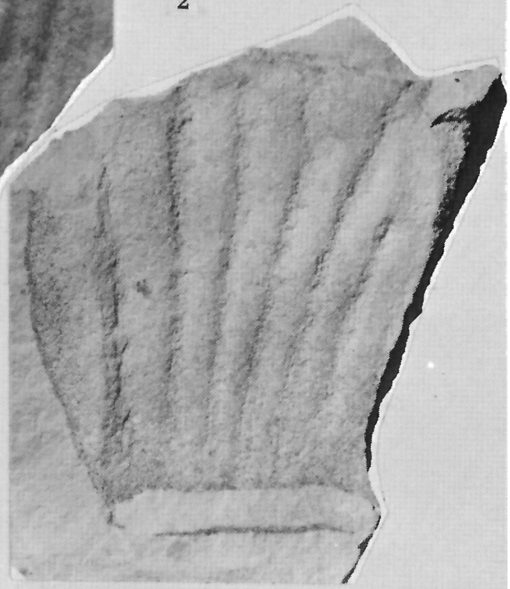

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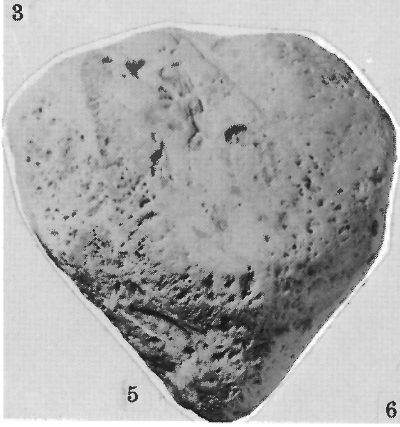

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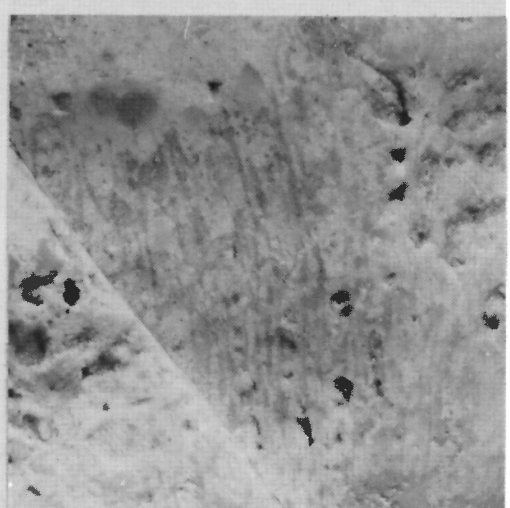

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