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# MIDDLE SILURIAN LUDLOVIAN AND WENLOCKIAN SPONGES FROM BAILLIE-HAMILTON AND CORNWALLIS ISLANDS, ARCTIC CANADA

J. Keith Rigby
Brian D.E. Chatterton

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**Authors' addresses**

*J. Keith Rigby*
*Department of Geology*
*Brigham Young University*
*Provo, Utah, U.S.A.*

*Brian D.E. Chatterton*
*Department of Geology*
*University of Alberta*
*Edmonton, Alberta*

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# PREFACE

This report describes one of the most diverse Silurian sponge faunas known in North America. The fossils are from the Cape Phillips Formation on Baillie-Hamilton and Cornwallis islands, and are part of a distinct biogeographic realm that stretches north and west of the Transcontinental Arch. The fossils were obtained from both allochthonous and autochthonous beds that represent slope or basin margin environments of the Franklinian Geosyncline.

Five new genera and nineteen new species are described and, when combined with other previously described assemblages from Somerset Island, help to define biogeographic realms and biostratigraphic zones more accurately. Detailed paleontological studies such as this lead to a better understanding of the paleoecology of faunas, and facilitate a more precise biostratigraphic zonation and correlation of strata in the frontier regions. This is essential if the full economic potential of these rocks is to be realized.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

# PRÉFACE

Le présent rapport décrit l'une des faunes d'éponges siluriennes les plus diverses qui soient connues en Amérique du Nord. Les fossiles proviennent de la formation de Cape Phillips de l'île Baillie-Hamilton et de l'île Cornwallis, et font partie d'un domaine biogéographique distinct qui s'étend au nord et à l'ouest de l'arche transcontinentale. Les fossiles ont été prélevés de couches allochtones et autochtones qui représentent les pentes ou les bordures du bassin du géosynclinal franklinien.

La combinaison des cinq nouveaux genres et dix-neuf nouvelles espèces décrits dans le présent rapport avec d'autres ensembles connus provenant de l'île Somerset, a premis la délimitation plus exacte des domaines biogéographiques et les zones biostratigraphiques. De telles études paléontologiques mènent à une meilleure connaissance de la paléoécologie des faunes, à l'établissement plus précis de la zonation biostratigraphique et de la corrélation des strates dans les régions pionnières. L'acquisition de ces connaissances s'impose si l'on veut comprendre le plein potentiel économique de ces zones rocheuses.

Elkanah A. Babcock
Sous-ministre adjoint
Commission géologique du Canada

# MIDDLE SILURIAN LUDLOVIAN AND WENLOCKIAN SPONGES FROM BAILLIE-HAMILTON AND CORNWALLIS ISLANDS, ARCTIC CANADA

## *Abstract*

The Silurian sponge fauna described here from Baillie-Hamilton and Cornwalls islands is one of the most diverse known from North America. The fossils are from Wenlockian-Ludlovian age deposits of the Cape Phillips Formation, which accumulated on the slope and in the basin of the Franklinian Geosyncline. The Cape Phillips Formation consists of interbedded shale, calcareous shale, and limestone, and most of the fossils are found in allochthonous limestone beds, mass movements having transported much of the fossil material downslope. Silurian sponges described here are representative of a distinct sponge biogeographic province that occurs north and northwest of a line along the Transcontinental Arch and contrasts with one to the southeast where sphaerocladine lithistid and heteractinid calcareous sponges are dominant.

New genera within the demosponges include the rhizomorine *Parodospongia* and the orchocladines *Antrospongia* and *Cauliculospongia*. New hexactinellid genera include *Corticulospongia* and *Lumectospongia*. New species described here include the rhizomorines *Haplistion frustrum* and *Parodospongia euhydra* and the extensive orchocladines *Antrospongia aberans, Aulocopium nana, Calycocoelia micropora, Cauliculospongia solida, Dunhillia fistulosa, D. megaporata, D. pluraliporosa, Patellispongia alternata, Perissocoelia* (?) *gelasinina, Perissocoelia* (?) *spinosa, Psarodictyum attenuatum,* and *Somersetella amplia. Astylospongiella* (?) *lutera* and *Astylospongiella striola* are the only new representatives of the Sphaerocladina. The hexactinellid Amphidiscosa are represented by *Lumectospongia uncinata* n. gen. et sp. and the Lyssacinosa by the new *Corticulospongia floccosa* n. gen. et sp. and *Dictyospongia apache* n. sp.

*Carpospongia globosa* (Eichwald, 1830) is reported here from North America for the first time. The broadly distributed *Archaeoscyphia minganensis* (Billings, 1859), *Hindia sphaeroidalis* (Duncan, 1879), and species of *Patellispongia* and *Psarodictyum* add "universal" elements to the assemblage.

## *Résumé*

La spongiofaune silurienne décrites le présent document provient des îles Baillie-Hamilton et Cornwallis et constitue l'une des faunes les plus diversifiées identifieés en Amérique du Nord. Les fossiles proviennent de gisements wenlockiens-ludlowiens de la formation de Cape Phillips qui se sont formés le long du talus et dans le bassin du géosynclinal franklinien. La formation de Cape Phillips est composée de schiste argileux, de schiste calcaire et de calcaire interstratifiés et la plupart des fossiles se trouvent dans des couches de calcaire allochtone, des mouvements de masse ayant transporté la plupart des matériaux fossilifères vers le bas du talus. Les spongiaires siluriens décrits dans le présent document sont représentatifs d'une province biogéographique spongiaire distincte située au nord et au nord-ouest d'une ligne longeant l'arche transcontinentale et fait contraste avec une autre province située au sud-est où l'on trouve surtout des spongiaires calcaires lithistides et hétéractinides du genre des sphaerocladines.

Les nouveaux genres des demosponges sont notamment le rhizomorine *Parodospongia* et les ochocladines *Antrospongia* et *Cauliculospongia*. Les nouveaux genres d'hexactinellides sont notamment *Corticulospongia* et *Lumectospongia*. Les nouvelles espèces décrites comprennent, entre autres, les rhizomorines *Haplistion frustrum* et *Parodospongia euhydra* et les orchocladines répandues *Antrospongia aberans, Aulocopium nana, Calycocoelia micropora, Cauliculospongia solida, Dunhillia fistulosa, D. megaporata, D. pluraliporosa, Patellispongia alternata, Perissocoelia* (?) *gelasinina, Perissocoelia* (?) *spirosa, Psadodictyum attenuatum* et *Somersetella amplia. Astylospongiella* (?) *lutera* et *Astylospongiella striola* sont les seuls nouveaux représentants du genre Sphaerocladina. Les hexactinellides Amphidiscosa sont représentées par la nouvelle espèce *Lumectospongia uncinata* et les Lyssacinosa par les nouvelles espèces *Corticulospongia floccosa* et *Dictyospongia apache*.

Pour la première fois en Amérique du Nord, on signale la présence de *Carpospongia globosa* (Eichwald, 1830). Du fait de la présence répandue d'*Archaeoscyphia minganensis* (Billings, 1859), de *Hindia sphaeroidalis* (Duncan, 1879) et d'espèces de *Patellispongia* et de *Psarodictyum*, cet association comporte des éléments "universels".

## *Summary*

The Silurian sponge fauna described here from Baillie-Hamilton and Cornwallis islands is one of the most diverse known from North America. When combined with the sponges previously described from Baillie-Hamilton Island (Rigby and Lenz, 1978) and from Somerset Island (Rigby and Dixon, 1979), the entire suite forms the most varied Silurian sponge fauna known.

The fossils described here were collected principally by Chatterton, during the summers of 1977 and 1979, from Baillie-Hamilton and Cornwallis islands. The sponges came from beds of Wenlockian to Ludlovian age in the Cape Phillips Formation, which comprises sediments deposited on the slope and in the basin of the Franklinian Geosyncline, north and west of a broad shelf along the northern margin of the continent.

The Cape Phillips Formation consists of interbedded shale, calcareous shale and limestone. Most of the fossils are found in allochthonous limestone beds, much of the assemblage having been transported downslope by mass movements. Sections containing allochthonous carbonates are located close to the boundary between the shelf carbonates and basinal shales and, presumably, represent slope or basin margins adjacent to the base of the slope. Autochthonous limestone units tend to be thin and nodular and contain principally pelagic faunas, which include disassociated sponge spicules rather than the firmly fused sponge skeletons that characterize the allochthonous beds.

Silurian sponge biogeographic realms are poorly defined, worldwide, largely because of the poor fossil record of the group. In North America, however, two distinctive sponge provinces are recognizable. One province occurs north and northwest of a line that runs generally along the Transcontinental Arch, which passes diagonally from the Great Lakes region, southwestward toward Arizona, and the other province lies south and southeast of that line. Assemblages of the southeastern province are dominated by sphaerocladine lithistid and heteractinid calcareous sponges, although other groups play minor roles. The assemblage of the province to the northwest, like that described here, consists principally of diverse orchocladine lithistid demosponges, with only minor representatives of other lithistid suborders and hexactinellid and calcareous forms.

Many fossil sponge lineages show a general phyletic increase in size and an increase in spicule dimensions, either with time or from the interior to the exterior of the sponge, as for example in the tricranocladine *Hindia*. Two species, described here, show evidence of skeletal evolution.

*Calycocoelia micropora* n. sp. is a conical-cylindrical to tubular sponge, with a characteristic anthaspidellid skeletal structure in the lower part. Long shafted, smooth dendroclones combine to make up the trabs in the uniform skeleton. These kinds of spicules become less dominant in the middle and upper part where X-, Y- and T-shaped dendroclone spicules become increasingly dominant and smaller, resulting in an increasing irregularity in the skeletal structure.

*Perissocoelia* (?) *spinosa* n. sp. shows a more dramatic ontogenetic shift in the nature of the skeleton. The interior of the obconical to stalked, subhemispherical, sponge has an anthaspidellid skeletal structure, with well organized trabs in the regular, dendroclone based skeleton. Parts of the skeleton added later show the coarse, beam-like trabs as more irregular and ranging upward and outward from continuous beams to a linear-beaded structure and finally to isolated, though aligned, spherical, bead-like clusters of spicules. Such lines of beads are spaced essentially the same as trabs in the parts of the skeleton formed earlier. The outer spherical clusters are made of fused ray tips of spicules that appear increasingly like didymoclones. Where the spherical clusters or knots are well developed, oxeas that characteristically core the linear trabs, elsewhere, now radiate spherically from centres of the clusters. Association of didymoclone-like spicules and long dendroclones suggest an early origin for the Didymmorina and that perhaps didymoclones may be polyphletic, with Jurassic didymoclones having been derived later, independently, from crepidal strongyles (Reid, 1970, p. 86).

New genera within the demosponges include the rhizomorine *Parodospongia* and the orchocladine *Antrospongia* and *Cauliculospongia*. New hexactinellid genera include *Corticulospongia* and *Lumectospongia*. New species described here include the rhizomorine *Haplistion frustrum* and *Parodospongia euhydra* and the extensive orchocladine *Antrospongia aberans*, *Aulocopium nana*, *Calycocoelia micropora*, *Cauliculospongia solida*, *Dunhillia fistulosa*, *D. megaporata*, *D. pluraliporosa*, *Patellispongia alternata*, *Perissocoelia* (?) *gelasinina*, *Perissocoelia* (?) *spinosa*, *Psarodictyum attenuatum*, and *Somersetella amplia*. *Astylospongiella* (?) *lutera* and *Astylospongiella striola* are the only new representatives of the *Sphaerocladina*. The hexactinellid Amphidiscosa are represented by the new *Lumectospongia uncinata* and the Lyssacinosa by the new *Corticulospongia floccosa* and *Dictyospongia apache*.

The association of the small genus *Dunhillia* with *Perissocoelia* (?) and a variety of demosponges, along with hexactinellids, is similar overall to that found in the slope assemblages from the Ordovician of Australia, recently described by Rigby and Webby (1988).

*Carpospongia globosa* (Eichwald, 1830) is reported here from North America for the first time. The broadly distributed *Archaeoscyphia minganensis* (Billings, 1859), *Hindia sphaeroidalis* (Duncan, 1879), and species of *Patellispongia* and *Psarodictyum* add "universal" elements to the assemblage.

When the assemblages from Baillie-Hamilton, Cornwallis and Somerset islands are combined, all suborders of the Lithistida that have been previously recognized from Paleozoic rocks are represented. Six species of Rhizomorina, three of Megamorina, eighteen of Orchocladina, one of Tricranocladina and four of Sphaerocladina are included in the Canadian Arctic faunas. Four species of Hexactinellida also occur, but intact Calcarea are not represented in the collections, although loose heteractine spicules were reported earlier from Somerset Island, by Rigby and Dixon (1979), and the new sphinctozoan, *Rigbyspongia catenula*, was described from Cornwallis Island by de Freitas (1987).

## *Sommaire*

La spongiofaune silurienne décrite dans le présent document provient des îles Baillie-Hamilton et Cornwallis et constitue l'une des faunes les plus diversifiées identifiées en Amérique du Nord. Combinée aux spongiaires déjà décrits dans l'île Baillie-Hamilton (Rigby et Lenz, 1978) et dans l'île Somerset (Rigby et Dixon, 1979), elle constitue la série d'éponges siluriennes la plus variée.

Les fossiles décrits ont été principalement recueillis par l'auteur au cours des étés de 1977 et 1979 dans les îles Baillie-Hamilton et Cornwallis. Les spongiaires proviennent de couches wenlockiennes-ludlowiennes de la formation de Cape Phillips, couches composées de sédiments déposés sur le long du talus et dans le bassin du géosynclinal franklinien, au nord et à l'ouest d'une grande plate-forme longeant la bordure nord du continent.

La formation de Cape Phillips est composée de schiste argileux, de schiste calcaire et de calcaire interstratifié. La plupart des fossiles se trouvent dans des couches de calcaire allochtone, la grande partie de l'assemblage ayant été transportée au bas du talus par des mouvements de masse. Des coupes contenant des roches carbonatées allochtones sont situées près de la limite entre les roches carbonatées de plate-forme et les schistes argileux de bassin et, correspondent présumément à des bordures de talus ou de bassin près de la base du talus. Les unités de calcaire autochtone ont tendance à être minces et nodulaires et à contenir surtout des faunes pélagiques, notamment des spicules spongiaires dissociés plutôt que les squelettes spongiaires bien soudés qui caractérisent les couches allochtones.

Les domaines biogéographiques des spongiaires siluriens sont mal définis, à l'échelle du globe, du fait, qu'en grande partie, les fossiles de ce groupe ont été mal conservés. En Amérique du Nord, cependant, on distingue deux provinces spongiaires distinctes. L'une se situe au nord et au nord-ouest d'une ligne longeant de façon générale, l'arche transcontinentale qui s'étend de la région des Grands Lacs vers le sud-ouest jusqu'en Arizona; l'autre province s'étend au sud et au sud-est de cette ligne. Les associations de la province du sud-est sont surtout composées de spongiaires calcaires lithistides et hétéractinides du genre des sphaerocladines mais d'autres groupes s'y trouvent aussi en minorité. L'association de la province du nord-ouest, soit celle qui est décrite dans le présent document, est principalement composée de divers demosponges lithistides orchocladines avec quelques représentants seulement d'autres sous-ordres de lithistides et de formes d'hexactinellides et de calcaires.

De nombreuses lignées spongiaires fossiles affichent une augmentation phylogénique générale de leur taille ainsi qu'une augmentation des dimensions de leurs spicules, soit chronologiquement ou de l'intérieur vers l'extérieur de l'éponge, comme c'est le cas, par exemple, de l'espèce tricranocladine *Hindia*. Deux espèces, décrites dans le présent document, présentent des indices d'évolution squelettique.

*Calycocoelia micropora* n. sp. est une éponge dont la forme varie de conique et cylindrique à tubulaire et dont la partie inférieure est caractérisée par une structure squelettique anthaspidellide. Les dendroclones lisse et à longue tige forment en se combinant les travées du squelette uniforme. Ces types de spicules sont de moins en moins nombreux dans les parties intermédaire et supérieure où des spicules dendroclones de formes X, Y et T augmentent en nombre mais diminuent en taille, causant une irrégularité crossante de la structure squelettique.

*Perissocoelia* (?) *spinosa* n. sp. connaît une modification ontogénétique plus spectaculaire de son squelette. La structure squelettique de l'intérieur de l'éponge subhémisphérique, de nature obconique à pédonculée, est anthasidellide et comporte des travées bien organisées dans le squelette régulieur à base de dendroclones. Dans les parties du squelette qui se sont ajoutées par la suite, les travées grossières en forme de poutres sont plus irrégulières et sont alignées vers le haut et vers l'extérieur de façon à former un ensemble dont l'aspect varié de celui de poutres continues à celui d'une structure linéaire et en chapelet et, enfin, à celui d'essaims de spicules sphériques, en forme de perles, isolés bien qu'alignés. Ces alignments de perles sont espacés essentiellement de la même façon que les travées dans les parties du squelette formées antérieurement. Les essaims sphériques extérieurs sont composés de pointes de rayons de spicules soudées qui ressemblent de plus en plus à des didymoclones. Lorsque les amas ou noeuds sphériques sont bien développés, les oxes qui se trouvent au centre des travées linéaires, ailleurs, rayonnent sphériquement à partir du centre des essaims. La présence de spicules semblables aux didymoclones conjugués à des dendroclones longs semble indiquer une origine antérieure pour les Didymmorina et que, peut-être, les didymoclones sont polyphylétiques, les didymoclones jurassiques formés indépendamment par la suite provenant des strongyles crépidaux (Reid, 1970, p. 86).

Les nouveaux genres de demosponges sont notamment le rhizomorine *Parodospongia* et les orchocladines *Antrospongia* et *Cauticulospongia*. Les nouveaux genres d'hexactinellides sont, entre autres, *Corticulospongia* et *Lumectospongia*. Les nouvelles espèces décrites dans le présent document comprennent les rhizomorines *Haplustion frustrum* et *Parodospongia euhydra* et les orchocladine répandues *Antrospongia aberans*, *Aulocopium nana*, *Calycocoelia micropora*, *Cauliculospongia solida*, *Dunhillia fistulosa*, *D. megaporata*, *D. pluraliporosa*, *Patellispongia alternata*, *Perissocoelia* (?) *gelasinina*, *Perissocoelia* (?) *spinosa*, *Psarodictyum attenuatum* et *Somersetella amplia*. *Astylospongiella* (?) *lutera* et *Astylospongia striola* sont les seuls nouveaux représentants du genre Sphaerocladina. Les hexactinellides Amphidiscosa sont représentées par la nouvelle espèce *Lumectospongia uncinata* et les Lyssacinosa par les nouvelles espèces *Corticulospongia floccosa* et *Dictyospongia apache*.

L'association du petit genre *Dunhillia* avec *Perissocoelia* (?) et d'une variété de demosponges, ainsi que d'hexactinellides, est semblable dans l'ensemble à celle que l'on trouve dans les associations ordoviciennes de talus en Australie, décrites récemment par Rigby et Webby (1988).

Pour la première fois en Amérique du Nord, on signale la présence de *Carpospongia globosa* (Eichwald, 1830). Du fait de la présence répandue d'*Archaeoscyphia minganensis* (Billings, 1859), de *Hindia sphaeroidalis* (Duncan, 1879) et d'espèces de *Patellispongia* et de *Psadodictyum*, cet association comporte des éléments "universels".

En combinant les associations provenant des îles Baillie-Hamilton, Cornwallis et Somerset, tous les sous-ordres de lithistides qui ont été auparavant observés dans des roches paléozoïques sont représentés. Six expèces de Rhizomorina, trois de Mégamorina, dix-huit d'Orchocladina, une de Tricranocladina et quatre de Sphaerocladina font partie des faunes arctiques canadiennes. Quatre espèces d'Hexactinellida se manifestent également; cependant, les collections ne comportent pas de Calcarea intacts bien que des spicules hétéractines libres ont déjà été observés dans l'île Somerset par Riby et Dixon et le nouveau sphinctozoan, *Rigbyspongia catenula*, a été décrit dans l'île Cornwallis par de Frietas (1987).

## INTRODUCTION

One of the most diverse Silurian sponge faunas known from North America was recently recovered from the Canadian Arctic. When combined with Silurian assemblages described from Somerset Island (Rigby and Dixon, 1979), they constitute the most varied Silurian sponge faunas known, and include both shelf and slope suites. The sponges described in this work were collected from two localities on Baillie-Hamilton Island and Cornwallis Island (Fig. 1) by Chatterton during the summers of 1977 and 1979. In addition, a small collection made by A. Boucot (Oregon State University), in the summer of 1972 is also included, as is a spectacular specimen of a new dictyosponge, collected earlier by D. Perry and B.D.E. Chatterton.

The sponges occur in strata of Wenlockian and Ludlovian age in the Cape Phillips Formation (Thorsteinsson, 1958, p. 78), the strata of which were deposited on the slope and in the basin of the Franklinian Geosyncline, north and west of a broad shelf. The formation outcrops in a broad crescent across Cornwallis and Little Cornwallis islands and then is exposed northward through Baillie-Hamilton Island, across the Grinnell Peninsula of Devon Island and along the west side of Ellesmere Island. A map of the geology of Baillie-Hamilton Island and Cornwallis Island was published by Thorsteinsson and Kerr (1968).

Sections of the Cape Phillips Formation from which the sponges were obtained consist of interbedded shale, calcareous shale, and limestone. Limestone units range from thin beds and nodules that contain mainly pelagic faunas (primarily graptolites, radiolarians, chitinozoans, acritarchs, with rare conodonts, pelmatozoan ossicles, and common sponge spicules) to thicker beds that commonly contain chaotically oriented shelly faunas. The latter beds contain a predominantly shelly benthic fauna and are apparently allochthonous. Sections containing allochthonous carbonates are located close to the boundary between shelf carbonates and basinal shales and, presumably, represent a slope region, or basin margin adjacent to the base of the slope. In some areas, olistostromal blocks of carbonate occur in shales that accumulated near or on the slope (north side of Beaumann Fiord and Eureka Sound, Ellesmere Island).

Some fossils have already been described and/or illustrated from the sections on Baillie-Hamilton Island. These include: a monoplacophoran (Boucot, 1975a), trilobites (Perry and Chatterton, 1977), gastropods (Rohr et al., 1984), predatory borings in the brachiopod *Dicoelosia* (Rohr, 1976; Boucot, 1981), a sponge (Rigby and Lenz, 1978), radiolarians (Goodbody, 1982), and graptolites (Lenz, 1978; Jackson et al., 1978).

The two sections from which sponges were collected on Baillie-Hamilton Island are located on the south coast (Fig. 1) along or just above the shoreline. Section BH2 is located stratigraphically above and to the east of Section BH1. These sections are separated by an area of cover, through which flows (in high summer) a small creek. The stratigraphic interval between these sections was not measured, and there is the possibility of minor faulting between them. Their relationships are shown in Figure 2.

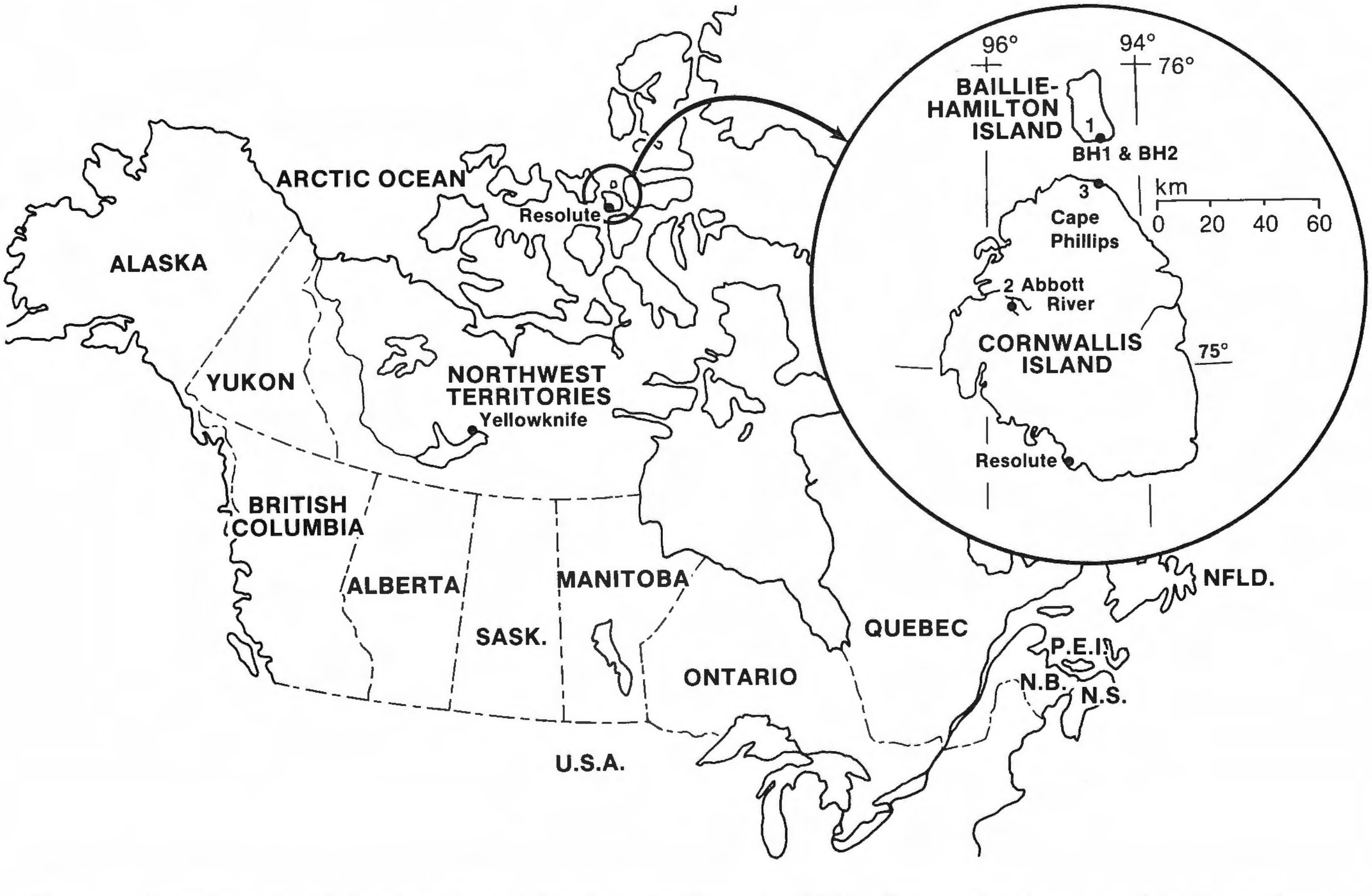
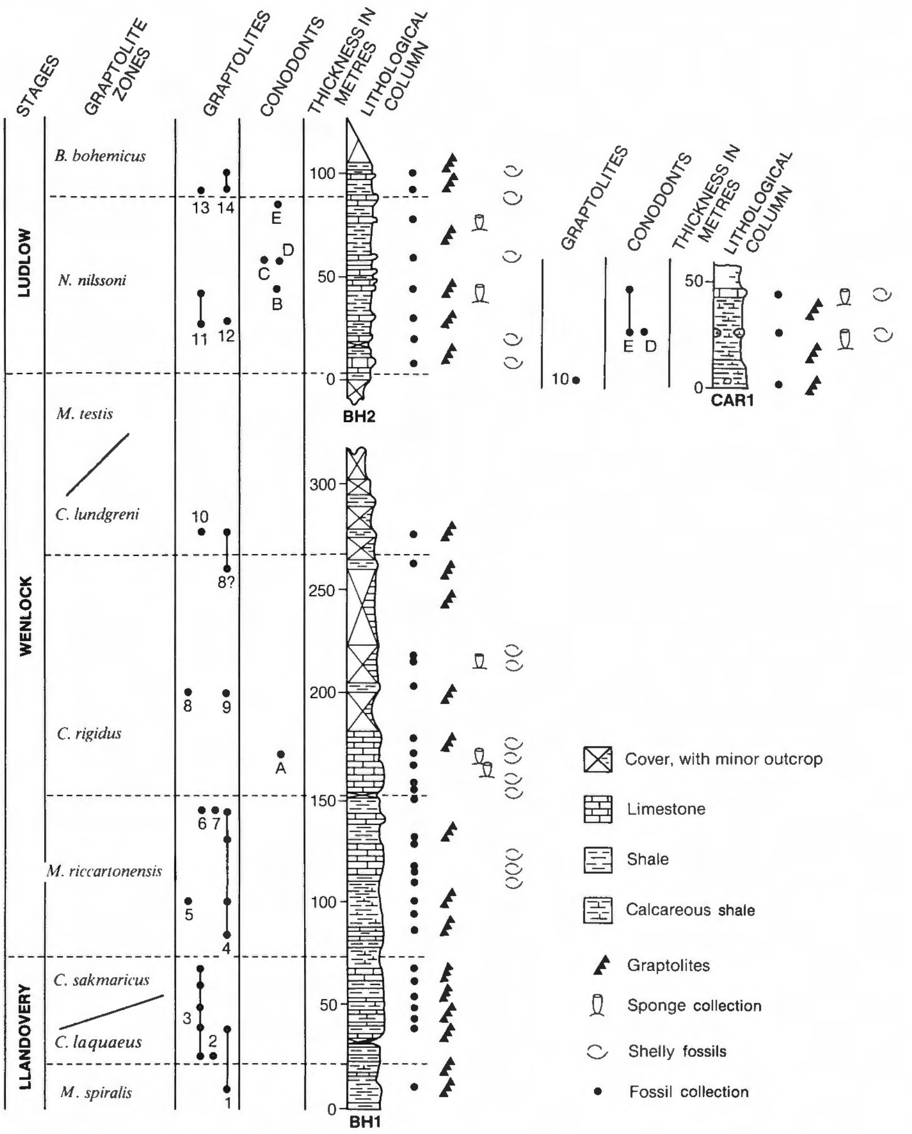


***Figure 1.*** *Location map of Sections BH1, BH2, Cape Phillips and CAR1, from which the extensive sponge faunas described here were obtained.*



Ranges of the following graptolite taxa are shown:

| | | | |
|---|---|---|---|
| 1. | *Monograptus spiralis* Geinitz | 8. | *Monograptus flemingii?* Salter |
| 2. | *Cyrtograptus solaris* n. subsp.? Lenz, 1979 | 9. | *Monoclimacus vomerina* (Nicholson) |
| 3. | *Cyrtograptus sakmaricus* Koren | 10. | *Monograptus testis* (Barrande) |
| 4. | *Monograptus priodon* Bronn | 11. | *Neodiversograptus nilssoni* (Barrande) |
| 5. | *Cyrtograptus* aff. *C. rigidus* Tullberg | 12. | *Plectograptus macilentus* (Tørnquist) |
| 6. | *Cyrtograptus rigidus* Tullberg | 13. | *Saetograptus varians* (Wood) |
| 7. | *Monograptus riccartonensis* Lapworth | 14. | *Bohemograptus bohemicus* (Barrande) |

Ranges of the following conodont taxa are shown:

| | | | |
|---|---|---|---|
| A. | Apparatus A Uyeno, 1981 | D. | *Ozarkodina excavata* (Branson and Mehl) |
| B. | *Ozarkodina confluens/douroensis* Uyeno, 1981 | E. | *Ozarkodina confluens* alpha morphotype of Klapper and Murphy, 1975 |
| C. | *Ozarkodina douroensis* Uyeno | | |

***Figure 2.*** *Correlation of lithological columns representing Sections BH1, BH2, and CAR1. Correlations are based on ranges of conodont and graptolite taxa. Occurrences of sponge faunas, shelly benthic faunas, and graptolites are shown.*

The section from which most of the sponges were collected on Cornwallis Island is a steep exposure, on the east bank and outside a large incised meander of a tributary to Abbott River (Fig. 1). The sponges were collected from two horizons near the top of this section (Fig. 2). These horizons also contain shelly faunas that include fish (mainly cyathaspidids), brachiopods, trilobites, gastropods and a few bryozoans and tabulate corals (auloporoids). The sponges were collected in place in the upper horizon. The lower horizon contains large calcareous nodules in a part of the section that is predominantly calcareous shale (containing some graptolites). Because of the steep nature of this part of the section, and the incompetent nature of the shales, some of the nodules that contain the sponges may have moved a short distance down section.

The new dictyosponge was collected from the type section of the Cape Phillips Formation, at Cape Phillips on Cornwallis Island. This sponge was collected from the lower part of the section, just above the Llandovery-Wenlockian boundary (equivalent to the published section of Thorsteinsson [1958] from 4630 to 4643 ft). This section contains more shale with graptolites and less allochthonous limestone than the other three sections.

All four sections that contain the silicified sponges consist of alternating shale, calcareous shale and limestone. The sponges were obtained from the limestone. The shale contains a predominantly pelagic fauna of graptolites, radiolarians, acritarchs, and chitinozoans, with sparse conodonts. These sections also contain rare horizons with abundant heterostracan and anaspid fish. The limestone beds and nodules are from units that are in part autochthonous, containing three-dimensional graptolites and radiolarians, and other units that are clearly allochthonous.

Sponges occur in both autochthonous calcareous nodules and allochthonous beds. In the former, they occur predominantly as loose spicules. In the latter, the fossils described in this work frequently have essentially intact skeletons or spicules still associated within a fabric. Such a distribution may appear to be a contradiction, especially when sponges occur with fragmented coral specimens. However it is not, because sponges representative of the deeper facies (autochthonous beds) had skeletons made of spicules that were not fused to one another, and sponges occurring in the allochthonous beds probably travelled comparatively short distances, as indicated by the presence of articulated brachiopods. The allochthonous beds are located in regions of slope, where remains of organisms from the shelf-slope margin were transported down the slope by mass movement of sediment. Fossils that moved the farthest are the most fragmented. Corals and stromatoporoids, representative of the shallowest shelf-margin facies, occur in these beds as angular fragments. However, they occur in the same beds as complete, well preserved, articulated brachiopods, which could only have travelled short distances. Orientations of specimens are, on the whole, chaotic.

Allochthonous beds contain faunas that were predominantly benthic, consisting of brachiopods, trilobites, bryozoans, corals and sponges with a minor pelagic component of graptolites and radiolarians. Mass movement of sediment picked up fossils from a variety of environments as the material moved down the slope. Shells from more distal environments travelled shorter distances and are less worn. This is thought to explain why some brachiopods and sponges are essentially complete. The brachiopod faunas usually contain abundant specimens of *Dicoelosia*, a characteristic genus of Boucot's (1975b) benthic assemblages 4-5. Thus, the well preserved nature of the sponges in these beds suggests that they were moved comparatively short distances, and were probably derived from near the base of the slope in regions where debris flows slowed down and came to rest. Some of the horizons containing lithistid sponges with fused skeletons, especially those in Section BH2, may have been autochthonous, because the rest of the associated fauna is predominantly pelagic (in BH2-84.3, the fauna consists predominantly of radiolarians and minute articulated lingulid brachiopods – less than 1 mm in size).

Thus, from the state of preservation of the sponges, and their occurrence in both autochthonous and allochthonous beds, it is deduced that they lived on or near the base of the shelf-basin slope.

The measured sections are dated and correlated on the basis of the graptolite and conodont faunas (Fig. 2). Most of the graptolite identifications were made in the field with the assistance of A.C. Lenz. Some identifications are based on published data from these sections (Lenz, 1978; Jackson et al., 1978). The conodont identifications are by Chatterton. The graptolite zones used in Figure 2 are a combination of the international/European zones, summarized by Rickards (1976), and the northern Canadian zones, suggested by Lenz (1978). Insufficient work has been completed on the magnificent graptolite faunas from these sections, and in the future it will be possible to refine the zonation in these sections substantially. Data of fossil occurrences added to Figure 2 are included primarily to demonstrate the approximate ages of the sponge collections, and partly to illustrate the occurrences of sponges, described here, in the region where allochthonous and autochthonous shelly fauna facies are interbedded with pelagic facies.

The new dictyosponge from Cape Phillips is early Wenlockian in age. The sponge collections from Section BH1 are mid-Wenlockian. The sponge collections from Sections BH2 and CAR1 are early Ludlovian in age.

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Generally speaking, sponge assemblages from the Silurian are moderately poorly defined on a worldwide basis. Without question, the most extensive assemblages are those recorded from North America. However, even here the faunal record is inadequate for good geographic or stratigraphic zonation.

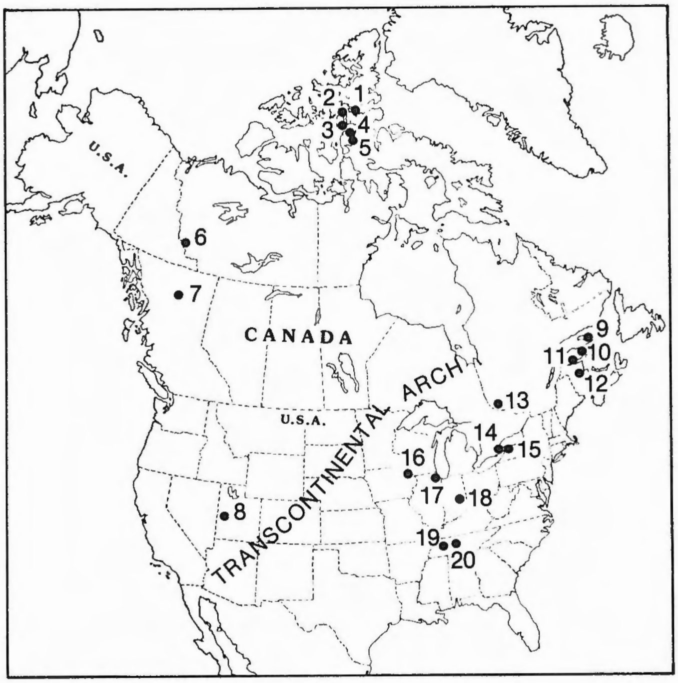
In Europe, *Aulocopium* and *Astylospongia* are reported from the Silurian of northern Europe and elsewhere (Rauff, 1893, p. 31-48, for example) along with *Hindia* (?) and *Caryospongia*. In some of the earlier citations, there is uncertainty about whether the assemblage is Silurian or whether it is in reality Ordovician. This certainly seems to be the case, in particular for references to *Aulocopium*, but less certainly for *Astylospongia*, *Caryospongia*, and *Hindia*.

In South America, only the genus *Protachilleum* has been reported from Silurian rocks of Argentina (Zittel, 1877b). It is the sole representative, to date, of Silurian sponges known from that continent.

*Astylospongia radiata* Pickett (1969, p. 18, 19; 1983, p. 117) from New South Wales is apparently the only Silurian sponge discovered so far from Australia. It was apparently cited earlier as *Carpospongia* by Brown (1940), according to Pickett (1983, p. 96).

Representatives of Silurian sponges found in England are limited to the hexactinellid *Oncosella* Rauff (1894). *Amphispongia* Salter (1861), a second "sponge," may be a spicule core of an alcyonarian rather than a sponge. On the basis of such limited data, it seems unwarranted to do more than note occurrences of Silurian sponges outside North America.

Within North America, the earliest described Silurian sponge assemblages are those from Tennessee, in studies made by Roemer (1848, 1860, 1874). His collection came from Middle Silurian rocks of western Tennessee, along the Tennessee River and its tributaries (Fig. 3, loc. 19). The assemblage described by him and later workers is dominated by the sphaerocladine astylospongiids *Astylospongia*, *Caryospongia*, and *Carpospongia*, by abundant tricranocladine *Hindia*, by common anomaloclonellid *Anomoclonella* and *Pycnopegma*, by the chiastoclonellid *Chiastoclonella*, and by the locally numerous heteractinid calcareous sponge *Astraeospongium meniscus* (Roemer, 1848), probably the first named fossil sponge from North America. In many respects, this assemblage is reminiscent of the northern European assemblages where astylospongids are major constituents, along with the orchocladine *Aulocopium* and several other species. Later works by Hinde (1883), Rauff (1893-1895), Foerste (1903, 1909), Pate and Bassler (1908), Howell, (1937, 1940, 1942), Amsden (1949), and Wilson (1949) added details about occurrences and stratigraphy of sponges of western and central Tennessee, such as in the Nashville Dome (Fig. 3, loc. 20), and minor constituents, to the already well described suite, magnificently illustrated by Rauff (1894, 1895).



1. Devon Island, Greiner (1963).
2. Baillie-Hamilton Island, Rigby and Lenz (1978); this paper.
3. Cornwallis Island, this paper.
4, 5. Somerset Island, Rigby and Dixon (1979).
6. Mackenzie Mountains, N.W.T., undescribed.
7. Ware area, northern B.C., Rigby and Harris (1979).
8. Confusion Range, Utah, Rigby (1967b).
9. Anticosti Island, Twenhofel (1928); Rigby (1974).
10. Gaspé region, Burke (1941).
11. Chaleur Bay region, Parks (1933); Northrup (1939); Dresser and Denis (1941); Rigby (1967a).
12. New Brunswick, Duncan (1879).
13. Lake Timiskaming, Rigby (1973).
14, 15. Niagara region, Billings (1874); Sollas (1881); Rauff (1894); Walter (1895); Williams (1919); Bolton (1953, 1957).
16. Northeastern Iowa, Thomas (1923).
17. Northwestern and northeastern Illinois, Meek and Worthen (1868); Croneis and Grubbs (1939); Ball and Greacan (1946); Lowenstam (1948, 1957).
18. Eastern Indiana, Hall (1853, 1864, 1875, 1882); Rigby, Hanum and Frest (1979).
19. Western Tennessee, Roemer (1848, 1860, 1874); Hinde (1883); Rauff (1893-95); Foerste (1903, 1909); Pate and Bassler (1908); Howell (1939, 1940, 1942); Amsden (1949); Wilson (1949).
20. Nashville Dome, Wilson (1948, 1949).

***Figure 3.*** *Locality map of Silurian sponge occurrences from North America. Localities southwest of the major Transcontinental Arch are dominated by **Astylospongia** and related sphaerocladine genera, and by **Astraeospongium, Hindia,** and several orchoclad genera. Localities to the north of the arch, particularly those along the outer continental slope described here, have more diverse assemblages, and have a paucity of heteractinid and sphaerocladine genera.*

Silurian sponges have been described from the northern part of the Illinois Basin and southwestern part of the Michigan Basin and adjacent areas in Indiana and Illinois. The first descriptions of Silurian sponges from the region were by J. Hall (1863a, b, 1864) and were based on small specimens he named *Astylospongia praemorsa.* He further documented sponge occurrences (1875, 1882) in the Waldron Shale, near Waldron, Indiana (Fig. 3, loc. 18). He described relatively small new species, *Caryospongia juglans nuxmoschata* and *Palaeomanon bursa*, and a single specimen of *Astylospongia imbricato-articulata* Roemer. Meek and Worthen (1868) described the new species *Astylospongia* (?) *christiani* from the Middle Silurian of Carroll County, in northwestern Illinois. Ball and Greacen (1946) compiled a list of sponges in collections of the Chicago Academy of Sciences and listed *Astylospongia* and *Caryospongia* as occurring in collections of the museum from Indiana, Tennessee, Illinois and Ontario. The classic work on Silurian reefs of the northern part of Indiana and Illinois (Fig. 3, loc. 17) by Lowenstam (1948, 1957) documented occurrences of sponges such as *Astraeospongium, Astylospongia, Carpospongia, Caryospongia, Palaeomanon* and *Hindia* as essentially accessory to the reef fabric, from stillwater, inter-reef faunas from around the prominent bioherms of that district.

Richardson (1950) tabulated species of *Astraeospongium* and summarized spicule dimensions and occurrences of the species known to that date. He concluded that most assignations to *Astraeospongium*, except for *Astraeospongium meniscus* (Roemer, 1848), were based on detached spicules and that the variability of such spicules within a single sponge makes a nomenclature based on isolated spicules of that genus, in particular, strongly suspect. Croneis and Grubbs (1939) discussed the spherical chert nodules from Niagaran dolomite in the Chicago area as "sea balls" that contain hexactinellid and astraeospongiid spicules. Thomas (1923) discussed Paleozoic sponge occurrences in Iowa and noted that *Astylospongia* occurs there.

Silurian sponges have also been reported from around the northeastern margin of the Michigan Basin, principally from Niagaran rocks in the Niagara escarpment, from southern Ontario and northern New York. Billings (1874) was the first to describe *Aulocopina* in limited Silurian sponge occurrences from the Niagara Falls region (Fig. 3, loc. 14). Sollas (1881) later described *Astroconia* also from near Hamilton, Ontario. Walker (1895) commented on the occurrence of silicified *Aulocopina* and *Astylospongia* in the resistant cuesta-forming carbonates of the Niagara region. Williams (1919) noted that many sponges had been collected from the Lockport Dolomite and listed *Astylospongia praemorsa* (?) in a faunal list. Bolton (1953), in a discussion of Silurian formations of the Niagara escarpment (Fig. 3, locs. 14, 15), cited *Astylospongia* and *Aulocopina* as having been collected from these same Silurian beds. Bolton (1957), later added *Hindia* to the species occurrences. Rigby (1973) described a new *Calycocoelia* species from near Lake Timiskaming (Fig. 3, loc. 13) southwestern Quebec, in an outlier of the Silurian section, but somewhat to the northeast of the Michigan Basin.

The Niagara escarpment assemblage is dominated by moderately common astylospongiids, by *Hindia* and orchoclads such as *Aulocopium* and *Aulocopina.* These are essentially the same kinds of fossils as those that characterize Silurian collections from Indiana and Illinois, along the southwestern margin of the Michigan Basin, and from Tennessee, along the southeastern margin of the Illinois basin and in the western part of the Nashville Dome.

A considerably less diverse assemblage of fossil sponges has been collected from Silurian rocks of the Gaspé Peninsula area of southeastern Quebec and from New Brunswick. Duncan (1879) described the new genus and species *Hindia sphaeroidalis* from Silurian occurrences in New Brunswick (Fig. 3, loc. 12). *Hindia fibrosa* (= *sphaeroidalis*) was reported by Dresser and Denis (1941) from the Chaleur Series, from the northern margin of Chaleur Bay (Fig. 3, loc. 11). Burke (1941) cited *Hindia* from the Silurian rocks of the Gaspé region (Fig. 3, loc. 10), as did Rigby (1967a), who also described the hexactinellid *Malumispongium* from the Silurian La Vieille Formation at Black Cape, Quebec (Fig. 3, loc. 10), a sponge identified in an exhibit as *Aulocopium hartnageli* by Clarke (1924, p. 10). Parks (1933) had earlier cited the occurrence of *Caryospongia* from the La Vieille Formation at Port Daniel, Quebec. Northrop (1939) also noted the occurrence of Silurian *Hindia* and *Caryospongia* from the Chaleur Bay exposures.

Twenhofel (1927) described *Hyalostellia anticostiana* from Anticosti Island (Fig. 3, loc. 9) from the Silurian Jupiter River Formation. Rigby (1974) redescribed the hexactinellid as *Twenhofelella*.

Generally speaking, Silurian sponges from Tennessee, Indiana, Illinois, from the Niagara escarpment region and from southeastern Quebec and New Brunswick are part of an assemblage dominated by *Astylospongia*, *Caryospongia*, *Astraeospongium*, and *Hindia*. As such, they characterize a sponge suite typical of Silurian rocks southeast of the Transcontinental Arch that divided the southeastern part of North America from the northern and northwestern parts (Fig. 3).

In western United States, only isolated hexactinellid sponge spicules have been reported from Utah (Rigby, 1967b) (Fig. 3, loc. 8). These are generalized body spicules and, perhaps, root tuft spicules that are generically unidentifiable. To the north, a Silurian hexactinellid fauna was described from northern British Columbia (Fig. 3, loc. 7) by Rigby and Harris (1979). An as yet undescribed varied assemblage of Silurian sponges has been collected from the Mackenzie Mountains (Fig. 3, loc. 6) by Brian Chatterton. It appears to have much in common with the Baillie-Hamilton-Cornwallis fauna.

The most extensive Silurian sponge faunas known to date, from anywhere in the world, are those from the Canadian Arctic (Table 1). Possible Silurian sponges were first reported from the region by Greiner (1963, p. 216-219) when he noted the occurrence of *Astraeospongium* from the Ordovician-Silurian Allen Bay Formation on Devon Island (Fig. 3, loc. 1). The occurrence is based on isolated spicules, but does indicate that heteractinid calcareous sponges extend beyond the region southeast of the Transcontinental Arch into northern Canadian basins. This is not surprising because Canada was probably a refuge area or a locus of endemic development of Ordovician-Devonian heteractinid sponges.

Rigby and Dixon (1979) described from Somerset Island the first major Silurian sponge suite known from the Canadian Arctic Archipelago (Fig. 3, locs. 4, 5). It consisted of a moderately diverse assemblage of sponges and contained common rhizomorine sponges, including three new species of *Haplistion*, and three new megamorine sponges, *Eochaunactis radiata*, *Haplistionella garnieri* and *Haplistionella minitraba*. The new orchoclads, *Finksella turbinata*, *Somersetella conicula* and *Somersetella digitata*, were moderately common fossils in the fairly diverse Silurian assemblage. The tricranocladine *Hindia* was questionably represented by a single, subspherical, poorly preserved specimen. The sphaerocladine astylospongiids were not represented in the Somerset Island suite. The hexactinellid species *Pelicaspongia perforata* was named from Somerset Island, where the sponges are moderately common.

So far, Silurian heteractinid calcareous sponges are represented in Canadian Arctic faunas only by isolated octactines and sexiradiates. The paucity of heteractinid and astylospongiid species is striking and contrasts sharply with the composition of assemblages from southeast of the Transcontinental Arch, where these kinds of sponges are the major elements.

De Freitas (1987) recently described the first known Silurian sphinctozoan sponge *Rigbyspongia catenula*, from Cornwallis Island. It was collected from the Cape Phillips Formation.

Fossils reported here from collections from the Cape Phillips Formation on Baillie-Hamilton and Cornwallis islands (Figs. 1, 2; Fig. 3, locs. 2, 3) increase the number of sponges known from the Canadian Arctic and, in particular, add new species and genera of rhizomorine, orchocladine and sphaerocladine sponges. In addition, the geographic range of *Hindia spheroidalis* Duncan is clearly extended into the Canadian Arctic, for it is a moderately common Silurian sponge on Baillie-Hamilton Island. *Carpospongia globosa* (Eichwald) had been known, previous to the citation here, only from northern Europe. Extension of the geographic range of this species into Arctic Canada is particularly significant because it, as well as two new species of astylospongids and *Astylospongiella megale* Rigby and Lenz (1978) constitute the only published occurrences of sphaerocladine sponges in regions far north and northwest of the Transcontinental Arch in North America. However, even these species are known from only a few specimens, in contrast with the literally tens of thousands of sphaerocladine sponges known, for example, from the Silurian of Tennessee.

The assemblages of Baillie-Hamilton and Cornwallis islands have a general aspect more in common with Upper Ordovician faunas recently described from New South Wales in Australia (Rigby and Webby, 1988). Both the New South Wales and Baillie-Hamilton/Cornwallis assemblages are from continental slope or basin margin environments, and silicified sponges have been recovered from exotic limestone blocks or from rocks representing debris flows. This suggests that the outer slope of island arcs or margins of continents may have been populated by diverse sponge faunas, perhaps even more diverse than faunas of the shelf margin or cratonal basins. So far, we have had only a few glimpses into this period of great diversity of the Cambrian to Silurian record. We see a marked contrast between slope-to-basin assemblages and those on the craton or shelf margin. Unfortunately, outer slope Paleozoic rocks are only preserved in a few areas of the world. These few areas need to be examined in detail because they may hold the record of beginnings of many major groups of fossil sponges.

## ONTOGENETIC DEVELOPMENT

The ontogeny of fossil sponges has not been investigated in great detail, except for changes in gross form and increase in size. For some genera, like the beaded sphinctozoans, changes in size of chamber or additions of structures are moderately well documented in numerous examples. However, within the Demospongia, examples of fossils showing ontogenetic changes of microstructure or changes of canal patterns with growth are less adequately documented.

Among sponges in Silurian assemblages from Baillie-Hamilton and Cornwallis islands, *Perissocoelia* (?) *spinosa* n. sp. and *Calycocoelia micropora* n. sp. show distinct changes in spicule patterns with growth. *Calycocoelia micropora* is a moderately large, conical-cylindrical to tubular sponge (Pl. 7, fig. 5) in which the skeleton shows increasing complexity upward, documenting the ontogenetic changes of the sponge morphology. Canal patterns remain essentially the same, but the anthaspidellid skeleton changes character. Long-shafted, smooth, dendroclones make up regular trabs, which are characteristic of the genus and family, in lower parts of the sponges (Pl. 7, fig. 6). These fairly coarse dendroclones have only moderately differentiated brachyome and cladome tips, such as those that characterize most primitive members of the family. The spicules are distinctly Y-shaped to modified X-shaped and the lower skeleton is ladder-like and regular. However,

# TABLE 1

## Known occurrences of Silurian sponges in Arctic Canada

| | SLOPE TO BASIN ASSEMBLAGES | | NORTHERN CRATON OR SHELF ASSEMBLAGES |
|---|---|---|---|
| | **BAILLIE-HAMILTON ISLAND** | **CORNWALLIS ISLAND** | **SOMERSET ISLAND** |
| **DEMOSPONGEA** | | | |
| **Rhizomorina** | | | |
| *Haplistion* sp. | 2-84.3[1]; 2-97.1 | | |
| *H. cylindricum* Rigby and Dixon, 1979 | | | • |
| *H. minutum* Rigby and Dixon, 1979 | | | • |
| *H. cresswelli* Rigby and Dixon, 1979 | | | • |
| *H. frustrum* n. sp. | 402Y[2] | | |
| *Parodospongia euhydra* n. sp. | 2-97.1 | | |
| **Megamorina** | | | |
| *Eochaunactis radiata* Rigby and Dixon,1979 | | | • |
| *Haplistionella garnieri* Rigby and Dixon, 1979 | | | • |
| *H. minitraba* Rigby and Dixon, 1979 | | | • |
| **Orchocladina** | | | |
| *Archaeoscyphia minganensis* (Billings) | 1-172; 402Y[2] | 1-44.5 | |
| *Antrospongia aberanns* n. sp. | 2-84.3 | | |
| *Aulocopium nana* n. sp. | 2-84.3 | | |
| *Calycocoelia micropora* | | 1-44.5 | |
| *Cauliculospongia solida* n. sp. | | 1-44.5 | |
| *Dunhillia fistulosa* n. sp. | | 1-24.4+; 1-44.5, 6a | |
| *D. megaporata* n. sp. | 2-84.3 | 1-44.5 | |
| *D. pluraliporosa* n. sp. | 1-44; 2-84.3 | 1-24.4+ | |
| *Finksella turbinata* Rigby and Dixon, 1979 | | | • |
| *Patellispongia alternata* | 1-172 | | |
| *Patellispongia* sp. | 2-84.3 | | |
| *Perrisocoelia* (?) *gelasinina* n. sp. | 2-84.3 | | |
| *P.* (?) *spinosa* n. sp. | 1-44.5 | | |
| *Psarodictyum attenuatum* n. sp. | 2-84.3; 402Y[2] | | |
| *Somersetella conicula* Rigby and Dixon, 1979 | | | • |
| *S. digitata* Rigby and Dixon, 1979 | 2-84.3 | | • |
| *S. amplia* n. sp. | 2-84.3 | | |
| *Somersetella* sp. fragments | 2-44 | | |
| **Tricranocladina** | | | |
| *Hindia sphaeroidalis* Duncan, 1879 | 2-44; 2-84.3<br>2-97.1; 402Y[2] | | |
| *H.* (?) sp. | | | • |
| **Sphaerocladina** | | | |
| *Astylospongia* (?) *lutera* n. sp. | | 1-44.5 | |
| *Astylospongiella megale* Rigby and Lenz, 1978 | • | | |
| *A. striola* n. sp. | 2-44?; 2-84.3 | 1-24.4+?; 1-44.5? | |
| *Carpospongia globosa* (Eichwald) | 2-84.3 | | |
| **HEXACTINELLIDA** | | | |
| **Lyssacinosa** | | | |
| *Lumectospongia uncinata* n. sp. | 2-84.3 | | |
| *Corticulospongia floccosa* n. sp. | 2-84.3 | | |
| *Dictyospongia apache* n. sp. | | CP[3] | |
| *Pelicaspongia perforata* Rigby and Dixon, 1979 | | | • |
| **CALCAREA** | | | |
| **Heteractinida** | | | |
| Genus uncertain, spicules | | | • |

[1] Section 2 - 84.3

[2] Locality 402Y is approximately equal to Baillie-Hamilton Island Section 1-120

[3] Cape Phillips

in the middle and upper part of the sponge, the spicules are significantly smaller, with shorter shafts, and various elements have a smaller diameter. Most of the spicules are X-, Y-, or distinct T-shaped dendroclones that become increasingly irregularly spaced and oriented in the upper part of the sponge. The regular trab-based structure is less evident. Coring oxeas of the trabs are most evident in the simple middle and lower part of the sponge. Such coring spicules play major roles in some precursor Middle and Upper Ordovician sponges.

*Perissocoelia* (?) *spinosa* n. sp. shows an even more dramatic change in the skeleton from early to later stages in the growth of the sponge. Earliest parts of the skeleton show a typical regular anthaspidellid net, with trabs radiating upward and outward from near the base. As in most members of the family, the skeleton there is composed of simple Y-shaped dendroclones, each with a long, smooth shaft and with brachyome and cladome terminations evident. The moderately well organized lower skeleton is composed of porous trabs.

Unlike many genera in the family, the trabs become discontinuous upward and grade into linear or isolated spherical bead-like clusters of spicules in subsequent parts of the skeleton. They are spaced essentially the same as trabs in the lower part of the skeleton. These porous spherical knots, however, are made of fused ray tips of spicules, some of which lack subdivided Y-shaped cladomes and have both tips like undivided brachyomes. They become increasingly like didymoclones. It is the junction of these tips that produces the subspherical knots that are the large elements of the upper part of the skeleton. Where the knots are well developed, oxeas that characteristically core the trabs now radiate spherically out from centres of the knots between zygomes of the didymoclone articulation (Pl. 5, fig. 5; Fig. 5).

An origin for the didymoclones may be suggested by the association of the didymoclones and long dendroclones. Didymoclones in Mesozoic and Recent sponges are monaxial desmas that appear like two sphaeroclones connected with a smooth shaft between their centra. Reid (1970, p. 86) concluded that didymoclones are single desmas developed from a crepidal strongyle and that through irregularity they may grade into rhizoclones. Didymoclones may appear like small dumbbells because they produce swollen knots where they merge at their tips. The gradational structure and association here in *Perrisocoelia* (?) *spinosa* would suggest that Paleozoic didymoclones, rather than being derived from crepidal strongyles, may have been derived by modification of dendroclones, at least in this early Paleozoic occurrence.

Finks (1967, p. 338) concluded that the Didymorina of Rauff (1893, p. 195) are equivalent to the suborder Anomocladina of Zittel (1878). With this definition, he noted that the oldest didymorine is *Melonella ovata* (Sollas, 1883) from the Bajocian Inferior Oolite in England (Hinde, 1893, p. 207, 208). *Cylindrophyma milleporata* (Goldfuss, 1833) from the Kimmeridgian Weiss Jura of Germany is the stratigraphically youngest known species of the suborder.

The apparent occurrence of didymorine spicules here in the Silurian suggests that the spicule type may be polyphyletic, that the rare Paleozoic occurrences may have been derived from dendroclones, and that, perhaps, the Jurassic spicules may have been derived independently from crepidal strongyles, as Reid (1970, p. 86) proposed.

## SYSTEMATIC PALEONTOLOGY

### Class DEMOSPONGEA Sollas, 1875

### Order LITHISTIDA Schmidt, 1870

### Suborder RHIZOMORINA Zittel, 1878

### Family HAPLISTIIDAE De Laubenfels, 1955

*Discussion.* Finks (1960, p. 86, 87) excluded *Lasiocladia* from the family, although it had initially been included with *Haplistion* Young and Young (1877, p. 428) in the family by De Laubenfels (1955, p. E37). Finks included *Kazania* Stuckenberg (1895, p. 183) and *Chaunactis* Finks (1960, p. 93, 94) in the family, thereby restricting the range of the family from the Mississippian to the Permian. Additional species of *Haplistion* were described from the Silurian Read Bay Formation by Rigby and Dixon (1979, p. 592-603), which then extended the range of the family to the Silurian. Rigby and Webby (1988) named *Warrigalia*, *Taplowia*, *Lewinia*, and *Boonderooia* from the Upper Ordovician Malongulli Formation of New South Wales and extended the range of the family as far back as the Ordovician. As presently understood, the family has greater diversity in the early part of the Paleozoic than it does in the late Paleozoic. However, *Haplistion* is probably the most common sponge of the family, both in terms of geographic range and numbers of specimens. The family is now recognized from Eurasia, North America and Australia.

### **Genus** *Haplistion* Young and Young, 1877

*Haplistion* is characterized by a distinct three-dimensional structural gridwork for a skeleton. Each element of the skeleton is composed of tracts of rhizoclones. Species of the genus range from massive or subspherical irregular to digitate subcylindrical sponges.

*Type species.* *Haplistion armstrongi* Young and Young, 1877.

### *Haplistion* (?) sp.

Plate 1, figures 7, 9, 10

*Description.* A single small fragment, approximately 14 mm high and 8 to 9 mm in diameter, occurs in the collection. It is principally the moderately coarsely silicified lower part of the sponge and shows a few, fairly large, vertical and horizontal tracts that are characteristic of the three-dimensional net of the genus. The specimen (Pl. 1, fig. 7) is too small, however, to be identified with certainty.

The skeletal fragment shows considerable irregularity, but where most uniform, tracts are spaced, centre-to-centre, approximately 0.8 to 1.0 mm apart, with most essentially 1.0 mm apart. This results in openings between the intersecting tracts approximately 0.4 to 0.5 mm across (Pl. 1, fig. 6), although there is one exceptional large opening 1.1 to 1.2 mm across. Most vertical and horizontal openings in the net are circular to rounded subrectangular. Their margins are smooth because of spacing of numerous long rhizoclones and the curving tract edges.

Most tracts have essentially circular cross-sections (Pl. 1, fig. 10) but become elliptical in areas of common junction. They combine to produce the more or less rectangular gridwork net characteristic of *Haplistion.* Tracts are commonly 0.30 to 0.35 mm in diameter but locally range up to approximately 0.5 mm across, as measured across their narrow middle part. They may expand up to 0.4 to 0.7 mm across at their common junction. Spacing of tracts is essentially the same, horizontally and vertically, and there are 4 to 6 tracts in 5 mm.

Details of the skeletal net are excellently preserved locally but elsewhere the skeleton is coarsely silicified and details have been destroyed. Tracts have a moderately open porous texture with a fairly loosely packed, rhizoclone-based, net. Openings 0.02 to 0.04 mm across are fairly common between spicules. As much as one third of the tract volume may be open interspicular space.

Individual rhizoclones have smooth, rounded shafts approximately 0.02 to 0.03 mm in diameter and 0.3 to 0.4 mm long. Interior spicules have fairly straight shafts but those around canal peripheries are curved. Finger-like zygomes occur regularly along the sides of the shaft and are clearly preserved on some tract exteriors. Zygomes are generally 0.015 to 0.025 mm across at their bases and may be circular or elliptical. They are commonly 0.03 to 0.04 mm long. Some have flaring hand-like tips, but others are somewhat club-like or with moderately pointed or rounded finger-like ends. They occur with moderate regularity along spicule axes and are spaced 0.04 to 0.06 mm apart, centre-to-centre. Spicules may be only lumpy where zygomes are somewhat aborted in the canal area. Some spicules articulate zygome-to-zygome but other zygomes attach to axes of adjacent spicules. Most porous areas in the tracts are produced where articulation is zygome-to-zygome. These types of articulations produce a rather rigid, although open and porous, structure.

*Discussion.* Several Silurian species of *Haplistion* were described by Rigby and Dixon (1979) from nearby Somerset Island out of the somewhat younger Silurian Read Bay Formation. Of these, the small fragment appears most similar to *Haplistion minutum* Rigby and Dixon (1979, p. 598-602). Tracts in the Baillie-Hamilton fragment are essentially the same diameter, and spacing is roughly the same as in *H. minutum.* The skeletal net in *Haplistion minutum* is made of rhizoclones of essentially the same size as those evident in the Baillie-Hamilton specimen. However, dendroclones and possible rare oxeas also occur in *H. minutum.* These two kinds of spicules were not recognized in the Baillie-Hamilton specimen but could have been present because so little of the skeleton is available for investigation.

The skeletal net in *Haplistion cylindricum* Rigby and Dixon (1979, p. 592-598) is somewhat more open textured than in the fragment described here. *Haplistion cylindricum* has openings measuring 0.7 to 1.3 mm across. Tract dimensions of approximately 0.5 mm in diameter are somewhat similar in both occurrences and rhizoclones also appear to be of the same general proportions. However, spicules tentatively identified as smooth oxeas make a central core of tracts in *Haplistion cylindricum* and these spicules are not evident in the small Baillie-Hamilton fragment.

*Haplistion creswelli* (Rigby and Dixon, 1979, p. 602, 603) has radial tracts of essentially the same dimensions as those in the Baillie-Hamilton fragment. Spicule details are not preserved in the calcareous replacement of *Haplistion creswelli.* However, the Baillie-Hamilton fragment is so small that identification at species level is impossible.

The specimen lacks the distinctive bracing dendroclones that are common in *Haplistion frustrum* n. sp., although the skeletal tracts are of similar size and spacing in the two specimens. Elements in the associated *Parodospongia* are distinctly coarser.

*Materials.* The single figured specimen, UA 7698, from Baillie-Hamilton Section 2-84.3 m. An additional questionable fragment was collected from Baillie-Hamilton Section 1-97.1.

### *Haplistion frustrum* n. sp.

Plate 1, figures 1-3, 6

*Diagnosis.* Discoidal to funnel-shaped *Haplistion* whose skeleton is three-dimensional and of subcylindrical tracts of rhizoclones with common cross-bracing dendroclones. Vertical tracts 0.15 to 0.35 mm in diameter spaced approximately 0.5 mm apart. Horizontal tracts 0.2 to 0.4 mm in diameter and 0.6 to 0.9 mm apart. Dermal layer of broad, leaf-like rhizoclones.

*Description.* The species is represented in the collection by an elongate fragment, approximately 27 mm long and 17 mm across. It represents a piece of a flabellate to open, funnel-shaped sponge, with a wall 3.5 to 4.0 mm thick. It has a moderately well defined, dense, basal or dermal layer over part of the structure. The concave surface is interpreted as the gastral layer and it shows the skeleton moderately well. The skeleton is made of tracts of rhizoclones and, somewhat less commonly, dendroclone spicules, arranged in moderately uniform, though not geometrically predictable, patterns around openings of at least two distinct sizes.

The larger canals are 0.8 to 1.2 mm in diameter. They are somewhat irregularly quadrangular to rounded triangular, or some may be moderately round. These openings are formed by mergers of smaller canals that are evident in the interior of the wall, although some of the larger openings extend nearly through the wall.

The smaller canals are more common and are 0.3 to 0.5 mm in diameter, most being approximately 0.4 mm across. Some of these are distinctly circular in cross-section, but others are irregularly rounded, polygonal to triangular. These are the most abundant canals in the very porous walls and generally surround the larger openings. It is the smaller series that develops into the larger openings as they are traced parallel to the prominent radial tracts through the wall. Individual openings are not aligned in any general pattern, other than being moderately uniformly spaced over the entire surface of the sponge.

Canals are generally defined as subparallel openings between 4 to 8 tracts, which extend virtually continuously as prominent elements through the wall. These tracts are generally subcylindrical and are spaced 0.4 to 0.5 mm apart, centre-to-centre, with considerable regularity. Their spacing and the spacing of horizontal interconnecting tracts define sizes of canals. Radial tracts are cross-braced by horizontal tracts and are approximately normal to radial ones in sections through the wall and make ladder-like series. Vertical or radial tracts are approximately 0.15 to 0.25 mm in thinnest sections, opposite openings within the ladder-like series. Most tracts are 0.17 to 0.20 mm in diameter, but they expand up to 0.30 to 0.35 mm across near their junction with horizontal tracts. Some appear as almost straight rod-like structures, others sweep and curve, or zig-zag, vertically on a segment by segment basis, where individual segments are traced from junction to junction. The tracts are made of closely spaced spicules, with numbers of spicules varying with diameters of tracts.

Horizontal tracts are of more irregular size and spacing than radial or vertical ones. Many horizontal cross-connecting elements are single spicules, either dendroclones or rhizoclones. Horizontal tracts measure up to 0.4 mm in diameter, although most are approximately 0.2 to 0.3 mm in diameter. They also are composed of subparallel spicules. Spicules curve around tract margins of canals, to more or less round out what otherwise would be rectangular or polygonal openings. Horizontal elements are essentially subparallel to the gastral and dermal surfaces. They are spaced 0.6 to 0.9 mm apart, such that there are five or six in 4 mm measured through the wall. They range from moderately robust tracts, however, to single spicules. There are no uniform levels in the skeleton where the tracts extend as a floor-like structure, but they are moderately uniformly spaced within almost ladder-like series between two parallel radial or vertical tracts.

Horizontal openings separate tracts in the ladder-like structure. These pores occur between horizontal elements and are generally 0.3 to 0.5 mm in diameter. Larger openings tend to be circular but smaller ones tend to be elliptical. Small openings are often bounded by single spicule elements in the ladder-like structure.

The most conspicuous spicules at first glance are the long, smooth, isolated dendroclones that extend from vertical tract to tract. These spicules have smooth shafts and radiate across some openings as distinct single elements. They may define triangular pores, which contrast with round openings made by the more densely spiculed tracts. Dendroclones generally have smooth shafts 0.035 to 0.040 mm in diameter, at their narrowest point and about midshaft. Shafts range 0.20 to 0.25 mm long, where most well developed. Cladomes and brachyomes normally are lost because these spicule tips interdigitate with rhizoclones in tract interiors. Diameters of cladome shafts are generally 0.03 to 0.04 mm. They expand abruptly into the root-like, or digitate to hand-like, articulating zygomes at the tips. These sometimes expand to flower-like elements with central structures 0.06 to 0.08 mm in diameter in the cladomes. From these radiate numerous irregular, finger-like, toe-like or branching zygomes that are generally 0.01 to 0.015 mm in diameter and that may be up to 0.03 mm long. These complex terminations interdigitate with those of other dendroclones and rhizoclones to produce the solidly fused skeletal tracts.

Although dendroclones are the more impressive spicules, at first glance, nonetheless the skeleton is made principally of rhizoclones. These are firmly fused to one another by digitate zygomes that occur on spicule tips and along shafts. Isolated rhizoclones may be up to 0.35 to 0.40 mm long and have average shaft diameters of 0.025 to 0.040 mm. In general, these are sculptured with round nodes, or in some instances steeply conical or pyramidal elements or with branching finger-like zygomes. Nodes are approximately 0.005 to 0.010 mm high, are rounded or conical, and have basal diameters of approximately 0.008 to 0.010 mm. Where zygomes are digitate or branching, they have basically the same diameter but may be two or three times as long. Some also have nailhead- or rivethead-like irregular terminations at their tips, but most spicules have nodes and cones. These elements are moderately regularly spaced along the spicules, commonly in four or five irregular rows. Others may be even more widely spaced, so that there is almost a complete gradation from smooth-shafted dendroclones to the complexly sculptured isolated rhizoclones. Generally speaking, zygomes are moderately regularly spaced 0.015 to 0.025 mm apart along the spicules.

Rhizoclones in tracts appear to be of essentially the same size but may have more complex zygomes than the spicules around the margins of the canals, where the spicules are most evident. Even around canals, however, surfaces are knobby or spinose. As a result, all tracts are moderately nodose, on a scale of 0.010 to 0.015 mm. This results in distinctly sculptured exteriors of tracts in contrast with the smooth tract exteriors in other species of *Haplistion*. Smooth rhizoclones are moderately rare in the overall net. Those that are smooth appear to represent a curved margin of exposure around one of the canal walls.

Horizontal tracts range from single spicules up to ones with 20 or 30 spicules in a cross-section. Most small tracts, 0.10 mm in diameter, are made of four or five rhizoclones, each with a lumpy exterior.

A localized dermal or basal layer occurs on part of the fragment. It is a dense thin layer, essentially lacking pores except along margins of growth or silicification. The dermal layer is made of broad, leaf-like, rhizoclones that have petal-like zygomes, rather than ones with circular cross-sections. These tend to be moderately irregularly and complexly branching, more than in any other skeleton zone. These zygomes surround small pores, 0.015 to 0.020 mm in diameter, where spicules are first developed along the expanding edge of the dermal layer. These pores are filled as individual elements of a spicule expand, or they are filled in by subsequent layers of additional rhizoclones that thicken up the layer or mat of the dermal layer.

The dermal layer is marked by annulate growth lines, spaced 0.5 to 1.0 mm apart. Such annuli are most pronounced where the mat is thickest, up to 0.15 mm thick. Pores are most evident in the dermal layer where that layer is less than 0.05 mm thick. This dermal layer covers only a very small part of the sponge along one margin of the fragment.

A somewhat more massively infilled part of the sponge is well developed on what may be the gastral part of the sponge. Canals are filled with botryoidal silica (chalcedony) that appears distinctly secondary. Spicules are locally preserved in great detail around margins of canals that are preserved in the dense infilling. The botryoidal silica appears principally to fill canals and for this reason is thought to be secondary rather than a thickening of individual skeletal elements in the dermal layer.

No oxeas are evident as coring spicules anywhere on the sponge.

*Discussion.* The species appears to be moderately distinctive, based on growth form and the intergrowth of isolated single dendroclones and tracts of rhizoclones. At first glance, the sponge appears to have much in common with *Boonderooia* Rigby and Webby (1988, p. 25-27) from the Ordovician of New South Wales. However, *Boonderooia* has tract axes cored by oxeas that occasionally protrude and produce the diadem-like structure typical of that genus. *Boonderooia* also lacks the prominent isolated dendroclones.

Perhaps the most similar species is *Haplistion regularis* Rigby and Webby (1988, p. 16-18) from New South Wales. It, too, is a massive, moderately sheet-like sponge in which the principal skeletal elements are strong, subcylindrical, vertical tracts that are cross-connected by horizontal ones, in addition to distinctive, pin-like, single dendroclones. However, overall texture of the Australian species is somewhat coarser and the number of single cross-bracing dendroclones is considerably less. Tracts in *H. regularis* are made of considerably greater numbers of spicules, for up to 200 spicules may occur in cross-sections of vertical tracts in the Australian species.

The Silurian *Haplistion minutum* Rigby and Dixon (1979, p. 598-602), from Cornwallis Island, is similar in having long spicules as isolated, cross-connecting elements between the coarse radial and vertical tracts. However, *Haplistion minutum* has tracts that are only one-half the dimensions of those in the Baillie Hamilton species. In addition, *Haplistion minutum* and *H. regularis* both appear to be massive or lobate species, in contrast with the moderately sheet-like structure of the Baillie-Hamilton species.

*Etymology.* Latin, *frustrum*, bit, piece, scrap, because only fragments of the distinctive sponge are known.

*Type specimen.* Holotype, UA 7736, Baillie-Hamilton Island, collected by Zhang Ning, Oregon State University, in 1985, from his locality 402Y from the Cape Phillips Formation (~Baillie-Hamilton Section 1-120 m).

### Genus *Parodospongia* n. gen.

*Diagnosis.* Thin-walled, cup- or bowl-shaped rhizomorine sponge with skeleton of tracts of rhizoclones. Tracts become distinctly blade-like in the middle and gastral part of the wall and form moderately well-differentiated, anastomosing and upward-oriented elements around canals that enter the wall essentially horizontally and then rise steeply to the gastral margin. The deep spongocoel penetrates to near the base. Tracts of loosely spaced, small rhizoclones are moderately subparallel to tract axes and produce irregular ragged tract surfaces.

*Discussion.* Among early and middle Paleozoic sponges, with which *Parodospongia* might be confused, are some of the thin-walled rhizomorine and helomorine sponges. *Eochaunactis* (Rigby and Dixon, 1979, p. 604-608, Textfigs. 8, 9) is a bladed to flabellate form that has been reported from the Silurian Read Bay Formation on Somerset Island. It, however, has a much more regular skeleton than the moderately irregular anastomosing structure of *Parodospongia*. It does have bladed elements within the skeleton, somewhat like those in *Parodospongia*, but they are made of heloclones rather than the very spinose-appearing rhizoclones of the present genus.

Several Silurian species of *Haplistion* (Rigby and Dixon, 1979, p. 592-603) have spicules that are very similar to those in *Parodospongia* but the *Haplistion* species described from Sommerset Island have distinctly different growth forms. Some of the species are massive and others are cylindrical. In addition, their skeletal tracts tend to be subcylindrical rather than like the distinctive bladed features of the Baillie-Hamilton species.

Among Ordovician rhizomorine forms described from Australia (Rigby and Webby, 1988, p. 18-21), *Warrigalia* has a skeleton made of rhizoclones of essentially the same shape and size as those in the Baillie-Hamilton sponges, and has moderately thin, open vase-shaped forms with anastomosing tracts that may be somewhat ribbon-like. However, the skeleton of *Warrigalia* is well organized, with the tract ribbons forming a three-dimensional elliptical series of openings in a considerably more open-textured and well organized skeleton than that developed in *Parodospongia*.

*Taplowia* from the Ordovician of Australia (Rigby and Webby, 1988, p. 21, 22) is a stromatoporoid-like genus with well organized, horizontal, and vertical skeletal elements in a moderately massive, obconical, growth form distinctly different from *Parodospongia*. *Boonderooia*, also from Australia (Rigby and Webby, 1988, p. 25-27), is known only from fragmental material but probably was an open, bowl-shaped or obconical sponge. It, too, has moderately bladed tracts, although its skeleton is made principally of subcylindrical tracts that are cored with oxeas, which project in spinose or needle-like fashion from ray junctions in a skeletal pattern quite distinct from that of *Parodospongia*. Such coring oxeas are not known in the tracts of *Parodospongia*.

*Etymology.* Greek, *parodos*, byway or side entrance; *spongia*, sponge; referring to the moderately porous walls of the sponge.

### *Parodospongia euhydra* n. sp.

Plate 1, figures 4, 5, 8

*Diagnosis.* Moderately small, vase-shaped, rhizomorine sponge with a deep, simple, spongocoel that penetrates to near the base, surrounded by thin walls three to five mm thick, perforated by irregular canals, 0.6 to 2.5 mm in diameter in the gastral layer and 0.5 to 1.5 mm in the dermal layer. Dermal part of canals are horizontal to the midwall and then swing abruptly upward to meet the gastral surface at an acute angle. Tracts made of irregular ragged rhizoclones, with shafts up to 0.3 mm long, loosely packed to produce irregular, ragged blades and tracts, 0.4 to 0.5 mm across and up to 2 mm high, measured radially.

*Description.* A single specimen, the holotype, is in the collection. It is a flattened partial sponge showing both an upper and lower flattened wall in the lower 20 mm of the specimen but only the lower wall in the upper 30 mm. The sponge is obconical and curves upward from a moderately complete but ragged base, 14 to 15 mm across as now preserved. It expands upward to approximately 20 to 21 mm across, 20 mm above the base, and to a broken flattened width of 30 mm at about 40 mm above the base, above which the fragment narrows with ragged torn walls.

A spongocoel apparently penetrates from the oscular margin to near the base, as a smooth simple opening. It is now shown only by a thin, silty filling, approximately 0.5 mm thick, in the lower part of the specimen.

The walls are 3 to 5 mm thick, except near the base where they are only 1 to 2 mm thick. They are smooth, without wrinkles or horizontal annuli, but are marked by moderately coarse openings of canals that pierce the wall.

In general, canals penetrate straight into the midwall from the dermal layer, essentially normal to the dermal surface, then flex upward sharply in the inner or gastral half, to meet the spongocoel margin at acute angles of approximately 45° to 60°. Ostia on the exterior range from moderately small circular openings, 0.5 to 0.6 mm in diameter, up to the larger canals, 1.2 to 1.5 mm across. The larger openings tend to be subcircular to rounded, irregularly quadrate, or irregularly elongate where two or three of the smaller canals are not separated by tracts but have merged to produce a common opening. The latter tend to be vertically elongate, with some irregularity. Openings in the lower one third of the sponge tend to be more prominently normal to the dermal surface and more nearly circular, whereas those in the upper part become more vertically elongate. Some become almost slit-like to distinctly vertically elliptical. The larger openings in the lower part of the sponge are spaced seven to eight openings a centimetre, as measured horizontally, but only six to seven openings a centimetre in the upper one third, where average openings are larger and the smaller series of canals is less extensively developed.

Canals of the gastral surface appear to be in gradational series, with most of the smaller circular openings approximately 0.6 to 0.7 mm in diameter. Ostia in vertical series expand to circular or rounded subquadrate openings 1.0 to 1.2 mm in diameter, then to largest openings in the sponge wall, approximately 2.0 to 2.5 mm in diameter. The latter are circular to distinctly vertically elongate and, where circular, extend virtually normal to the gastral margin. Most of the openings, however, appear vertically elongate because the canals rise upward and inward toward the spongocoel. The large openings are spaced four to nine in one centimetre, as measured horizontally. They are separated by single spicules or bladed tracts that are approximately 0.4 to 0.5 mm across, or by several tracts or blades that combined, may be up to 1.5 mm across, where two or three tracts are subparallel and have merged to produce the somewhat rounded lower wall of the inward and upward converging canals.

The skeleton is made of a series of subcylindrical tracts, 0.5 to 0.6 mm in general diameter, that diverge upward and outward essentially from the middle of the wall. These are cross-connected, irregularly horizontally, by tracts of similar size. In the interior of the wall and in much of the gastral part of the wall, tracts become radially elongate to produce irregular blades, 1.5 to 2.0 mm high and generally 0.3 to 0.4 mm wide, ranging up to 0.6 mm thick. These appear as short fin-like blades, which are crudely anastomosing vertically in the gastral part of the wall, but are almost vertical in the dermal part of the wall. These blades produce short discontinuous segments that may be variously oriented. They are most pronounced in the gastral part of the wall, where they commonly result from merging of two or three of the subcylindrical tracts and produce distinctly curved plates that outline the lower part of the upward-converging canals.

Both dermal and gastral layers are characterized by irregularity and by short tract segments. The gastral wall has more irregularly curved or sweeping to anastomosing longer tracts and blades along elongate elliptical canals. They appear as arched ribbons over the lower margins of canals or as broad segments, when viewed normal to the gastral surface, but as outlining distinctly circular canals when viewed from above, diagonal to the oscular margin. The blades are commonly connected by short radial tracts that have circular to slightly elliptical cross-sections.

Spicules of the skeleton are all very spinose rhizoclones. These spicules are approximately 0.2 mm long and have shafts 0.015 to 0.020 mm in diameter. They are irregularly curved to straight and moderately branched. Generally speaking, shafts end in both directions in branching zygome tips. Zygomes occur along the shaft with moderate regularity, spaced generally 0.02 to 0.04 mm apart. Zygomes are up to 0.03 to 0.04 mm long and range from slight nodes to distinct branches that are up to 0.02 mm in diameter and that have irregular secondarily branched tips. Some of the small nodes are subhemispherical or conical; some have weakly expanded heads and others have branched tips. The spicules articulate generally zygome to shaft, although some instances of zygome to zygome articulation occur. Spacing is such that there is considerable interspicule porosity. Up to one-third of the tract volume is made of pore spaces, with openings approximately 0.02 to 0.04 mm in diameter.

*Discussion.* Comparisons of genera and species of sponges with which the present species might be confused have been presented in discussions of the new genus, above.

*Etymology.* Greek, *euhydra*, well watered; referring to the open canals and the obvious ease of circulation of water through the porous skeleton.

*Type material.* Holotype, UA 7699, from Baillie-Hamilton Island Section 2-97.1 m.

### Suborder ORCHOCLADINA Rauff, 1895 (nom. trans., Reid)

### Family ANTHASPIDELLIDAE Miller, 1889

### Genus *Archaeoscyphia* Hinde, 1889

*Archaeoscyphia minganensis* (Billings, 1859), the type species of the genus, was one of the first fossil sponges described from North America. It was named from Ordovician rocks in the Mingan Islands, along the north shore of the Gulf of St. Lawrence. Billings initially included these fossils in *Archaeocyathus* because of their pronounced radiate pattern and strong similarity to archaeocyathans found elsewhere in lowermost Paleozoic rocks of Eastern Canada. However, once the spicule nature of the skeleton was established, it became evident that the fossils should be included in the Porifera. *Archaeoscyphia* has a broad geographic distribution and has been reported as part of every major Ordovician sponge fauna worldwide. However, recognition that the genus persists up into the Silurian is new here.

*Type species. Archaeocyathus minganensis* Billings, 1859.

### *Archaeoscyphia minganensis* (Billings, 1859)

Plate 2, figures 1, 2;
Plate 3, figures 1, 2

(For a complete synonymy to 1985, see Rigby and Webby, 1988)

*Petraia minganensis*, Billings, 1859, v. 4, art. 27, p. 346.

*Archaeocyathus minganensis*, Billings, 1861, v. 21, p. 5.

*Ethmophyllum minganensis*, Walcott, 1886, Pl. 77, figs. 6-8.

*Archaeoscyphia minganensis*, Hinde, 1889, v. 45, p. 143, Pl. 5, figs. 12-14; Rauff, 1894, v. 40, Pl. 1, figs. 1-10; DeLaubenfels, 1955, v. E., p. E53-E54, figs. 34.3a, 34.3b; Rigby and Webby, 1988, p. 29-31, Pl. 8, figs. 1-6.

*Diagnosis.* Annulate medium to large tubular sponge with smooth conical to subcylindrical spongocoel; skeleton typically anthaspidellid composed of dendroclones that unite at ray tips to produce the characteristic trabs, with a surface of pinnation at mid-wall to gastral side of the wall. Wall perforated by three series of canals, the largest of which are the vertically stacked radial series that arch upward both from the gastral and dermal margins and produce a marked radial appearance in cross-section. Somewhat smaller canals are subvertical and arch upward and outward parallel to trabs; these are interconnected by smaller canals. A thin dermal layer occurs, particularly on annulations; gastral layer is not differentiated.

*Description.* Five, nearly complete, small specimens and one additional large specimen represent the species. The nearly complete specimens are annnulate, obconical to conical-cylindrical forms ranging up to approximately 11 cm high. One nearly complete specimen is 53 mm high from the base up to a round, nearly complete, oscular margin. The latter sponge expands upward from a base 15 mm across to a maximum diameter of 37 to 38 mm in the two upper annuli (Pl. 2, fig. 1), but a large specimen is up to 55 mm in diameter (Pl. 3, fig. 2).

Exterior annuli are irregular and 6 to 12 mm high. They are rounded and separated by somewhat less rounded indentations that are 3 to 5 mm deep below annular crests.

The sponge is pierced by a simple tubular spongocoel with a smooth even gastral surface that does not reflect the annulations. The spongocoel expands upward from a basal circular opening, approximately 3 mm in diameter, up to approximately 15 mm across at the rounded oscular rim in the smaller specimen (UA 7700) and 25 mm across in the larger one (UA 7701).

Walls range from 6 mm thick at the base up to 7 to 8 mm thick at the osculum in the smaller sponge, but may be up to 19 mm thick through some of the annulations in the larger one (Pl. 3, fig. 1).

The canal system consists of three series. Large, upward arcuate, subhorizontal, radial canals pierce the wall. Ostia on the exterior are approximately 0.4 to 0.5 mm in diameter. Canals in the interior are somewhat larger, 0.5 to 0.6 mm across, and up to 0.6 to 0.7 mm high where elliptical. Large openings are moderately irregularly spaced in the outer part of the wall but occur in vertically stacked rows in the intermediate and gastral parts. Gastral ostia are 0.6 to 0.7 mm wide, where circular, and up to 1.0 to 1.4 mm high where elliptical. They occur six to seven a millimetre in vertical rows with eight or nine rows a centimetre, horizontally, in the upper part of the wall. Gastral ostia are separated by 0.5 to 0.7 mm of skeletal material, vertically, and by 0.4 to 0.5 mm of skeleton, horizontally.

Canals of a second series are approximately normal to the horizontal radial ones and are also 0.4 to 0.5 mm in diameter. These canals are parallel to the trabs and have sharp angular junctions with the radial horizontal series. The second series also occurs in tracts between the radiating canals.

Smaller canals, 0.2 to 0.3 mm in diameter, occur between the two larger series and serve to interconnect them and the skeletal pores. These smaller canals are approximately parallel to the trabs and are continuous virtually through the full wall.

Essentially triangular skeletal pores are the same size as the small canals but are outlined by three trabs or spicule series, and are not circular.

Ostia of larger canals, 0.4 to 0.5 mm across, are more common on upper shoulders of annulations and those 0.2 to 0.3 mm across and the skeletal pores are more common on lower flanks, as a function of arcuate growth of the skeleton.

The skeleton is upward and outward pinnate, characteristic of the anthaspidellids (Pl. 2, fig. 2), and is made of smooth, long-shafted dendroclones, like those shown in Plate 3, figures 4 to 6. Endosomal trabs are generally 0.18 to 0.20 mm in diameter. Where best preserved, they are porous, almost hollow structures, with openings 0.01 to 0.02 mm in diameter between the zygomes that unite to form the trabs. Openings along axes of several trabs may have been produced by solution of monaxial coring spicules, but it is impossible to be certain. The zygomes certainly surround a continuous central opening in interior trabs of the skeleton but that opening may be the impression of an organic fibre.

Dendroclone shafts are 0.3 to 0.4 mm long in the interior of the wall. They are approximately 0.05 to 0.06 mm in diameter at their thinnest and thicken to 0.10 mm across near brachyome and cladome tips. The brachyome is hand-like with finger-like zygomes that are 0.01 to 0.02 mm across and perhaps two or three times that long. Clads are approximately 0.04 to 0.05 mm in diameter and may be approximately that long in normal dendroclones. Clads also terminate in finger- or toe-like, blunt, zygomes. Y-shaped spicules in the skeleton have clads and shafts 0.06 to 0.08 mm in diameter and up to 0.10 mm long. They also have blunt or stubby zygomes.

Gastral trabs are considerably smaller, 0.10 to 0.12 mm in diameter, and there are four in one millimetre, horizontally, which is approximately twice the packing of the dermal layer. Spaces between gastral trabs are approximately 0.18 to 0.20 mm across and connect dendroclones only half the size of typical endosomal spicules. Some appear more robust because diameters are essentially the same.

Trabs diverge upward and outward in a smooth arc from the gastral margin to meet upper surfaces of annulations at almost 90°. Trabs locally flex sharply downward in lower parts of annulations to meet that outer surface also at 90°. Some trabs may be subparallel to surfaces of indentations between ridges.

There is no significant dermal layer, although details of the outer part of the sponge are largely lost due to intensive silicification.

*Discussion.* The sponges treated here are significantly smaller than type specimens from the Mingan Islands area (Billings, 1859, 1865; Twenhofel, 1938, p. 34). General canal and skeletal patterns are similar, although dimensions of the skeleton may be somewhat different. Similarly, the dimensions of canals and skeletal elements are smaller in the Cornwallis Island specimen than in a large fragment of the species from Australia. There may be some ontogenetic increase in dimensions within a sponge. This would allow larger canals and spicules in upper parts of the large specimens that may be several times the size of the specimen described here.

The species is differentiated from less annulate sponges of the collection by growth form and sharp contrasts in size of openings in the skeleton. Ostia on the gastral surface are two to three times the size of ostia on related forms, even on the same block, which allows their ready differentiation.

*Type material.* The small figured specimen, UA 7700, is nearly complete and is found on block CAR 1-44.5, along with several other sponges from Cornwallis Island on block 1. A small fragment identified by its distinctive large excurrent openings in the gastral margin occurs at the same locality, but on block 2. The large specimen, UA 7701, is from Baillie-Hamilton Island Section 1-172, as is UA 7702, a smaller near-basal specimen.

### Genus *Antrospongia* n. gen.

*Diagnosis.* Thin-walled obconical sponge with deep simple spongocoel whose gastral margins are perforated by large conical pits into which excurrent canals empty. Incurrent system of large conical openings bridged with an irregular clustered screen in the dermal area. Middle part of the wall of moderately well oriented anthaspidellid nature, but trabs of dermal and gastral layers have irregular orientation and development. Trabs commonly connected by clusters of subparallel dendroclones that produce the irregular gastral and dermal layers.

*Discussion.* There are numerous moderately thin-walled genera within the Anthaspidellidae. Most of these sponges, however, have relatively well organized skeletons of regular ladder-like series of dendroclones arranged in some upward-and-outward pinnate relationships. None of these have the combined regular distinctive shape, large pits on the gastral margin, bridged incurrent areas and the irregularly cross-connecting tracts of clustered dendroclones. For example, *Psarodictyon* (Raymond and Okulitch, 1940, p. 212-214) may have a general form like *Antrospongia* and fairly large openings on the gastral layer, but *Psarodictyon* has a well developed, regularly radiating skeletal pattern that contrasts sharply with the irregularity of *Antrospongia*. Similarly, *Patellispongia* (Bassler, 1941, p. 97, 98) has a growth form quite similar to the thin-walled *Antrospongia* but has a very regular skeleton. *Anthaspidella* (Ulrich and Everett, 1890, p. 256, 257) may have a conical-cylindrical to open-funnel shape but it, too, has a moderately regular endosomal skeleton. In addition, the gastral layer of *Anthaspidella* is marked by radial astrorhiza-like excurrent canals around oscular mounds, in contrast to the distinct regular pits of *Antrospongia*.

Other genera in the family, such as *Allosaccus* (Raymond and Okulitch, 1940, p. 208-210), *Lissocoelia* (Bassler, 1927, p. 392; 1941 p. 96), *Streptosolen* (Ulrich and Everett, 1890, p. 274) and *Dendroclonella* (Rauff, 1895, p. 242) all have moderately irregular skeletons with poorly organized trabs or lack a regular network of trabs. These genera, however, have growth forms ranging from massive subhemispherical to branching dendroid and all contrast sharply with *Antrospongia* in these significant respects.

*Etymology.* Latin, noun, *antrum*, sinus or cavity; *spongia*, sponge; referring to the large excurrent pits on the gastral surface.

*Type species. Antrospongia aberrans* n. sp.

### *Antrospongia aberrans* n. sp.

Plate 2, figures 3-5, 9

*Diagnosis.* Moderately thin-walled conico-cylindrical sponge, with skeleton of dendroclones clustered into trabs in the endosome interior in a moderately regular pattern, but with irregular trabs in the exterior and gastral part. Gastral surface with moderately large excurrent pits, 2.5 mm across and up to 4 mm deep, arranged in regular vertical and horizontal series spaced approximately 3 mm apart, centre-to-centre. Conical incurrent canals, 1.0 to 1.5 mm across, screened by a dermal layer that is perforated by circular openings, 0.4 to 0.6 mm across, such that three to four such ostia empty into one of the large incurrent funnel-like canals. Trabs of the interior are 0.22 to 0.24 mm in diameter, and moderately regularly spaced 0.2 to 0.4 mm apart. Trabs near the exterior are somewhat smaller and considerably more irregularly oriented. Trabs throughout the skeleton are formed by clusters of subparallel dendroclones rather than uniformly spaced ladder-like spicules.

*Description.* The holotype, UA 7703, is the only known specimen. It is a steeply conical-cylindrical to steeply obconical sponge, approximately 50 mm high, that is flattened and crushed (Pl. 2, figs. 4, 5). It is approximately 34 mm wide, at the maximum width near the oscular margin. The sponge expands upward from a less crushed, somewhat elliptical base, 11 x 15 mm in diameter, in which no spongocoel is evident. Walls are generally 5 to 6 mm thick but are locally up to 7 mm thick. Walls are perforated by principally radial canals, in the outer part, that tend to be parallel to short trabs, but contain large, deep, conical excurrent depressions on the gastral margin. Other than ostia, the exterior of the sponge is smooth or marked by weak annulations.

Major excurrent pits on the gastral surface are conical, circular, to slightly elliptical, openings that are approximately 2.5 mm across and up to 3.5 mm high and 4 mm deep. They have smooth walls that slope inward to a rounded base that is approximately 1 mm in diameter. These openings are arranged in vertical and horizontal rows spaced 3 mm apart centre-to-centre. They are generally separated at the gastral margin by a rounded ridge that is 0.5 to 0.6 mm wide, both horizontally and vertically. Axes of these excurrent pits extend roughly horizontally, straight out into the spongocoel, or extend upward and outward into the spongocoel from approximately the middle of the wall.

Excurrent canals open into the pits, near their base, and other smaller, circular openings also occur on ridges between the pits. These canals are approximately 0.3 to 0.4 mm across and are circular openings in the moderately dense, finely spiculed, gastral layer.

Incurrent canals are also basically conical openings that are approximately 1.0 to 1.5 mm in diameter, beneath the dermal layer. They may be subquadrate or triangular but become circular in cross-section at about midwall where they are approximately 0.3 to 0.5 mm in diameter. In the silicified state of preservation, they have dense impervious margins, but whether this was the original condition or not is uncertain. Incurrent canals are spaced 3 to 4 mm apart, but appear somewhat more irregular than the uniform excurrent openings.

The large funnel-like incurrent canals are screened by a reticulation within the dermal net. This screen is made of subparallel tracts of spicules and contains smaller openings that range from 0.4 to 0.6 mm across, although most are approximately 0.45 to 0.50 mm in diameter. These are the prominent circular ostia that are widely distributed in the dermal layer. Clusters of three or four of these ostia, separated by tracts approximately 0.2 to 0.4 mm wide, have a somewhat triangular cross-section. Clusters are widest at the exterior but narrow down to a round, single canal.

Other canals also perforate the dermal layer in the 1.5 to 2.5 mm of skeletal material between the large clusters. In general, these are short canals, 1 to 3 mm long, that are parallel to the irregular trabs. These canals may bend to meet the large canals in the interior of the wall, but many appear to end blind; they are 0.15 to 0.25 mm in diameter, are circular, and grade in size down to the triangular skeletal pores that are irregularly developed within the skeleton.

The skeleton is a moderately well organized anthaspidellid net in which trabs form the regular large structures of the interior endosomal skeleton (Pl. 2, figs. 3, 9). Trabs, however, become irregular in size, orientation and continuity in both gastral and dermal parts of the endosomal layer and in the thickened dermal layer. Trabs in the interior are 0.22 to 0.24 mm in diameter and 0.2 to 0.4 mm apart, with most approximately 0.20 to 0.24 mm apart where the skeleton is regular. This results in skeletal pores between the trabs being approximately 0.3 mm across.

Trabs are approximately pinnate at about midwall, where the most regular part of the endosomal skeleton is developed. They become highly irregular in the outer and inner 2 mm of the wall, the latter because of deep pitting within the gastral layer. Outer trabs may radiate regularly and meet the exterior almost at right angles, but in the same general area there may be several short horizontal or irregularly steeply inclined segments. Some short trab segments are almost subspherical in the dermal layer, particularly those that have their origins in centres of clusters above the funnel-like incurrent canals.

The trabs are distinctly porous and made of only loosely articulated zygomes of dendroclones and may include some rhizoclones and chiastoclones, as well. Most trabs appear to have at least one third of their volume as interzygome pore space.

Trabs in the dermal layer are spaced 0.1 to 0.2 mm apart and are commonly formed by radiating clusters of dendroclones and related spicules. As many as 20 spicules occur in a dense cluster and produce the compact part of the skeleton. These small segments may be horizontal, variously inclined, or rise directly out of the dermal layer.

Irregular clustering and orientation of dendroclones characterize the skeleton. Dendroclones usually have smooth shafts that may be 0.2 to 0.4 mm long. Most are in the lower part of the range and are moderately robust, with common diameters of 0.04 to 0.05 mm in the narrow part of the shaft. A few spicules may be as small as 0.03 mm across. Shafts expand up to approximately 0.06 to 0.07 mm in diameter, and there are a few rare ones up to 0.08 mm across, where clads diverge. Clads are 0.04 to 0.05 mm across in typical spicules, but may be only 0.05 to 0.08 mm long. Zygomes are typically finger- or toe-like, with rounded tips rather than sharp dendroid terminations. Brachyomes are similar and are approximately 0.08 to 0.10 mm across, parallel to the plane that would include the clads.

Y-, X- and H-shaped dendroclones are also moderately common. They are of the same general robust character and tend to bridge fairly large openings. They may be up to 0.3 to 0.4 mm across tip-to-tip, although most are somewhat smaller. Peculiar T-shaped dendroclones are moderately common in the irregular parts of the skeleton. In these, the shaft is short and the two cladome rays are long. These types of spicules occur along borders of dendroclone clusters where the short brachyome and shaft connect to shafts of adjacent spicules.

The gastral layer is composed of tangentially-arranged dendroclones that are somewhat smaller than those of the normal endosome. The layer generally lacks trabs but spicules are arranged in moderately well organized radial clusters, with tips forming knots approximately 0.1 mm in diameter and spaced 0.2 mm apart. In general, spicules are about half the dimensions of those of the main endosomal net, with diameters of 0.02 to 0.03 mm and ray lengths of generally 0.10 to 0.15 mm. Overall, both dermal and gastral spicules tend to cluster in almost star-shaped, irregularly radiating patterns rather than in ladder-like series.

*Discussion.* Comparisons with related genera have been presented in discussions of the new genus above.

*Etymology.* Latin, *aberrans*, wandering or deviating, referring to the irregular skeleton, particularly of the dermal layer.

*Type material.* Holotype, UA 7703, from Baillie-Hamilton Section 2-84.3.

## Genus *Aulocopium* Oswald, 1847

*Aulocopium* is a mushroom-shaped to subhemispherical stalked sponge with a single deep spongocoel impressed into the generally domed top. Most prominent canals of the skeleton are vertically stacked incurrent canals that have an arcuate upward pattern that appears to mark former upper surfaces of the sponge. A second series includes large vertical canals near the centre of the sponge and others that radiate upward and outward through the wall, generally in tracts between the vertically stacked series. These canals are essentially normal to the upper domed surface. Such sponges are widely reported from Ordovician rocks in northern Europe (i.e., Rauff, 1895, p. 257-267; Van Kempen, 1983, p. 363-378). Regularity of the skeleton is often distinctive. The genus has been reported from Ordovician rocks in the United States but has not been reported before from Silurian rocks of Canada.

*Type species. Aulocopium aurantium* Oswald, 1847.

### *Aulocopium nana* n. sp.

Plate 2, figures 6-8, 10, 11

*Diagnosis.* Small, obconical to open funnel-shaped *Aulocopium* with a central simple spongocoel; canals in alternating series, one parallel and tangent to the upper margin, the other in intercanal spaces roughly at right angles to the upper margin. Skeleton of small trabs, typical of the family, made of moderately small, delicate dendroclones that range from simple long-shafted spicules with small brachyomes and short cladomes to Y-shaped and X- or H-shaped spicules. Principal tangential canals approximately 0.20 mm in diameter and principal large vertical to subvertical canals 0.25 to 0.35 mm in diameter in the large central series and down to smaller more discontinuous openings 0.10 mm across parallel to the larger set.

*Description.* Two small sponges of the species are in the collection. Both are open obconical and pierced by a central simple spongocoel. Both have moderately well defined stalks armoured by a dermal layer and have the upper convex surface moderately open. These nearly complete sponges range from 8 mm to 10-11 mm high and 16 mm in diameter (near the upper crown in the holotype) to 10 x 12 mm in diameter in the paratype.

The spongocoel in the holotype is (Pl. 2, figs. 6, 7) 3.0 to 3.5 mm deep and up to 4.5 x 5.0 mm in diameter at the rounded oscular rim. The spongocoel is somewhat shallower, 2 to 3 mm deep, and narrower, 1.5 x 2.5 mm in diameter, in the paratype. Both openings have moderately rounded bases that are approximately 1 mm in diameter, but details of the lower part of the spongocoel and relationships to canals are obscured by partial matrix fill.

These sponges expand upward from a somewhat annulate stalk that is 6 to 7 mm in diameter and produce a mushroom-like profile, particularly in the paratype which has the most complete base. Annuli that mark the exterior are spaced irregularly 0.5 to 1.5 mm apart, vertically, and wrinkle the dense but thin dermal layer. Wrinkles are approximately 0.5 mm high at maximum height.

The dermal layer lacks pores where completely preserved but is minutely porous where only the inner part is silicified, where rhizoclones or branching arborescent dendroclone ray tips are best preserved. The dermal layer is made principally of tangential elements that are distinctly arborescent and branching. These elements could be complex zygomes of radially-arranged dendroclones or branching small rhizoclones. It is impossible to be certain because of the preservation. Both kinds of spicules could be present.

Generally speaking, major elements in the dermal layer are approximately 0.02 mm in diameter. A complex of variously sized, small, zygomes or branches diverge from somewhat serpentine or curved spicule axes or larger ray branches. These small branches are 0.01 mm or less in diameter and may be up to 0.02 mm long. They combine to produce small circular pores approximately 0.02 to 0.03 mm in diameter in the inner part of the dermal layer. Where the dermal layer is complete, however, even these small pores are filled by skeletal material.

The canal system consists basically of canals with two major orientations. One set is upwardly arcuate and crudely radial, tangential to the convex upper surface and the other set is approximately normal to this (Pl. 2, fig. 11). Tangential canals form grooves in the upper surface and may be partially roofed. These canals form the stacked upward-convex series and are subparallel in the interior of the sponge where the canals are totally roofed. These canals are 0.20 to 0.28 mm across, with most approximately 0.25 mm wide along much of their length. They may branch radially to maintain a spacing of approximately 1 mm in the outer part of the sponge. They are spaced so that there are two to three in 2 mm measured horizontally around the osculum. These canals may expand up to approximately 0.3 to 0.4 mm across at the gastral margin.

Some radial canals may form oval, vertically elongate, gastral ostia. They measure up to 0.6 mm in height and there are approximately three openings a millimetre vertically, separated by single spicules or tracts 0.10 to 0.20 mm thick. These canals occur in skeletal tracts that are approximately 0.3 to 0.5 mm wide and are separated by one or two spicules from the vertical canals.

Three distinct sizes of canals occur in the subvertical series. The largest of these are 0.25 to 0.35 mm in diameter, and are distinctly circular. Most are approximately 0.3 mm across, and are spaced 2 or 3 mm apart, radially, in an aligned series, as seen on the oscular margin. There are three to four in 4 $mm^2$ on that surface.

Intermediate-size canals are approximately 0.15 to 0.20 mm in diameter. These are more common than the larger openings and are subparallel to that subvertical series. There are five to six in 4 $mm^2$ and they may alternate with the coarse canals or occur as somewhat irregularly placed canals in the general skeleton net.

The third and most common of the subvertical upward fan-like series are small openings 0.10 mm in diameter. These are circular and interrupt the ladder-like skeleton, but are probably discontinuous. They appear to interconnect the larger vertical series and tangential radial canals in the interior of the skeleton. There are approximately 15 of these smaller openings every 4 $mm^2$, although they have considerable irregularity.

The entire canal structure produces alternating radial panels of stacked subhorizontal canals and panels of essentially vertical canals. The latter canals are nearly parallel to the spongocoel margin but swing upward and outward, essentially normal to the upper surface, so that outer canals may be as much as 30° to 40° from the vertical, virtually parallel to the lower dermal layer.

Trabs in the interior of the sponge are comparatively small (Pl. 2, fig. 10), approximately 0.06 to 0.08 mm in diameter, are somewhat irregular, and are distinctly porous where best preserved. They are generally spaced 0.14 to 0.18 mm apart, centre-to-centre, and are cross-connected by horizontal rung-like dendroclones, typical of the family.

Trabs may be cored by one or two small oxeas per cross-section, but these spicules are rare. They are largely moulds 0.015 to 0.020 mm in diameter along the axes of trabs. Well-preserved oxeas, 0.015 mm across, have zygomes of dendroclones wrapped around them.

Most common dendroclones have smooth shafts that are long and subcylindrical. Most are approximately 0.02 mm in diameter, but may range 0.015 to 0.022 mm in diameter in the narrower parts. They increase to approximately 0.04 mm across in areas where the cladomes diverge to produce the articulating elements.

H- and X-shaped dendroclones also occur. All of the latter spicules have cladomes 0.016 to 0.025 mm in diameter that are approximately equal to or slightly smaller than principal spicule shafts. Rays of Y-shaped forms may be up to 0.10 to 0.14 mm long, a fairly large spicule for the skeletal structure. Clads of similar lengths occur in H- and X-shaped spicules, but have considerably shorter shafts. Their shafts are essentially 0.02 mm in diameter. The skeletal net is not well organized nor regularly ladder-like because of the common occurrence of spicules other than the long-shafted dendroclones.

Details of spicule articulation are largely obscured but a few areas of delicate silicification show hand-like to arborescent zygomes at brachyome and cladome tips. Zygomes may be only 0.02 mm in maximum diameter and abruptly thin to elements far less than 0.01 mm across and long. The structure of the skeleton tends to be fairly open, only moderately regular, and fine-textured.

*Discussion.* *Aulocopium nana* n. sp. has the characteristic shape of the genus but is one of its most fine-textured species. It contrasts, for example, with specimens of *Aulocopium aurantium* Oswald, 1850, from the Ordovician of Australia (Rigby and Webby, 1988, p. 31, 32; Pl. 8, figs. 7, 8; Pl. 9, figs. 1-5) in being consistently finer-textured and with smaller canals, although the general patterns are essentially the same.

*Aulocopium nana* n. sp. contrasts with the two species of associated *Dunhillia* in having a distinctly different canal system, in which major subvertical upward radiating canals are prominent elements rather than minor elements. *Aulocopium* also has stacked ostia as well.

*Somersetella* (Rigby and Dixon, 1979, p. 618) lacks the prominent vertical canals, although the radial series and the general skeletal structure may be quite similar. *Dunhillia* (Rigby and Webby, 1988) has a distinctly different dermal structure where oval tile-like elements form the moderately thick dermal layer in contrast with the decidedly arborescent dense structures in *Aulocopium* and *Somersetella*.

*Etymology.* Latin noun, fem., *nana*, dwarf, referring to the small size and fine texture of the skeleton and canal system of the species.

*Type material.* Holotype, UA 7704, and paratype, UA 7705, both from Baillie-Hamilton Island Section 2-84.3.

### Genus *Calycocoelia* Bassler, 1941

### *Calycocoelia micropora* n. sp.

Plate 7, figures 5, 6

*Diagnosis.* Moderately large conical-cylindrical, stalked, to distinctly tubular, thin-walled sponges with a prominent large spongocoel. Exterior smooth, perforated by moderately irregular to vertically-stacked ostia, 0.3 to 0.4 mm in diameter, which open to straight radial canals. Interior canals are in uniform vertical rows. Lower skeleton of moderately coarse, long-shafted, X- and Y-shaped smooth dendroclones; shafts approximately 0.06 to 0.08 mm in diameter and 0.18 mm long. Trabs 0.12 to 0.16 mm in diameter and spaced two to three a millimetre, radially and concentrically. Middle and upper part of skeleton increasingly complex, with smaller trabs, 0.06 to 0.12 mm in diameter and spicules with shafts 0.015 to 0.030 mm in diameter and 0.10 mm long. X-, Y- and T-shaped dendroclones most common as moderately large spicules subdividing skeletal pores and commonly irregularly oriented within the parallel trab system. One or two coring monaxons occur per trab cross-section. Dermal and gastral layer basically one thickened spicule thick of various dendroclones.

*Description.* Conico-cylindrical, stalked to tubular sponges, up to 75 mm tall and 25 mm in diameter, are well represented by numerous fragments. These include specimens with complete upper oscular margins but generally with broken bases. These sponges may curve up to 50° and upper parts tend to be subcylindrical. Walls of the sponges are 4 to 6 mm thick from near the base to the wide oscular margin. Upper walls commonly show weak annulations, particularly in the zone of curvature or in the most mature part of the sponge.

A simple smooth-margined spongocoel penetrates virtually the full length of the sponge. The lower 5 to 10 mm near the base contains an axial cluster of coarse excurrent canals, common in many genera of the family. These are the coarsest canals in the sponge and are 0.6 to 0.8 mm in diameter. The cluster may be 3 to 4 mm across. Marginal canals may be slit-like where they mark the abrupt upward bend of the radial horizontal series into the coarse vertical series. Excurrent axial canals are generally separated by a single ladder-like series of dendroclones, which may be closely spaced to produce well-defined openings.

Canals in the middle and upper part of the sponge lead inward from moderately uniformly, though not obviously vertically nor horizontally-arranged, ostia. Ostia are 0.3 to 0.4 mm across, and locally two to three openings in the dermal layer connect beneath the layer into slightly larger canals. Most ostia, however, feed directly into single radial canals that become remarkably uniformly spaced in the interior. Largest endosomal canals are 0.30 to 0.42 mm across, where most are approximately 0.35 to 0.40 mm in diameter. Circular ones tend to be somewhat smaller and vertically elliptical ones are up to 0.42 mm high. They are characteristically spaced 0.5 to 1.0 mm apart in any vertical row. Vertical rows occur between parallel trabs and may extend virtually the full length of the sponge. Rows occur two or three a millimetre, measured horizontally essentially at midwall. The dermal canals are spaced 0.5 to 1.0 mm apart and appear as straight to gently arched tubes that may be lined by flattened spicules. That lining is 0.04 to 0.05 mm thick and may be well defined and moderately porous, or open and poorly defined.

Smaller parallel canals, 0.20 to 0.30 mm in diameter, occur in the same series or in positions crudely alternating with larger canals, both horizontally and vertically. They are commonly distinctly circular but may be elliptical and 0.20 mm wide and 0.30 mm high. They are spaced like the larger series, but are not as common. Discontinuous openings of essentially the same dimensions may interconnect various radial series.

Openings within spicule rows may connect radial series. They are up to 0.20 mm across and are produced by loss of one or two spicules in the ladder-like series.

Skeletal structure is characteristically anthaspidellid. Trabs are upwardly pinnate from a surface of pinnation approximately 2 mm in from the gastral margin. Trabs inside the surface meet the gastral margin at 15° to 20°. Outer trabs flex sharply to meet the dermal layer at approximately 60° to 70°.

The skeleton of the lower part of the sponge is fairly regular and composed principally of long-shafted, smooth dendroclones with minor, coarse X- and Y-shaped forms too. Spicule makeup increases in complexity, upward, although the canals remain essentially the same. Shafts of coarse spicules in the lower part of the sponge are 0.06 to 0.08 mm in diameter and clads are 0.03 to 0.05 mm in diameter. Clads are particularly evident in X- and Y-shaped dendroclones where they may be approximately 0.18 mm long. They subdivide into arborescent or finger-like tips that may be vertically elongate articulating units, 0.10 to 0.20 mm high, that produce the trabs. Brachyomes may be of the same proportions.

Lower trabs are 0.12 to 0.16 mm in diameter. They are spaced approximately two to three a millimetre whether measured radially or concentrically in the middle part of the sponge wall.

Sizes of spicules generally decrease upward but complexity of the entire skeleton increases. Middle and upper spicules may have shafts only 0.015 to 0.030 mm across, with most simple dendroclone shafts approximately 0.02 mm in diameter. Most of the middle and upper part of the skeleton, however, is made of X-, Y-, or T-shaped spicules in which rays are of small diameter, only 0.01 to 0.02 mm across and only 0.10 mm long. The upper part of the skeleton is made more complex by irregular spacing and orientation of what appears to be two sizes of spicules. Coarser spicules produce most of the trabs and the regular structure of the sponge. Smaller spicules are generally oriented at irregular angles and produce small openings one half to one third the size of the skeletal pores. Some of these smaller spicules may be rhizoclones, although details have been obscured by moderately irregular and ragged silicification.

A few coring oxeas are evident, particularly in the lower and middle parts of the sponge. They are approximately 0.02 mm in diameter and are long, thin, smooth spicules that show only very gentle tapering. One or two spicules occur per cross-section and make up a relatively minor part of the trab. They are rarely preserved in the massive silicification.

The dermal layer of the middle and upper part of the sponge is only one spicule thick and consists of thickened dendroclones. These dendroclones are essentially the same size as the somewhat coarser spicules in the lower part of the sponge where the dermal layer is less well defined. Dermal spicules have shaft diameters of approximately 0.10 mm, but with significant variation.

*Discussion.* Distinctive features of the sponge are its shape, remarkable uniformity in the midwall area and the generally small size of the pores. Perhaps even more diagnostic is the change in character of the skeleton from the relatively coarse, moderately simple, lower part of the sponge into the moderately light spicules with fairly complex shapes in the middle and upper part of the sponge. In the latter respect, the species appears virtually unique among the anthaspidellids.

*Malongullospongia*, from the Ordovician of New South Wales (Rigby and Webby, 1988) has a skeleton where dendroclones may be vertically or irregularly oriented rather than horizontally in normal ladder-like structures. These dendroclones, however, are far from the delicately developed spicules seen in the Cornwallis Island species. In addition, *Malongullospongia* is a massive subhemispherical anthaspidellid that lacks a spongocoel. It also has prominent vertical canals that alternate with radial horizontal ones.

*Somersetella conicula* (Rigby and Dixon, 1979, p. 615-618) lacks a prominent vertical canal series, other than the variously developed skeletal pores between the parallel trabs, and *Somersetella* is a digitate sponge. When *Somersetella* was proposed, (Rigby and Dixon, 1979, p. 614, 615) the very common occurrence of coring oxeas in trabs of the family was not appreciated. In fact, features presumed to be diagnostic of the genus were development of coring oxeas and dermal specialization.

Other subcylindrical or conical-cylindrical sponges with which the species might be confused would include *Calycocoelia typicalis* (Bassler, 1927, p. 392; 1941, p. 96) and the several species of *Nevadocoelia* (Bassler, 1927, p. 392; 1941, p. 94) but none of these Ordovician Nevada species has a differentiated dermal layer and they are consistently coarser-textured than *Calycocoelia micropora* n. sp.

*Calycocoelia micropora* is associated in the Cornwallis Island collection with *Archaeoscyphia annulata* but they are easily differentiated because *Archaeoscyphia* is distinctly annulate and has large ostia on the gastral surface, as well as a fairly coarse skeleton. Where the forms are well preserved, the complexity of skeleton in *Calycocoelia micropora* would also clearly differentiate them.

*Type material.* The holotype, UA 7720, and paratype, UA 7721, came from Cornwallis Island section CAR 1-44.5 on block 1 and three fragments of the species also occur on block 2. Block 1 also includes the holotype of *Cauliculospongia solida* n. sp., specimens of *Archaeoscyphia minganensis* and the holotype of *Perissocoelia* (?) *spinosa* n. sp.

### Genus *Cauliculospongia* n. gen.

*Diagnosis.* Small twig-like branched or unbranched sponge lacking spongocoel, with axis of pinnation along the stem axis. Skeleton of ladder-like series of dendroclones that radiate upward and outward from the axis to meet the dermal surface at 60° to 90°.

*Discussion.* Because of the nature of the skeleton and the necessity of moving water through the sponge, most members of the family have a central or axial opening or at least a series of canals that allow ready egress of water from the centre of the sponge. However, in *Cauliculospongia*, there is no spongocoel or axial cluster of canals, although there may be some vertical canals in various parts of the sponge. Its small size apparently allowed incurrent and excurrent movement of the water through canals and the porous anthaspidellid skeleton. The sponge has about the proportions of many twiggy trepostome bryozoans. Were its spicule-based skeleton not sufficiently well preserved, there could be opportunities for confusion.

Similarly, if the skeleton is not well preserved, *Cauliculospongia* could be confused with *Arborohindia* (Rigby and Webby, 1988). *Arborohindia*, however, has a tricranoclone-based skeleton typical of the Hindiidae rather than a dendroclone-based skeleton as in *Cauliculospongia*.

*Etymology.* Latin, *cauliculus*, small, stemmed; *spongia*, sponge, referring to the twig-like growth of the species.

*Type species.* *Cauliculospongia solida* n. sp.

### *Cauliculospongia solida* n. sp.

Plate 4, figures 1, 2

*Diagnosis.* Small, smooth, twig-like sponges that lack a spongocoel. Skeleton of upward radiating anthaspidellid pattern diverging from a central axis of pinnation. Dermal layer not differentiated. Canals 0.20 mm in diameter at the exterior are subparallel to trabs. A smaller series, 0.10 to 0.12 mm in diameter, also parallels the trabs and grades down into the triangular skeletal pores between adjacent ladder-like series of dendroclones. Spicules long, smooth-shafted dendroclones, with short clads. X- and Y-shaped dendroclones rare.

*Description.* A single, moderately well preserved specimen (Pl. 4, fig. 2) occurs in the collection. It is a stem approximately 14 mm long and with a subcylindrical diameter of 3.2 to 4.0 mm. The stem lacks a spongocoel and has a relatively smooth exterior that appears to lack dermal differentiation.

The skeleton is open-textured and upward radiate about the axis of the sponge, so that pinnation is radial (Pl. 4, fig. 1). Trabs are approximately 0.10 to 0.14 mm in diameter, although they may be as small as 0.06 mm in diameter near their origin along the axis of the sponge. They are of average dimensions approximately 1 mm from the axis along its length. Trabs are spaced four to five a millimetre, near the exterior, measured at right angles to their trends.

The skeleton is interrupted by uniformly circular canals that are 0.18 to 0.22 mm across. These circular openings are generally surrounded by four to six ladder-like series of regular spicules and parallel trabs. They are clearly differentiated in the outer part of the sponge, parallel to the trabs, but lose their identity in the middle third of the stem.

A second smaller series of canals, approximately 0.10 to 0.12 mm in diameter, occurs parallel to the larger ones. These are also round and parallel to the trabs. These canals occur between three or four trabs and are essentially the same size as the triangular skeletal pores.

Cross-sections show rare vertical canals that are approximately 0.2 to 0.4 mm in diameter. They are isolated round openings and are not along the axis. However, they may have functioned as widely scattered excurrent openings.

Dendroclones of the skeleton have long shafts and relatively short clads. Shafts may be 0.02 to 0.03 mm in diameter and up to 0.14 mm long, although most are only approximately 0.10 mm long. Eight to nine rung-like dendroclones occur per mm along a single series.

Openings between spicules tend to be elliptical or rectangular with rounded corners and are approximately 0.08 to 0.10 mm high and wide.

Details of articulation of spicule tips are largely lost in the massive coarse silicification and partial pyritization of the sponge. In a few interior areas, however, cladomes and brachyomes are preserved. Clads tend to be short and stubby, approximately 0.02 to 0.04 mm long and in diameter. Finger-like zygomes occur on both cladome and brachyome ends of spicules. The most dense part of the skeleton is the axial area where trabs are branching from each other and where spicules are relatively short.

Whether trabs were cored by monaxial spicules or not is uncertain because the skeleton is largely replaced by massive, dense silica. Morphological details have been destroyed.

*Discussion.* Comparisons with other twiggy sponges, with which *Cauliculospongia solida* n. sp. might be confused, were presented under discussion of the genus.

*Etymology.* Latin, *solidus*, thick, dense, or firm; referring to the relatively solid stem that lacks a spongocoel.

*Type material.* The holotype, UA 7706, occurs with several other specimens on a large block from Cornwallis Island Section CAR 1-44.5.

### **Genus** *Dunhillia* Rigby and Webby, 1988

*Dunhillia* was based on Ordovician sponges from New South Wales in eastern Australia (Rigby and Webby, 1988). There it is a minute, tubular sponge with an anthaspidellid skeleton and a prominent dermal layer of tile-like flattened rhizoclones or flattened tips of dendroclones that produced the tile-like appearance. The Baillie-Hamilton specimens are included within the genus with some reservations because of moderate differences in the canal system, but those differences are here interpreted as being of specific, rather than generic, significance.

*Type species. Dunhillia tubulara* Rigby and Webby, 1988.

### *Dunhillia fistulosa* n. sp.

Plate 4, figures 3, 8, 10, 11

*Diagnosis.* Moderately large, subcylindrical, weakly annulate *Dunhillia* in which incurrent canals are clustered into subcircular or moderately irregular fields, as principal openings through the dense dermal layer. Pore fields, 2 to 3 mm across and spaced 1 to 3 mm apart, contain 10 to 15 ostia 0.1 to 0.3 mm in diameter. Incurrent canals lead to discontinuous, irregularly developed, horizontal canals in the midwall, or are lost in the open porous skeleton. Excurrent ostia vertically elliptical, 0.16 x 0.25 mm in diameter, in vertical and horizontal series spaced three to four per mm. Skeleton principally of smooth, long-shafted dendroclones with trabs pinnate from the gastral surface and spaced four to five a millimetre internally and at the subdermal surface.

*Description.* Several nearly complete specimens and fragments of the distinctive obconical to steeply cylindrical sponge occur in the collection. The holotype is approximately 35 mm high and 14 to 15 mm in diameter (Pl. 4, figs. 8, 10). The near basal subconical tip of the sponge is preserved on a paratype on the large block. It expands upward from a basal diameter of approximately 2 mm. The basal section, which is broken, does not show the spongocoel and is bent at a moderate angle from the axis of the upper more mature part of the sponge. All but the base of the sponge is perforated by a tubular spongocoel approximately 3.0 to 3.5 mm in diameter. Walls are generally smooth to weakly annulate, with accentuated growth (?) lines that are 1 to 2 mm deep and irregularly 5 to 10 mm apart. They produce a rounded annulate to moderately smooth profile.

The exterior is interrupted by clusters of incurrent canals that form pore fields, which are circular to irregularly elliptical, 2.0 to 2.5 mm high and 2.0 to 3.0 mm wide. The fields are not rimmed but appear as gentle indentations in the surface of the sponge. They are spaced 1.5 to 3.0 mm apart, sometimes occurring in a horizontal ring where six to eight fields occur at one level around the periphery of the sponge. Elsewhere, however, they are more irregularly spaced and appear staggered or to be in alternating series that produce a fairly uniform distribution of openings over the entire sponge. They occur one to three fields per 25 $\text{mm}^2$, with moderate regularity.

Ostia in the pore fields are generally 0.26 to 0.32 mm in diameter, although a few small openings, as small as 0.10 mm across, and a few large ones, up to 0.45 mm across, occur. They are commonly circular, although some may be irregularly elliptical or somewhat triangular where two or three ostia have not been clearly subdivided. Generally speaking, ostia are separated by 0.2 to 0.3 mm of dense skeletal material that forms a sieve-like structure of the field. There is no regular pattern in size distribution nor ostia position within the pore fields, other than a general tendency for small openings to occur near the periphery.

Incurrent canals lead into the interior where they are either lost in the open porous skeletal structure or connect to moderately rare and discontinuous horizontal concentric canals that occur essentially at the midwall, although with much variation. These horizontal canals are circular to vertically elliptical and 0.25 to 0.30 mm across.

Connection of the horizontal ring canals with excurrent ones is less obvious and, in fact, the excurrent canals are only well defined within 1 mm of the gastral surface. On that surface, excurrent ostia are generally 0.16 to 0.18 mm wide and a few may be as much as 0.3 mm high where they occur in vertically stacked series. Within a series, they are commonly separated by a single ladder-like series of spicules, but the vertically aligned rows are separated by dense skeletal material approximately 0.2 mm wide, which is only slightly larger than diameters of single trabs. Excurrent ostia occur three to four a millimetre, whether measured vertically or horizontally on the gastral surface.

Most common openings within the endosome are skeletal pores that are roughly parallel to the trabs. These openings are 0.15 to 0.20 mm across and may be triangular, subprismatic or locally distinctly circular. They occur between ladder-like series of spicules and generally it is into these open pores that other larger structures grade and become discontinuous. Skeletal pores are interconnected by gaps in spicule rows that are circular to sometimes vertically elongate perforations. They open only from pore to pore.

The skeletal structure is moderately uniform and consists principally of ladder-like rows of dendroclones. The trabs are pinnate upward and outward from the gastral margin to the dermal layer (Pl. 4, fig. 3). Innermost trabs are parallel to the gastral surface but outer ones meet the dermal layer at angles of 40° to 50°. Trabs are generally 0.10 to 0.14 mm in diameter and appear fairly uniform throughout their length. They increase by branching, although insertion may also occur. They are spaced so that there are four to five trabs a millimetre, normal to their trends, in the middle and outer parts of the wall. They are made of articulated tips of dendroclones, but details are lost because of fairly coarse silicification. Dendroclones are spaced so that there are six to seven a millimetre where most uniformly spaced in a vertical ladder-like series. However, an uninterrupted section even 1 mm long is rare because of canals or pores.

Generally speaking, the dendroclones have moderately smooth subcylindrical shafts 0.03 to 0.04 mm in diameter and 0.15 to 0.20 mm long. Shafts thicken toward the cladome end of the spicule, but the clads are commonly lost in massive silica. Some spicules are up to 0.06 mm in diameter, but these may have been significantly thickened by the silicification.

In addition to the normal rung-like spicules that make up most of the skeleton, some spicules with long clads or others that are nearly equally three-rayed occur. These have essentially the same diameters as the rung-like spicules and may have shafts and clads approximately 0.08 to 0.10 mm long.

The dermal layer is 0.5 to 1.0 mm thick, as presently silicified. This is an unusually thick dermal layer and probably has been thickened by the moderately coarse silicification. The exterior of the sponge has numerous, hemispherical node-like concentrations of silica that are 0.15 to 0.20 mm across. Some of these may be enlarged tips of trabs but others occur in intertrab spaces. They produce an almost studded or nailhead-like appearance. Details of individual elements are largely destroyed.

There is no differentiated gastral layer.

*Discussion.* The most similar previously described species is *Dunhillia cribrata* (Rigby and Webby, 1988) from the Ordovician of Australia. *Dunhillia cribrata* has clustered ostia in pore fields and has a general skeletal fabric and canal pattern like that considered typical of *D. fistulosa* n. sp. Principal differences are overall sizes of the sponges and sizes of skeletal elements. *Dunhillia fistulosa* n. sp. is considerably larger and more coarsely textured. For example, in *D. fistulosa* n. sp. trabs are spaced such that there are four to five a millimetre, measured at right angles to their trend, in contrast to seven to eight a mm in *D. cribrata*. *D. fistulosa* has six to seven dendroclones a millimetre in a ladder-like series and *D. cribrata* has one to two. Pore fields in *D. cribrata* are generally defined by a distinct rim. In most other respects, the two species appear similar and *D. fistulosa* is considered to have been derived from *D. cribrata* by a general increase in dimensions of the sponge and its skeleton.

*Dunhillia megaporata* n. sp., described here from Ludlovian rocks of Baillie-Hamilton Island, has a dense dermal layer and size and skeletal structure range like *D. fistulosa*, but *D. megaporata* has widely spaced, isolated ostia rather than pore fields of clustered ostia. Only fragments of *D. megaporata* n. sp. occur in the Cornwallis collections but even fragments are so distinctive in their pore distribution that there seems little likelihood of confusion.

*Etymology.* Latin, *fistulosa*, full of holes, named for the distinctly porous pore fields in contrast with the dense dermal areas between.

*Type material.* Holotype, UA 7707, and paratypes UA 7708 and 7709. The types are from the Cape Phillips Formation at Section CAR 1-44.5 on Cornwallis Island.

### *Dunhillia megaporata* n. sp.

Plate 4, figures 4-6, 12, 15, 16

*Diagnosis.* Conico-cylindrical to steeply obconical small sponges with an anthaspidellid skeleton of trabs of ladder-like articulated dendroclones. Tubular spongocoel extends completely through the sponge. Circular to elongate double ostia of incurrent canals moderately uniformly spaced, although in crude vertical rows. Ostia approximately 0.5 mm in diameter lead to radial canals that may completely pierce the wall or extend only approximately halfway into the wall, where they are lost in the coarse skeleton. Vertical subdermal smaller canals, approximately 0.3 mm in diameter, are continuous and may interconnect with radial horizontal incurrent canals. Ostia on the gastral margin small, arranged in regular rows to produce almost septate margins to the spongocoel.

*Description.* The two sponges most representative of the species in the collection (Pl. 4, figs. 4, 5) are steeply obconical, nearly complete specimens that range from 22 up to 26 mm in height and expand upward from bases of 5 to 7 mm in diameter to maximum widths of 9 to 12 mm a short distance below the round oscular rim. The sponges are pierced throughout by a tubular, simple spongocoel that is 1.3 x 1.8 mm in diameter at the base, in both, and that measures up to 3 mm across, where circular, or 3.0 x 3.5 mm across and slightly elliptical in the other. Basal walls are approximately 1.6 to 2.0 mm thick and thicken upward to approximately 2.5 to 3.0 mm thick in the area of greatest diameter at the rounded oscular rim.

Exterior of the sponge is smooth to weakly annulate, marked only by low-mounded rims around incurrent ostia and by weak annulations that apparently mark growth lines. Small mounds around the ostia are up to 0.10 to 0.15 mm high and have a dense rim, 0.1 to 0.3 mm wide. These rims are 0.05 to 0.07 mm thick at their upper edge but thicken to nearly double that at the lower edge of the somewhat volcano-like small mounds. These rims stand sharply out from the tile-like dermal layer that produces the essentially impervious outer wall of the sponge virtually along its full length.

Three patterns of ostia are evident within the little volcano-like rims (Pl. 4, fig. 12). Smallest ones are generally circular and are occupied by single canals that extend into the interior of the wall. These make up to 70 to 80 per cent of dermal openings in the sponge. These ostia are 0.45 to 0.55 mm in diameter, with approximately 60 per cent of these measuring 0.5 mm across.

Less common mounds are those where two canals feed into an elliptical crater-like opening 0.7 to 1.0 mm high and 0.4 to 0.5 mm wide. These canals are separated 0.25 to 0.30 mm by clusters of dendroclones. Mounds that contain two canals are generally vertically elongate, although some are irregularly diagonal and others are rarely horizontally elongate.

Much more rare are those openings where three small circular ostia occur within a somewhat triangular rim. These ostia are as small as 0.3 mm in diameter but may be up to 0.6 mm across, perhaps in the same triangular cluster. These triangular fields or rims are approximately 1.5 to 1.6 mm across on a side and orientations of sides are somewhat irregular.

Dermal ostia also occur in crude vertical rows with approximately four ostia a centimetre, vertically. The rows are 1.0 to 1.5 mm apart, horizontally, with considerable irregularity. Some laterally adjacent openings may be separated only 0.4 to 0.5 mm, rim-to-rim, on the small mounded openings.

The small radial canals continue into the wall with essentially the diameter of ostia at the exterior, at least on those few that can be traced toward the interior, but they may be smaller on the gastral margin. Some of the subdermal small vertical canals appear to be ends of sharply upward or downward flexed branches or terminations of one of the radial series, particularly in those where two dermal ostia occur in one mound.

Ostia on the gastral surface are generally 0.2 to 0.4 mm in diameter although some may be as much as 0.6 mm across. They generally occur in distinct vertical rows that are 0.4 to 0.5 mm apart, centre-to-centre. Two or three rows occur per mm, measured horizontally and vertically. Prominent grooves of aligned ostia produce an almost septate margin to the spongocoel edge.

The dermal layer is dense and generally 0.2 to 0.3 mm thick, although it may be up to 0.6 mm thick locally. It is made of irregularly oval to distinctly lenticular elements that may be flattened rhizoclones or flattened outer ends of dendroclones that terminate radially in the wall rather than into trabs. These oval tile-like elements have mutually accommodating irregular borders. They are generally 0.20 to 0.25 mm across, although some may be significantly larger and some significantly smaller. They are generally separated by narrow porous grooves, 0.02 to 0.04 mm wide. Short zygomes, 0.015 to 0.020 mm in diameter, interconnect between elements and leave small irregular pores 0.02 to 0.03 mm in diameter. Dermal elements may taper or slope down to merge into the small zygomes along the junction area. Outer flat surfaces of dermal elements are marked by clusters of irregularly to distinctly uniformly spaced small spines. These spines are generally 0.008 to 0.010 mm in diameter. Most appear to be moderately circular in cross-section and measure up to 0.02 mm in height, although most are approximately half that high. They are spaced 0.02 to 0.03 mm apart, centre-to-centre, and three to five occur in a line 0.10 mm long. They are not in any predictable geometric pattern, but are spaced fairly uniformly over the surface.

The endosomal skeleton is characteristically anthaspidellid (Pl. 4, figs. 15, 16), with prominent trabs produced by articulation of brachyomes and cladomes of X-, Y-, and markedly elongate, almost I-shaped dendroclones. Trabs are irregular and many appear distinctly porous. They range from 0.08 to 0.12 mm in diameter, with most measuring approximately 0.10 mm across where they are thinnest. Trabs are spaced 0.2 to 0.3 mm apart with fair regularity, except where aborted to produce the canal systems.

Oxeas (?) core the trabs and there are generally one or two in a cross-section. Where most evident, they are 0.02 to 0.03 mm in diameter but could deviate substantially from that. Walls are 15 to 20 trab units thick, as might be suggested by their radial, as well as horizontal, nearly uniform spacing.

Simplest dendroclones of the skeleton are those with long simple, smooth shafts from which diverge two distinct cladomes on one end and a somewhat hand-like brachyome on the other. These spicules are 0.15 to 0.20 mm long, with average shafts approximately 0.04 to 0.05 mm across at their thick ends and 0.02 to 0.03 mm across at their narrow ends, before that narrow end abruptly expands into the brachyome. Cladomes may be relatively short and range upward from 0.02 to 0.03 mm wide. Articulating zygomes may be somewhat finger-like or complexly arborescent. They diverge from two cladome rays that are separated by a distinct arch opposite the end of the shaft. Zygomes may be 0.02 mm or less across and long, although details of the structure are largely lost in the silicification. Details of spicules show only where the entire structure has not been obliterated by silicification.

Y-shaped dendroclones are also common. These commonly bridge or terminate canals. They have clads nearly equal to the shafts and 0.10 to 0.12 mm long, although with considerable variation. These and I-shaped spicules articulate through a series of hand-like or arborescent zygomes or clutch coring oxeas of the trabs. Y-shaped spicules may have vertically elongate zygome areas, and appear somewhat H-shaped in cross-section. These vertical extensions may be up to 0.10 to 0.20 mm high along the general trends of the trabs.

H- or X-shaped dendroclones also occur. They have a thickened central shaft of essentially the same length as in associated dendroclones, but have four subequal clads. In some, the shaft may be up to 0.07 mm in diameter and from it may diverge cladome or brachyome rays 0.04 to 0.05 mm across and up to 0.12 or 0.14 mm long. These have articulating zygome-bearing tips like other dendroclones in the net. These H-shaped spicules span the largest gaps and are the largest spicules in the skeleton. All three kinds of dendroclones are moderately common, although those with short cladome rays are the most common and form the most regular ladder-like part of the skeleton.

A surface of pinnation is irregularly defined near or at the gastral margin. Interior trabs rise almost vertically, parallel to the spongocoel margin, but those in the outer part of the wall diverge upward and outward to meet the dermal layer at moderately low angles (generally 15° or less). Where individual elements of the endosomal skeleton are traced toward the dermal layer, they may expand up to twice their normal diameters for one or two spicules inside the tile-like dermal layer. Unfortunately, skeletal details in this part of the wall are obscured because of thickening and silicification. Thus it is impossible to be certain whether the tile-like elements of the dermal layer are really separate rhizoclone spicules or markedly thickened and flattened brachyome and cladome tips of dendroclones.

*Discussion.* The most similar sponge is *Dunhillia multiporata* Rigby and Webby (1988) from the Upper Ordovician of New South Wales, Australia. Both have the same general growth form and both have a dense dermal layer perforated by somewhat gently mounded ostia. *Dunhillia multiporata*, however, is a smaller, more twiggy-appearing form and has exterior ostia only approximately 0.20 mm in diameter, which is considerably smaller than openings in the Baillie-Hamilton species. Ostia in *D. multiporata* also have constricting spicular rings made of smooth rhizoclones inset from the dermal surface. Such constricting elements are not evident in *D. megaporata* n. sp. The small, vertical, subdermal canals of *D. megaporata* were not noted in the Australian forms, but separation of the species is based essentially on sizes of individual elements in the canal system.

*Brianispongia quadratipora* (Pickett and Rigby, 1983, p. 727, 728, Fig. 2b-s) is also a subcylindrical form with an anthaspidellid skeleton and a dense dermal layer. However, *Brianispongia* lacks a prominent spongocoel, although it does have an open, spicular fabric in the interior that probably functioned as an excurrent area. Incurrent ostia in the dermal layer of *Brianispongia* occur in clusters of four, in nearly square openings, which contrasts with the simpler pattern in *D. megaporata*.

Most other species of the family lack the prominent dermal layer and, as a consequence, are moderately easily differentiated since this would be one of the most consistently preserved parts of the skeleton. *Finksella* (Rigby and Dixon, 1979, p. 620-622) has a distinct dermal layer but that layer is made of spicules essentially like those in the internal part of the skeleton, except they are somewhat more robust. In addition, they have their long axes at a tangent to the dermal surface rather than at right angles, as was apparently the case in *Dunhillia*. *Finksella* is a turbinate to low conical sponge and so contrasts in shape as well.

*Etymology.* Latin, *mega*, large; *porata*, pore bearing, referring to the moderately large pores that pierce the dense dermal layer.

*Type material.* The holotype, UA 7710, and paratype, UA 7711 came from Baillie-Hamilton Section 2-84.3. One additional reference specimen came from Cornwallis Island, Section 1-44.5.

### *Dunhillia pluraliporosa* n. sp.

Plate 4, figures 7, 9, 13, 14;
Figure 4A, B

*Diagnosis.* Conicocylindrical to obconical *Dunhillia* with numerous circular ostia approximately 0.24 to 0.30 mm in diameter that pierce the dense dermal layer made of irregularly lenticular, thin, tile-like spinose rhizoclones. Ostia gently rounded. Skeleton typically anthaspidellid with trabs 0.10 to 0.16 mm in diameter and spaced 0.2 mm apart. Skeleton of regular, long-shafted, smooth, dendroclones that are I-, Y-, and X-shaped with shafts approximately 0.04 mm in diameter. Radial canals apparently penetrate completely through the wall or are lost at about midwall; midwall canals ill-defined. Small, discontinuous, vertical canals interconnect the radial series.

*Description.* The holotype, UA 7712, is a nearly complete lower part of a sponge (Pl. 4, fig. 7) and is 28 mm tall. It expands upward from a somewhat broken base, approximately 9 mm across, to a maximum width, as now flattened, of approximately 15 mm. It has a simple, tubular spongocoel that is approximately 2 mm across at the base and expands upward to a now flattened irregular opening 10 mm wide.

Walls, where uncrushed, are approximately 3 mm thick at the top and the bottom in the holotype, and in the lower part and oscular rim of the paratype. Walls thicken up to approximately 4 mm at the maximum diameter in the paratype, 5 mm below the round oscular rim.

The paratype, UA 7713, is an uncrushed fragment of the upper 18 mm of a cylindrical sponge 13 mm across (Pl. 4, fig. 9). It lacks a base but the taper suggests an original sponge 35 to 40 mm high.

Three principal kinds of canals are recognized in the skeleton. Most prominent and numerous are horizontal radial ones (Pl. 4, fig. 13) that are so distinctive of the species. The second are less common, discontinuous, vertical excurrent openings and the third are vertical axial canals. Axial excurrent canals appear to be upflexed proximal ends of the radial series. They are 0.08 to 0.12 mm across, with most approximately 0.10 mm in diameter. Three or four of these canals occur as a central cluster in the lower part of the holotype. More occur at 4 or 5 mm above the sponge base, which is at the upper end of a radial series and the base of the spongocoel. These canals are separated by rows of single spicules that are somewhat coarser than endosomal spicules and are more irregularly oriented. These thickened spicules are like those of the thin gastral layer that lines the spongocoel higher up in the specimen.

Most common openings in the skeleton are the gently arched to almost straight radial series that either pierce straight through the wall or terminate at midwall at junctions with either vertical or horizontal canals. Exterior ostia range from 0.18 to 0.30 mm in diameter. Most openings are approximately 0.28 to 0.30 mm in diameter. Two series may be represented, but they are not in a distinct pattern nor at other orientations and so are treated here as parts of one series. They occur in very crude rows that are approximately 0.5 to 0.8 mm apart. Ostia are spaced eight or nine in 5 mm, vertically in a row, and six to eight rows occur in 5 mm, horizontally. This results in eight to twelve ostia per 4 $\text{mm}^2$ on the exterior.

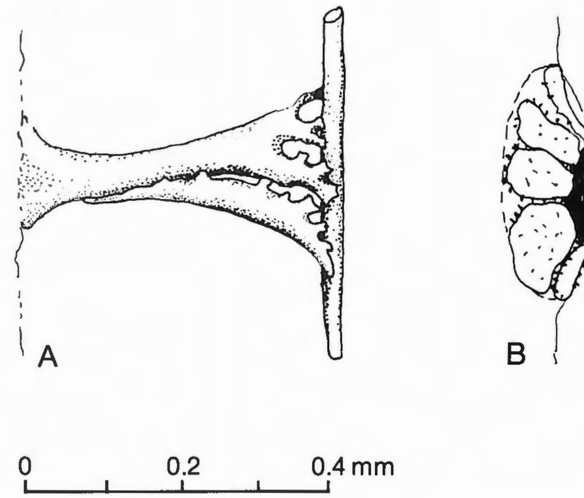


***Figure 4.*** *Sketch of spicules from the holotype of* ***Dunhillia pluraliporosa*** *n. sp., UA 7712, Baillie-Hamilton Island, Section 2-84.3. A. isolated coring oxea, at the right, attached by zygomes to the cladome of a long, smooth dendroclone. An irregular rhizoclone occurs below; B. small rhizoclones of the dermal net surround a low-mounded dermal ostium. Small zygomes occur at lateral margins and mark the somewhat irregular surface.*

Canals continue through the wall to the gastral margin as subtubular openings with more or less the same diameter. There they occur in moderately well organized vertically stacked series. These stacked ostia are generally 0.20 to 0.25 mm in diameter, where circular, although many are vertically elongate oval slits approximately 0.5 mm high. Gastral rows are separated by 0.25 to 0.35 mm of spicular skeleton and there are approximately two rows of ostia a millimetre. Ostia in vertical rows are separated by 0.2 to 0.3 mm of horizontal dendroclones or by irregular, somewhat coarser and longer spicules that form the thickened gastral layer, which is approximately 0.2 to 0.3 mm thick. Irregularity of spicule orientation and somewhat thickened elements characterize the layer.

Less common, but very evident, vertical canals are approximately 0.2 to 0.4 mm in diameter. They connect the radial series and occur as short, discontinuous openings between adjacent vertically stacked radial canals, or as somewhat more continuous openings where they connect several such canals.

Midwall horizontal ring canals, if present, are ill defined on surfaces available for examination.

The skeleton is typical of the genus, with prominent upward diverging trabs made of fused zygome ray tips of essentially horizontal, smooth-shafted, dendroclones (Pl. 4, fig. 14). Gastral trabs are essentially parallel to the spongocoel margin, but diverge upward and outward from that surface of pinnation to meet the dermal layer at approximately 20° from vertical. Trabs are the most regular part of the skeleton and are rarely interrupted, even by large canals. They range from approximately 0.10 mm in diameter, where thin and delicate, up to approximately 0.16 mm in diameter, where several dendroclones have merged. They are somewhat porous where best preserved and are cored by one oxea in a cross-section. These oxeas are generally 0.02 to 0.25 mm in diameter, but only tips of the spicules project beyond broken or incompletely silicified ends of trabs so it is difficult to know the full range of spicule size.

Pores between rung-like dendroclones are approximately 0.20 to 0.24 mm across, and high, where circular, but they may be only about a third that high where ladder-like and regularly spaced. Trabs are spaced three to five a millimetre, mostly approximately four in one millimetre where regularly spaced, either radially or tangentially.

Long, smooth-shafted, I-shaped dendroclones and prominent Y- and H-shaped dendroclones make up the skeleton. Most spicules have shafts approximately 0.15 to 0.25 mm long that are 0.04 to 0.05 mm in diameter in their narrow parts. Shafts may expand up to 0.10 to 0.12 mm across in fairly thick spicules where they diverge to the cladome ray. Clads are generally only 0.02 to 0.03 mm across and terminate in zygomes that are approximately 0.2 mm across as stubby finger-like to arborescent pointed tips. Only rarely are details of zygomes preserved, however, because of moderately coarse silicification.

Long I-shaped dendroclones with short cladomes are most common where the skeleton is regular. Elsewhere, long, equal rayed, Y-shaped dendroclones are common, particularly near canal junctions. X-shaped dendroclones with more or less equal rays that radiate from a short shaft, are somewhat less common. Shafts and clads are of essentially the same diameter on all spicules, but lengths range considerably, depending upon separation of trabs and interruptions of canals.

A few rhizoclones (Fig. 4A) occur in the skeleton, particularly around canals. These spicules have essentially the same proportions as dendroclones, but have irregular zygomes along their shafts as well as at the tips.

The dermal layer is locally well preserved on the holotype and consists of irregularly lenticular or oval, plate-like rhizoclones (Fig. 4B). These range from approximately 0.16 mm up to 0.24 mm across, with most approximately 0.20 to 0.22 mm across. Each dermal rhizoclone is 0.02 to 0.04 mm thick and each has marginal zygomes, with which the spicules articulate. Zygomes are generally 0.02 mm long and 0.01 mm in diameter. They are spaced 0.02 mm apart around the rim and articulate with zygomes of adjacent spicules. Zygomes may be subcylindrical, distinctly pointed, or finger-like, and some appear to be bifid to almost arborescent at their tips.

Distal surfaces of dermal rhizoclones are marked by distinctly conical to somewhat hook-shaped small spines that are 0.005 to 0.010 mm in diameter. They are approximately 0.01 to 0.02 mm high and are uniformly spread over the entire surface, although not in a distinct pattern. They are commonly 0.02 to 0.03 mm apart where best preserved.

Dermal rhizoclones flex up near ostia to produce small rims. These rims are 0.05 to 0.10 mm high and are moderately solid structures, 0.08 to 0.10 mm wide. Ostia are fringed by small, zygome based spines.

*Discussion.* The most similar species is *Dunhillia megaporata* n. sp., which is also found in the collection. *Dunhillia pluraliporosa* n. sp. has a considerably greater number of ostia and a distinctly more porous dermal layer than *D. megaporata*. *Dunhillia multiporata* (Rigby and Webby, 1988), from the Ordovician of Australia, appears somewhat similar, but the Australian species is considerably more twiggy, with a diameter of only approximately 4 mm. Ostia are essentially the same dimensions in both species but their spacing in the dermal layer is quite different, with 14 to 16 in 25 mm$^2$ in the Australian *D. multiporata*, and 40 to 50 in 25 mm$^2$ in *D. pluraliporosa*, the Baillie-Hamilton form. Vertical canals in *Dunhillia pluraliporosa* are not as well defined as in the Australian *D. multiporata*. Other species of *Dunhillia* from Australia (Rigby and Webby, 1988) either have clearly differentiated multi-ostiate pore fields or exaules and are thus clearly differentiated from the species described here.

*Somersetella digitata* (Rigby and Dixon, 1979, p. 618-620) is a digitate anthaspidellid sponge, but fragments of it might appear similar to *Dunhillia pluraliporosa* n. sp. The thin dermal layer of associated *Somersetella* has a considerably more arborescent base, as though made of articulating tips of endosomal dendroclones or of more sinuous rhizoclones. Associated specimens of *Somersetella* also have dendroclones with minute spines scattered uniformly along the shaft, which allows even small fragments to be separated. *Somersetella* lacks the vertical canal series, as defined by Rigby and Dixon (1979, p. 618). *Dunhillia pluraliporosa* n. sp. appears to be an unbranched species, in contrast to the bushy associated *Somersetella*.

*Aulocopium* has a distinctly different canal system, with vertically stacked radial canals in panels alternating with panels where vertical canals dominate. These differences would allow separation, even where silicification is moderately coarse.

*Etymology.* Latin, *pluralis*, more than one; *porosus*, full of holes, referring to the numerous canals in the wall and the very perforate appearance of the dense dermal layer.

*Type material.* The holotype, UA 7712, and paratype, UA 7713, are the best preserved specimens of the species known. They came from Baillie-Hamilton Island Section 2-84.3. Less well preserved specimens came from Baillie-Hamilton Island Section 1-44, and from Cornwallis Island Section 1-80+.

### Genus *Patellispongia* Bassler, 1941

*Discussion.* Two genera have been proposed for broad discoidal to saucer-shaped, smooth, thin walled sponges in the Anthaspidellidae. *Patellispongia* was named by Bassler (1941, p. 97) for large saucer-like sponges from Ordovician rocks of Nevada. Somewhat earlier, Raymond and Okulitch (1940, p. 212) proposed the genus *Psarodictyum* for regular discoidal anthaspidellids that apparently lack a differentiated dermal layer, from Chazyan rocks of New York and from approximately equivalent beds from Tennessee and Oklahoma. The description by Raymond and Okulitch is so short and provides so little definitive information, other than a discoidal shape, that virtually any broad saucer-shaped or funnel-shaped sponge of the family could be included in their genus. Bassler provided somewhat more information and noted that a thick dermal layer is developed on *Patellispongia*. Rigby and Webby (1988) noted that it was basically this difference in skeletal structure that was utilized to separate *Psarodictyum* from *Patellispongia*. Type specimens of both of these Ordovician genera are preserved as calcareous replacements. Perhaps the most conservative view would be to continue recognition of the two genera until a detailed review of the type specimens is undertaken. We have continued to use them in the present paper, with the realization that their status is moderately uncertain.

### *Patellispongia alternata* n. sp.

Plate 3, figure 3;
Plate 6, figures 5-7

*Diagnosis.* Broad, open, saucer-shaped *Patellispongia* with distinct rows of canals on both the subdermal and gastral surfaces, rows separated by blade-like elements composed of small dendroclones, openings within rows of pores separated by large dendroclones, all combining to produce the characteristic trab-dominated anthaspidellid skeleton. Regular gastral ostia are 0.6 to 0.7 mm in diameter, there are six to seven a centimetre along a row, with eight to ten rows in ten millimetres measured at right angles to the radial rows. Dermal layer thin, dense, of irregular dendroclones that somewhat obscure the uniform radial nature of the skeleton.

*Description.* A single fragment of a discoidal, low patelliform to open funnel-shaped, moderately thick-walled sponge occurs in the collection. It is a fragment that extends radially for approximately 12 cm from near the centre of the disc. The fragment has a maximum width of approximately 4 cm and represents a sponge, if it was circular discoidal, of at least 26 cm in diameter. However, neither the centre nor the outer rim of the sponge is preserved so it could have been a much larger specimen than that.

The silicified specimen shows the moderately smooth gastral surface, marked essentially only by radial ridges of spicule tracts separating impressed rows of excurrent ostia. The sponge lacks a differentiated gastral layer and is marked by striking regularity of the radial rows of pores.

The dermal surface shows weak annulation on a principally smooth surface, with annulations produced by ring-like thickening of the wall of the sponge. The dermal part of the endosome is marked by distinct radial rows of spicules and pores immediately beneath the thin, relatively dense, dermal layer. But that outer layer lacks regularity. It is because of the development of a prominent dermal layer that the species is placed within *Patellispongia.*

The discoidal sponge is moderately thick, up to 14 mm thick near its central part, but thins to an average of 8 to 9 mm in the outer part. Gastral and dermal surfaces are essentially parallel, except where the round annuli are developed and the wall thickens up to 12 to 13 mm there, in a somewhat wavy pattern. There is no particular thickening of the dermal layer over crests of annulations, except near the centre of the sponge where the silicified dermal layer is most prominent.

The gastral layer shows remarkable regularity, with prominent pores of excurrent ostia. Most of these openings are 0.6 to 0.7 mm in diameter, but they range from 0.5 up to 0.9 mm across. Larger openings tend to be rounded subquadrate and smaller ones to be distinctly circular. There are eight to ten rows of ostia a centimetre, six to seven ostia a centimetre along individual rows. These rows are separated by septate-appearing skeletal structures, with outer trabs separated by rows of dendroclone spicules. Ostia are up to 0.7 to 0.9 mm in height, measured radially, and are separated within rows by spicule clusters 0.4 to 1.0 mm wide that occur as ladder-like and commonly closely packed spicules oriented essentially normal to the rows between the pores. Generally speaking, there is approximately 0.5 to 0.7 mm of skeleton between canals in the rows. New rows are inserted between trabs where trabs diverge to make room for new ladder-like series of spicules and the new rows of pores.

A second smaller series of canals in some rows on the gastral surface is apparent. These ostia are 0.2 to 0.3 mm in diameter. They are circular but have an irregular distribution. Where they occur, separation of the larger excurrent ostia is somewhat greater.

In cross-section, canals curve through the wall. They enter steeply inward and upward in the outer part, but curve to become essentially perpendicular to the axis, at midwall, then decline down toward the centre of the sponge in the gastral part of the wall where they emerge at approximately 60° to the gastral surface.

Two distinct sizes of dendroclones occur in the skeleton on the gastral surface. The larger of these bound the pores and occur in tracts between pores in the rows. The smaller ones form the tiny tracts between pores in the rows, as well as the somewhat smaller trabs in the blade-like divisions between the rows of pores.

The dermal layer is moderately well defined, particularly on the lowermost part of the sponge. It is composed of densely packed coarse spicules in a layer approximately 0.5 mm thick. It thins radially and most of the undersurface of the sponge, as presently preserved, is not covered with a differentiated dermal layer, although the evident skeleton is somewhat more irregular and dense over crests of annulations than in the thin parts of wall between.

Ostia in the dermal layer occur in less regular rows, evident in even the outer part of the endosomal layer. They are commonly irregularly elliptical to subquadrate with rounded margins, and most are approximately 0.5 mm in diameter although there are smaller openings 0.2 to 0.3 mm and approximately 0.1 mm across. Intermediate sized openings are distinctly circular, but smaller ones are irregularly elliptical and commonly appear as skeletal pores between coarse dermal dendroclones.

Rows of ostia within and in the immediately subdermal parts of the wall are parallel to the strong radial rows of trabs. Here there are eight to ten rows of openings a centimetre, measured normal to the trend of the rows. The canals may show diplorhysis through the wall but evidence is inconclusive in the moderately coarsely silicified sponge.

The skeleton is typically anthaspidellid, with an upward and radially pinnate series of trabs. The surface of pinnation is essentially at midwall, with trabs diverging radially to meet both gastral and dermal surfaces at 60° to 70°. Trabs are generally 0.12 to 0.18 mm in diameter, where best developed through the skeleton. Most appear to be moderately porous, with considerable interspicular space between articulating zygome tips of dendroclones.

Smooth-shafted dendroclones form "rungs" in the ladder-like skeleton. Spicules are generally of two sizes. Larger ones have smooth axes 0.4 to 0.5 mm long and extend from trab to trab between pores. Their shafts are approximately 0.07 to 0.08 mm in diameter and a few expand up to approximately 0.09 mm across before shafts subdivide into cladomes, which are 0.05 to 0.06 mm in diameter and of variable length.

The smaller dendroclones connect trabs within the blade-like partitions between the rows of pores. Their smooth shafts are 0.12 to 0.20 mm long but show considerable variation. The smaller spicules have diameters of approximately 0.03 to 0.05 mm but smallest elements may be as small as approximately 0.01 mm in diameter. Cladome rays of the small spicules are approximately 0.02 to 0.03 mm in diameter and, like their larger components, subdivide into arborescent or hand-like articulating zygomes that unite tip-to-tip, although some junctions of zygome tips have a small, discontinuous cylindrical opening that may suggest they joined around some fibre. Most trabs, however, appear to be only irregularly porous and lack any evidence of a continuous central structure.

*Discussion.* *Patellispongia australis* Rigby and Webby (1988) is essentially the size of, and has walls essentially the same thickness as, the Baillie-Hamilton sponge. However, most trabs in the Australian species are made of coring monaxons, spicules that appear to be totally missing in the Canadian *atellispongia alternata*. Ostia in the two species are nearly the same diameter, but dermal ostia in *Patellispongia australis* are low cones, which makes the ostia look like small craters. The Australian species also has coarse, horizontal, tangential canals as dermal and subdermal openings. These large canals are not developed in the Baillie-Hamilton species.

*Patellispongia oculata* (Bassler, 1941, p. 97, Pl. 22, figs. 1, 2) has small dermal ostia, only 0.4 mm in diameter. They are spaced almost twice as close as larger openings in the Baillie-Hamilton species. Bassler used size of openings and spacing as specific characters, features that would separate *P. oculata* from *P. alternata*. Similarly, *Patellispongia clintoni* (Bassler, 1941, p. 97-98) has small ostia that are closely spaced. These small openings also occur on cones, as in *P. australis*, but differ from the Canadian Silurian species in that respect. *Patellispongia minutipora* (Bassler, 1941, p. 98) has ostia approximately 0.5 mm in diameter, but they are even more closely spaced than in other species described by Bassler, which would clearly differentiate them from the moderately coarse openings in *P. alternata*.

Perhaps the most similar species is *Patellispongia magnipora* (Bassler, 1941, p. 98), which has longitudinally grouped ostia, approximately 0.6 mm in diameter. Even in *P. magnipora*, however, the number of ostia in one centimetre, measured along any single row, is nearly double that seen in the Silurian *P. alternata*. In addition, walls of *P. magnipora* are only 3 to 8 mm thick, which makes them thinner than the average thickness of the species described here.

*Anthaspidella* (Ulrich and Everett, 1890) has a similar growth form, but has prominent astrorhiza-like canals marking the gastral surface. These canals are commonly on low mounds and are part of a canal pattern totally foreign to the distinct, regularly radiating structure of the Silurian *P. alternata* from Baillie-Hamilton Island.

*Type material.* Holotype, UA 7714, from the Cape Phillips Formation on Baillie-Hamilton Island Section 1-712.

*Etymology.* Latin, *alternata*, *alternus*; first one then the other, successively, calling attention to the alternating rows of small and large dendroclones evident on the gastral surface.

### **Genus** *erissocoelia* Rigby and Webby, 1988

*Perissocoelia* was recently described by Rigby and Webby (1988) from well preserved silicified specimens from the Upper Ordovician of Australia. The genus is characterized by its stalked to regularly massive, almost subspherical, form and by the numerous conical excurrent depressions on the rounded summit. Tangential astrorhiza-like canals radiate from the various oscula and occur as stacked arcuate canals in the interior. The skeleton is characteristically anthaspidellid, but the trabs are moderately discontinuous, which produces some irregularity in the skeleton.

The genus does appear somewhat similar to the Permian *Multistella* (Finks, 1960, p. 61, 62), for the two genera have a generally massive form and several areas of emergence of large excurrent canals. *Multistella* has groups of excurrent canals that do not occur in deep pits but are in sharply delineated stellate clusters.

*Phacellopegma* (Gerth, 1927, p. 103; Finks, 1960, p. 60) is also a massive form with several clusters of excurrent openings. However, *Phacellopegma* has the surface of the sponge sculptured with deep anastomosing grooves into which the excurrent canals open, in contrast to the distinct pits in *Perissocoelia*.

*Type species.* *Perissocoelia habra* Rigby and Webby, 1988.

### *Perissocoelia* (?) *gelasinina* n. sp.

Plate 5, figures 1-3

*Diagnosis.* Moderately large, obconical, stalked hemispherical to mushroom-shaped sponges; dense dermal layer flanks lower stalked part. Upper hemispherical surface indented with numerous small pit-like oscular openings 2 to 3 mm in diameter. Upper surface lacks prominent radial-tangential canals, but is marked principally by ostia of subvertical canals oriented normal to upper surface. Trabs discontinuous, flexuous to sharply bent or unevenly discontinuous, 0.10 to 0.18 mm in diameter and composed of tips of long-shafted, smooth, normal dendroclones. Spicules up to 0.4 mm long in fairly irregular, radiating to sub-ladder-like, but frequently interrupted, series. Many spicules appear as isolated rays not in stacked series and skeleton appears spinose.

*Description.* The holotype is a stalked sponge with an upper mushroom-like hemispherical crest dented by numerous oscular pits (Pl. 5, figs. 1-3). The upper part has an open skeleton, in contrast to the lower, abruptly expanding obconical stalk, which has a dense dermal layer. The sponge is approximately 40 mm high and has an elliptical cross-section 40 to 48 x 38 mm at approximately mid height.

The oscula occur 6 to 10 mm apart and are dimpled pits or gentle depressions 2 to 3 mm in diameter and 1 to 2 mm deep. They have a rounded upper rim. Their bases are approximately 0.5 to 1.5 mm in diameter. A cluster of three to four vertical excurrent canals empties into the base of each pit. Such canals are no larger than parallel, though more widely spaced, canals that empty onto the upper surface between pits.

Principal canals are of at least three sizes. They are subparallel to the upward and outward radiating trabs, which are oriented essentially normal to the upper arched surface.

There are no distinct tangential canals impressed into the upper surface and, in fact, the subhorizontal series is generally discontinuous and without a distinct pattern. Canals are rarely traceable for more than two or three millimetres.

Excurrent canals that empty into the bottom of an oscular pit tend to be circular to subprismatic pentagonal, or hexagonal and approximately 0.5 to 0.8 mm in diameter. These openings are parallel to the trabs and are defined by a moderately complete ladder-like series or by clusters of thin tracts of dendroclones. They are generally separated by single series of spicules between canals but are commonly separated from other parts of the skeletal net by moderately massive tracts that have irregular courses other than being tangential to the subcylindrical openings.

Ostia of canals of essentially the same size and shape occur exteriorly, between the oscular pits. These are up to 0.8 mm in diameter, although most are approximately 0.5 to 0.6 mm across. Many of these ostia tend to be elongate, elliptical or almost double-canalled. There are eight to ten in 4 $mm^2$ in representative areas. They are generally spaced 1.0 to 1.5 mm apart and are separated by a regular skeletal net.

The canals of a smaller series, 0.3 to 0.4 mm in diameter, are also circular to subprismatic. They occur between the larger openings and are cross-connected to them by short discontinuous canals or circular perforations in the ladder-like series that separate them. The smaller canals are spaced so that there are approximately 30 in 4 $mm^2$. They may well be the major incurrent canals of the system.

More common, and considerably more discontinuous, are smaller circular openings that are, on average, 0.2 mm or less in diameter. These are circular, where largest, and grade downward into the triangular skeletal pores between the ladder-like series of dendroclones. There are 60 to 70 in 4 $mm^2$ and they may interrupt only two or three spicules before discontinuing. They may be the lateral connections, as well, between the larger canal series.

More discontinuous subcircular canals occur at a tangent to the upper surface and connect laterally between various canal series. Largest of these are up to 0.4 to 0.5 mm in diameter and are rarely traceable for more than 2 or 3 mm. They appear to be irregular and not part of a prominent canal system. Most lateral connections between vertical canals appear as circular interruptions or loss of single spicules in a ladder-like series between canals. Some of the subhorizontal canals may be lined or that lining may be an artifact of silicification.

One distinctively large isolated tube, approximately 1 mm in diameter, interrupts the skeleton. It may represent the burrow of a foreign organism.

Trabs are the principal skeletal structure (Pl. 5, fig. 2), but are not particularly well preserved interiorly. They are irregularly undulating and in only a few areas are more than five or six trabs subparallel to each other for some distance. Rather, they are mainly short, subparallel segments that may flex sharply, often through 90°, particularly in the outer part of the sponge. Where best preserved, trabs are 0.10 to 0.18 mm in diameter, although most throughout the skeleton appear to be 0.12 to 0.14 mm across. Numbers of series of convergent dendroclones vary, so diameters of the trabs also vary considerably.

Details of dendroclones are not well preserved interiorly but do show in a few areas exteriorly. These spicules are mainly long, simple, smooth-shafted dendroclones with shafts 0.03 to 0.05 mm in diameter. They range between 0.10 mm and 0.40 mm long. Lengths vary because of irregular swerving of the trabs and variations in angles of divergence and convergence of spicules, even within single, fan-like clusters.

Most common spicules have only weakly expanding brachyomes that may be only double the diameter of the shaft. Cladome terminations are slightly more expanded, however, although each cladome ray is short. Cladomes terminate in finger-like rather than arborescent zygomes. Many spicules occur as isolated elements, somewhat like radiating fingers of an expanded hand, rather than occurring in uniform rung-like series. Elsewhere four to five dendroclones may occur side-by-side in clusters almost as large as the trabs, which are usually the main element of the skeleton. Spicules in the single series may diverge from one another by 50° to 60°, although remaining in essentially a planar fan-like pattern.

A few stubby Y-shaped dendroclones also occur in the skeleton. These may be almost twice the diameter of the long dendroclones and generally have individual ray lengths of less than 0.10 mm. These stubby spicules are more common in the outer 1 to 2 mm of the endosomal layer, where they bridge or terminate canals.

Rhizoclones may occur in the skeleton, but details are largely destroyed in the interior. Some subparallel clusters, in particular, may have rhizoclones as part of their spicule complement.

The dermal layer is moderately well developed over the lower 23 to 25 mm of the sponge. It shows weak annuli, 1 to 2 mm high, that are indented irregularly up to 1 mm deep. Individual annuli are not traceable around the sponge, so growth must have been irregular. Where most clearly defined, the dermal layer is approximately 0.1 to 0.5 mm thick. Where thickest, it appears to have been secondarily thickened, for diameters of trabs, various spicules and tracts have been increased. Details are most evident where the dermal layer is thin. It was apparently produced by expansion of individual dendroclone tips, by marked enlargements of trabs and by an increase in numbers of clusters of subparallel dendroclones that produce massive trabs. There is no evidence of differentiated spicules producing the dermal layer, but it is a combination of thickened units.

*Discussion.* The genus was initially erected (Rigby and Webby, 1988) to include mushroom-like to subhemispherical sponges, with a dendroclone-based skeleton, that have minor oscular pits well developed on the upper surface. In the type species, *Perissocoelia habra* Rigby and Webby, astrorhiza-like canals mark the upper surface, but such canals are largely missing from the Baillie-Hamilton species. *Perissocoelia habra* has both moderately well organized radiating and vertical canal series, whereas the system in *Perissocoelia* (?) *gelasinina* n. sp. is dominated by the subvertical radiating series. In addition, the skeletal net of *P.* (?) *gelasinina* is significantly more irregular than in the Ordovician Australian species.

Several genera of anthaspidellids in the family have a general subhemispherical shape and excurrent pits on the upper surface. *Phacellopegma* was described by Gerth (1927, p. 103) from the Permian of Timor and an additional species has been described from West Texas by Finks (1960, p. 606). The genus has excurrent canals in radiating tangential deep slits that produce a distinctly radiating sculpture on the surface.

*Anthaspidella* (Ulrich and Everett, 1890, p. 256-261 and Bassler, 1941, p. 99-100) may have prominent pits on the upper or excurrent surface, but they, too, have radiating tangential excurrent canal systems that commonly occur on low mounds. In addition, *Anthaspidella* is also open fan- or saucer-shaped and commonly has a distinctly more regular skeleton than *P.* (?) *gelasinina*.

*Multistella* (Finks, 1960, p. 61-63) is also a massive form with basic anthaspidellid radial architecture. However, excurrent canals in *Multistella* are generally arranged side by side in stellate depressions and the genus is differentiated from *Perissocoelia* and other genera by that stellate pattern with nearly straight rays. In many other respects, however, *Multistella* appears much like the Silurian Baillie-Hamilton sponge.

*Etymology.* Latin, *gelasinus*, dimple, referring to the small dimple-like oscular pits that mark the upper surface.

*Type material.* The holotype, UA 7715, was collected at Baillie-Hamilton Section 2-84.3, and the paratype, UA 7737 by Zhang Ning from the Baillie-Hamilton Section 1 area, at approximately 120 m.

### *Perissocoelia* (?) *spinosa* n. sp.

Plate 5, figures 4-6
Plate 7, figure 5;
Figure 5

*Diagnosis.* Massive obconical to stalked subhemispherical sponges with numerous, shallow excurrent oscular pits on the upper mounded surface, spaced 8 to 10 mm apart. Lower surface has dense, imperforate dermal layer. Excurrent canals radially arranged around each oscular pit. Skeleton in lower part typically anthaspidellid with short, somewhat discontinuous, trabs radiating upward and out from near the base; composed of long simple dendroclones and possible didymoclones. Upper part of skeleton consists more prominently of didymoclones that unite to form subspherical knots rather than trabs. Small oxeas radiate spherically from the knots.

*Description.* Only the holotype is known of the species. It is a stalked, broadly upward expanding obconical sponge that has a rounded, subhemispherical summit. The sponge is 32 to 33 mm high, as presently preserved, and has a maximum diameter of approximately 65 mm at the upper edge of the dense, encrusted, dermal layer, at the upper edge of expansion of the obconical part of the sponge.

The lower stalk-like part is blanketed with a weakly annulate, dense dermal layer. Annuli are 1 to 2 mm high, with some irregularity. Annulations mark pulses in secretion of the skeleton because indentations of annulation are more or less continuous with thin, plate-like, interruptions of parts of the upper arched layers of the skeleton. These layers are approximately 0.1 to 0.2 mm thick and are undulating or irregularly wavy over the domed crest. Where best preserved, both the dermal layer and the irregular encrusting, sheet-like deposits appear to be made of complexly arborescent zygomes of rhizoclones or complex tips of dendroclone or didymoclone spicules. Generally speaking, these layers are dense and massive so that details of the structure are largely destroyed.

The upper surface of the sponge is marked by dimpled clusters of excurrent canals. The clusters are 3 to 4 mm in diameter and occur approximately 8 to 10 mm apart over the entire summit. They may be closer in the middle part of the sponge but are particularly well defined, on this specimen, near the periphery, at the maximum diameter of the sponge.

Excurrent canals of the clusters are generally 0.40 to 0.55 mm across in centres of the clusters and are essentially of the same diameter where traced diagonally down into the endosome. They do not form a marked astrorhiza-like system that is tangential on the upper surface and certainly do not form indented slits, nor do they occur in radial star-like fashion. Clusters may include 5 to 15 canals. Circumference of each canal is generally defined by five equally spaced trabs or knots in the skeleton. Some of the canals have an almost pentagonal cross-section.

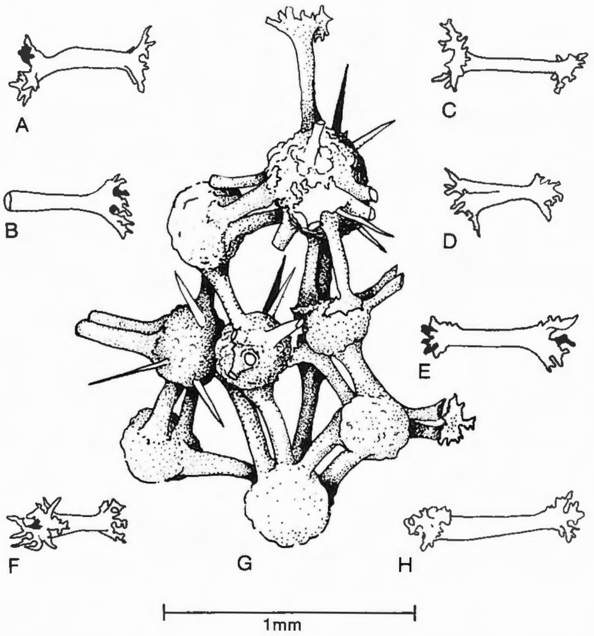


***Figure 5.*** *Drawings of spicules from the holotype of* ***Perissocoelia (?) spinosa*** *n. sp., UA 7716, from Cornwallis Island Section CAR 1-44.5, block 2. A-E, smooth dendroclones with irregular bifid cladomes and less pronounced brachyomes characteristic of anthaspidellid spicules; F, H, possible didymoclones lack a distinct bifid cladome but have more or less equal brachyome-like development at both ends of the smooth shaft; G, camera lucida drawing of spherical bead-like ray tip clusters probably produced by mixture of dendroclones and didymoclones. Tips of sharp oxeas radiate from the centres of the knots. Fragments from near the top of the sponge.*

Ostia of the same dimension also occur across the entire upper domed surface. They are approximately 1 to 2 mm apart and are of simple, straight, subvertical canals and are not associated with excurrent clusters.

More common are canals that are 0.3 to 0.4 mm across. They are similarly scattered, approximately 1 mm apart, centre-to-centre, over the entire upper surface. They are circular and four or five knots or trabs define their margins. How far these canals extend into the skeleton is unknown, but they appear to be moderately discontinuous where they can be traced into the fairly porous interior. These canals are generally parallel to the trabs or the linear beaded series of knots and may form at right angles to some of the diagonal excurrent canals of the cluster system.

Still more common are the distinctly triangular skeletal pores that are 0.2 to 0.3 mm on a side. These are parallel to the trabs and five or six of these triangular openings occur around each trab at any particular level. They continue to be triangular, but somewhat more discontinuous, where the skeleton is made principally of knots in parallel beaded fashion.

Horizontal connections between the upward and outward radiating canals and the skeletal pores is apparently accomplished by interruptions in the net. There are no well organized horizontal canals, either concentric or radial, in the sponge.

The lower skeleton is composed of porous trabs that radiate upward and outward from a radiante near the base. Even there trabs are discontinuous and traceable for only 3 to 5 mm, although the entire fabric is a moderately well organized and an upward and outward radiating structure. Trabs are approximately 0.14 mm in diameter in the interior and lower parts of the sponge. They are generally spaced 0.3 to 0.5 mm apart, and appear to originate by insertion, rather than branching, because they are such discontinuous elements.

Trabs grade into linear beaded knots of spicules in the upper part of the skeleton. The discontinuous trabs or knots are 0.13 to 0.16 mm in diameter in the lower part of the skeleton but are commonly 0.10 to 0.15 mm in diameter in the upper part, near the surface. The knots, like the trabs, are spaced approximately 0.3 to 0.5 mm apart, centre-to-centre, with most approximately 0.40 to 0.45 mm apart, horizontally and vertically. This tends to produce a more uniformly textured upper skeleton than the distinctive linear middle and lower parts of the sponge. The porous spherical knots are commonly made by junctions of ray tips of five to six or more tips of dendroclones or ends of didymoclones.

Small oxeas radiate spherically out of the knots (Pl. 5, fig 5; Fig. 5G). Generally, these oxeas are 0.01 to 0.02 mm in diameter, at the periphery of the knots, and they may extend as straight needle-like spicules up to 0.3 mm out from the knot surface. Up to five or six oxeas commonly occur per knot as spinose spicules between the larger dendroclones and didymoclones.

Dendroclones in the lower part of the sponge have long, smooth, simple shafts (Pl. 5, figs. 1-5) and grade almost imperceptibly into spicules clearly identifiable as didymoclones, as spicules develop two terminations that look like brachyomes (Pl. 5, figs, 6, 8). These spicules may be up to 0.5 mm long in the open porous part of the skeleton and have shafts 0.02 to 0.04 mm in diameter. Expanded zygome articulations at both ends may be up to 0.08 to 0.12 mm across and affect the distal 0.05 to 0.08 mm of both ends. The articulating tips may be somewhat swollen and club-like rather than complexly hand-like. Zygome articulations may branch from the shaft near both ends, as well as in the abrupt expansions at the tips.

Spicules in the upper part of the sponge are somewhat more delicate, approximately 0.035 to 0.040 mm in diameter and 0.18 to 0.22 mm long. These are the didymoclones that combine at their tips to produce the spherical knots or clusters distinctive of the species.

A few normal dendroclones with short Y-shaped cladomes and a few nearly equal-rayed Y-shaped dendroclones occur in the skeleton, particularly in the lower part where trabs are most continuous. These spicules have total lengths essentially the same as the long smooth dendroclones, but with diameters of 0.02 to 0.03 mm.

*Discussion.* The species is placed in *Perissocoelia* with some reservation because of its distinctive skeleton that includes beaded knots of didymoclones as well as trabs of long-shafted dendroclones. However, it does have the overall gross shape of the genus and several excurrent canal clusters in its upper part. It differs from the type species, *Perissocoelia habra* (Rigby and Webby, 1988) from the Ordovician of Australia, in having the canal clusters less obviously in pits and, to some degree, in lacking well defined astrorhizal-like tangential canals. In addition, the details of the skeletons of the two species differ significantly. Although the type specimens of *Perissocoelia habra* are well preserved and silicified, there is no evidence of the spinose knots in the upper part of the sponge, nor are there prominent oxeas associated as radiating elements in the knots.

*Etymology.* Latin, *spinosus*, thorny, referring to the spinose-appearing spicule knots in the upper part of the skeleton.

*Type material.* Holotype, UA 7716, from Cape Phillips Formation, Cornwallis Island Section CAR 1-44.5, block 2.

### Genus *Psarodictyum* Raymond and Okulitch, 1940

*Type species. Psarodictyum magnificum* Raymond and Okulitch, 1940.

### *Psarodictyum attenuatum* n. sp.

Plate 5, figures 7-9

*Diagnosis.* Thin walled, distinctly funnel-shaped to broadly obconical sponges, generally lacking dermal and gastral layers in the well organized, regular, radiating anthaspidellid net; indistinct to crudely aligned canals of several series that range from discontinuous canals, 0.10 mm in diameter, up to the largest openings, 0.2 to 0.3 mm in diameter. Trabs 0.06 to 0.10 mm thick, cored by numerous small oxeas that produce a spinose corona on the dermal and gastral margins. Dendroclones mainly simple, smooth, long shafted forms with short cladomes and brachyomes, although occasional Y-shaped dendroclones also occur. Gastral surface lacks differentiated ostia.

*Description.* Steeply obconical to low obconical or funnel-shaped, thin walled, *Psarodictyon* with smooth dermal and gastral surfaces are included here. The holotype is a moderately complete, flattened, specimen, approximately 65 mm tall and, as presently flattened, approximately 47 mm wide. The base is lost but part of the oscular margin is preserved.

The thin walls surround a broad open spongocoel, now collapsed (Pl. 5, fig. 7), but its initial width is defined because folded edges include part of both the upper and lower walls. Walls are generally 3 mm thick but become even thinner in the upper or distal 10 mm. The dermal surface curves inward to produce a cross-section like that of an airplane wing, with the leading edge near the gastral margin. Dermal and gastral layers are not differentiated, although spicules show some thickening toward the dermal surface area, but no distinct layer of differentiated spicules is evident on that smooth exterior.

Excurrent oscular mounds, like those on *Anthaspidellida*, are not developed and the sponge lacks tangential dermal canals, like those that are well differentiated on some species of *Patellispongia*.

Three series of canals are differentiated in the walls. The larger of these have ostia approximately 0.26 to 0.30 mm in diameter on the exterior. In general, these canals feed straight through the wall and are approximately 0.18 to 0.22 mm in diameter at midwall, at the surface of pinnation. Most canals there are approximately 0.20 mm across.

Gastral ostia of these canals are approximately 0.14 to 0.16 mm across, where circular, although they may be slightly elliptical, elongate parallel to the radial trabs.

There are four to six ostia in 5 mm on the exterior in a single radiating row, parallel to the trabs, and five or six such rows in 5 mm, measured at right angles to the trabs and parallel to the oscular margin. There are ten to twelve ostia in 4 $mm^2$ on the exterior and they are generally separated by dendroclone tracts 0.3 to 0.5 mm across. In the interior, these same canals, or others approximately parallel to them, are spaced such that there are three to four a millimetre in a row between parallel trabs. There may be only 2.5 to 3.0 openings a millimetre where they are elongate. They are separated by only one or two spicules in the interior, in contrast to separation by rather thick tracts on the exterior. Openings are somewhat more closely spaced on the gastral margin than on the dermal margin.

A second series of canals of intermediate size is apparent in the dermal layer. These are 0.19 to 0.20 mm in diameter and occur between the larger openings; there are 15 to 16 in 4 $mm^2$. These canals are approximately parallel to the larger ones, but are more discontinuous.

A third series, which is even more discontinuous, has ostia 0.10 mm in diameter that occur 25 to 35 in 4 $mm^2$. These are only slightly larger than the triangular to prismatic skeletal pores between the radiating subparallel trabs but they do form distinct circular openings. The skeletal pores are approximately 0.12 to 0.14 mm across and are the smallest openings in the skeleton. Gaps in the ladder-like spicule series may be approximately the same width but are considerably less high where there are several spicules in one millimetre.

The skeleton is characteristically anthaspidellid and made principally of dendroclones arranged in rung-like fashion to produce regular ladder-like complexes bounded by trabs (Pl. 5, fig. 9). Trabs are produced by the mutual articulation of zygome tips of several series of dendroclones. Trabs in this species are moderately dense and small, 0.06 to 0.08 mm thick, although some may be up to as much as 0.10 mm thick, particularly in the outer part of the wall. Whether this variation is a result of differential silicification, or was original, is impossible to tell.

Trabs are cored by smooth oxeas and there are as many as four or five in a cross-section. One or two are evident on most surfaces where they have not been broken, but they become particularly numerous, like radiating fingers or a crown of spines, at the tips of trabs that have been preserved on both dermal and gastral surfaces. Where only one or two oxeas occur in a cross-section, they tend to be parallel to the principal axis but may diverge as much as 20° or 30° from that axis where two or more occur. These spicules are generally 0.008 to 0.010 mm in diameter and appear to be moderately long spicules, for some segments show little tapering. They must be at least 0.20 to 0.25 mm long and could be several times longer than that where complete. Surfaces where the spicules are well preserved appear very spinose because of the numerous radiating oxeas.

Trabs diverge from a surface of pinnation that is approximately 1 mm in from the gastral margin. Trabs gastral to that surface diverge moderately gently and meet the spongocoel margin at 15° to 30°. Trabs in the outer part of the wall, however, flex sharply and meet the dermal surface almost at right angles and are, thus, seen in cross-section on the exterior.

Spicules appear to be essentially the same size throughout the wall. They are mainly long, smooth shafted, dendroclones with short cladomes and bushy brachyomes. The shafts are 0.10 to 0.14 mm long, with most approximately 0.10 to 0.12 mm long, and 0.015 to 0.025 mm in diameter, with most approximately 0.02 mm across for much of their subcylindrical length. They increase up to approximately 0.03 mm across near where the cladomes diverge. Cladome rays are generally 0.010 to 0.015 mm in diameter, whether relatively short in long-shafted spicules or long in the Y-shaped dendroclones. Clads are 0.04 to 0.08 mm long and generally terminate with finger-like rather than dendritic zygomes. They are evident only where the skeleton is well silicified.

*Discussion.* Sponges described here are included in *Psarodictyon* even though they are not open-funnel or discoidal forms like those initially included there. They have thin walls and are somewhat steeply obconical forms, which should be within the range of forms included in the genus.

*Psarodictyum attenuatum* n. sp. is characterized by thin walls, shape, small sizes of various canal series and a moderately fine textured skeleton. *Psarodyctyum attenuatum* and the very thick-walled, saucer-like form *Psarodictyum crassum* Rigby and Webby (1988) are the only species of the genus where the trabs include coring oxeas. However, most other species have been described from calcareous replacements and details of trab make-up there may not be preserved. *Psarodictyum crassum* has walls up to 23 mm thick and contrasts with the approximately 3 mm thick walls in *P. attenuatum* n. sp.

*Psarodictyum magnificum* and *Psarodictyum planum* were both described by Raymond and Okulitch (1940, p. 212-214) from the Ordovician of the Appalachian region. These Ordovician species might be differentiated in growth form, alone, from *P. attenuatum.* Raymond and Okulitch noted that walls of both the Appalachian species are thin, but he gave no measurements of thickness. From a review of the type material, it appears that the walls are considerably thicker than in *P. attenuatum.*

Fragments of various species of *Patellispongia* (Bassler, 1941, p. 97, 98) all have walls considerably thicker than those of the present species and, in general, have ostia that are significantly larger, and skeletal spacing that is considerably coarser, than in the fine-textured Baillie-Hamilton sponges. *Patellispongia magnipora* Bassler (1941, p. 98, Pl. 21, fig. 6) has a disk that may approach the thinness of *Psarodictyum attenuatum*, but *Patellispongia magnipora* has ostia almost three times as large as those seen in *P. attenuatum*, although the spacing in 5 mm along a single row is only slightly closer.

*Etymology.* Latin, *attenuatus*, drawn out, weakened, thin, with reference to the relatively thin walls of the species.

*Type material.* The holotype, UA 7717, is the only presently known specimen of the species. It consists of several large fragments (probably all derived from the same specimen, but separated in processing) from Baillie-Hamilton Island Section 2-84.3.

### Genus *Somersetella* Rigby and Dixon, 1979

Digitate high-conical to conical-cylindrical sponges with a well organized anthaspidellid skeleton were placed by Rigby and Dixon (1979, p. 614-620) within the genus *Somersetella*. Each digitation of these sponges has a simple subcylindrical spongocoel that penetrates nearly the full length of the digitation. Rigby and Dixon considered the growth form, the cored nature of the trabs, and the development of a well defined dermal layer as characteristic features. At that time, few sponges other than *Climacospongia* Hinde (Finks, 1967, p. 1142), within the Anthaspidellidae were known to have oxeas as coring spicules in the trabs. Since that time, however, coring oxeas have been reported from many genera within the family and such spicules now seem to be more common than not. Nonetheless, the irregular, distinctly digitate growth form, the prominent dermal layer and development of the deep spongocoel seem adequate to characterize the generally smooth to weakly annulate sponges. Other comparisons with somewhat similar genera and species are treated in discussion of the various species below.

*Type species.* *Somersetella conicula* Rigby and Dixon, 1979.

### *Somersetella digitata* Rigby and Dixon, 1979

Plate 7, figures 1-4

*Somersetella digitata* Rigby and Dixon, 1979, p. 618-620, Pl. 2, figs. 1, 2.

*Diagnosis.* Digitate anthaspidellid with annulate cylindrical branches, each pierced by interconnected (?) spongocoel. Horizontal canals in vertically stacked series pierce walls in an upward arch. Skeletal net of horizontal dendroclones united to form prominent trabs that are cored by oxeas and are pinnate upward; trabs meet the gastral surface at low angles and dermal surface at high angles; surface of pinnation parallel to the spongocoel surface approximately one fourth the wall thickness from the gastral surface. Prominent thin dermal layer over much of the sponge.

*Description.* One nearly complete sponge occurs in the collection as a digitate form with several finger-like branches, each approximately 10 to 12 mm in diameter (Fig. 5B). One branch is approximately 10 x 17 mm in diameter, approximately at a position of subdivision. The upper end of each branch is pierced by a round spongocoel approximately 2.0 to 2.5 mm in diameter. Oscular ends of the walls are rounded and the upper surface has a generally subhemispherical profile.

The summit is marked by faint impressions of radial canals. These canal grooves are approximately 0.5 to 0.6 mm wide and are generally less than one half that deep. They are upper canals of the stacked series that produces vertically aligned rows of ostia on the gastral margin. Those ostia are approximately 0.4 to 0.5 mm in diameter and spaced 0.3 to 0.5 mm apart, vertically, in those few openings where details can be seen. The rows are spaced 1.0 to 1.5 mm apart, centre-to-centre.

Walls in the upper oscular rim area are 3.5 to 4.0 mm thick, but are approximately 5 mm thick in the middle and lower part of the sponge.

Canals consist of a cluster of several larger vertical excurrent canals in the centre and floor of the spongocoel and somewhat smaller radial canals parallel to the skeletal structure. Vertical excurrent canals are approximately 0.6 to 0.8 mm in diameter, where best exposed in a cross-section as a cluster 2.0 mm in diameter in the lower part of the sponge. The cluster is composed of six canals: one in the centre and five arranged in a circular rim in side-by-side pattern separated by vertical rows one spicule thick. These canals apparently were filled by spicules in the lower part of the sponge, which suggests that canals were not functional below a few mm from the base of the spongocoel. The lower part of the sponge, once sealed by the dense dermal layer, may not have remained alive.

Largest of the essentially horizontal canals have ostia 0.3 to 0.4 mm in diameter on the exterior. They show best on the curved summit of the sponge and in the upper part of the exterior, above the thin dermal layer. They may be circular to slightly vertically elongate and are spaced 0.5 to 1.0 mm apart, fairly uniformly, but without a prominent geometric pattern. These canals are approximately horizontal or may arch slightly parallel to earlier oscular margins.

A smaller canal series, approximately 0.2 mm in diameter, is circular and parallel to trabs. These openings are little more than modified skeletal pores and appear to grade into the pores because these small canals are fairly discontinuous.

Skeletal pores are triangular to variously subrectangular openings that are 0.1 to 0.2 mm across. They generally are oriented such that five or six occur in radial fashion around each trab, in a pattern common to many of the anthaspidellids. These small openings interconnect all larger openings and are parallel to the ladder-like series of trabs.

The skeleton is characteristically anthaspidellid, composed of linear series of dendroclones united at their ray tips to produce the rod-like trabs (Fig. 5C, D). The spicules are arranged in fairly well organized ladder-like series that are upwardly pinnate about a surface of pinnation that is approximately 1 mm into the wall from the gastral margin. Trabs are 0.12 to 0.18 mm in diameter and show considerable variation when traced vertically. They are spaced approximately 0.25 to 0.30 mm apart. They are somewhat more closely spaced in the interior of the wall than in the divergent outer part, particularly in that area immediately below the thin dermal layer.

Numerous loose oxeas occur in canals but no certain coring oxeas are evident in the numerous cross-sections of trabs visible throughout the sponge.

Dendroclones are principally those with long, simple, robust shafts and short brachyomes and cladomes. Shaft and cladomes on almost all spicules have tiny spines that are conical, approximately 0.01 mm in diameter and high and spaced approximately 0.02 to 0.04 mm apart. The spines are considered to be primary because of their uniform spacing, uniform size and consistent occurrence regardless of the degree of silicification of individual spicules. Shafts of the dendroclones are approximately 0.03 to 0.04 mm in diameter and range between approximately 0.20 and 0.35 mm long. Details of the hand-like brachyomes have been obscured where they articulate with trabs. The short cladomes are somewhat better defined. These are up to approximately 0.03 mm in diameter and are fairly robust elements 0.04 to 0.06 mm long. They seem to articulate in stubby hand-like zygomes with each other in the trabs. Regularity of the small, fairly robust elements is what produces the uniformity of the skeleton.

A few Y-shaped spicules and, less commonly, H- or X-shaped dendroclones also occur. Spicule shafts are 0.06 to 0.08 mm in diameter in the massive X-shaped forms where rays are 0.6 to 0.08 mm long. Clads are 0.04 mm in diameter. Y-shaped spicules are somewhat less massive and generally have equal to subequal rays, approximately 0.10 to 0.14 mm long and 0.040 to 0.045 mm in diameter. These spicules are most common immediately under the dermal layer and where they bridge between several trabs at terminations of canals within the skeleton.

The dermal layer is moderately thick in the lower part of the sponge, but thins upward. It is a dense, impervious layer, 0.10 mm thick in the upper part and up to 0.25 mm thick on annulations in the lower part. The dermal layer appears to be made of moderately irregular, closely packed, tangential, long-shafted rhizoclones. These rhizoclones have shaft diameters of 0.02 mm and are up to 0.2 mm long. They have well developed zygomes that are 0.01 to 0.02 mm in diameter and length. Zygomes may be club-like, finger-like or moderately dendritic. Some dendroclones also make up part of the dermal layer. The spicule structure of the dermal layer is generally obscured but upper edges and areas of delicate silicification show individual spicules.

The Baillie-Hamilton specimen is cut by numerous, thin, irregular silicified zones that are interpreted as largely secondary, although some are moderately evenly spaced and appear to be subparallel to early oscular margins. Some of the silicified zones may be early incipient dermal layers below where the sponge experienced rejuvenation. Silicified layers are approximately 0.1 to 0.2 mm thick and somewhat irregular in their course. Most do not interrupt the regular skeletal patterns and, consequently, are interpreted as surfaces of silicification that are secondary. They are localized in some digitations but are particularly common in the lower part of the sponge. Were they a basic part of the skeleton, one would anticipate more uniform development.

*Discussion.* The single specimen from the Baillie-Hamilton collection is a somewhat larger clump than type material from the Silurian Read Bay Formation on Somerset Island, but in growth form and skeletal characteristics the specimens are in close agreement. The axial cluster of vertical excurrent canals, considered possible in the type specimen, is here shown to be well developed. The Baillie-Hamilton material also demonstrates the spicules of the dermal layer.

*Cockbainia palmata* Rigby (1986, p. 15-17) is an upright bladed to palmate sponge that has finger-like digitations along the upper edge. It could appear similar to *Somersetella digitata* but *Cockbainia* lacks a spongocoel in the digitations, although it does have radiating canals there. The skeleton of *Cockbainia* is made of moderately robust dendroclones and has trabs cored by large oxeas that make up much of the trab diameter, in contrast with trabs of *Somersetella* that may lack oxeas or certainly have trabs where oxeas play a minor role.

*Lissocoelia* (Bassler, 1941, p. 96) is a branching dendritic form rather than a clustered digitate sponge and has a skeleton that is moderately irregular and made of fairly small spicules. *Archaeoscyphia boltoni* (Rigby and Nitecki, 1973) is also a digitate sponge, but it is a very large coarse-textured sponge compared with *Somersetella digitata.*

*Available material.* Only the figured specimen, UA 7718, and two additional small fragments of digitations occur in the collection. All are from Baillie-Hamilton Island Section 2-84.3.

### *Somersetella amplia* n. sp.

Plate 6, figures 8-11

*Diagnosis.* Branching digitate to palmate digitate sponges with finger-like branches 14 to 18 mm in diameter, pierced by a deep, moderately wide, open spongocoel one third the diameter of the branch. Dominant canals are horizontal, radial, vertically stacked openings; on the gastral margin they occur in horizontal rows spaced approximately 1 mm apart, centre-to-centre, to produce an almost pulsing texture to the anthaspidellid skeleton. Trabs are pinnate upward and 0.12 to 0.15 mm in diameter. Dendroclones are mainly long-shafted and simple, although other types occur. Dermal layer comprises small dendroclones and rhizoclones, not tile-like. Circular canals are of two sets parallel to trabs; the coarser are 0.2 to 0.3 mm and the finer are approximately 0.10 to 0.14 mm in diameter and grade down to triangular skeletal pores.

*Description.* Sponges included in the species are digitate, almost arborescent, to palmate digitate, somewhat like a human hand (Pl. 6, fig. 10). They expand upward from nearly blade-like bases to branches generally 14 to 18 mm across. The holotype is a sponge approximately 48 mm high and wide, across the base of the blade where digitations become clearly differentiated.

Each digitation is perforated by a deep, simple, smooth-walled spongocoel (Pl. 6, fig. 11) that is 5 to 6 mm across in the larger branches, although one has a spongocoel only 4 mm and another only 3 mm in diameter. The gastral margin is marked by weak grooves of vertically stacked ostia of radial-horizontal canals, but otherwise appears smooth.

Walls of the branches are 5 to 6 mm thick and have an upward convex oscular margin that is generally unmarked by canals. Growth of the sponge was apparently episodic and these particular branches were "caught" in stages between canal development. The sponge expands upward from a somewhat bladed base 10 x 20 mm, that appears to be virtually complete, but the exact base of attachment is not preserved.

The horizontal radial canals branch and converge toward major openings in the gastral margin. Ostia of these canals on the exterior are approximately 0.3 to 0.4 mm across and may be circular to slightly vertically elongate. They are spaced 1 to 2 mm apart, both horizontally and vertically, and in some areas, appear in crude horizontal layers. These layers approximately match the prominent openings and alternating skeletal layers near the gastral margin. The canals appear to be essentially circular throughout their length, but expand at the gastral margin to approximately 0.4 to 0.6 mm in diameter. Ostia are spaced approximately 1 mm apart, vertically, on the gastral margin. Rows are spaced 0.6 to 1.0 mm apart, centre-to-centre. Because of the regular canal spacing, the skeleton does look considerably more regular in the interior of the wall than it does on the oscular rim.

Coarse, irregular vertical canals are clustered in the axial area and empty into the base of the spongocoel. These excurrent canals mark sharply upward flexed inner ends of earlier radial series. They are 1.0 to 1.5 mm across and there are five to eight canals in a cluster 3 to 4 mm in diameter.

Somewhat smaller intermediate sized canals are parallel to the upward and outward radiating trabs of the skeleton. They are also subparallel to subdermal ends of the horizontal radiating series but are almost normal to that series in midwall. The intermediate canals are 0.2 to 0.3 mm in diameter and occur in tracts between the larger radiating canals. The larger ones are spaced such that there are five to six in 4 $mm^2$. There are up to ten smaller ostia in 4 $mm^2$ in the upper part of larger branches.

A small series of circular canals, approximately 0.1 mm in diameter, grades into the sharply triangular skeletal pores between the ladder-like rows of dendroclones. As many as 40 to 50 may occur in 4 $mm^2$ but their numbers are variable depending upon the numbers of larger openings. The triangular skeletal pores are approximately 0.10 to 0.14 mm across, on a side, and are somewhat larger in the outer part of the endosome than they are near the surface of pinnation.

There are no prominent vertical canals in the interior two thirds of the sponge wall. Openings parallel to the trabs do become more common in the outer part of the wall.

The skeleton is characteristically anthaspidellid, composed of ladder-like series of dendroclones arranged in uniform patterns (Pl. 6, figs. 8, 9). Spicule series and trabs are upwardly pinnate from a surface of pinnation, 1 to 2 mm in from the gastral margin. Inner, more gastral trabs meet the spongocoel margin at 15° to 20°.

Trabs are 0.12 to 0.15 mm in diameter and are fairly porous, smooth structures formed by the union of moderately distant zygomes of articulating dendroclones. Most trabs have a central opening that might have been the position of coring monaxial spicules, but no conclusive bits of such spicules were seen. Coring spicules may have been more easily replaced or quickly dissolved, leaving only a mould. An organic fibre may have been the coring structure.

Dendroclones are dominantly long, smooth shafted forms with short cladomes and short, bushy brachyomes. Shafts are 0.10 to 0.25 mm long, length varying to some degree because of position in the fabric and relationships to adjacent canals. Shafts are 0.03 to 0.04 mm in diameter, at their narrow end, and expand up to 0.04 to 0.06 mm in diameter toward the cladome, where they may be vertically elliptical. They subdivide to short clads that range from 0.04 mm long in normal dendroclones up to 0.10 to 0.14 mm long in the Y-shaped forms. Basal diameters of clads are approximately 0.02 to 0.03 mm in smaller spicules and 0.03 to 0.04 mm in the larger ones. Cladomes subdivide at ray tips into numerous toe-like or finger-like zygomes that articulate with adjacent spicules to produce the trabs.

Openings between zygomes produce the moderately porous trabs. These circular to moderately irregular or elliptical pores are only 0.01 to 0.02 mm in diameter, essentially the same size as the toe-like zygomes of the spicules.

Distinct X- and H-shaped dendroclones occur moderately commonly in the outer few millimetres of the skeleton. These spicules are somewhat more robust, with fairly thick axes.

Small conical to bifid spines occur on shafts and clads alike. They generally have circular to slightly elliptical bases, 0.005 to 0.010 mm across. They are commonly smooth cones, up to 0.02 mm high, and are spaced 0.02 mm apart along most shafts where best seen in profile. Their regularity and virtually ubiquitous occurrence suggest that they were initial parts of the skeleton, rather than secondary and related to silicification.

The dermal layer is discontinuous, probably because it was initially very thin or only locally secreted. Where best preserved it is 0.05 to 0.15 mm thick and composed of complex interdigitating rhizoid rhizoclones, Y- to H-shaped dendroclones, or dentate tips of subdermal dendroclones. Small X- and Y-shaped dermal dendroclones may have a full spicule length of only 0.10 to 0.15 mm. They are therefore significantly smaller than principal endosomal spicules. Most dermal spicules have shafts 0.015 to 0.020 mm in diameter and are considerably smaller than main endosomal spicules. Rhizoclones have irregularly curved to abruptly angular central shafts that may be branching or somewhat finger-like. Small, stubby zygomes extend laterally from axes and combine with adjacent spicules to produce the essentially impervious dermal layer. Pores are evident only where the dermal layer is delicately silicified and, perhaps, only where the internal part of the layer is preserved. These pores are 0.01 to 0.02 mm in diameter between adjacent spicules. Elsewhere, the thin layer appears dense and smooth. Where several layers of dermal spicules occur, the structure is essentially sealed.

*Discussion. Somersetella amplia* n. sp. is closely related to *Somersetella digitata* (Rigby and Dixon, 1979, p. 618-620) but is a somewhat larger sponge and has a considerably coarser texture from the size and spacing of the canals throughout. Orientations of canals and skeletal elements are the same in both species, but the dermal layer in *S. amplia* n. sp. is thinner and more discontinuous than it is in *S. digitata.*

*Somersetella amplia* n. sp. is generally separable from the other digitate species, on the same basis that *S. digitata* Rigby and Dixon is separated from those forms. Comparisons with related sponges are discussed under the latter species.

*Etymology.* Latin, *amplius,* larger, referring to a somewhat larger and more coarsely textured sponge, in comparison with *Somersetella digitata.*

*Type material.* Holotype, UA 7719, and a smaller fragmentary reference specimen were collected at Baillie-Hamilton Section 2-84.

## Suborder TRICRANOCLADINA Reid, 1968

## Family HINDIIDAE Rauff, 1893

## Genus *Hindia* Duncan, 1879

Genera included within the Hindiidae were summarized by Rigby (1986, p. 28-33), as part of his study of sponges from the Devonian reefs of the Canning Basin of Western Australia. Rigby (1983) also discussed characteristics of the suborder and genera included within the family as part of the overall view of the Porifera. Most recently, Rigby and Webby (1988), described several new hindiid sponges from the Ordovician of New South Wales. *Hindia* is one of the most widespread sponges of the early Paleozoic, although it had only been provisionally identified (Rigby and Dixon, 1979, p. 622, 623), from the Silurian of Arctic Canada prior to the present report.

*Type species. Hindia sphaeroidalis* Duncan, 1879

### *Hindia sphaeroidalis* Duncan, 1879

Plate 7, figures 7-10

(For a complete synonymy to 1985, see Rigby and Webby, 1988)

*Hindia sphaeroidalis,* Duncan, 1879, p. 91, Pl. 9, figs. 1-6; Rauff, 1894, p. 335, Pl. 15; Pl. 16; Pl. 17, figs. 1-4; Rigby and Webby, 1988, p. 61-63, Pl. 26, figs. 1-10; Pl. 27, figs. 1-3.

*Hyalostelia solivaga,* Ulrich, 1890, p. 232, Pl. 2, fig. 4c.

*Astylospongia inornata,* Hall, 1863a, p. 70.

*Microspongia sphaeroidalis grandis*, Howell, 1946, p. 1-2, Pl. 1.

*Hindia fibrosa*, Hinde, 1883, p. 57, Pl. 13, fig. 1a, b; de Laubenfels, 1955, p. E60, figs. 45, 1-3.

*Microspongia fibrosa*, Easton, 1960, p. 108, Figs. 3, 4, 6a-c.

*Diagnosis.* Spherical, tricranoclad-bearing sponges measuring up to approximately 50 mm in diameter. Skeletons of radially stacked series of tricranoclones in which the three sculptured cladomes articulate to prominent sculptured brachyomes of proximal spicules. Canals are straight and increase in diameter radially.

*Description.* Spheroidal sponges included here from Baillie-Hamilton Island range from approximately 18 mm to 28 mm in diameter and are essentially complete, except for one specimen. It has been crushed and demonstrates the probably hollow nature of the other specimens, for many hindiids have resorbed interiors.

The largest specimen shows the skeletal structure and canal system with three sizes of radial openings (Pl. 7, fig. 10). Largest canals are presumed to be excurrent. These are circular to slightly elliptical and are 0.35 to 0.40 mm across on the exterior. Each is bounded by six series of spicules, three more distal ones alternate with three more proximal ones in a zig-zag arrangement of centres of tricranoclones in adjacent series.

The next smaller series of openings are 0.20 to 0.25 mm across and are considered as probably incurrent. They are similarly circular and have four or five spicules involved in definition of their walls, two or three series are distal and two or three proximal in the alternating pattern.

More numerous are smaller circular openings that are approximately 0.15 to 0.20 mm across. These are the smallest consistently circular openings in the skeleton. They grade into the skeletal pores that may be more elliptical to triangular, but are of essentially the same size. Skeletal pores can be as little as 0.05 to 0.06 mm across and may be in vertical series because the entire structure of the skeleton is so distinctly radial.

Tricranoclones, when viewed from above, have a swollen centre from which radiate the three arching, proximally directed, cladomes. They taper toward their tips but then enlarge abruptly to articulate with the sculptured brachyomes of more proximal spicules. These brachyomes have shafts, 0.02 to 0.03 mm in diameter, that expand upward to a sculptured knob, approximately 0.04 mm across. Three to five irregular nodes, 0.01 mm across and high, occur on each brachyome tip. Brachyomes are approximately 0.04 mm high. They expand into the common ray junction that may be broadly subtriangular and approximately 0.06 mm across.

Cladomes are approximately 0.06 mm wide, when seen from above, and narrow to 0.03 to 0.04 mm across, 0.12 to 0.14 mm out from the common ray junction. They flare to approximately 0.04 to 0.05 mm wide at their tips where they articulate with adjacent brachyomes. They have digitate finger-like zygomes that wrap around the brachyomes and interdigitate with similar tips of adjacent spicules. The distal half of the upper surface of each cladome is smooth. Proximal under surfaces of the distinctly arched cladome rays are also smooth. Near the brachyome, however, each cladome is sculptured with low nodes and small conical spines. These nodes or spines may be 0.06 to 0.08 mm wide and high. Some have rounded nailhead-like knobs, but others are distinctly and sharply conical.

Arched cladome rays produce the elliptical to circular skeletal openings visible when spicule series are viewed from the side. Rays of a spicule rise approximately 0.10 mm from the lower part of the articulating cladome tip to the axis or centre of the tricranoclone. This results in an arch approximately 0.08 mm high and approximately 0.15 to 0.16 mm across at its base, cladome tip to cladome tip.

Tips of a few radiating oxeas are evident along axes of some canals. These spicules are 0.04 to 0.05 mm across, at the surface of the sponge, and may have been broken off. Such spicules are common as canal-filling elements in several members of the family and appear to be present in all species of *Hindia*.

Centres of spherical *Hindia* are commonly resorbed. A crushed specimen indicates that resorption of the skeleton also affected the species at this locality.

*Discussion.* The remarkable uniformity of *Hindia* throughout its wide geographic and long geological range is startling. The skeleton was obviously structurally and physiologically well adapted. *Hindia* is so widespread that it might have been a planktonic form. Resorption of the centre of the sponge and development of a gas-filled central opening certainly could have made the organism light enough to float easily. The sponges are almost perfectly spherical, which would also suggest that they lived free of the bottom and avoided the distortion that a benthonic habit produces in related genera.

*Materials.* The three figured specimens, UA 7722-7724, and two additional specimens occur in the collection from Baillie-Hamilton Island Section 2-84.3, others came from Baillie-Hamilton Island Sections 2-44 and 2-97. The species is also represented in collections from Cornwallis Island Section CAR 1-28.5+.

## Suborder SPHAEROCLADINA Schrammen, 1910

### Family ASTYLOSPONGIIDAE Zittel, 1877a

Paleozoic sphaerocladine sponges have been variously classified during the last 25 years. Rigby (1986, p. 33-35) has summarized genera of the family, known up to early 1984, in a generalized treatment of the family as part of a study of Devonian sponges from Australia. Definition of the family presented there is followed here.

The subspherical *Astylospongiella megale* was described by Rigby and Lenz (1978) from Ludlovian rocks on Baillie-Hamilton Island. It is known from a single specimen, and is a large sponge for the family. The appearance of *Carpospongia globosa* Rauff and the new *Astylospongia* (?) *lutera* n. sp., and *Astylospongiella striola* n. sp. make the Baillie-Hamilton assemblage one of the most diverse sphaerocladine assemblages known, even though these forms may not be numerically abundant.

### Genus *Astylospongia* Roemer, 1860

*Diagnosis.* Subglobular to bowl-shaped sponges, with prominent central spongocoel; large excurrent canals vertically stacked in concentric series, parallel to the dermal surface, cross-connected by smaller upward and outward radiating canals. The skeleton of sphaeroclones with spinose centra; not prominently radiating.

*Discussion.* Comparisons with related genera have been treated by Rigby (1985) in his discussion of the Devonian sponges of Canning Basin of Western Australia.

*Type species. Astylospongia praemorsa* (Goldfuss, 1826).

### *Astylospongia* (?) *lutera* n. sp.

Plate 8, figures 12-14

*Diagnosis.* Thick-walled flabellate to open, bowl-shaped or funnel-like astylospongiids with gentle vertical ribbing on the exterior, but a smooth interior. Major canals 0.7 to 0.8 mm in diameter, in radial series arcuate parallel to former positions of the oscular rim. Canals enter the dermal layer at low angles on the ribs or at high angles in the inter-rib area, but then swing abruptly to become distally arcuate. They exit at aligned ostia on the gastral margin. Skeleton of sphaeroclones of essentially one size throughout, with centra approximately 0.16 to 0.22 mm in diameter spaced 0.3 to 0.4 mm apart.

*Description.* Only a fragment of the sponge is in the collections and it is part of an obviously transported cluster of sponge fragments. The fragment is approximately 48 mm high and had a virtually complete, rounded oscular rim. It is approximately 65 mm wide with broken sides and base. The sponge shows weak vertical ribs, approximately 20 mm wide. The wall is 19 to 20 mm thick at the crest of the ribs and 14 to 15 mm thick in inter-rib areas.

Rib areas are marked by subtangential subvertical grooves that flex sharply to form covered canals in the interior of the wall, as part of the major canal system. Grooves of major incurrent canals are approximately 0.6 to 0.8 mm across. They are essentially vertical-radial along crests of the ribs but slope upward and outward, off the ribs, toward the oscular margin before plunging into the wall as canals. Ostia for the same canal series in inter-rib areas are subcircular and 0.6 to 0.8 mm in diameter. These canals are essentially normal to the dermal layer for approximately 1 mm but then turn sharply upward, and run parallel to the general fabric of the entire system. The canals generally diverge from the dermal surface at approximately 30° to the midwall, but then flex through smooth arcs to become approximately normal to the gastral surface.

Canals are approximately 0.7 to 0.8 mm wide in the exterior. Outer parts of canals are approximately circular, but inner parts may be moderately elliptical openings 0.7 to 0.8 mm wide and 1.0 to 1.3 mm high. Ostia of these same canals on the gastral margin are elliptical and 0.7 mm wide and 1.2 mm high. They occur in distinct series, both in the inner endosome and on the gastral margin. In the interior, there are six to eight a centimetre in a row, vertically, and seven to eight rows a centimetre horizontally. Ostia on the gastral margin have essentially the same spacing of six to eight a centimetre in vertical radial rows and eight to nine rows a centimetre in horizontal series, parallel to the oscular rim.

Smaller canals occur in the skeletal tracts between the large canals. These small circular openings are 0.20 to 0.25 mm across and are roughly normal to the larger canals in the outer half of the walls. The small canals are indistinct in the open, porous inner half of the wall.

Two additional series of openings are evident within the dermal layer. Moderately large canals, 0.5 mm across, feed through the dermal layer and into the outer part of the large, arcuate, dominant system. Smaller openings, 0.18 to 0.25 mm in diameter, occur between the large ostia. These are dermal expressions of small canals seen in isolated areas in the interior.

More common openings throughout the sponge are subtriangular to locally subcircular skeletal pores that occur between rays of sphaeroclones. They are approximately 0.10 mm across in the dermal layer but up to 0.2 to 0.3 mm across in the more open-textured endosomal layer.

The dermal layer is approximately 1 mm thick and is composed of somewhat more robust sphaeroclones than those in the interior. Dermal centra have diameters of 0.16 to 0.22 mm, have stubby rays generally only 0.1 to 0.2 mm long and 0.04 to 0.05 mm in diameter. They are 0.18 to 0.20 mm apart.

Endosomal sphaeroclones are remarkably uniform (Pl. 8, fig. 12), except right at the dermal and gastral margins. They have spherical centra that are 0.15 to 0.22 mm in diameter and are commonly spaced 0.3 to 0.4 mm apart. Four to six cladomes radiate from each centrum. The straight cladomes have basal diameters of 0.07 to 0.08 mm and taper to a minimum diameter of approximately 0.04 to 0.05 mm, immediately proximal to where they expand into the hand-like articulation zygomes with which spicules fuse to adjacent centra. Centra in the interior have clads 0.2 to 0.3 mm long, although some may be even longer. Zygomes at clad tips produce articulating expansions approximately 0.10 to 0.1 mm across. Finger-like zygomes enclose or abut spines of adjacent centra.

Spines of centra have basal diameters of 0.03 mm or slightly more. They are up to 0.04 to 0.05 mm high and may be steeply and smoothly conical or hook-shaped, like barbs on roses. Some are irregularly ragged and subcylindrical but others may be capped by diverging smaller spines. Generally speaking, bases of spines are 0.01 to 0.02 mm apart. Approximately 40 spines may occur on a single centrum, generally on the sides and distal surface. Proximal surfaces of centra and clads generally lack spines.

*Discussion.* The species is placed within the genus *Astylospongia* because its canal pattern has most in common with that form, particularly to the open saucer-or bowl-shaped species. Because the sponge described here is only the outer part of what may be a bowl-shaped or flabellate form, we are uncertain about the nature of canals in the central part of the sponge. However, the occurrence of stacked concentric canals, with minor canals at high angles to the primary openings, is most similar to patterns in *Astylospongia.*

Endosomal spicules of *A.* (?) *lutera* n. sp. are essentially of uniform size. This contrasts sharply with *Caryospongia* (Rauff, 1894, p. 296, 297) or *Carpospongia* (Rauff, 1894, p. 304), which show a radial increase in spicule size. The Cornwallis Island species is similar to *Astylospongiella* (Rigby and Lenz, 1978, p. 158, 159) in having spicules essentially of the same dimensions throughout the sponge. However, *Astylospongiella* has large, irregularly spaced canals that are not in vertically stacked series. Thus, it is fairly easily differentiated from *Astylospongia* (?) *lutera.* It contrasts with the *Astylospongia* described here in being consistently more irregular as well.

*Etymology.* Latin, *luter*, bathtub or basin, in reference to the assumed basin-like form of the sponge.

*Type material.* Holotype, UA 7725, on one of the large blocks that contains several sponges from the Cape Phillips Formation on Cornwallis Island at Section CAR 1-44.5.

### **Genus** *Carpospongia* Rauff, 1894

*Discussion. Carpospongia* Rauff (1894, p. 304-306) includes spherical to subspherical or pear-shaped sponges that lack a prominent spongocoel. The skeleton is consistently radial, with nearly straight incurrent and excurrent canals that radiate evenly throughout the sponge body, rather than being stacked in organized series. Sphaeroclones with spinose centra are the principal spicules of the skeleton and they increase in size radially, so that the largest spicules of the skeleton are those at the dermal surface.

De Laubenfels (1953, p. E61) concluded that *Carpospongia* and *Caryospongia* are synonymous because of their common subspherical form and skeletal similarity. Finks (1960, p. 96, 97) rejected that conclusion and pointed out that de Laubenfels effectively negated the differences in canal pattern in the interior. *Caryospongia* Rauff (1894, p. 296, 297) has a canal system in which large canals radiate from the centre in middle and lower parts of the sponge but sweep upward and outward in the upper part. Smaller radiating canals apparently cross-connect the large openings. Differences in canal structure certainly separate *Caryospongia* and *Carpospongia*. These differences were illustrated by Rigby (1986, Fig. 12B, C).

### *Carpospongia globosa* (Eichwald, 1830)

Plate 8, figures 1-6

*Manon globosum* Eichwald, 1830, p. 188; Bronn, 1848, p. 701; Eichwald, 1859, p. 336, Pl. 22, figs. 11a, b.

*Manon globus* Eichwald, 1840, p. 208.

(?) *Achilleum cerasus* Eichwald, 1859, p. 334, Pl. 22, figs. 5a, b.(?)

*Astylospongia pilula* in part F. Roemer, 1861, p. 12, Pl. 3, fig. 4a, but not fig. 4b; Martin, 1877a, p. 14; Martin 1877b, p. 489; Martin, 1878, p. 26, 27, 43, 67; Roemer, 1880, p. 310; Roemer, 1885, p. 63.

*Astylospongia globosa* Zittel, 1877c, p. 711; Schluter, 1885, p. 62.

(?) *Astylospongia cerasus* Zittel, 1877c, p. 711 (?).

*Carpospongia globosa* Rauff, 1894, p. 304-306, Pl. 10, figs. 8-12; Pl. 11, fig. 1; Pl. 12, figs. 1, 2; Pl. 14, figs. 1, 2.

*Diagnosis.* Egg-shaped to subspherical sponges consisting of radially-built skeleton of sphaeroclones; lacks a spongocoel; straight incurrent and excurrent canals radiate from the centre; not in stacked series; sphaeroclones with spinose spherical centra and tapering rays concentrated on one side. Spicules increase in size from the centre out.

*Description.* Three more or less complete sponges and several fragments of the species occur in the collection. Complete sponges are somewhat egg-shaped and range from between 16 x 20 mm and 20 x 25 mm. The larger one has been broken through the centre. The smaller fragment is only the exterior few mm of a piece approximately 1 cm square.

The interior of the sponge is best shown on the larger specimen as a cross-section (Pl. 8, fig. 2). It clearly demonstrates the straight radiating nature of the canal system that includes three series. Generally speaking, each canal expands toward the exterior, but remains steeply conical to conical-cylindrical. At a diameter of approximately 20 mm, the larger, presumably excurrent, canals are 0.8 to 0.9 mm across. Their ostia are spaced 1 to 3 mm apart, moderately uniformly over the entire sponge. Intervening skeletal material is pierced by smaller openings, presumably the incurrent series, that are 0.4 to 0.5 mm across. These smaller canals are spaced 1 mm or less apart and occur in interspaces between the large excurrent openings. There are four large openings and 15 smaller openings in 25 mm$^2$. An additional smaller series of circular openings, approximately 0.15 to 0.20 mm across, occurs in the outer skeleton. These are larger than the somewhat triangular or subprismatic skeletal pores between spicules and are probably of a third canal series that has less continuity than the others. There are as many as five or six of these small ostia in a square millimetre, although they occur with some irregularity.

On the smaller specimens, the large canals are approximately 0.6 to 0.7 mm across and intermediate ones are 0.35 to 0.50 mm across. The smallest canals are 0.15 to 0.20 mm across where most evident. Smaller skeletal pores are triangular to somewhat rounded subprismatic and are generally 0.08 to 0.10 mm across on the side. They occur between radiating rays of the sphaeroclone spicules.

Texture of the skeleton is remarkably uniform (Pl. 8, fig. 1). Spicules are well preserved on the smaller specimen where spinose to nodular spherical exterior centra are 0.14 to 0.16 mm in diameter. Tapering rays radiate from each spicule and articulate with adjacent centra. These rays have proximal diameters of 0.035 to 0.045 mm and taper smoothly to 0.025 to 0.030 mm in diameter near their distal ends, before they expand in the hand-like articulation with adjacent centra. Articulating zygomes may be 0.06 mm across and affect the outer 0.03 to 0.04 mm of each ray. Rays are generally 0.10 to 0.14 mm long, from the centra to tips of the articulation with adjacent spicules.

Centra bear conical spines that are approximately 0.08 to 0.10 mm in diameter, at their bases, and taper evenly to sharp tips. Spines may be up to 0.04 mm long, but most are 0.02 to 0.03 mm long where not obscured by articulation with adjacent ray tips. In some spicules, where centra have been partially aborted, there is an almost crown-like radiation of the small spines from a common ray junction. Spines of other centra radiate from only distal surfaces. The proximal surface is relatively smooth. Spines are commonly spaced 0.02 mm apart, centre-to-centre. As many as 20 to 25 spines may occur on the distal hemisphere. Tips of the spines may protrude between articulated zygomes as nodes or sharp conical tips. Spines show best where centra are adjacent to the canals.

Numbers of radiating rays vary with placement in the skeleton but four to six rays are common, although some centra adjacent to canals have only two or three rays.

*Discussion.* Among species of *Carpospongia* described by Rauff (1894, p. 304-308, p. 325-327) only *Carpospongia globosa* (Eichwald, 1830) is a uniformly smooth form, generally marked only by pits of ostia; Rauff noted that the outer surface is generally characterless and mostly smooth in that species. Other species have irregularly impressed tangential canals or furrows that may form an irregular net or may radiate from an area of concentrated excurrent canals. For example, *Carpomanon glandulosum* (Rauff, 1894, Pl. 13, figs. 11, 12) has an irregular, almost flower-like, petalloid appearance produced by the radiating canals. *Carpospongia stellatim-sulcatum* (Rauff, 1894, p. 325, 326, Pl. 12, figs. 4-13; Pl. 13, figs. 9, 10) has canals arranged in moderately linear series in impressed furrows.

*Carpospongia globosa*, *Carpospongia castanea* and *Carpospongia conwentzi* are known from Europe. *Carpospongia castanea* (F. Roemer) (Rauff, 1894, p. 307, 308) is a knobby form, rather than smooth, and contrasts with the Baillie-Hamilton sponge in that aspect. *Carpospongia conwentzi* (Rauff, 1894, p. 308) is even more distinctly nodular, with large "warts", although the inner skeletal structure appears to be essentially the same in all of the species. Because of their lack of sculpture, nature of their skeletons and canal patterns, the Baillie-Hamilton specimens are placed in *C. globosa* (Eichwald, 1830).

*Material.* The figured specimens, UA 7726 and UA 7727, and reference specimen UA 7728 are from Baillie-Hamilton Island Section 2-84.3.

### Genus *Astylospongiella* Rigby and Lenz, 1978

*Astylospongiella*, as originally described (Rigby and Lenz, 1978, p. 158, 159), is a massive obconical to subspherical sponge with a canal system that consists of radiating, irregularly spaced, canals that extend upward and inward from the outer lower surface, arching into the simple spongocoel. A smaller series of canals occurs roughly at right angles to these large openings.

*Type species. Astylospongiella megale* Rigby and Lenz, 1978.

### *Astylospongiella striola* n. sp.

Plate 8, figures 7-10,
Plate 10, figure 2; Figure 6

*Diagnosis.* Steeply to moderately obconical *Astylospongiella*, with deep simple spongocoel. Incurrent canals arise as subtangent dermal to subdermal vertical grooves that anastomose or branch vertically, for some distance, then turn abruptly and arch inward toward the gastral surface. Grooves up to 0.8 mm wide lead to canals up to 0.6 mm wide and 1.2 mm high, radially, that arch to become the large openings on the gastral margin. A second smaller series, at right angles or normal to the dermal surface, is 0.3 to 0.5 mm in diameter and may feed directly through the wall. Sphaeroclones are typical of the family, virtually the same size throughout the sponge, with centra 0.14 to 0.18 mm in diameter and rays up to 0.18 mm long that taper away from the centra of their origin. Centra spinose.

*Description.* The steeply obconical holotype (Pl. 8, fig. 8) is a nearly complete sponge that is approximately 35 mm high. It rises from a subtriangular broken base, 6 to 7 mm in diameter, up to the subcircular to slightly elliptical maximum diameter of approximately 21 mm at about two thirds of the height. Uppermost part of the sponge narrows to the distinct, rounded, oscular margin.

The sponge is perforated by a simple tubular spongocoel. It is approximately 16 mm deep and expands upward from a rounded base, approximately 3 mm in diameter, to the maximum width of 6 mm at the osculum.

A somewhat more fragmentary paratype is of a larger sponge, but only the upper more flaring part is preserved. It is 35 mm in diameter but is only a fragment 17 to 18 mm high. It has a spongocoel approximately 12 mm in diameter, which suggests that the walls in more mature stages probably thicken and, perhaps, flare funnel-like from a steeply obconical stalk.

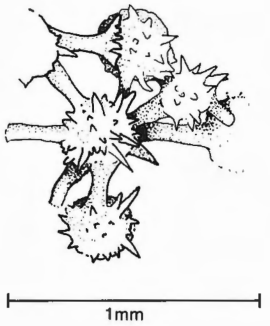


*Figure 6. Camera lucida drawings of spicules from the holotype of **Astylospongiella striola** n. sp., UA 7729, Baillie-Hamilton Island Section 2-84.3. Spinose subspherical centra have moderately robust rays that articulate to adjacent centra, sometimes with finger-like zygomes like those shown near the top. Complete spicules are commonly fused so that the junction is obscured. Rays generally taper distally from the centrum of their origin and expand at tips to articulate with adjacent centra.*

Numerous shallow subvertical grooves mark the surface and are distinctive of the species. These may anastomose, branch, or may be vertically continuous as sinuous single grooves. Some grooves may be partially roofed along their trace and may curve in and out in the general dermal or subdermal zone. They generally are traceable for up to 10 mm from their inception as weak indentations on the lower part of the sponge wall. Each becomes more pronounced as a rounded groove and is deepest immediately before it is completely roofed. Most turn sharply inward toward the spongocoel at about where they are completely roofed. These grooves are 0.6 to 0.8 mm wide at about mid-depth.

Dermal grooves lead upward to canals that are 0.5 to 0.6 mm wide. These openings are approximately 1.0 to 1.2 mm high, where they are first completely roofed and are radially elliptical and elongate. They curve abruptly inward, parallel to former positions of the oscular margin, and pierce the gastral surface as ostia that are approximately 0.6 to 0.8 mm wide and 1.0 to 1.4 mm high. There they are separated 1.0 to 1.5 mm, vertically, and 0.6 to 1.5 mm, horizontally. They do not occur in linear, horizontal, or vertical patterns. There are three or four ostia in 5 mm, as measured horizontally around the gastral surface.

A series of smaller canals, 0.3 to 0.5 mm in diameter, have ostia in round pits that are 0.5 to 0.6 mm wide and deep. The canals are circular and at right angles to the dermal surface and the tangential grooves. They occur in skeletal space between the grooves and are irregularly 1.0 to 1.5 mm apart. They may feed into some of the larger interior vertical canals in the wall but most appear to pierce straight through the wall with little change in diameter.

Spicules of the skeleton are sphaeroclones characteristic of the family, in which spinose spherical centra have four to six radiating rays on one side. These rays articulate with centra of adjacent spicules to produce an interbraced fused structure. Centra are spherical and 0.14 to 0.18 mm in diameter, with most near the upper end of the range. Tapered rays, 0.12 to 0.18 mm long, extend from centra to centra to form the braced skeleton. Rays have a somewhat mound-like base, 0.05 to 0.06 mm in diameter, and quickly taper to a basal ray diameter of 0.04 to 0.05 mm. They continue to taper smoothly and evenly to minimum diameters of approximately 0.02 to 0.03 mm, immediately proximal to flaring hand-like elements that articulate with adjacent centra. The flaring articulation may be up to 0.06 mm across and affect the distal 0.03 to 0.05 mm of the rays. Fusion is usually so complete that identification of individual elements in ray tips is difficult.

Centra are distinctly spinose (Figs. 6, 8B), with long conical spines that have basal diameters of 0.01 to 0.02 mm and that are up to 0.09 mm long. In general, spines on the centra are straight and radiate like needles, but a few curve and develop hooks like the thorns of rose bushes. Zygomes of adjacent rays embed the spines and help produce the strongly "riveted" skeleton characteristic of the family.

Spicules tend to be the same general size from the most juvenile part preserved on the paratypes and holotype up to the most adult part of the sponge, near the oscular margin. Skeletal pores between rays generally form triangular openings that are 0.08 to 0.12 mm across and help produce the moderately porous, though very thoroughly fused, skeleton typical of the family.

*Discussion. Astylospongiella striola* n. sp. contrasts with *Astylospongiella megale* Rigby and Lenz (1978), the type species of the genus, principally in growth form and in having somewhat smaller canals than those in the massive, robust, subspherical type species. *Astylospongiella megale* also has tangential, impressed canals only on middle and upper parts of the sponge, whereas they are probably most pronounced on the lower part in *A. striola*.

In some characteristics, *A. striola* appears like *Phialaspongia* Rigby and Bayer (1971, p. 622, 623) but *Phialaspongia* has a series of distinct, large, vertical canals that rise somewhat at a tangent to the stalk but pierce vertically through the obconical upper part of the sponge to open on the spongocoel floor. In addition, *Phialaspongia* generally lacks arcuate upper ends of tangential canals but has a series of large canals that are more or less at right angles to the upper funnel-like part of the sponge. It would be possible to confuse the genera, however, in partially preserved juveniles were it not for the pronounced, large, vertical canals that affect almost all but the central part of the stalks of juvenile *Phialaspongia*.

As with the type species, *Astylospongiella striola* contrasts with species of *Astylospongia* (Roemer, 1860, p. 7), which are characterized by having concentric canals arranged in vertically stacked series that are cross-connected by a radiating series of canals. *Astylospongia* thus has a considerably more regular skeleton than *Astylospongiella*.

*Caryospongia* Rauff (1894, p. 296, 297) and *Carpospongia* Rauff (1894, p. 303) have distinctly more regularly organized canal systems than *Astylospongiella*, as well as strong radiating systems. These forms also have spicules that increase in size from the small juvenile stages to the more mature parts of the sponge. Other genera included within the family have been described by Rigby (1983; 1986, p. 33-35) in his discussion of the Devonian sponges of the Canning Basin, and differences that separate the various genera have been treated.

*Etymology.* Latin, *striola*, furrow, hollow, fluting or line, in reference to the characteristic tangential canals or furrows on the exterior.

*Material.* Holotype, UA 7729 and paratypes, UA 7730 and 7731, plus two additional somewhat more fragmentary specimens are in the collection. All are from Baillie-Hamilton Island Section 2-84.3. Three questionable fragments also occur, one each from Baillie-Hamilton Section 2-44, and Cornwallis Island Section 1-80+ and 1-44.5.

## Class HEXACTINELLIDA Schmidt, 1870

## Subclass HEXASTEROPHORA Schulze, 1887

## Order LYSSACINOSA Zittel, 1877a

## Family LUMECTOSPONGIIDAE new family

*Diagnosis.* Hexactinellid sponges whose skeleton consists principally of an irregular "felted" mass of uncinates with less common, irregularly spaced and oriented, smooth-rayed hexactines.

*Discussion.* Certain placement of the family within one of the subclasses of Hexactinellida, as summarized by Finks (1983), is impossible because definitive microscleres were not found in the Silurian sponges that are the basis of the family defined here. Fossil hexactinellid sponges with skeletons composed of coarse uncinates and isolated smooth-rayed hexactines have not been previously described, although uncinates do occur fairly widely within the Hexactinellida (Reid, 1958, p. xxx-xxxi). The family is tentatively placed within the Hexasterophora Schulze, 1887 because of the common occurrence of uncinates within that subclass. The sponges lack dictyonal strands and, hence, are included in the Lyssacinosa Zittel, 1877.

Uncinates were utilized as distinguishing spicules in the hexasterophoran hexactinellids separated as the Uncinataria by Schulze (1887). That differentiation was used by Schrammen (1912, p. 208-226), in his monographic study of the Upper Cretaceous sponges of northwestern Germany. Schrammen noted that uncinates occur in the families Euretidae Schulze, 1904; Chonelasmatidae Schrammen, 1912; Aphrocallistidae Schulze, 1904 and the Tretocalycidae Schulze, 1904, as used by him. These families all have a dictyonine skeletal structure, however, and consequently their skeletons contrast sharply with the skeleton of "felted" uncinates and isolated hexactines of sponges included here in the family Lumectospongiidae.

Uncinates also occur in other classes of sponges, as for example in the Sclerospongiae in *Goreauiella auriculata* Hartman, 1969. Such sponges, however, do not have the associated hexactines in their skeletons and can be clearly differentiated, even though they may be strikingly similar in gross form.

*Type genus. Lumectospongia* n. gen.

### Genus *Lumectospongia* n. gen.

*Diagnosis.* Thin-walled obconical to bowl- or cup-shaped sponges with skeleton of associated uncinates, up to 2 mm long, and less common smooth-rayed hexactines, of essentially the same size, in an irregular felt-like mass. Hexactines irregularly oriented and spaced within the wall. Pores widely spaced and ill-defined.

*Discussion.* Discussion of other fossil forms with which *Lumectospongia* might be related or confused has been presented in treatment of the family. Gross form of the sponge, its thin walls and ill-defined pores might be considered distinguishing features at the generic level, whereas sizes of spicules, nature of the felted skeleton, and sizes of openings within the skeleton are considered distinguishing specific features.

*Type species. Lumectospongia uncinata* n. sp.

### *Lumectospongia uncinata* n. sp.

Plate 9, figures 1-4, 16;
Figure 7

*Diagnosis.* Very thin-walled, obconical to steeply conical sponges with skeleton made of a felted mass of uncinates, with rare smooth hexactines. Uncinates up to 2 mm long, with axes approximately 0.02 to 0.03 mm in diameter; barb-like hooks up to 0.05 mm long in loose spirals or in three to five rows. Moderately widely spaced pores through the wall are ill-defined, some, 0.5 to 0.6 mm in diameter, are spaced 1 to 2 mm apart and others, 0.3 to 0.4 mm across and more numerous, are spaced approximately 0.5 mm apart.

*Description.* There are three fragments of a single, very thin-walled sponge in the collection. The largest fragment is approximately 40 x 50 mm and shows upper and lower walls folded over, with loose open matrix filling a now-crushed spongocoel (Pl. 9, fig. 1). The walls are 0.6 to 1.1 mm thick and are now commonly composed of secondary beekite spheres from which the uncinate spicules extend. A few exceptional areas near the margin of the wall have spicules moderately well defined in a felted, almost tumbled-looking mass (Pl. 9, figs. 2, 4).

Canals are ill-defined in the massive replacement, but a few matrix-filled circular openings, 0.5 to 0.6 mm across, occur in both the upper and lower walls. They are 1 to 2 mm apart and very irregularly spaced.

More common and more numerous canals are approximately 0.3 to 0.4 mm across. They are also now matrix-filled subcircular openings through the loosely felted uncinate mass. These canals are generally 0.5 mm apart, although lacking any predictable pattern. Whether these represent original openings in the walls or gaps left by the beekite replacement is impossible to tell.

Uncinates (Pl. 9, fig. 4; Fig. 7E, F) are up to 2 mm long, although most are 1.5 to 1.7 mm long as presently preserved. They have curved to irregularly sinuous or straight axes that are up to 0.02 to 0.03 mm in diameter at mid-length. Axes taper in both directions so that the spicules appear as spinose oxeas. The spines or hooks look like barbs on a rose bush, where curved, or else like slightly bent small cones with circular to elliptical bases. Most of the hooks are 0.01 mm across, but may be up to 0.15 to 0.20 mm long, parallel to the spicule axis where elliptical. Most spines are bent cones approximately 0.020 to 0.025 mm long but a few are almost recurved hooks that are up to 0.05 mm long. Some uncinates appear to have hooks arranged in three to five moderately linear, equally spaced, series around the axis, with most approximately four to five long rows that appear 30° to 50° apart. Individual hook-like spines are in somewhat alternating positions or in a loose, open spiral. Within the spiral, hooks are spaced 0.04 to 0.06 mm apart along the axis, but within a single row, individual hooks may be 0.10 mm apart.

Hooks are considerably more closely spaced and much tinier at tips of the spicules. Hooks generally point in one direction, like thorns in a rose bush, but may be variously directed. Tips of the tapering spicules may terminate in one large hook, or virtual protriaene, where spines extend forward at moderately high angles to the pointed axis. In others, the hooks point back toward mid-length and are barbed, somewhat like a harpoon. They merely decrease in size toward the tip, which may be a sharp point that is almost the same size as the spines.

There appears to be no dermal or gastral differentiation in the skeleton, based on the silicified fragments.

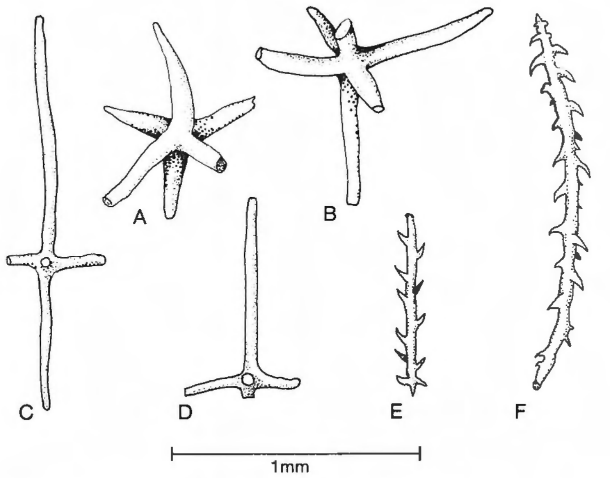


***Figure 7.** Camera lucida drawings of spicules from the holotype of **Lumectospongia uncinata** n. sp., UA 7732, Baillie-Hamilton Island Section 2-84.3. A-D, more or less uniform hexactines with six rays oriented mutually at right angles to each other. Short, robust rays are moderately complete but long, thinner rays are characteristically broken; E, F, spinose uncinates that make up most of the endosomal part of the skeleton. These spicules are characteristically curved, taper in both directions and have barbs like those on a rose bush, generally directed in a single direction. Such barbs may be irregularly spaced or occur in linear patterns.*

Smooth hexactines of various ranks occur (Fig. 7 A-D) throughout the sponge wall within the uncinate-dominated fabric. Largest ones have basal ray diameters of approximately 0.03 mm and rays up to 1 mm long. These are the most common hexactines. Others have rays as small as 0.006 to 0.010 mm in diameter. Those with narrowest rays appear like long rhabdodiactines with short, abruptly tapering, cross-rays that may be only 0.06 to 0.08 mm long. Relationships of various spicules within the skeleton are uncertain because the hexactines do not occur commonly enough for their orientation to be determined with certainty, but they commonly have longest rays parallel to the associated uncinates.

A few smooth oxeas, up to 0.6 mm long and 0.04 to 0.05 mm in diameter, also occur in the skeleton, but their relationships are uncertain. They may even be foreign spicules that are part of the matrix in which the sponges occur.

*Discussion.* Comparisons with possible related forms or sponges with which the genus and species might be confused have been discussed in treatment of the family.

*Etymology.* Latin, *uncinatus*, hooked, barbed, for the diagnostic spinose spicules that make up most of the skeletal wall.

*Type material.* One large fragment and two small fragments, of what was probably a single specimen, are all included as part of the holotype, UA 7732, which came from Baillie-Hamilton Island Section 2-84.3.

## Superfamily EUPLECTELLOIDEA Finks, 1960

## Family EUPLECTELLIDAE Gray, 1867

### **Genus *Corticulospongia* n. gen.**

*Diagnosis.* Open-conical to bowl-shaped, thin-walled hexactinellids with smooth, thin walls with full diplorhizal canal development. Walls of three layers. Dermal layer of coarse, irregular, curved or radiating tracts of rhabdodiactines or oxeas, tracts generally at a tangent to the surface. Subdermal endosomal part of wall composed of irregular, generally upward and outward radiating to subtangential tufts of rhabdodiactines, and oxeas generally parallel to margins of incurrent ostia. Gastral layer comprises less clustered thatch of smaller diactines and tiny hexactines, including hexactine and oxyhexaster microscleres.

*Discussion.* Among the thin-walled hexactinellids of the early Paleozoic that appear related to *Corticulospongia* is the Australian Ordovician genus *Tiddalickia* (Rigby and Webby, 1988). *Tiddalickia,* however, is a thin-walled form whose skeleton is composed of rectangularly arranged straps in a pattern significantly better organized than the skeleton of *Corticulospongia* and, thus, can be moderately clearly differentiated. *Tiddalickia* does have a skeleton made principally of monaxons or rhabdodiactines, as in *Corticulospongia.*

*Wongaspongia,* from the Ordovician of Australia (Rigby and Webby, 1988), is also a thin-walled, moderately loosely organized form, but it has an armouring dermal layer made of coarse, irregularly oriented, hexactines. The gastral layer is made of clustered, long-rayed hexactines or rhabdodiactines that produce an inner skeleton, which could appear similar to that of *Corticulospongia,* but the abundance of moderately coarse hexactines in the skeleton in *Wongaspongia* separates the genera.

*Liscombia* (Rigby and Webby, 1988) also has a gastral layer of ropy tracts of long rhabdodiactines. However, it, too, has an outer, dermal layer of small to large, irregularly oriented, normal hexactines and can thus be differentiated.

*Regadrella* (Schmidt, 1880; Rigby, 1981) from Tertiary and Cretaceous rocks of eastern North America and Europe, has an irregular skeleton, but one made of ladder-like beams where spicules are fused with synapticulae or synapticular webs, rather than the moderately open, irregular, essentially unfused skeleton in *Corticulospongia. Corticulospongia* also has a zoned wall which is significantly different from walls of *Regadrella, Euplectella,* or *Proeuplectella* (Moret, 1926). These latter genera have basically untufted irregular skeletons that contrast sharply with the clustered rope-like skeleton of *Corticulospongia.*

*Etymology.* Latin, *corticulus,* bark; *spongia,* sponge; referring to the almost bark-like dermal layer of the sponge.

*Type species. Corticulospongia floccosa* n. sp.

### *Corticulospongia floccosa* n. sp.

Plate 9, figures 5-9; Figure 8

*Diagnosis. Corticulospongia* with thin walls that show full diplorhysis, with incurrent ostia approximately 1 mm in diameter, spaced in crude vertical rows such that there are four or five ostia in one centimetre, both vertically and horizontally. Incurrent ostia alternate with excurrent openings, 1.5 to 2.0 mm across, with roughly the same spacing. Dermal layer consists of tracts of rhabdodiactines or oxeas, tufts 0.5 to 1.5 mm across, irregularly curving or radiating like flattened clumps of reeds. Outer endosomal layer composed of clusters of oxeas or rhabdodiactines at a tangent to upward and outward radiating canals. Spiny tips of clusters interdigitate with dermal tracts. Inner endosomal tracts radiate upward and inward toward the gastral layer, which is made of finer smooth rhabdodiactines but also includes small hexactine megascleres and hexactine and oxyhexaster microscleres. Clemes are rare in gastral endosomal part of the net.

*Description.* One large fragment, the holotype, is associated with somewhat smaller fragments. The species is open funnel-shaped to flaring obconical with thin walls that are smooth, except for ostia on both dermal and gastral surfaces. A simple, deep spongocoel is well defined.

Incurrent ostia are approximately 1.0 to 1.2 mm in diameter. Most are circular to elliptical, vertically, and occur as round pits, with rounded tips essentially at mid-wall. They occur in crude vertical rows that are spaced approximately 2 mm apart, centre-to-centre, so that there are four to five openings a centimetre, both vertically and horizontally. Incurrent pits are approximately 1 mm deep below the tufted dermal layer.

Excurrent openings are 1.5 to 2.0 mm across and similarly indent the gastral margin. Like incurrent pits, these extend approximately to mid-wall and arch upward and outward, roughly parallel to tracts of the skeleton. Canals are separated by skeletal tracts that are 1.5 to 2.0 mm across. There are four in one centimetre, horizontally and vertically, or approximately 16 in one square centimetre. The shallow pits are up to 1 mm deep. They may be vertically elongate and extend upward and inward to the spongocoel.

Coarse dermal spicules may obscure incurrent ostia, but excurrent openings are relatively unobstructed.

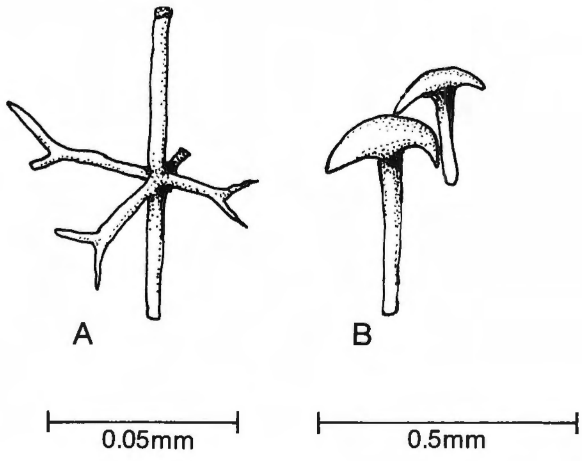


***Figure 8.*** *Camera lucida drawings of spicules from the holotype of* ***Corticulospongia floccosa*** *n. sp., UA 7733, Baillie-Hamilton Island Section 2-84.3. A, fragment of oxyhexaster shows prominent simple rays that subdivide into secondary rays. These are the oldest oxyhexasters known. B, clemes with curved anchor-shaped rays of small spicules may have been part of the wall or of a root tuft associated with the sponge.*

The skeleton consists of three layers. The dermal layer is made of monaxial or rhabdodiactine spicules that are at a tangent to the sponge wall. Two inner endosomal layers are separated at a surface approximately 1 mm in from the gastral margin. Outer endosomal spicules range from being subtangent to distinctly clustered in vertically ascending and outwardly radiating tracts, in contrast to gastral spicules that are either subtangent or in a thatch that rises upward and inward toward the gastral margin.

The dermal layer is composed of moderately coarse, irregularly curved to fanning or radiating tufts of rhabdodiactines or oxeas (Pl. 9, figs. 6, 7). No good examples of ray crosses were observed in coarse spicules. The tufts are generally 0.5 to 1.5 mm across, where well defined, but are very irregular. The entire outer surface appears like flattened, somewhat tumbled clumps of reeds or long grass, or like fibrous rough bark. Tufts spiral crudely upward, or have an irregular subvertical fabric, although both patterns are only poorly defined. The dermal layer is composed of relatively coarse spicules and is probably the coarsest part of the skeletal net. The layer is between 0.5 and 1.0 mm thick, but because of the irregular bark-like pattern, it varies considerably.

The outer endosomal skeleton is made of long smooth oxeas or rhabdodiactines that arc upward and outward from a surface of pinnation, at about mid-wall, as clusters of subparallel, smooth spicules. Tufts may occur at angles up to about 60° from the dermal layer, as well as at a tangent to canal walls or subtangent to the dermal layer. This produces a ropy, fibrous surface that is partially covered by the dermal layer. This part of the endosomal skeleton is 1.0 to 1.5 mm thick, but is very irregular. Most spicules in this layer are long, smooth, and doubly-tapering. They range from 0.008 up to 0.180 mm in diameter. Most of these spicules are 0.04 to 0.06 mm in diameter at mid-length and taper to sharp tips in both directions. Axial canals are not well preserved, and there is little evidence of even short crossing rays that would conclusively show the long ropy monaxial (?) spicules to be rhabdodiactines. Spicules smaller than 0.02 to 0.03 mm in diameter are relatively rare in this layer. Those that do occur appear to be "foreign" spicules from the gastral part of the endosome.

The inner part of the endosome (Pl. 9, figs. 5, 8, 9) is distinctly more finely textured than either the outer endosomal or dermal layer. The inner layer is made of a thatch of small monaxons or perhaps rhabdodiactines, but with a significant admixture of small hexactines. These range from moderately short-rayed megascleres, with rays that range from essentially the same diameter as the rhabdodiactines down to small microsclere hexactines. Most spicules have diameters of approximately 0.04 to 0.05 mm and are doubly tapering. Largest spicules have diameters of approximately 0.08 to 0.09 mm, in the principal thatch, but these are rare.

Largest megasclere hexactines have rays up to 0.02 to 0.04 mm in diameter. Most of them, however, are only approximately 0.01 mm in diameter and 0.2 to 0.4 mm long. These are irregularly spaced and oriented. There appears to be a moderately complete gradation from small spicules up to ones with rays essentially the size of the rhabdodiactines.

Tiny hexactines with rays 0.003 to 0.004 mm in diameter and 0.02 mm long occur as microscleres throughout the inner gastral layer (Pl. 10, fig. 3). They have smooth tapering rays. These microscleres are irregularly distributed and oriented.

A few rare oxyhexasters (Fig. 8A) occur in the skeleton. They are of the same general size as the tiny hexactines, with basal ray diameters essentially like those of the smallest hexactines. Individual rays, however, are somewhat longer. Basal hexactine rays may be up to 0.03 mm long, up to the point of subdivision and second-order rays may be an additional 0.03 to 0.04 mm long, as they taper to sharp tips. Second-order tips diverge approximately 30° from principal ray axes and are moderately straight, although one fragment has a somewhat bell-shaped appearance where the rays are gently S-shaped.

Anchor-shaped small clemes (Fig. 8B) also occur in the inner part of the skeleton, although they are rare. Curved anchor-shaped rays of small spicules have basal diameters from 0.03 to 0.04 mm up to moderately large rays 0.05 mm in diameter. The small spicules have shafts approximately 0.03 mm across, in the "anchor" part of the spicule, but which taper to approximately 0.02 mm in diameter for much of the long ray. Total lengths for these rays are not known. Shafts of large clemes are 0.05 mm across, in the "anchor" part, but taper to approximately 0.04 mm in diameter, 1 mm from the anchor-like end. Anchors in small spicules are approximately 0.16 mm across and in the large forms are up to 0.2 mm across. The anchors have rounded to moderately sharp tips that are reflexed toward the axis of the shaft, although they diverge from that axis at approximately 60°.

*Discussion.* Comparisons with related forms have been treated under the discussion of the new genus. Because the genus is monotypic, differentiation of specific and generic characteristics are uncertain, but sizes of ostia and spicules could be considered as specific characters, in contrast with the general make-up of the skeleton, and the canal pattern that might be considered to be of generic significance.

Until these hexasters were discovered, the oldest known such spicules were of early Mississippian age within the paraclavule-bearing *Griphodictya* (Hall and Clarke, 1898, p. 179-181). Hexasters were also recorded by Kling and Reif (1959) from the amphidisc-bearing *Itararella*. Finks (1983, p. 111) included *Griphodictya* in the Amphidiscophora. Thus, isolated Carboniferous hexasters are also known. Finks noted, however, that none have been found physically within sponges that he would consider to be hexasterophoran. Early Paleozoic sponges assigned to the Hexasterophora by him (1983, p. 111) were assigned basically on their gross morphology and megasclere development. *Corticulospongia* thus becomes the oldest known hexaster-bearing Paleozoic sponge. The small hexasters are of the same size as related small hexactine microscleres. There seems little doubt that the very common hexactines and the fairly rare hexasters are part of the same general complex. This would suggest that hexactines are probably microsclere precursors to hexasters that characterize the subclass, as used by Finks (1983, p. 111, 112).

*Etymology.* Latin, *floccosum*, tufted or woolly, referring to the gently fibrous and clustered appearance of the skeleton.

*Type material.* Holotype, UA 7733, and small paratype, UA 7734, are from Baillie-Hamilton Island Section 2-84.3.

### Family DICTYOSPONGIIDAE Hall and Clarke, 1898

### Subfamily DICTYOSPONGIINAE Hall, 1882

### **Genus** *Dictyospongia* Hall and Clarke, 1898

*Type species. Dictyophyton sceptrum* Hall, 1890.

### *Dictyospongia apache* n. sp.

Plate 10, figures 1, 4, 5

*Diagnosis.* Smoothly expanding, thin-walled, obconical to vasiform sponge whose skeleton is made of subcylindrical tangential tracts of at least four ranks arranged parallel to and normal to the length of the sponge. Spicules include hexactines and hexactine derivatives. Distinctly ranked quadrate mesh has first-order openings approximately 5 mm across and high, enlarging slightly upward.

*Description.* A single specimen, the holotype, is a flattened fragment of upward-expanding skeletal mesh. The fragment is approximately 13 cm high and expands upward in the upper 9 cm from approximately 8 cm wide to 10.5 cm wide. Neither the base nor the oscular margin of the sponge is preserved, but the gently upward expanding skeletal fragment indicates the sponge was vasiform to steeply obconical. The smooth impression lacks any marked indication of prismatic development.

The distinctly reticulate skeleton is formed by vertical and horizontal strands or tracts of clustered hexactines and hexactine-derived spicules (Pl. 10, figs. 4, 5). Ranked series of tracts subdivide rectangular openings between primary tracts much like the ranked spicules in *Protospongia.* Tracts in the Silurian sponge, however, are made of rope-like clusters of subparallel rays or spicules. Measured horizontally, there are 7.5 to 8.0 first-order openings in 4 cm in the lower part of the sponge. At essentially mid-height, approximately six quadrangles occur in 4 cm, and in the uppermost part of the preserved fragment, there are approximately 5.0 to 5.5 quadrangles in 4 cm, documenting a gradual upward expansion in the quadrangles and of the sponge as well. In a few instances, second-order tracts start in the lower part of the sponge, but become first-order tracts vertically.

Four sizes or ranks of tracts and quadrangles are clearly preserved, with a suggestion of a fifth order. First-order tracts are generally 0.35 to 0.50 mm in diameter, subcylindrical and composed of distinctly parallel rays. Large stauracts or hexactines with modified distal rays are preserved at most intersections. These large spicules have rays 5 to 6 mm long, in both vertical and horizontal tracts, with basal ray diameters of approximately 0.10 to 0.12 mm. They are paralleled by rhabdodiactines and possible diactines. Silicification is sufficiently coarse that one cannot be certain whether there is or is not spicule-to-spicule fusion.

Generally speaking, first-order tracts are two- or three-layered at intersections and show interdigitation of horizontal and vertical elements. Outer, somewhat more finely textured, parts of horizontal tracts overlie interfingering vertical spicules. The 30 to 40 spicules evident in cross-sections show a full range of diameters from approximately 0.010 mm across up to the coarse rays of the centre stauracts that are 0.12 mm in diameter. In any one cross-section, most appear to be approximately 0.02 to 0.04 mm across. Packing is moderately loose in many sections so that one fourth to one third of the volume inside a tract is open interspicular space.

Second-order tracts are composed of somewhat finer spicules and generally lie beneath or interdigitate with first-order tracts on the inner side of those larger elements. Second-order tracts are generally 0.20 to 0.30 mm in diameter. Coarsest spicules in these have basal ray diameters of approximately 0.05 to 0.06 mm where ray junctions are most clearly defined, either near first-order tracts or near intersections of two second-order tracts in centres of first-order rectangles. Second-order tracts have approximately 10 spicules per cross-section that range from very small rays up to the largest spicules near tract intersections. Second-order quadrangles are essentially half the size of first-order ones and measure between 0.25 and 0.30 mm across, horizontally and vertically.

Third-order tracts subdivide second-order quadrangles into four smaller ones, and are generally 0.10 to 0.20 mm in diameter. Their coarsest spicules appear to have basal ray diameters of approximately 0.03 to 0.04 mm. These small tracts generally have five to ten spicules per cross-section and are more finely textured than first-and second-order elements. They are consistently less uniformly preserved than the larger tracts. Third-order quadrangles are approximately 0.1 to 0.2 mm across and high, with a slight upward increase because of upward expansion of the skeleton.

Fourth-order tracts are rarely preserved but do occur in better-preserved parts of the skeleton. These small subcylindrical elements measure up to 0.08 mm in diameter and contain spicules with basal ray diameters up to approximately 0.02 to 0.04 mm. These tracts are occasionally made of single spicules but may include up to five spicules in any one particular cross-section, at least as presently preserved.

Impressions of rare fifth-order spicules or tracts occur in the upper calcareous part of the skeleton. These spicules have rays 0.3 to 0.4 mm long and basal ray diameters of approximately 0.01 to 0.02 mm. These tiny spicules are generally preserved as ghosts in the moderately dense limestone and only locally in the somewhat granular silica.

No microscleres are preserved in the moderately coarse skeleton.

*Discussion. Plectoderma scitulum* Hinde (1884, p. 132, 133, Pl. 31, figs. 1-1b) is known from beds of Ludlovian age of the Pentland Hills near Edinburgh. That species shows some similarity to the Canadian species in that both have clustered, tract-like, vertical rows of overlapping spicule rays. However, horizontal rays of the stauracts extend as single elements, almost like rungs in a ladder, to overlap those of joining rows, forming a somewhat irregular rectangular framework. Horizontal rays do not form distinct bundles and *Plectoderma* lacks the distinct strong ranking of first- to fourth-order tracts.

Finks (1983, p. 103) noted that the simplest and earliest dictyosponge recorded to that date is *Prismodictya* Hall and Clarke (1898, p. 79-92), which also appears in the Silurian. However, *Prismodictya* has a prismatic cross-section and contrasts with the relatively simple, smooth, upward expanding, vasiform skeleton of the Cornwallis species.

At first glance, the Silurian specimen appears like Cambrian and Ordovician species of *Protospongia*, but that genus lacks bundled tracts and has a reticulate skeleton composed of overlapping stauracts of ranked sizes.

*Norfordia gabrielsei* (Rigby and Harris, 1979, p. 976, 977, Pl. 2, figs. 3, 6, 7) is a high conical-cylindrical small sponge. It has a skeleton made of horizontal and vertical bundles that are approximately 0.5 mm across and spaced 1 mm apart, centre-to-centre. It is considerably smaller both in gross form and spacing of the somewhat reticulate tracts. In addition, only small diactines have been recognized in the skeleton of *Norfordia*, in contrast to the distinct hexactines and stauracts of the Cornwallis specimen.

*Cyathophycus reticulatus* Walcott (1879) may be a related species. It was described from the Ordovician of New York and is a steeply obconical sponge, whose skeleton is composed of weakly bundled hexactines and derivatives of hexactines. However, *Cyathophycus* has prominent marginalia and prostalia – spicules that are not evident, even along the flattened margin, in the Baillie-Hamilton sponge. In addition, *Cyathophycus* has less prominently ranked tracts.

*Dictyophytra* (?) *walcotti* Rauff (1894, p. 249, 250), at first glance, appears somewhat similar. This fasiculate species was recovered from the Ordovician Utica Shale of Holland Patent, Oneida County, New York. It appears to be made of ranked tracts, but reticulate microstructure of those tracts contrasts sharply with the distinctly parallel-rayed, subcylindrical tracts of the Cornwallis specimen. *Dictyophytra* (?) *walcotti* has tracts that have tiny spicules and quadrules within each tract.

*Tiddalickia* Rigby and Webby (1988) is also a thin-walled hexactinellid, with a skeleton composed of rectangularly arranged straps made principally of monaxons and rhabdodiactines, with large stauracts at ray junctions. *Tiddalickia* has only one order of tracts in the reticulate skeleton. *Tiddalickia* is similar, however, as is the Devonian *Physospongia* (Hall and Clarke, 1898, p. 187, 188), in having horizontal straps apparently dermal to vertical ones. This suggests that the sponge described here from Cornwallis Island is also seen from the dermal view, although there is no internal evidence to confirm this.

*Type specimens.* Holotype, UA 7735, and a small paratype fragment UA 7739, from the Cape Phillips Formation on Cornwallis Island. The specimens come from the graptolitic sequence and are probably of early Wenlockian age. They were collected by David Perry and loaned to us by Paul Smith from collections at the University of British Columbia.

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## PLATE 1

*Parodospongia* and *Haplistion* from the Silurian Cape Phillips Formation

Figures 1-3, 6. *Haplistion frustrum* n. sp., holotype, UA 7736, Cornwallis Island.

1. Photomicrograph of dermal surface showing irregular distribution of canals and radial tracts cross-braced by horizontal tracts or single rhizoclones or dendroclones, x10.

2. Photomicrograph of gastral surface showing skeleton of bundled radial tracts of rhizoclones oriented normal to the surface and cross-braced by finer horizontal or tangential tracts and isolated dendroclones and rhizoclones, x10.

3. Gastral view of holotype showing distribution of canals and the size of fragments, x1.

6. Dermal view of the fragment showing gently rounded, thin-walled and moderately large canals in the relatively delicate net, x1.

Figures 4, 5, 8. *Parodospongia euhydra* n. sp., holotype, UA 7699, Baillie-Hamilton Island Section 2-97.

4. Side view of gastral surface with moderately coarse, irregular, subrectangular canals bounded by ragged tracts of packed rhizoclones in gently upward and inward expanding skeleton, x1.

5. Photomicrograph of gastral view showing ragged tracts of closely packed rhizoclones in the relatively coarse skeleton, x10.

8. Dermal view of ragged tract composed of packed rhizoclones.

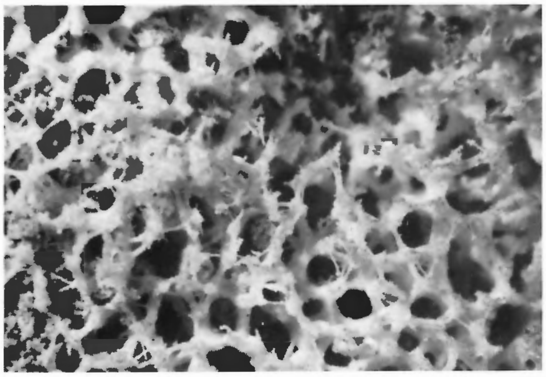
Figures 7, 9, 10. *Haplistion* (?) sp., UA 7698, Baillie-Hamilton Island Section 2-84.3.

7. Vertical view of small fragment showing the coarsely silicified, irregular tracts of the skeleton, size of the fragment, and subradiating tracts, x1.

9. Photomicrograph showing spicules of massive tracts in the upper right of figure 7. Irregular, small, closely-spaced rhizoclones make the ragged tracts, x10.

10. Photomicrograph of some delicate tracts made of ragged rhizoclones, x10.

PLATE 1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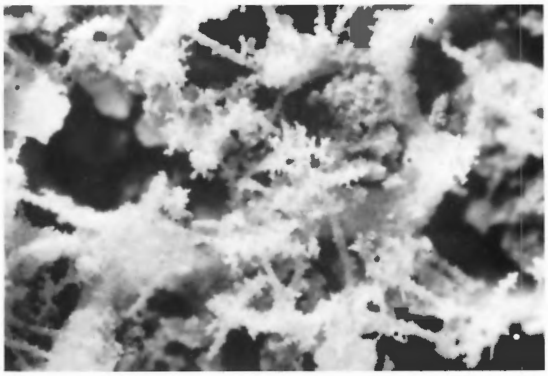
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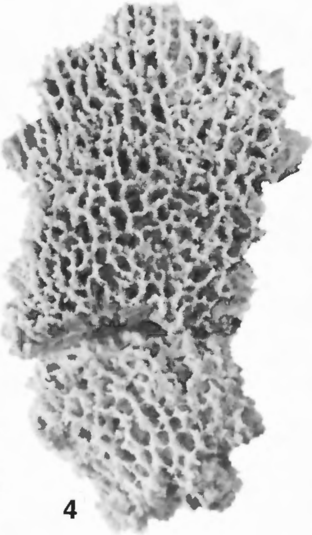
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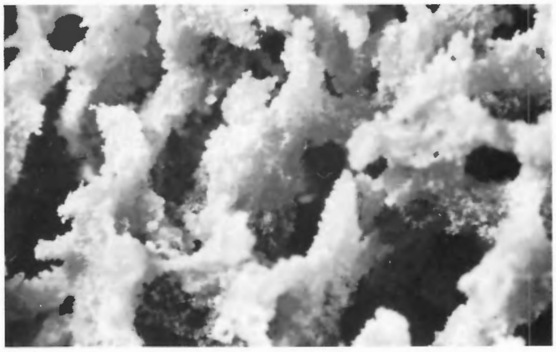
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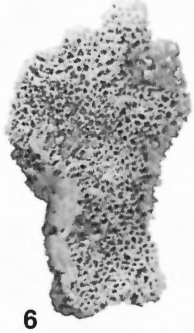
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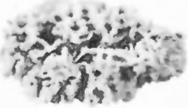
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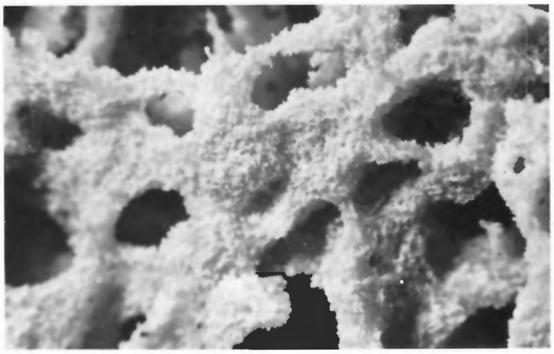
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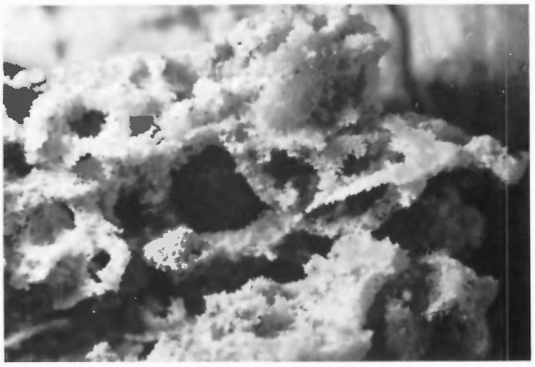
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## PLATE 2

*Archaeoscyphia, Antrospongia* and *Aulocopium* from the Silurian Cape Phillips Formation

Figures 1, 2. *Archaeoscyphia minganensis* (Billings, 1859), Cornwallis Island Section CAR 1-44.5.

1. Side view of moderately complete small specimen with characteristic annulate growth form, small dermal ostia, and large gastral ostia on the walls of the deep spongocoel, UA 7700, on small block, x1.

2. Photomicrograph showing regular upward and outward radiating skeleton. Smooth dendroclones extend rung-like between prominent trabs to produce the ladder-like skeleton, UA 7701, x10.

Figures 3-5, 9. *Antrospongia aberrans* n. sp., holotype, UA 7703, Baillie-Hamilton Island Section 2-265.

3. Photomicrograph of sponge exterior showing irregular structure of the dermal layer, circular to irregular ostia, close spacing of spicules, and irregular orientation of dendroclones and trabs, characteristic of the species, x10.

4. Dermal view of flattened, thin-walled, conical-cylindrical sponge showing irregular openings and structure of the dermal layer, x1.

5. View of side opposite from that in figure 4 showing irregular dermal layer, lower part; the flattened coarse ostia of the gastral margin with openings in crude vertical series, x1.

9. Photomicrograph of natural cross-section through middle part of the wall showing regular short trab segments cross-connected with other trabs, a feature characteristic of the species, x10.

Figures 6-8, 10, 11. *Aulocopium nanna* n. sp., Baillie-Hamilton Island Section 2-84.3.

6. Vertical view of small holotype showing central spongocoel and radiating canals as tangential impressions in the gently domed crest, UA 7704, x1.

7. Holotype, side view, showing stalked obconical form and rounded summit. Weakly annulate, dense, dermal layer covers stalk and lower part of the sponge, UA 7704, x1.

8. Paratype, summit view showing somewhat enlarged spongocoel pit and radiating tangential canals, separated by skeletal tracts with circular ostia of canals that rise essentially normal to the arched surface, UA 7705, x2.

10. Photomicrograph of side view of the lower part of the holotype showing small network of trabs and cross-bracing dendroclones in the endosomal wall and the dense, weakly annulate, dermal layer composed of expanded spicules of indeterminate origin, UA 7704, x10.

11. Paratype, photomicrograph of the upper oscular margin with deep spongocoel pit in the lower right. Two canal series are evident: one as tangential radial impressions on the domed summit, the other as circular ostia, in intervening spaces, of canals that are essentially normal to the stacked tangential ones and the domed crest of the sponge, UA 7705, x10.


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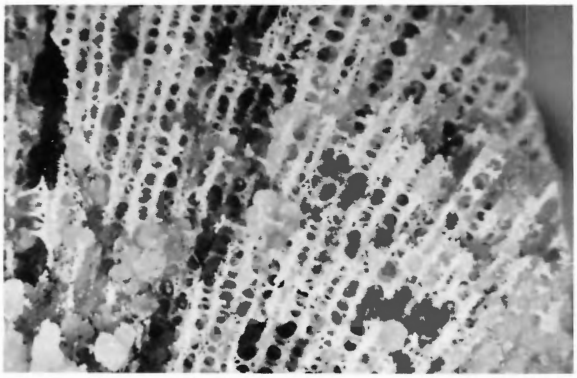
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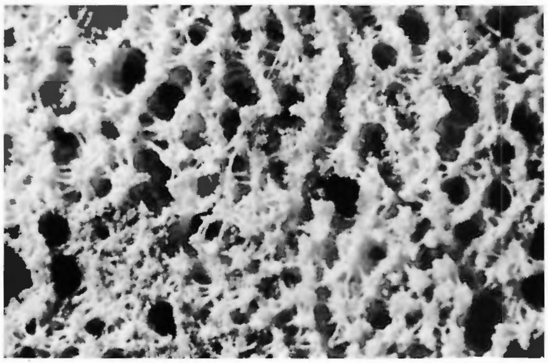
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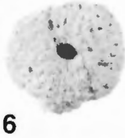
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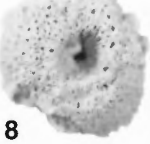
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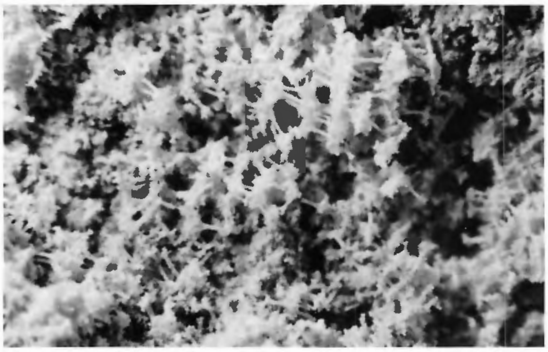
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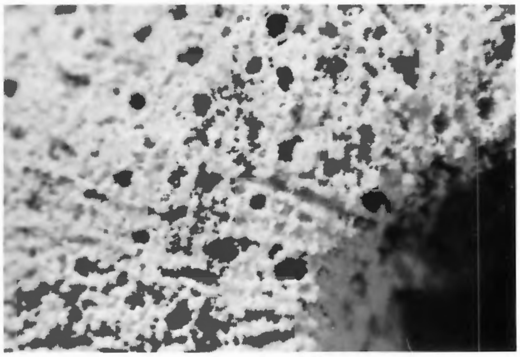
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## PLATE 3

*Archaeoscyphia*, *Patellispongia* and dendroclone spicules from the Silurian Cape Phillips Formation

Figures 1, 2. *Archaeoscyphia minganensis* (Billings, 1859), figured specimen, Baillie-Hamilton Island Section 1-172, UA 7701.

1. Natural section showing upward pinnate trabs of skeleton, arched incurrent canals and aligned excurrent ostia on gastral margin of the spongocoel below rounded osculum, x1.

2. Dermal view of annulate exterior and stacked incurrent ostia, x1.

Figure 3. *Patellispongia alternata* n. sp., holotype, Baillie-Hamilton Island Section 1-172, UA 7714.

3. Gastral view of regular skeleton and canals in fragments of discoidal to patelliform sponge, partially matrix-obscured, x1.

Figures 4-6. Scanning electron photomicrographs of dendroclones, as rungs between porous trabs, of unidentifiable orchoclad sponges, Baillie-Hamilton Island Section 1-165.5.

4. Toe-like zygomes articulate to form trabs and solid junction, bar equals 100 µm.

5. Porous trabs and rung-like dendroclones in characteristic orchoclad structure showing method of zygome articulation, bar equals 1 µm.

6. Dendroclones and less common rhizoclone, lower left, bar equals 400 µm.

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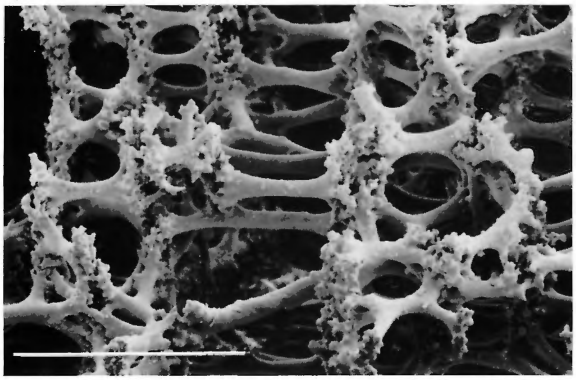

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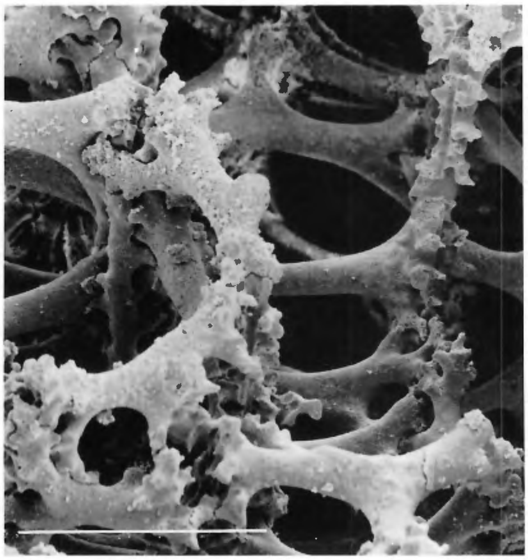

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## PLATE 4

*Cauliculospongia* and *Dunhillia* from the Silurian Cape Phillips Formation

Figures 1, 2. *Cauliculospongia solida* n. sp., holotype, UA 7706, occurs with several other sponges on large block from Cornwallis Island Section CAR 1-44.5.

1. Photomicrograph of natural cross-section through the centre of the stem-like sponge showing the upward pinnate, moderately coarse trabs and the uniform skeleton lacking a spongocoel, but perforated by canals arranged essentially normal to the trabs, x10.

2. Side view showing the moderately solid, ramose holotype, x1.

Figures 3, 8, 10, 11. *Dunhillia fistulosa* n. sp. Cornwallis Island Section CAR 1-44.5.

3. Photomicrograph of holotype, UA 7707. Large central opening is tubular spongocoel and on right, cross-section of wall shows surface of pinnation near the gastral surface. Ladder-like skeleton of trabs made of united tips of rung-like dendroclones. Details largely lost in moderately coarse silicification, x10.

8. Holotype, natural cross-section showing anthaspidellid skeleton, deep tubular spongocoel, smooth walls, and clustered incurrent ostia. Rounded oscular margin is nearly complete, x1.

10. Reverse view of holotype showing dense dermal layer perforated by clusters of incurrent ostia. Rounded summit is virtually complete with osculum around the deep spongocoel. Base is fractured, x10.

11. Paratype, side view showing dense dermal net and characteristic clustering of incurrent ostia, some of which are slightly mounded, UA 7708, x1.

Figures 4-6, 12, 15, 16. *Dunhillia megaporata* n. sp., Baillie-Hamilton Island Section 2-84.3.

4. Holotype, side view showing steeply obconical form with smooth to gently annulate walls, dense dermal layer perforated by large, low-rimmed ostia. Differences in dermal and endosomal layers show in the broken part of the skeleton, near the centre, UA 7710, x1.

5. Paratype, side view showing growth form and distribution of distinctive canals, UA 7711, x1.

6. Vertical view of broken holotype base showing central spongocoel; radiating endosomal skeleton and thin dermal layer, UA 7710, x1.

12. Photomicrograph of dermal layer of holotype showing broad, tile-like, rhizoclones around incurrent ostia, spicules somewhat irregular in coarse silicification, UA 7710, x10.

15. Tangential view of paratype fractured base showing trab-based skeleton, thin dermal layer and large excurrent ostium into tubular spongocoel. Rung-like dendroclones have smooth axes, UA 7711, x10.

16. Natural cross-section, broken summit of paratype showing thin, dense dermal layer, open texture of endosomal layer and ill-defined gastral layer around the central spongocoel. An incomplete horizontal mid-wall canal shows in the upper right. Relationships of radial canals to dermal ostia show well in lower right, UA 7711, x10.

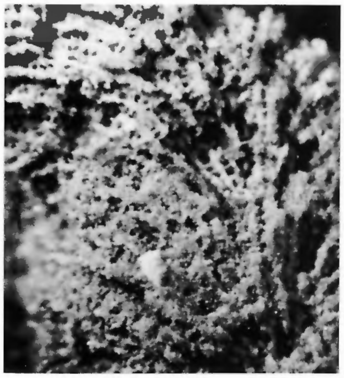
Figures 7, 9, 13, 14. *Dunhillia pluraliporosa* n. sp., Baillie-Hamilton Island Section 2-84.3.

7. Holotype, UA 7712, side view showing upward-expanding, weakly annulate, obconical sponge and distribution of incurrent ostia, x1.

9. Diagonal view of summit of paratype, UA 7713, showing tubular spongocoel, wall thickness, and dense dermal net perforated by small, irregularly distributed, incurrent ostia, x1.

13. Photomicrograph of dermal layer of holotype, showing dense rhizoclone net and irregular incurrent ostia, x10.

14. Natural cross-section through the endosome of holotype showing trab-based skeleton with prominent trabs and horizontal dendroclones; interruptions in skeleton are essentially horizontal incurrent canals, x10.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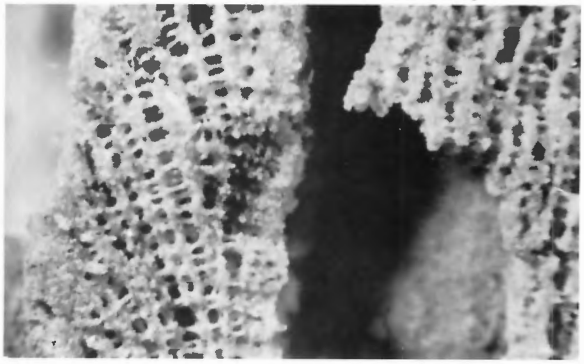
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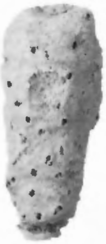
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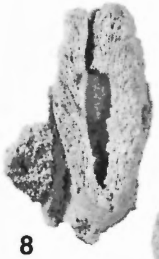
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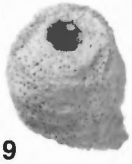
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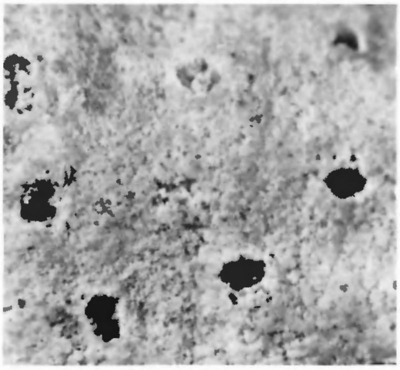
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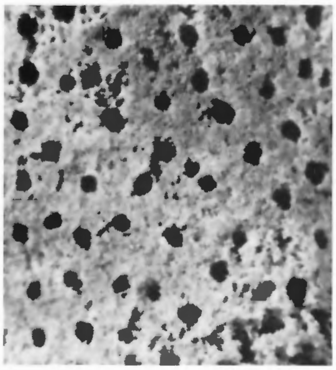
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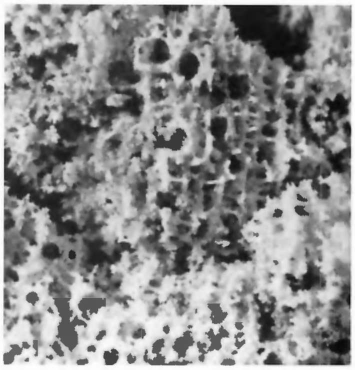
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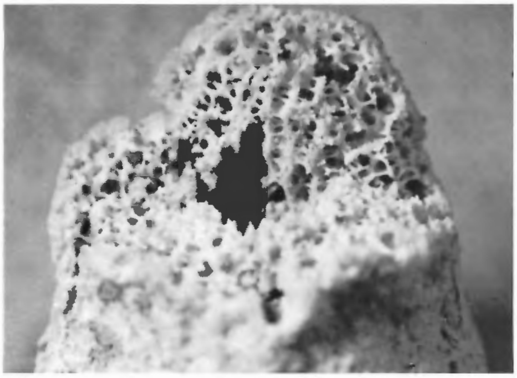
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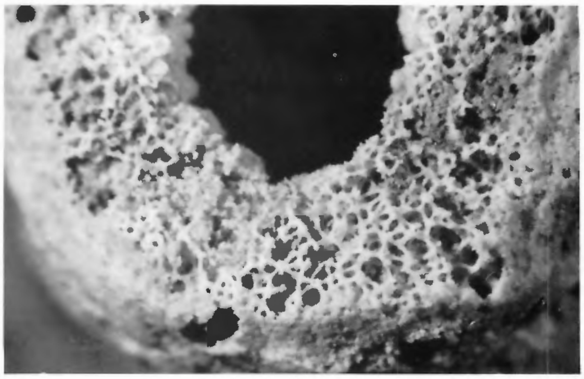
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## PLATE 5

*Perissocoelia* (?) and *Psarodictyum* from the Silurian Cape Phillips Formation

Figures 1-3. *Perissocoelia* (?) *gelasinina* n. sp., holotype, UA 7715, Baillie-Hamilton Island Section 2-84.3.

1. Vertical view onto rounded summit shows clusters of excurrent openings and finer canals in endosomal skeleton, x1.
2. Photomicrograph of skeletal structure of holotype showing irregular, somewhat beaded to distinct trabs, as coarse structures around the canals, cross-connected by single, smooth dendroclones or trab segments. The large excurrent opening, in the centre, is characteristic of multiple openings on the summit and intermediate and smaller openings are canals that are parallel to the somewhat irregular trabs, x10.
3. Side view of the obconical holotype showing rounded upper surface and dense, annulate lower dermal layer, x1.

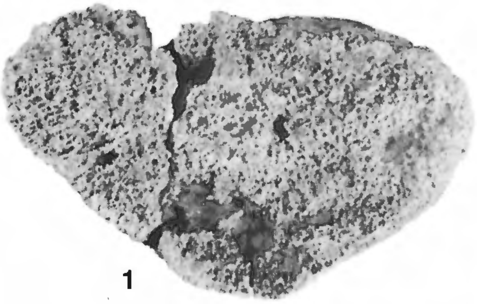
Figures 4-6. *Perissocoelia* (?) *spinosa* n. sp., holotype, UA 7716, Cornwallis Island Section CAR 1-44.5, block 2.

4. Vertical view of summit, partially obscured by matrix, showing numerous small canals and somewhat larger clusters of excurrent canals, x1.
5. Photomicrograph of skeleton showing beaded trabs in the lower part of the sponge. Skeleton of smooth dendroclones and didymoclones. Small oxeas (arrows) radiate from knots, x10.
6. Side view showing upward radiating skeleton with canals parallel to trabs in lower concave part of the sponge, normal to curved upper surface, x1.

Figures 7-9. *Psarodictyum attenuatum* n. sp., holotype, UA 7717, Baillie-Hamilton Island Section 2-84.3.

7. Plan view of crushed specimen showing the thin walls and the flattened, matrix-filled, spongocoel, as the dark intervening line, x1.
8. Side view showing density of the dermal layer, moderately aligned small ostia characteristic of the species, and the steep subcylindrical form, even though the base and oscular margin are incomplete, x1.
9. Photomicrograph of a natural section of wall shows the distinctly subparallel arrangement of trabs and rows of canals. Trabs are cross-connected by rung-like small dendroclones, x10.

PLATE 5



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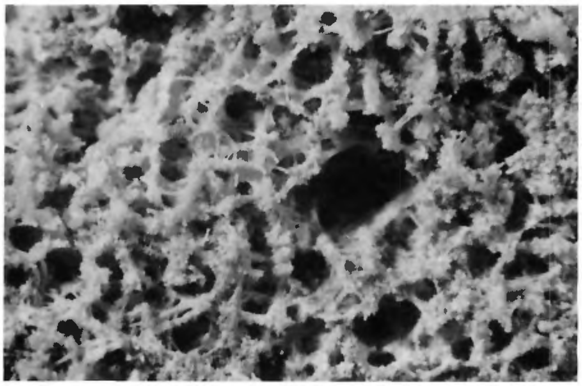

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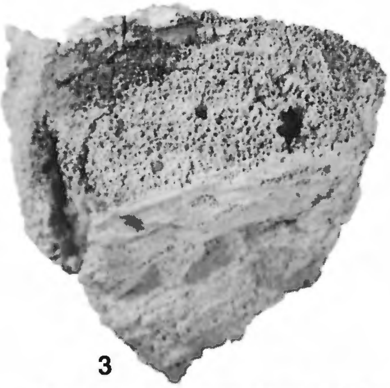

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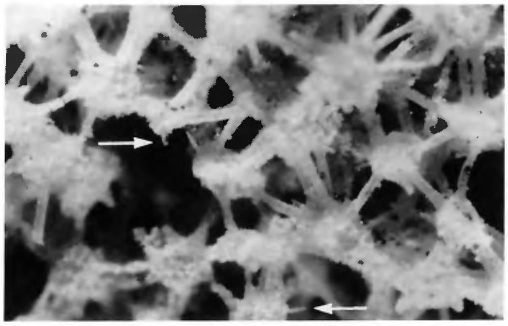

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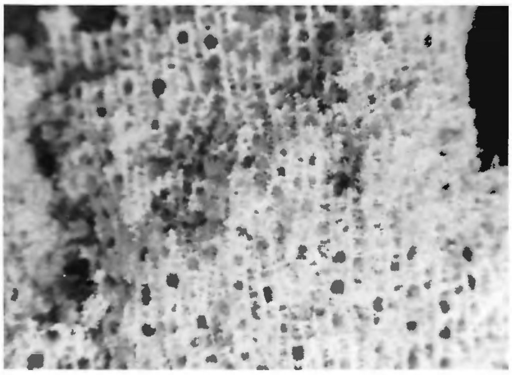

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## PLATE 6

*Patellispongia* and *Somersetella* from the Silurian Cape Phillips Formation

Figures 1-4. *Patellispongia* sp., figured specimen, UA 7738, Baillie-Hamilton Island Section 2-84.3.

1. Side view showing the collapsed thin walls of the sponge in which the tracts radiate upward and outward to meet the dermal surface at high angles. Walls separated by matrix fill of spongocoel in lower half, x1.
2. Side view of the fragment, inverted from figure 1, showing upward divergence of linear rows of ostia in the moderately irregular, somewhat wrinkled, dermal surface. Endosomal skeleton shows in fractured base as parallel trabs and elongate linear canals, x1.
3. Reverse side view from figure 3 showing dermal surface and irregular ostia in dermal layer, x1.
4. Photomicrograph of a natural cross-section through the skeleton showing the fine trabs and small, horizontal connecting dendroclones in an anthaspidellid net. Irregularity of the ragged dermal surface produced where trabs emerge at high angles, x10.

Figures 5-7. *Patellispongia alternata* n. sp., holotype UA 7714, Baillie-Hamilton Island Section 1-172.

5. Photomicrograph of gastral surface of the holotype showing pronounced regularity of parallel trabs that bound blade-like margins of the canals. Regular rows of coarse gastral openings are separated by tracts of coarse dendroclones within rows, and rows are separated by tracts of small dendroclones, resulting in two sizes of spicules in the distinctive skeleton. Trabs rise at approximately 60° to the flat gastral surface;
6. Dermal surface with thin irregular skeletal structure of well-preserved holotype, lacks distinct parallel rows of ostia, x2.
7. Gastral surface of holotype showing parallel structure and insertion of new rows of ostia as skeleton expands (arrows), x2.

Figures 8-11. *Somersetella amplia* n. sp., holotype, UA 7719, Baillie-Hamilton Section 2-84.

8. Photomicrograph of the dermal surface showing more or less circular trabs, in cross-section, rising steeply to that surface, with subparallel circular ostia. Ostia bounded by smooth rays of essentially horizontal dendroclones in anthaspidellid skeleton, x10.
9. Cross-section through part of the endosome and dermal layers shows subparallel, moderately coarse, trabs cross-connected by small dendroclones in a fairly regular network. A thin dermal layer, at the left, is considerably more dense, largely a result of thickening of trabs, x10.
10. Side view of the holotype showing digitate form of the species and small, uniformly distributed, ostia in the dense dermal layer. The dermal layer is more or less complete in the middle and right branches but has circular breaks in the branch on the left, x1.
11. Plan view of digitate upper surface. Holotype shows large circular spongocoel in each branch, partially filled with matrix, and moderately uniform walls of digitations, x1.


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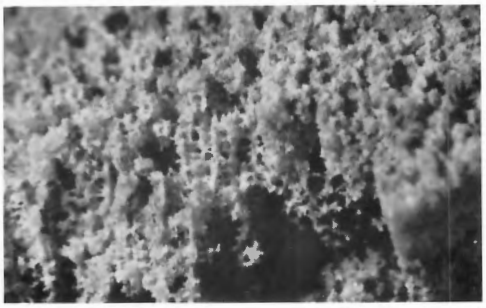
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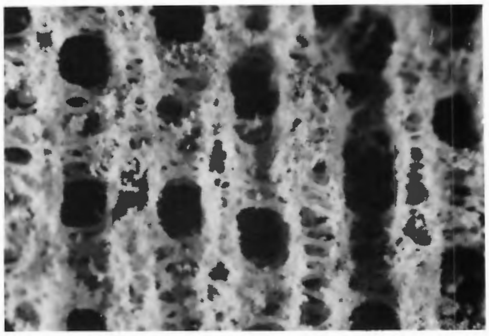
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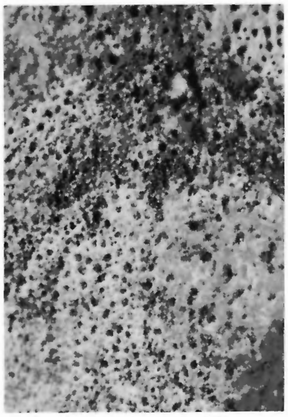
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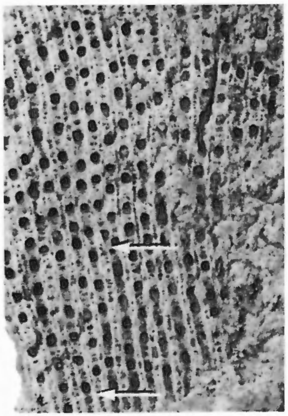
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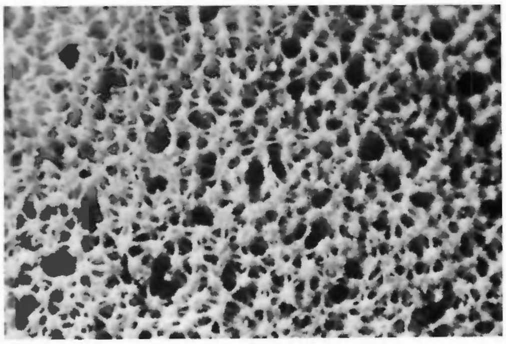
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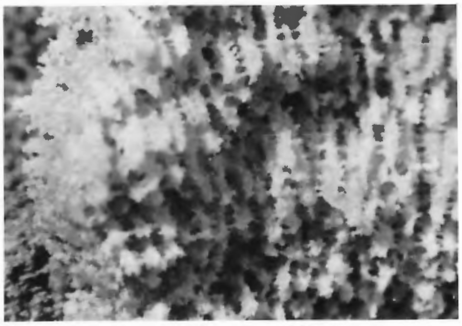
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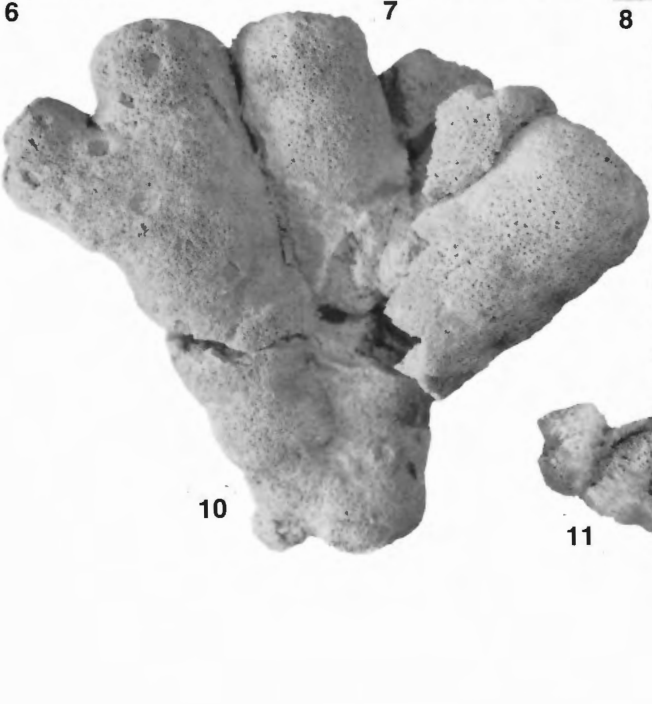
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## PLATE 7

*Somersetella, Calycocoelia,* and *Hindia* from the Silurian Cape Phillips Formation

Figures 1-4. *Somersetella digitata* Rigby and Dixon, 1979. Figured specimen, UA 7718, Baillie-Hamilton Section 2-84.3.

1. Plan view of summit of moderately small digitate sponge showing the tubular central spongocoel in each digitation and rounded summits marked by irregular radiating canals, particularly prominent in the large digitation right of centre, x1.
2. Side view showing the digitate skeleton with wrinkled dense dermal layer in the lower part of the sponge and round oscular tips at the top, x1.
3. Photomicrograph of lower part of the sponge showing bits of the dense dermal layer and the prominent, circular coarse endosomal trabs cross-connected by small dendroclones. Trabs rise essentially normal to the dermal surface, x10.
4. Side view of natural cross-section through part of the wall showing upward and outward radiating skeleton with porous trabs cross-connected by rung-like smooth dendroclones, x10.

Figures 5, 6. *Calycocoelia micropora* n. sp., holotype, UA 7720, Cornwallis Island Section CAR 1-44.5, block 1.

5. Side view showing the smooth cylindrical form of the species, on the left of the block, and prominent regular skeleton in broken surfaces near the base. The holotype of *Perissocoelia* (?) *spinosa* (UA 7716) is on the right of the block, x1.
6. Natural cross-section through the endosomal part of the wall showing prominent, vertically aligned, rows of circular ostia and distinctly parallel, fine skeleton made of trabs connected by rung-like dendroclones, x10.

Figures 7, 10. *Hindia sphaeroidalis* Duncan, 1879, Baillie-Hamilton Island Section 2-84.3.

7. Silicified specimen showing form and uniform distribution of the fine ostia in the skeleton, UA 7722, x1.
8. *Hindia,* and a conical-cylindrical *Dunhillia pluraliporosa* that show the spherical nature of the former, UA 7723, x1.
9. Silicified specimen, broken in the central part, reveals the uniform spacing of radial canals and spherical form of the sponge, UA 7724, x1.
10. Photomicrograph of the same specimen shown in figure 9, showing prominent uniform canals and a silicified skeleton made of tricranoclones, so thoroughly fused that individual spicules are almost impossible to isolate. However, each has three rays that diverge at approximately 120° from a common centre. Larger openings are considered to be excurrent canals and smaller ones, incurrent. Both are straight conical-cylindrical tubes that extend from the centre to the exterior, UA 7724, x10.


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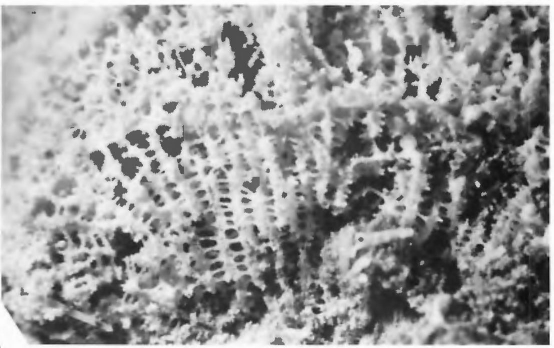
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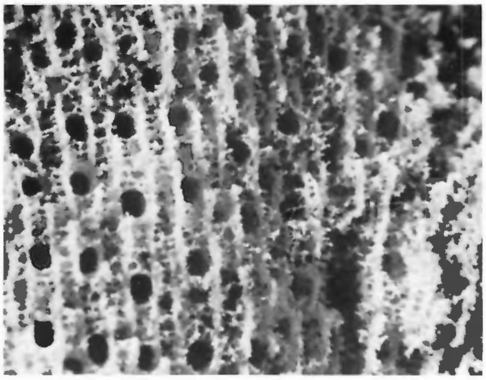
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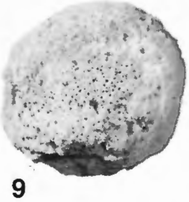
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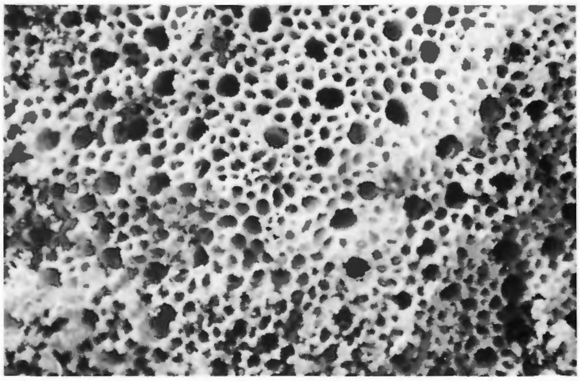
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## PLATE 8

*Carpospongia*, *Astylospongiella* and *Astylospongia* (?) from the Silurian Cape Phillips Formation

Figures 1-6. *Carpospongia globosa* (Eichwald, 1830), figured specimens, Baillie-Hamilton Island Section 2-84.3.

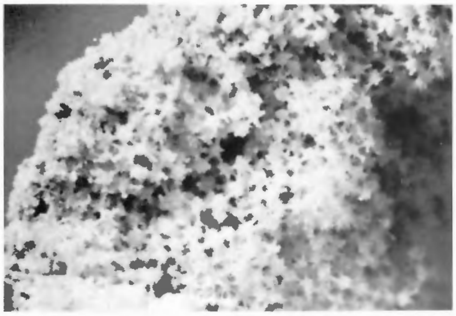
1. Photomicrograph showing the sphaeroclone-based skeleton and uniform size of subspherical centra, from which radiate nearly straight rays that articulate with adjacent centra in the nonlinear skeleton, UA 7726, x10.
2. Natural fractured surface through the centre of a pear-shaped specimen, typical of this species, showing the straight radial canals that interrupt the skeleton. Matrix adheres to the lower left, UA 7727, x1.
3. Dermal view of the same specimen shown in figure 2, with large excurrent ostia and somewhat smaller incurrent ostia in the pear-shaped sponge, x1.
4. Dermal view of broken subspherical sponge, UA 7726, with delicately spiculed, uniform skeleton pierced by two sizes of canals, characteristic of the species, x1.
5. View into broken base of same specimen shown in figure 4 showing radial canals and moderately dense dermal layer, x1. (Figure 1 is from near the centre.)
6. Side view of reference specimen showing characteristic canal expression in the somewhat pear-shaped sponge, UA 7728, x1.

Figures 7-10. *Astylospongiella striola* n. sp., Baillie-Hamilton Island Section 2-84.3.

7. Photomicrograph of the dermal surface of the holotype, UA 7729, showing moderately coarse canals piercing the uniform skeleton of sphaeroclones. Each spicule has a coarse centrum from which radiate straight rays that fuse to adjacent centra and produce the solid skeleton, x10.
8. Side view of holotype showing the tubular obconical form marked on the exterior by deeply indented incurrent canals and ostia. The rounded oscular margin is essentially complete. Gastral margin of the spongocoel perforated by large excurrent ostia, x1.
9. Paratype, UA 7730, showing a somewhat less sculptured dermal surface but with elongate ascending canals prominent in the upper centre and right parts of the sponge. Upper rounded oscular margin virtually complete, but base of sponge broken, x2.
10. Paratype, UA 7730, reverse view of that shown in figure 9, showing the thin wall crushed into the deep spongocoel and partially removed to show the coarse excurrent ostia along the gastral margin of the spongocoel, x1.

Figures 11-14. *Astylospongia* (?) *lutera* n. sp., holotype, UA 7725, Cornwallis Island Section CAR 1-44.5.

11. Photomicrograph of the dermal area pierced by large canals with two distinct orientations: one subtangential, like that in the centre, and others normal to that, shown with circular cross-sections. Sphaeroclones have spinose centra and radial straight rays that fuse with adjacent centra to make the solid skeleton, x10.
12. Natural cross-section of endosomal part of the skeleton showing coarse open skeleton with two series of canals essentially at right angles to each other; intervening space filled by sphaeroclone spicules, x10.
13. Side view of holotype showing upward expanding, funnel-like sponge with relatively dense dermal layer pierced by incurrent ostia, which produce the numerous subcircular openings between the ribs but enter at low angles on the ribs and arch into the skeleton, x1.
14. Vertical view shows cross-section of the thick-walled sponge with the dermal surface toward the top and concave gastral surface toward the bottom. Two canal series show in the left centre, one as elongate openings and the other as circular cross-sections, in a pattern moderately typical of the genus *Astylospongia*, x1.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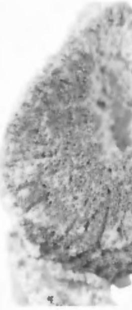
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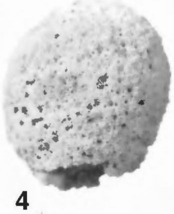
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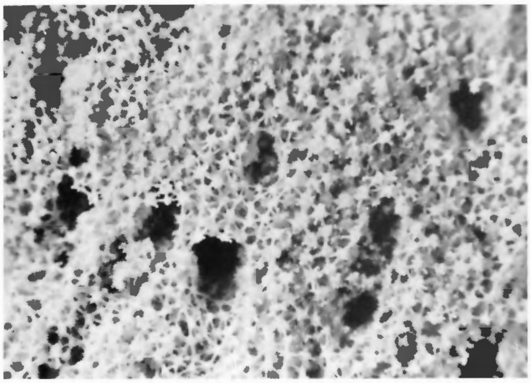
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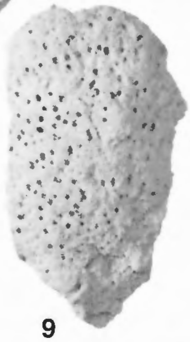
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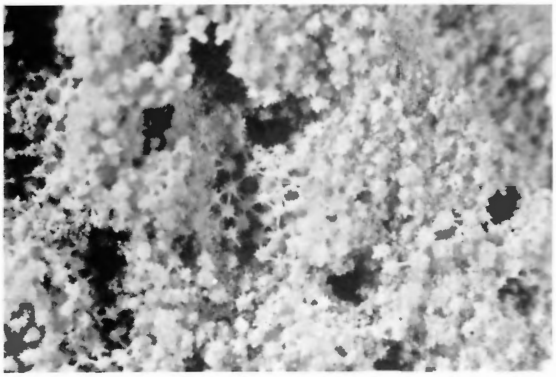
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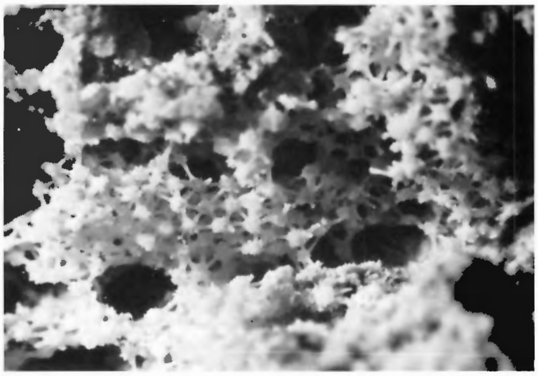
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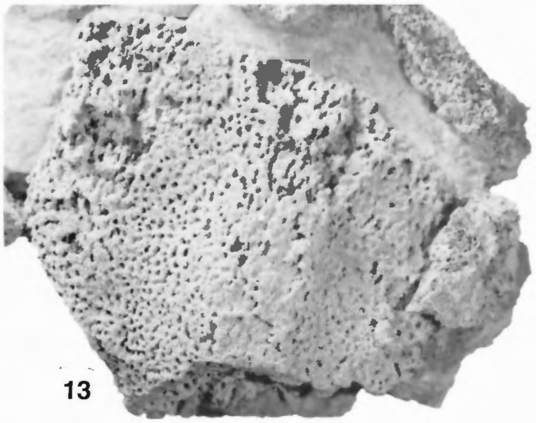
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# PLATE 9

*Lumectospongia* and *Corticulospongia* from the Silurian Cape Phillips Formation

Figures 1-4. *Lumectospongia uncinata* n. sp., holotype, UA 7732, Baillie-Hamilton Island Section 2-84.3.

1, 3. Side views of very thin-walled holotype showing the smooth surface and the uniform texture of the skeleton, which is composed of a felted mass of uncinates. The folded double wall is separated by a thin film of matrix in figure 1. Walls are only approximately 1 mm thick, x1.

2. Photomicrograph showing numerous irregularly oriented spicules in the felted gastral skeleton. The massive silicified area at the top is part of the dense dermal surface, near the edge of the broken upper wall in figure 1, x10.

4. Photomicrograph of spinose uncinate spicules in the felted skeleton, x50.

Figures 5-9. *Corticulospongia floccosa* n. sp., Baillie-Hamilton Island Section 2-84.3.

5. Holotype, UA 7733, gastral surface showing the range of spicules in irregularly subparallel but heaped skeleton composed of mixed rhabdodiactines and oxeas, with small hexactines as most delicate, hair-like, spicules between coarser main spicules. Irregular openings between crude clusters are excurrent ostia on the gastral margin, x10.

6. Photomicrograph of dermal surface of holotype, UA 7733, showing relatively coarse outer part of the skeleton with spicules in crude bark-like bundles. Irregular interruptions between the bundles are incurrent ostia, x10.

7. Dermal view of holotype, UA 7733, showing coarse clusters of subparallel spicules in outer surface of the sponge, x1.

8. Paratype, UA 7734, showing gastral surface of moderately fine, irregularly clumped to thatched rhabdodiactines and oxeas, x1.

9. Photomicrograph of the gastral surface of the small paratype, UA 7734, showing delicate, felted, subparallel, tiny rhabdodiactines and oxeas (?) that constitute much of the wall of the sponge. Circular openings are large excurrent ostia on the gastral surface, x10.

PLATE 9


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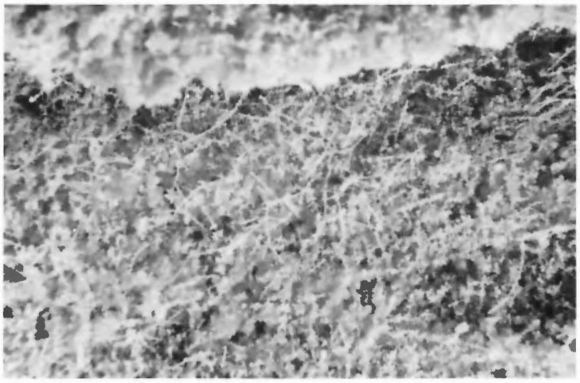
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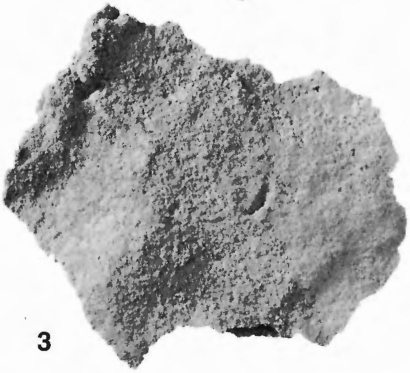
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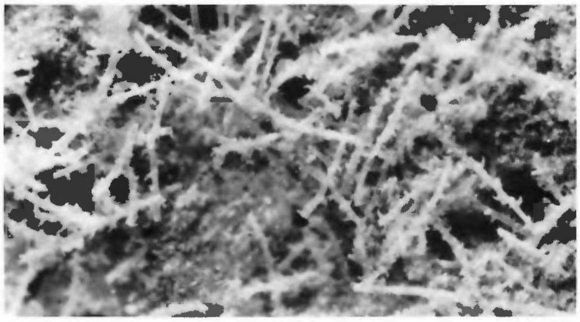
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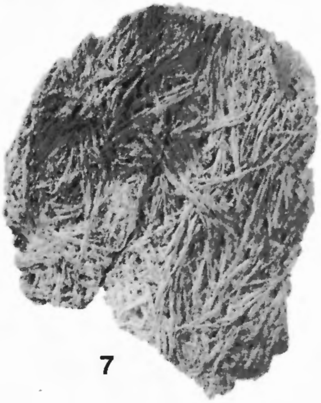
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## PLATE 10

*Dictyospongia*, *Astylospongiella* and *Corticulospongia* from the Silurian Cape Phillips Formation

Figures 1, 4, 5. *Dictyospongia apache* n. sp., holotype, UA 7735, Cornwallis Island, Cape Phillips Section, float (stratigraphic position equal to the interval between 4630 and 4643 ft. of Thorsteinsson [1958]).

1. Flattened holotype showing gentle upward expansion of smooth wall, made of ranked tracts of bundled hexactines and derivatives. Neither base nor oscular margin preserved, x1.

4. Enlargement of upper centre of holotype showing subcylindrical first-order tracts and bundled tracts of several orders, x2.

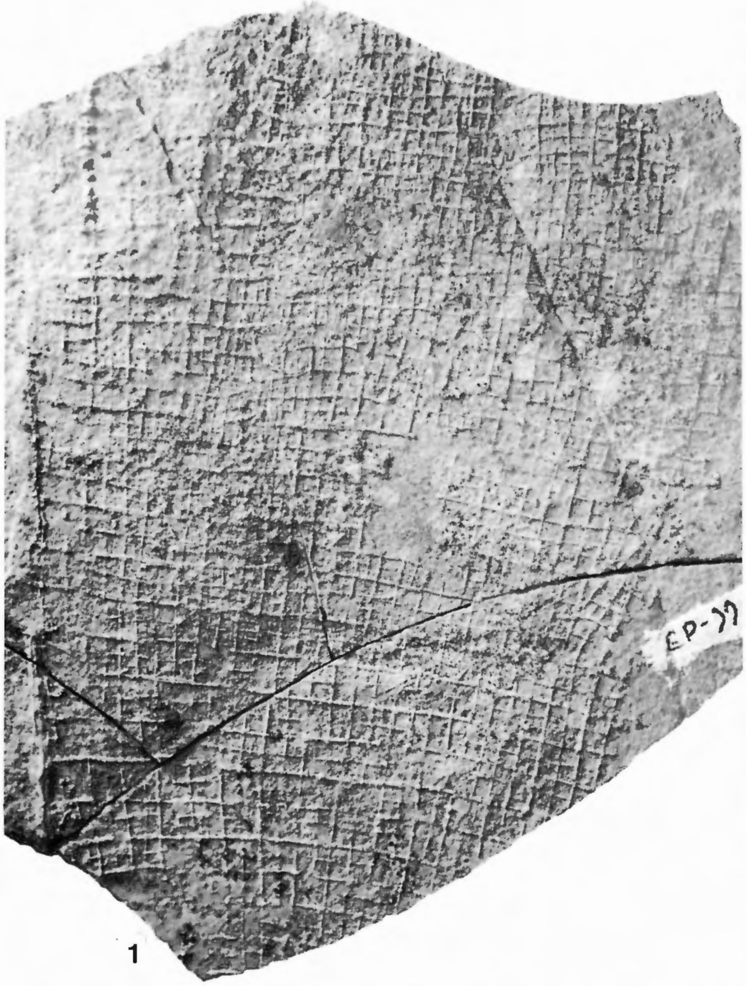
5. Enlargement of lower left of holotype showing bundled tracts and ranked skeleton, each rank subdividing larger quadrules into four subequal parts, x2.

Figure 2. *Astylospongiella striola* n. sp. Baillie-Hamilton Island Section 2-84.3.

2. Photomicrograph of sphaeroclones of the holotype, UA 7729, with spinose spherical centra, x50.

Figure 3. *Corticulospongia floccosa* n. sp., Baillie-Hamilton Island Section 2-84.3.

3. Photomicrograph of spicules from the holotype; tiny hair-like hexactines (arrows) are microscleres, UA 7733, x50.



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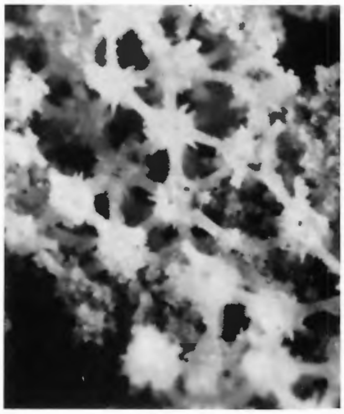

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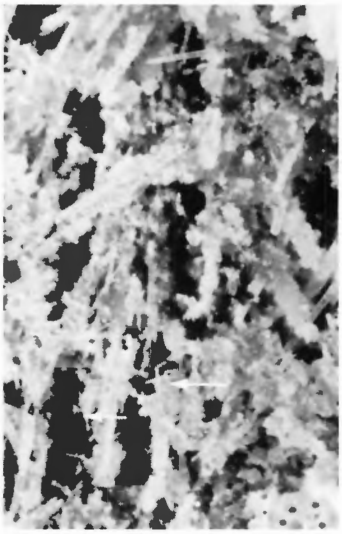

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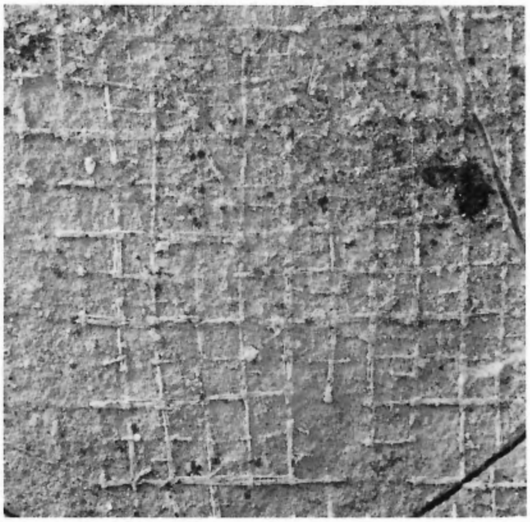

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