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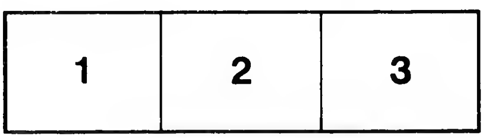
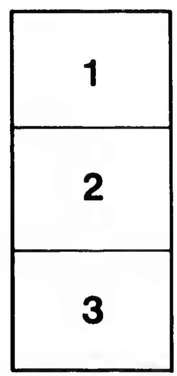
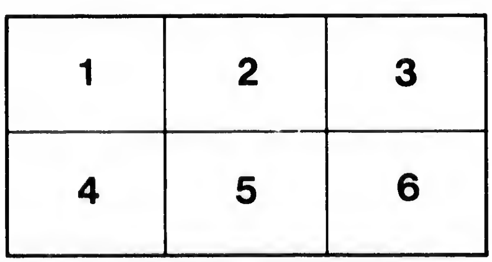






McGILL UNIVERSITY

PAPERS FROM THE DEPARTMENT

OF

GEOLOGY.

No. 4.—FOSSIL SPONGES AND OTHER ORGANIC REMAINS FROM THE QUEBEC GROUP AT LITTLE METIS.

BY

SIR J. WILLIAM DAWSON, C.M.G.

WITH FOUR PLATES.

[Reprinted from the Transactions of the Royal Society of Canada, Section iv., 1896, pp. 91-121.]

MONTREAL, 1897.

VI.—*Additional Notes on Fossil Sponges and other Organic Remains from the Quebec Group at Little Metis, on the Lower St. Lawrence.*

By SIR J. WILLIAM DAWSON, LL.D., F.R.S.

With Notes on Some of the Specimens by DR. G. J. HINDE, F.R.S.

(Read May 20, 1896.)

[I. Introductory; II. Subdivisions of the Quebec Group; III. Little Metis Bay; IV. General Remarks on the Fossil Sponges; V. Notices of the Several Species; VI. Other Animal Remains; Conclusion.]

I.—INTRODUCTORY.

The present paper is a continuation of that on the same subject contributed to the Royal Society of Canada in 1889, and published in its Transactions for that year. It is intended to bring the subject up to date with reference to discoveries of new species and additional facts as to those previously known, and also to fix more definitely the age of the beds containing the fossils, more especially in connection with the more recent observations of the officers of the Geological Survey of Canada.

The Quebec Group was instituted by Sir W. E. Logan, and described by him, in 1863, as a peculiar coastal and Atlantic development of the formations known in the interior of North America as the Calciferous and Chazy members of what was then known as the Lower Silurian system.[1] Logan understood that on the submerged continental plateaus and ocean depths of any given geological period there must be local as well as chronological differences in the deposits, and that the terms applicable to the formations in the inland seas, which in times of continental depression covered what are now interior continental plains, cannot rightly designate those laid down contemporaneously on the borders of the open and permanent ocean. We now know that these last are the most general and continuous records of the history of the earth, though the continental deposits, depending on subsidences alternating with elevations, give the most decidedly graduated scales of geological time in their successive and apparently distinct dynasties of marine life. Hence the plateau deposits

[1] Geology of Canada, p. 295 *et seq.*; Appendix to Murray's Report on Newfoundland, 1865, quoted by me in Journal of London Geological Society, 1888, p. 810, and in Canadian Record of Science, 1890, p. 135.

are the most easily available as geological chronometers, and have been so used both in Europe and America; but they do not accurately represent the series of changes going on in the great oceanic areas and their margins.

Viewed in this way, Logan's name, Quebec Group, designates the oceanic deposits formed on the Atlantic border of North America at a time when very different conditions prevailed in those now inland areas which afforded the classification of the New York Survey. The fact of this great difference remains, and the term designating it will continue to be of value to geologists, so long as they are desirous rationally to correlate the sequence of formations in America and in Europe, and to connect with their science those great facts of palæogeography which enable us to realize the diverse conditions of the depressed and elevated portions of the earth's surface in different geological times. The name is farther justified by the fact that the lower portions of our great St. Lawrence river follow a course in the Province of Quebec which enables them better than any other section in America to illustrate the difference between the depos s of the Atlantic and continental areas in the early Palæozoic period.

I regard these considerations as of great importance in relation to the fossils described in this paper, because they are members of a fauna of almost universal oceanic distribution; in its time extending continuously over vast spaces and periods, and serving to bridge over the gaps in the broken series of the continental plateaus. It is likely to gain in significance and in relative value as science advances; and, when more fully known and appreciated, to do much toward remedying that imperfection of our geological record, which depends, to some extent, on our basing it on localities where physical disturbances have interfered with the continuity and orderly succession of life. It is only by the patient and long-continued study of the formations deposited on those parts of the permanent oceanic areas available to us, that we shall ultimately be able to trace back the marine life discovered by the dredgings of the "Challenger," to early geological times.

When Logan commenced his survey of Canada in 1842, little of this was understood, and he had before him the task of solving the enigma of original differences of deposits and superadded mechanical disturbances in Eastern Canada, with the wholly inadequate key afforded by the inland series of formations worked out by the survey of New York, which itself, when it came into contact with the marginal series, became involved in that Taconic controversy, which has scarcely yet subsided, and which must remain in some degree unsettled as long as geologists fail to see that they cannot force into one system the dissimilar formations of the ocean and of the continental plateaus. I have no wish here to dwell on these controversies; but may refer for some statement of my views on the great natural facts which underlie them, to the publications named in the footnote to this section.[1]

II.—Subdivisions of the Quebec Group.

Confining ourselves to the sections on the south shore of the Lower St. Lawrence, the subdivisions, as worked out by Logan and Richardson and more recently by Ells, with the aid of Whiteaves in regard to the Trilobites, Brachiopods, etc., and of Lapworth[2] and Ami in the graptolitic fauna, may be stated as follows in ascending order:[3]

1. *The Sillery Series*, seen at the Chaudière River, near Quebec, and also at Matane and Cape Rosier, as well as at Little Métis. Among its characteristic fossils are the little brachiopod *Obolella* (*Linnarssonia*) *pretiosa*, Billings, and *Dictyonema sociale* of Salter (*D. flabellare* of Eichwald), also species of *Bryograptus* and *Clonograptus*. The prevalent rocks are grayish sandstones and conglomerates with shales of red, gray and black colours, and more rarely bands of limestone and dolomite. It may be regarded as the base of the Quebec Group proper, and as the equivalent of the Calciferous of more western districts and of the Tremadoc of Wales, and perhaps as the highest member of the Cambrian system.

2. *The Levis Series*; to which belong the shales, limestones and conglomerates exposed at Levis, opposite the city of Quebec, and which has been recognized as far east as Ste. Anne des Monts. Its most characteristic fossils are graptolites of the genera *Phyllograptus*, *Tetragraptus*, etc., most of which are described by Hall in his classical monograph on this fauna; while its Trilobites, etc., have been studied by Billings, and catalogued by Ami, who separates the fossils found in boulders in the conglomerate from those properly belonging to the formation.[4] This series is in the horizon of the Upper Calciferous and Chazy, and may be regarded as equivalent to the English Arenig and Skiddaw.

3. *The Marsouin Series*; found at that place and at Griffin Cove, White River, and elsewhere, and holding graptolites of the genera *Diplograptus*, *Cœnograptus*, etc. It is apparently of Chazy-Trenton age and equivalent to the English Bala.

4. Still higher beds holding *Diplograptus pristis* and other forms characteristic of the Utica shale, and therefore newer than the Quebec Group proper, occur west of Marsouin River, near Tartigo River and elsewhere. At this period, owing to the subsidence of northern land, the

[1] Appendix to Harrington's Life of Sir William Logan, p. 403 *et seq.*; On the Eozoic and Palæozoic Rocks of Eastern Canada, Journal London Geol. Society, 1888; The Quebec Group of Logan, Canadian Record of Science, 1890; Salient Points in the Science of the Earth, 1894.

[2] Transactions Royal Society of Canada, 1886.

[3] For notices of previous work and recent discoveries, see Report by Ells, Geological Survey of Canada, 1887-88.

[4] Report Geol. Survey of Canada, 1887-88.

Quebec Group conditions of cold water and muddy deposits overspread the whole interior of the continent, thus blending the oceanic and plateau conditions for a time, and forming the natural close of the Quebec Group, because temporarily obliterating the geographical distinction on which it is based.

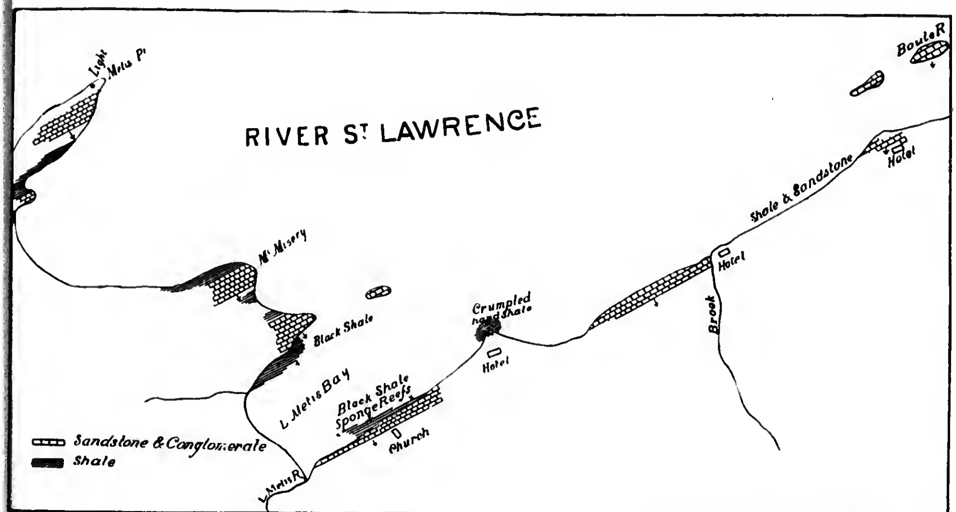
III.—Little Metis Bay.

The author of this paper has had occasion for many years to spend a portion of the summer at one or other of the health-resorts on the Lower St. Lawrence, and has latterly preferred Little Metis, as one of the most pleasant in its atmosphere and surroundings. He has there naturally endeavoured to familiarize himself with the rocks and fossils accessible in walks or short drives and boating excursions, and to devote some time and labour to any locality which seemed unusually promising.

At Little Metis, and indeed along the whole coast between the city of Quebec and Cape Rosier, a stretch of about 350 miles, the shore on the whole follows the strike of the great mass of sandstones, shales and conglomerates of the Quebec Group and which are everywhere thrown into sharp anticlinal and synclinal folds, and often repeated by longitudinal faults, while they are also much disturbed by transverse faults and flexures.

These older rocks are covered in places with the sands and clays of the Pleistocene period, locally containing marine shells, and accompanied with vast numbers of gneiss boulders from the Laurentian Mountains of the north shore, here about forty miles distant, and with occasional, but often very large, blocks of Silurian limestone from the hills to the southward. Though masked on the lower grounds by these superficial deposits, the older rocks appear everywhere in the hilly ridges and in the coast cliffs and reefs.

Little Metis Bay faces the northeast, and its outer boundary consists of a strong gray sandstone forming the Lighthouse Point and extending to the eastward in a long and dangerous reef, which it is hoped may, at some future period, form the basis of a harbour of refuge for shipping. Immediately to the southwest of the point, the shore recedes rapidly (see map), the sea having cut back along the outcrops of dark shaly bands which overlie the standstone, the whole dipping to the southward. These occupy the northern division of the bay, about half a mile in width. South of this a second reef of sandstone divides the bay, rising into a high bluff, known as Mount Misery. This is divided by a shallow cove, and at its southern extremity there projects a low point of sandstone and conglomerate, which seem to extend eastward on a little outlying island and a submerged bank, on which the sea breaks at very low tides, and which connects it with another and higher islet about two miles distant, called the Boule Rock. This consists of sandstone and conglomerate dipping southward at a high angle. South of the point above mentioned, the shore again bends rapidly westward along a belt of dark shaly beds, and forms the southern and narrower division of the bay, almost dry at low tide, and into the southwest corner of which the Little Metis River flows. From this southwest angle of the bay another bed of very hard sandstone capped by conglomerate extends along the coast to the north-eastward, and after a break reappears beyond Turriff's Hotel, in the cliff of the Crow's Nest, from which at a lower level it continues for some distance toward Sandy Bay.



Sketch-map of Little Metis Bay and vicinity, showing locality of Fossil Sponges. (Scale about two inches to a mile.) Geographical lines from a map by Dr. Ells.

Sectional view on the beach north of the church, represented in the sketch-map. (Length about 550 feet.)

(*A*) Conglomerate. (*B*) Sandstone or quartzite. (*C*) Olive arenaceous shale. (*D*) Black shales, with some olive bands and thin layers of hard, arenaceous dolomite; remains of sponges in a few layers. (*E*) Muddy shore: indications in places of soft, dark shale. (*F*) Hard, gray and olive shales, with bands of dolomite and sandstone. (*G*) Pleistocene sand and boulder clay.

The whole of these beds have southerly and southwest dips, though in places they become vertical and contorted. These disturbances, however, so far as can be ascertained, are local, and do not affect the general arrangement, except in so far as slips parallel to the strike may repeat the beds.

The layers holding fossil sponges, to be described in the sequel, are seen in low reefs or ledges of black and olive shale, extending along the south side of the bay from near the mouth of Little Metis River for about a furlong to the eastward, and are quite regular and undisturbed, though inclined at an angle of about 50°. The sandstone and conglomerate immediately overlying conformably this band of shales is capped with boulder-clay and sand, and forms the rising ground on which stands the Wesleyan church, indicated on the map. The section given on p. 95 shows the attitude and relation of these beds, and is drawn from the church to the northwestward.

Before proceeding to describe the sponge-beds and their fossils, it may be well to notice the overlying sandstone and conglomerate, and similar beds in the vicinity, with the fossils they contain, and the relations of these to other beds on the Lower St. Lawrence.

The upper sandstone (*B* in the section) is so hard that it might be regarded as a quartzite, differing in this respect from some of the other beds in the vicinity, as, for instance, those of Mount Misery and the Lighthouse Point. It dips S. 20° W. magnetic, at an angle of about 50°, and is about sixty feet in thickness, though apparently thinning to the eastward. Its lower side is remarkably flat and even, and has been undercut by the sea, owing to the softness of the shale below. On its strata planes are many fantastic, radiating forms indented on the weathered surfaces, and akin to those which in the Cambrian quartzites of Nova Scotia I have named *Astropolithon*.[1] No other fossils have been observed in it. In tracing this bed to the eastward, it is seen to be overlaid by, and to pass into, a very coarse conglomerate, with an arenaceous paste and partly angular or rounded boulders, some of them more than two feet in diameter. Some are of a light gray limestone, others are quartzite, sandstone and indurated slate. Some of the limestone boulders hold fossils, and from one of these I obtained the following forms, kindly identified for me by Mr. Matthew :

Olenellus Thompsoni, Emmons.	*Pleurotomaria ?*
Ptychoparia Metissica, Walcott.[2]	*Iphidea bella*, Billings.
P. (species).	*Hyolithes* (species).
Protypus senectus.	Branching organism (possibly a sponge).
Solenopleura (species).	Fragments of various small Trilobites.
Stenotheca rugosa, Walcott.	

These fossils are all, so far as determinable, of Lower Cambrian age, and must have been derived from limestones already undergoing waste

[1] Acadian Geology, Supplement, 1878, p. 82.

[2] First found some years ago in a similar boulder from the Boule Rock. Along with it was found a small sponge, *Trachyum vetustum*, described and figured by Walcott in his memoir on the Lower Cambrian.

at the time of the Quebec Group. Thus, though the conglomerate overlies and is newer than the shales holding sponges, the limestone boulders contained in it are of much greater age. It has long been well known that similar appearances occur in nearly all the limestone conglomerates of the Quebec Group, and at first they led to serious difficulties as to the age of the formation. Sometimes they are very deceptive. I have seen in the conglomerate at St. Simon a slab of limestone, eight feet in length, which might readily, in a limited exposure, be mistaken for a bed in place, but which is really a Lower Cambrian boulder containing numerous fragments of Olenellus and other ancient Trilobites, and several species of Hyolithes.

These g... t and irregular beds of conglomerate would appear to indicate ice-action in the Lower Palæozoic sea, and it would seem that the boulders must have been denuded from reefs of older Cambrian rocks now mostly covered up or removed by denudation, while, unlike the condition of things at the time of the Pleistocene drift, no Laurentian material seems to have been accessible.

Up to 1887 the beds in Little Metis Bay had been very unproductive of fossils. They had afforded to the late Mr. Richardson the little *Linnarssonia pretiosa*, and I had found in the sandstones of Mount Misery and the Lighthouse Point a few fragments of a *Retiolites*, apparently *R. ensiformis* of Hall, and in the shales near the Lighthouse Point abundance of worm trails, some of the type of that described by the Swedish geologists as *Arenicolites spiralis*. In so far as these fossils afforded information, they tended to refer the whole series to the lower part of the Quebec Group, and, as it seemed to be an ascending one to the southwest, the impression conveyed to me was that the black shales near the upper part might belong to the base of the Levis series. As already stated, however, the new facts ascertained respecting the position and fossils of the Sillery series now tend to the conclusion that the whole belongs to this lower member.

For detailed sections of the productive sponge-beds I may refer to my paper of 1889, merely remarking here that in a band of shale, with a few thin layers of dolomite, the whole more than 100 feet in thickness, only three or four layers, each from one to three inches in thickness, have been productive of fossils.

IV.—General Remarks on the Fossil Sponges.

The discovery of fossil sponges at Little Metis Bay was made by Dr. B. J. Harrington, F.G.S., in 1887, in examining loose pieces of black shale washed up on the beach. On searching for these shales *in situ*, they were found in low reefs on the shore at about half-tide level, and diligent search disclosed the fact that in a few thin bands of shale sponge remains were abundant, though from the extreme delicacy of their spicular skeletons they were not easily recognized, except in a bright light and on the moistened surfaces of the shale. In that and subsequent years I undertook detailed collecting in these beds. The thin productive layers being inclosed in ledges of compact shale, much material had to be quarried away in order to obtain access to them, and the work could be carried on only at low tide. The best method of proceeding was found to be to trace the fossiliferous layers along the ledges, and having quarried out as rge slabs as possible, to convey these to where they could be split up and examined at leisure. By pursuing this method sufficient quantities of material could be obtained to enable satisfactory comparisons to be made. The method, in short, was the same which I have pursued in collecting delicate fossil plants and the smaller animal remains from the Devonian and Coal formation, and which has enabled so many species of delicate vegetable organisms from Gaspé and Nova Scotia to be restored in their external forms.

The facts observed up to 1889 were detailed in the paper of that date, in preparing which I was indebted to Dr. G. J. Hinde, F.R.S., the author of the British Museum Catalogue of fossil sponges, and of so many valuable papers on these organisms, for most important information as to the structure and probable affinities of the species. In addition to the notes of Dr. Hinde given in the previous paper, I am indebted to him for further important suggestions contained in these pages, and for the description of an additional species.

Since 1889 excavations have been continued from time to time, with the view more particularly of discovering new species and of obtaining more perfect examples of those previously known. In noticing the results obtained, I shall first refer to certain points relating to mode of occurrence which have been more definitely settled, and shall then present a catalogue of the species, with short descriptions and figures.

In regard to the figures, I may explain that those in the text are of two kinds: (1) Camera tracings, slightly enlarged, of the picules, as seen under the microscope; (2) Restorations, mostly based on combining several more or less complete specimens. Those in the plates are produced from enlarged photographs taken usually from moistened surfaces under a bright light. These were printed and carefully retouched to render them more distinct, then reproduced in negatives of or near to the natural size, and copied from these for printing. Those which were sufficiently distinct for this, were reproduced without being touched.

In the former paper, of 1889, Dr. Hinde ably discussed at some length the state of preservation of the specimens. He remarks that the skeletons of the greater number of the species were made up of delicate spicules, often cruciform, and arranged in such a manner as to form a thin lattice-like framework inclosing a hollow space or sack, and supporting the soft animal membranes. In the meshes of this framework, and sometimes forming an external dermal coating, were minute spicules and delicate protective spines. The spicules, originally composed of amorphous or colloidal silica, are now for the most part entirely replaced by pyrite, and not infrequently they are also encrusted with a delicate coating of minute crystals of the same mineral, so as greatly to increase their apparent magnitude, though in most cases it is possible under the lens to distinguish the original spicule from its coating. The sponge thus appears as a delicate bronze-coloured framework or mass of spicules on the surfaces of the shale. In a few instances the spicules have retained their primitive siliceous material, and more rarely the material of the spicules has been entirely removed, leaving their impressions merely on the matrix. It sometimes happens, especially in the case of species with somewhat dense spicular walls, that the meshes included in the spicular framework are filled in with pyrite, so as to show merely the general form and faint indications of the spicular structure.

Originally rooted in the soft ooze of the sea bottom, the specimens seem sometimes to have been buried *in situ*, so that when the shale is split they appear in transverse section or as round flattened discs; but in most cases they seem to have drifted from their anchorage, either with or without their anchoring-rods, and to have been flattened laterally. When entire, they sometimes present, when the shale is split open, a surface of dermal spines, masking the skeleton proper. In other cases the dermal spines come away with the matrix, leaving the skeleton spicules exposed. Thus the same species may present very different appearances under different circumstances. In most cases the body of the sponge has been more or less disintegrated or reduced to patches of loose spicules, and some large surfaces are covered with a confused coating of spicules and anchoring-rods belonging to several species. In some cases also the loose spicules, or fragments of them, seem to have been gathered in little oval or cylindrical piles and inclosed in pyrite. At first I was disposed to regard these as coprolitic; but Dr. Hinde doubts this, and regards them as merely loose spicules drifted together into hollows or worm-burrows.

All these differences of preservation and exposure present considerable difficulties in discriminating the species; and these are sometimes increased by the association of specimens of different ages. It thus requires experience and abundant material to obtain definite results. Nevertheless Dr. Hinde, who has had very extensive acquaintance with fossil sponges in various conditions of preservation, makes the following remarks in reference to the specimens submitted to him :

"The Metis specimens are specially interesting, since they throw much fresh light on the character of the earliest known forms of these organisms, and their discovery is the more opportune from the fact that our knowledge of the existing hexactinellid sponges—the group to which all, or nearly all, these fossils belong—has been vastly increased by the work of Prof. F. E. Schulze, of Berlin, on the hexactinelled sponges dredged up by the Challenger Expedition, and thus we are now better enabled than hitherto to compare the fossil and the recent forms."

The conditions of accumulation of the Metis shales seem to have been very favourable to the pyritization of organic remains. The shells of Linnarssonia, small fragments of Trilobites and fronds of Algæ, seem, all alike, to have been amenable to this change, and cylinders and spirals of solid crystalline pyrite occupy the burrows of worms, while nodules of the mineral destitute of any organic form also occur. On the other hand, in some layers containing fossils, there is no trace of pyrite, but in these it is very difficult to see the spicules, owing to their similarity in colour and lustre to the slate.

V.—Notices of the Several Species.

The arrangement of Palæozoic fossil sponges is still to some extent provisional. That adopted below is the one most current at present, and necessarily depends entirely on the material and structure of the skeleton.

Viewed in this way, the whole of our Metis sponges, if we except a few uncertain forms to be mentioned in the sequel, belong to the order *Silicea*, including those which form their skeleton of siliceous needles or spicules. Under this are sponges with simple spicules (Monactinellids), and these seem to be the oldest of all, since the needles found in the Huronian cherts and those recognized by Mr. Matthew in the Laurentian appear to be mostly of this type. Others (Hexactinellids) present cruciform spicules, or spicules with six rays, placed at right angles to each other. These are arranged so that the rays are joined by their points, forming very complex and beautiful frameworks, the variety of which is increased by the fact that the different rays may be unequally developed, or some of them may be abortive, giving forms available for a great many beautiful constructive uses. We shall find that the complexity and diversity attainable by spicular forms, all based upon one general law, but admitting of countless differences and modifications, had already nearly reached its maximum in a very early geological period.

The Hexactinellids may again be divided into two groups, according to the united or loose condition of the spicules. When these are firmly cemented together by siliceous matter, we have the group *Dictyonina*, and when they are united merely by animal matter, and consequently fall asunder on decay, they belong to the group *Lyssakina*. Under these we have families, genera and species.

The following list is a revision, with important additions, of that given in 1889.

ORDER SILICEA.

Suborder HEXACTINELLIDA.

Group *Lyssakina*.

Family PROTOSPONGIDÆ, Hinde.

GENUS PROTOSPONGIA, Salter.

This genus was established by the late Mr. Salter from some remains of lattice-like spicular bodies found in the Middle Cambrian of Wales, and which, though fragmentary and obscure, that eminent naturalist was able to refer to the group of Siliceous sponges. The genus includes several of the Metis species, which have enabled us to complete the characters of Salter's genus.

1.—PROTOSPONGIA TETRANEMA, Dawson.[1]

(Figs. 1 to 5. Pl. I., Figs. 1 and 4.)

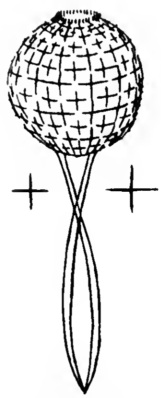


FIG. 1.—*Protospongia tetranema.* A small specimen restored.

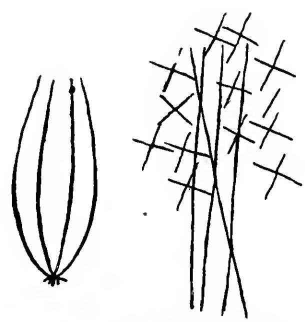


FIG. 2.—*Protospongia tetranema.* Anchoring-spicules slightly enlarged.

In the specimens in which the outline of the sponge has been preserved, the body appears to have been rounded or broadly oval. There was an aperture or osculum at the summit, though it can be distinguished only in a few specimens. The wall of the sponge appears to have consisted—as in the other species of this genus—of a single layer of cruciform spicules of various dimensions, disposed so as to form a framework of quadrate or oblong interspaces. The rays of the larger spicules constitute the boundaries of the larger squares; but owing to decay

[1] The characters of this and several of the following species were given in "Notes on Specimens in the Peter Redpath Museum," and in the Transactions of the Royal Society, 1889.

and flattening the spicules are usually much displaced. Within these, secondary and smaller squares are marked out by smaller spicules. Judging by the length of the rays of the larger spicules, the larger squares would be about 4 mm. in diameter, whilst the smallest do not exceed

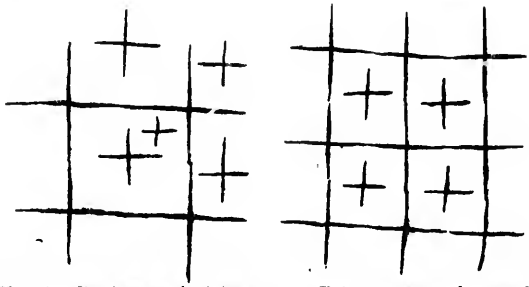


FIG. 3.—*Protospongia tetranema.* Primary, secondary and tertiary cruciform spicules, × 5.

1 mm. The rays of the individual spicules seem to have been united merely by the animal matter. and not by a silicious cement. The osculum is protected by defensive spines (Fig. 4), and in young specimens these are often very numerous. The rays of the larger spicules are conical, gradually tapering from the central node to the pointed extremity; whilst the rays of the smaller spicules appear to be nearly cylindrical.

From the base of the sponge, four slender, elongated, filiform rods project. They are approximately cylindrical, pointed at both ends, very slender, and from 50 to 70 mm, in length. Their proximal ends are inserted apparently in the basal part only of the sponge. In perfect specimens they are seen to approach and cross each other in the middle, and then to diverge, finally again approaching and forming a loop with a minute central point. So many examples of this structure have now

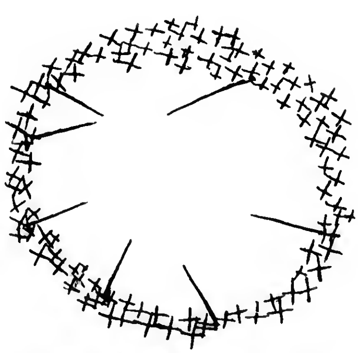


FIG. 4.—*Protospongia tetranema.* Osculum enlarged. and surrounded by minute spicules.

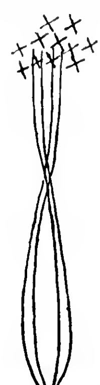


FIG. 5.—Anchoring-rods.

been found that there can be no doubt as to its true nature, though in a few instances the loop has broken asunder, leaving the rods free. Even in this case, however, they show their curved ends (Fig. 5).

This is one of the most abundant species at Little Metis. There can be no hesitation in placing it in the genus *Protospongia*, since the same arrangement of the spicular mesh-work is present in it as in the type of this genus. In the earlier examples of the genus, however, the presence of anchoring-spicules was not recognized, owing, no doubt, to their imperfect state of preservation, and this feature may now be reckoned as one of the generic characters. In the present species, however, these anchoring-spicules were very peculiar, and seem to be rays of a cruciform spicule, which were bent upward and lengthened, forming a stalk for the sponge. This would give a firm attachment, and adapt itself to the gradual rise of the bottom to which the sponge was attached. The mechanical properties of such an arrangement of spicula are obviously well suited to effect their purpose.

Some further remarks on the *lyssakine* character of *Protospongia* will be found in the paper of 1889, and the more recent collections also show that the skeleton spicules, at first small in the young specimens, grew in length, by additions to the ends of the rays as the body increased in size.

2.—PROTOSPONGIA MONONEMA, Dawson.

(Figs. 6, 7 and 8. Pl. I., Figs. 2 and 3.)

FIG. 6.—*Protospongia mononema.* Restored.

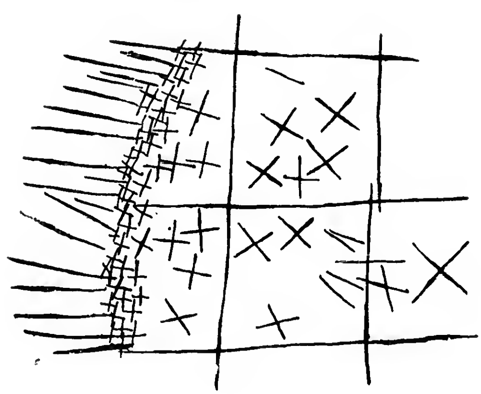


FIG. 7.—*Protospongia mononema.* Cruciform and protective spicules, × 5.

General size about one inch in diameter, originally globular but now flattened. Body spicules cruciform and more slender than those of

P. tetranema. Superficial or defensive spicules very numerous and somewhat long and slender, so as to give a hirsute appearance, and in flattened specimens often to obscure the body spicules. Root, single, stout, often three inches long, with two to four short, spreading branches at base. These terminal spicules are flattened at the extremities. The

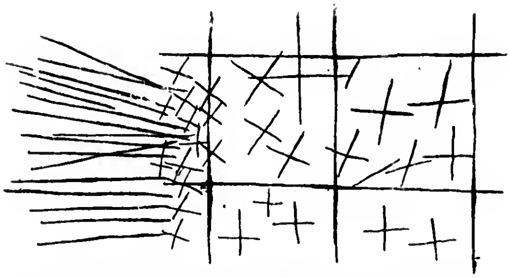


Fig. 8.—*Protospongia mononema.* Primary, secondary and tertiary spicules, × 5.

anchoring-rod in this species is often increased in thickness by a crust or frosting of pyrite, and this would seem to indicate that it had, like the modern Hyalonema, animal matter as well as silica in its composition, or that foreign organic bodies attached themselves to it.

Nearly as abundant as the preceding form, which it differs from in the character of the anchoring-rod, each of which may be regarded as a single elongated anchor-shaped spicule, with five rays. The skeleton spicules are also more slender and delicate, and their rays longer, and there is a greater development of protective dermal spines. The osculum is narrow and with many long defensive needles. (Plate I., Fig. 3)

3.—Protospongia polynema, Dawson.

(Figs. 9 and 10.)

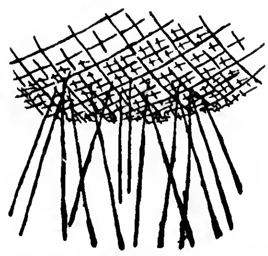


Fig. 9.—*Protospongia polynema.* Portion of base of large specimen.

A large sponge in great shapeless flattened patches, several inches in diameter, though there are smaller individuals also. Body spicules fine and slender, making a very open mesh. At base numerous simple root spicules, short, and, in some cases, expanded at their extremities. Young individuals seem to have been globular and probably sessile, while large individuals had a flat base; but the general form is greatly obscured by crushing, especially in the larger specimens.

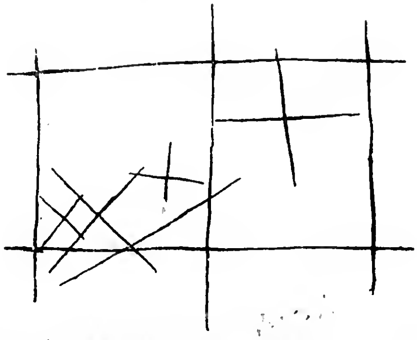


FIG. 10.—*Protospongia polynema.* Primary, secondary and tertiary spicules, × 5.

4.—PROTOSPONGIA DELICATULA, Dawson.

(Figs. 11 and 12.)

Globular or oblong in form, 1 to 4 cm. in diameter. Body spicules cruciform, regular, forming a very dense mesh, about 1 mm. or less in the opening. Osculum probably wide. Defensive spicules very short and close. Several short anchoring-rods. Some indications of a double row of spicules in the body-wall. The density of the spicular body-wall causes it often to be encrusted and obscured by pyrites.

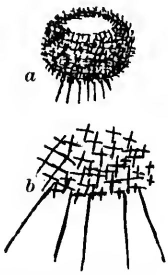


FIG. 11.—*Protospongia delicatula.* (*a*) Restored. (*b*) Portion of base enlarged.

FIG. 12.—Primary, secondary and tertiary spicules, × 5.

Rauff, in his monograph on fossil sponges, identifies this with Walcott's *Cyathophycus* (*Teganium*) *subsphæricus* of the Utica shale, but comparison with specimens kindly furnished by Dr. Walcott shows that there is no ground for this except a resemblance in general form. The structures, so far as known, are quite different.

NOTE.—The two following species, having the rows of spicules diagonally arranged, as I remarked in describing them in 1889, have been placed by Rauff in a new genus *Diagoniella*. I doubt the expediency of this on the mere ground of divergence of the rows of meshes from horizontality. But there are other peculiarities of these species, which might fairly entitle them to constitute distinct sections of the genus. I therefore, place them by themselves, noting these differences :

5.—PROTOSPONGIA CORONATA, Dawson.
(Figs. 13, 14 and 15. Pl. II., Figs. 5 and 6.)

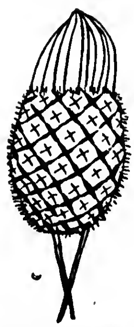


FIG. 13.—*Protospongia coronata.* Restored.

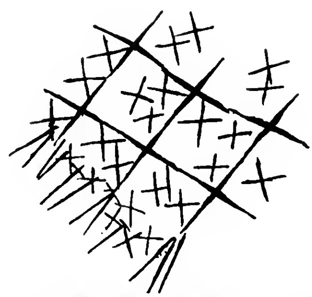


FIG. 14.—*Protospongia coronata.* Primary, secondary and protective spicules, × 5.

Body ovate, 2 cm. long, but fragments indicate that it grew much larger ; spicules coarse and four-rayed, so connected as to give the appearance by their obliquity of a diagonal network of rhombic openings. This may possibly be the effect of flattening. Numerous small cruciform flesh spicules. Root spicules strong, short or broken off. 2 to 4. Osculum

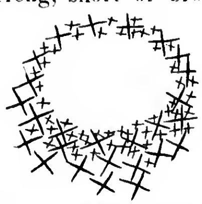


FIG. 15.—*Protospongia coronata.* Showing internal cavity.

large, terminal, covered with a conical hood made up of curved spicules converging to a point, and 1 cm. in height, in the smaller specimens, in which alone I have seen them, the larger specimens being usually imperfect. Short protective spicules visible at the sides.

6.—Protospongia cyathiformis, Dawson.

(Figs. 15 and 16. Pl. II., Figs. 7 and 8.)

Fig. 15.—*Protospongia cyathiformis.* Restored.

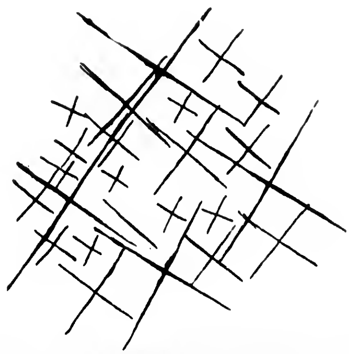


Fig. 16.—*Protospongia cyathiformis.* Primary, secondary and tertiary cruciform spicules, × 5.

General form inverted conical. When mature about 3 cm. wide at top and 5 cm. long, without the anchoring-spicules, which are sometimes very long. Top truncate as if with a wide osculum, with defensive spicules on its margin. Primary spicules cruciform, with long rays, in some 2 to 3 mm. in length, placed diagonally, loosely attached or free, but forming large rhombic meshes; secondary and tertiary spicules numerous and delicate, with slender arms. Root spicules simple, sometimes very long, five or more visible in the most perfect specimens, and passing up to the middle of the body. Indications of many interior minute flesh spicules, often constituting a pyritized mass, obscuring the meshes.

The oblique character of the transverse spicules deserves notice, but this may be the result of compression, though I think it more likely that it is an original feature.

This species is well characterized by its form, and by its multitudes of very minute cruciform spicules. These and the fact of the sponge being often represented by a dense, pyritous mass, indicate a thicker and more fleshy body-wall than in some other species.

Genus HYALOSTELIA, Hinde.

7.—Hyalostelia Metissica, Dawson.

(Fig. 17. Pl. III., Fig. 10.)

Fig. 17.—*Hyalostelia Metissica.* Spicules × 5.

General form broad, with a large osculum and a number of stout anchoring-rods. Body-wall formed of single long slender rods, woven into a very loose mesh and supporting cruciform and other spicules of varied form, attached only by the soft membranes, so that they are almost always found loose and disarranged. Up to 1889 I had seen the species only in this condition ; but was so fortunate in 1895 as to find a small specimen retaining its form, which I have figured in Plate III., Fig. 10. The spiral anchoring-rods figured with this species in 1889 really belong to Palæosaccus, which at one time I was disposed to connect with Hyalostelia, but am now convinced that they are altogether distinct, though Hyalostelia may form a connecting link between the Protospongidæ and the Dictyospongidæ, its body-wall being formed not of cruciform spicules, but of long slender and single rods woven together into square or rhombic meshes.

As to the use of the generic name Hyalostelia for this species, I am, by no means certain, since the sponges included previously in that genus are very imperfectly known to me.

Family DICTYOSPONGIDÆ, Hall.

GENUS CYATHOPHYCUS, Walcott.

8.—CYATHOPHYCUS QUEBECENSE, Dawson.

(Figs. 18 and 19.)

FIG. 18.—*Cyathophycus Quebecense.* Restored.

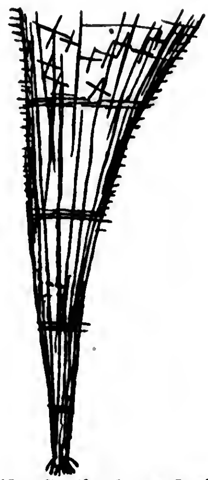


FIG. 19.—*Cyathophycus Quebecense.* Base enlarged.

Form elongated conical, composed apparently of numerous long, vertical spicules, crossed by horizontal or annular bars, and with a few cruciform spicules in the meshes. The vertical and transverse spicules may be cruciform spicules arranged vertically. The form terminates downward in a blunt point, with indications of a few short anchoring-spicules. This species closely resembles *Cyathophycus reticulatum* of Walcott from the Utica shale, but differs in detail, especially in the simplicity of the vertical rods and development of the transverse or circular bars. The largest specimens are 8 cm. long by 3 wide at top. There are signs of minute lateral defensive spicules. The general form and structure resemble those of the modern sponges of the genus *Holascus.*

I changed the generic name to *Cyathospongia* in my paper of 1889, as the termination seemed incorrect; but this name seems to have been pre-occupied by Prof. Hall. I therefore leave it in the original form until amended by the author.

The sponges of the genus *Cyathophycus* are not abundant in the beds explored at Metis, and most of them have been much broken up. Only one specimen was obtained in a tolerable state of completeness.

For further remarks on the structure and affinities of this sponge by Dr. Hinde, see the paper of 1889.

GENUS ACANTHODICTYA, *Hinde*.

Sponges approximately subcylindrical in form, consisting of a skeletal mesh-work of longitudinal and transverse spicular strands or fibres. The longitudinal strands are composed of somewhat loosely arranged fascicles of elongated overlapping spicules, and the spicules of the slender transverse fibres are as a rule disposed in a single series. From the outer surface of the sponge, numerous spicular rays project outwards at right angles. The sponge appears to have been anchored by a basal prolongation of the longitudinal strands. Owing to the present compressed condition of the specimens it is difficult to determine the original form of the constituent spicules. Some of the elongated longitudinal spicules may be merely simple rod-like forms, others are clearly cruciform and their transverse rays form the cross-fibres. The spicular rays of the projecting bristles of the surface may be the free distal rays of normal hexactinellid spicules, but only these projecting rays can now be clearly distinguished; the others are merged in the longitudinal fascicles.

The general structure of the skeleton resembles that of *Cyathophycus*, Walcott, but it is characterized by the presence of the projecting surface rays. The mesh is also of a looser character than in Cyathophycus and its arrangement in quadrate areas is only faintly recognisable.

9.—ACANTHODICTYA HISPIDA, *Hinde*.

(Figs. 20 and 21. Pl. III., Fig. 11.)

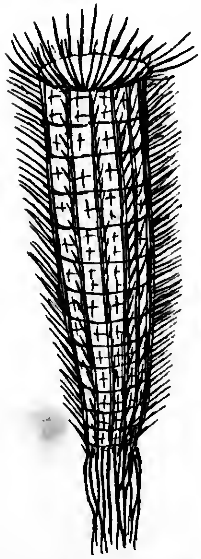


FIG. 20.—*Acanthodictya hispida.* Restored.

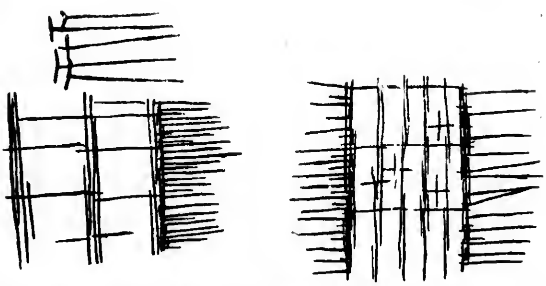


FIG. 21.—*Acanthodictya hispida.*—Portions enlarged × 5, showing framework and cruciform and protective spicules.

The examples of this species were probably nearly cylindrical tubes from 30 to 50 mm. in length, and about 12 mm. in width. The longitudinal fascicles are about 1 mm. apart and the transverse fibres from 1 to 2 mm. distant from each other. The projecting spicular rays of the surfaces are only seen in these compressed sponges at the lateral margins as a sort of fringe. The free rays are somewhat thickly set; they vary from 5 mm. to 3 mm. in length; the longer forms in some instances occur at regular intervals, probably at the angles of the mesh, and between these are the shorter rays. The extremities of many of the larger forms are slightly swollen or club-shaped, but it is uncertain whether this is an original feature or is due to an irregular deposition of the pyrites which has now in all cases replaced the silica.

This species appears as ribband-like bands composed of vertical and parallel bundles of delicate spicules, with slender transverse spicules crossing them at intervals like the rounds of a ladder. It was probably originally cylindrical, but the extremities have not been seen, though fragments nearly three inches in length have been found. One of its most conspicuous characters is the possession of dense fringes of long protective spicules at the sides, and these seem to be based on a cortical structure of crutch-shaped or cruciform spicules, from which the defensive spicules spring. Scattered cruciform spicules of small size appear also in the middle of the bands. The fascicles of longitudinal spicules are sometimes loosely twisted in a spiral manner. Hinde suggests that in some of our sponges this appearance may be caused by the accessory threads, indicated by Schulze as *Comitalia*.[1]

Sponges of the above species are sometimes associated with the larger masses of *Protospongia* in such manner as to suggest a parasitic or commensal relation; but this may be accidental, and may arise from the cortical spicules of *Acanthodictya* becoming entangled with the surface of neighbouring sponges. In one specimen I have the anchoring-rods of *Protospongia tetranema*, with a patch of pyrite inclosing some of the spicules at the top and apparently attached to this, and rising from it a specimen of *Acanthodictya*. This specimen certainly appears to suggest a commensal relation. Another specimen is attached laterally to the side of a fragment of *Protospongia*, and another is very long and much curved.

It is possible that some of the spirally twisted anchoring-rods mentioned below may have belonged to this species, but these have not been seen attached, and there are only faint indications of simple or loosely spiral roots.

The genus, no doubt, approaches to *Cyathophycus*, but is separated by its cylindrical form, the fascicled character of its longitudinal rods, and its cortical spicular arrangements.

[1] Challenger Report, vol. xxi., page 17.

GENUS PALÆOSACCUS *Hinde.*

(London Geological Magazine, February, 1893.)

Cylindrical globular or sac-like sponges, with thin walls of rhombic meshes. The strands of the mesh-work consist of fascicles of slender rods, cruciform, and, perhaps, five-rayed spicules; the interspaces are either open or covered with a thin layer of irregularly disposed rods and cruciform spicules. No anchoring spicules have been found in immediate connection with the sponge, but there are with it on the same surfaces elongated anchoring-spicules with ornamented spiral ridges which may belong to it.[1]

From *Cyathophycus*, Walcott, which appears to be nearest allied, this genus is distinguished by the rhombic character and large size of the mesh-work; the generally similar structure both of the longitudinal and transverse strands of the mesh, and the greater development of rod-like spicules. The same features likewise differentiate it from *Plectoderma*, Hinde, and *Phormosella*, Hinde.

10.—PALÆOSACCUS DAWSONI, Hinde.

(Figs. 22 and 23. Pl. III., Fig. 9, Pl. IV.)

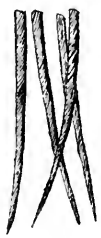


FIG. 22.—Spiral anchoring-rods, distal ends enlarged.

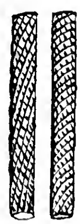


FIG. 23.—Portion of anchoring-rods, enlarged

Sponge of large size, apparently cylindrical in its complete form; the part preserved consists of a flattened portion of the wall-surface more than a foot in diameter; both the upper and the basal portions of the sponge are wanting. The rhombic meshes of the wall vary from 14 to 20 mm. in width, the average width is nearly 17 mm. The strands of the mesh mostly consist of very slender rod-like threads apparently simple, which are loosely arranged, in strands of five or more, generally parallel with each other. At the angles of the mesh there are, very frequently, if not in all cases, stouter cruciform, or perhaps five-rayed

[1] παλαιος, ancient; σακκος, coarse cloth, sack, strainer.

spicules, and slender cruciform spicules are likewise intermingled with the rods in the strands. In the interstices of the mesh-work, and apparently exterior to it, there is, in some portions of the sponge, a thin open layer, composed of slender rods and cruciform and other spicules, overlapping each other without definite arrangement. It is probable that this layer formed the outer surface of the sponge, for the spicules are of the same character as those of the strands of the mesh.

The manner in which the small spicules seem to have drifted to one side, shows that they probably formed the cortical layer covering the whole surface, but became disengaged on decay of the soft parts.

Some uncertainty arises respecting the anchoring appendages of the sponge, since the basal portion is wanting, and no anchoring-spicules are found in immediate contact with the specimen, but on the surface of the same rock-beds in which it occurs there are many peculiarly ornamented spiral rods which may belong to this species. They appear as if they consisted of several very minute filaments spirally twisted together, like the strands of a rope. Each filament has a row of projecting tubercles, which in the rod are definitely arranged in quincunx, so that the general ornamentation is very striking. At the distal end the rods are slightly curved, and the raised lines are more straight, and assume more the aspect of distinct fibres. As with the other spicules, these anchoring-rods are now of pyrites.

Later observations tend to connect these anchoring-rods almost certainly with the present species. The rods are found almost exclusively on the same surfaces with this sponge. They do not appear to belong to any other form in these beds. Fragments of the base of the sponge show that the strands of the framework have there an imperfect spiral arrangement, though slender, and if several of them coalesced at the base they would assume the form of the spiral rods.

So far as can be at present determined this sponge appears to have consisted simply of a delicate thin sack or cylinder of spicular strands forming a rhombic mesh, with a thin outer spicular layer. There is no evidence that the sack inclosed an inner spicular tissue, and probably this thin wall represents its entire skeleton. A similar condition seems to have been present in *Protospongia*, *Cyathyphycus*, and probably also in *Dictyospongia* and the genera allied to it, but in none of these do we find the structure on such a large scale as in the present form.

Suborder MONACTINELLIDA, or of doubtful affinity.

GENUS LASIOTHRIX, Hinde.[1]

Sponges small, depressed oval in outline, the outer surface covered by a layer of longitudinally arranged, apparently simple, acerate spicules; beneath this is another layer of spicules disposed transversely. From the base of the sponge several simple elongated spicules extend.

The peculiar arrangement of the surface spicules in this form indicates a probably new genus, but in its present condition one cannot tell with certainty whether it is monactinellid or hexactinellid. The outer surface seems to have been invested with a sheathing of regularly arranged acerate spicules, and beneath these other spicules, disposed transversely, can be distinguished, but whether these are really acerate or modified hexactinellid spicules there is no decisive evidence to show. In one or two instances the spicules appear to be cruciform, and the presence of the long, simple anchoring-spicules extending from the base of the sponge, precisely as in normal hexactinellids, is a further point in favour of its belonging to this division.

11.—LASIOTHRIX CURVICOSTATA, *Hinde.*

(Fig. 24.)

The type form is transversely oval, 8 mm. in height by 12 mm. in width, the anchoring-spicules can be traced to a length of 15 mm. from the body. The summit is rounded. There are some nodular elevations of pyrites in the body portion, but it is doubtful whether they represent

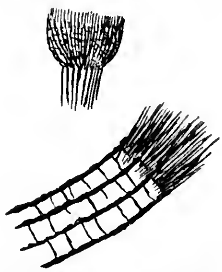


FIG. 24.—*Lasiothrix curvicostata.* Natural size and portion enlarged.

aggregations of spicules or are merely due to the chemical deposition of the mineral, in connection with the presence of organic matter.

This curious little sponge, of which few specimens were found, is remarkable for the strong curved spicules which support its sides, giving

[1] British Fossil Sponges, Pal. Soc., 1888, Pl. i., fig. 3.

the appearance of a rounded basket with strong vertical ribs and very slender horizontal bars, within which and at top were quantities of slender straight spicules.

12.—Lasiothrix flabellata, s. n.

(Fig. 25.)

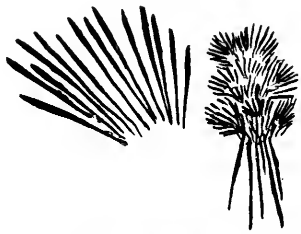


Fig. 25.—*Lasiothrix flabellata.* Restored, and spicules × 5.

I have some doubt as to the right of this species to be placed in Dr. Hinde's new genus; but the specimens much resemble the former species, and may accompany it provisionally. The surface appears to be covered with small ovoid bundles of stout biacerate spicules, diverging from the centre and sometimes in fan-shaped tufts. The specimens show indications of an external membrane, and they had somewhat strong root spicules, much larger than those of the body. It seems uncertain whether the fan-shaped bundles are really such or flattened groups of radiating spicules surrounding small oscula. In some specimens the spicules are confusedly scattered in films of pyritous matter with little indication of radiating arrangement. Dr. Hinde remarks as to this form that "the spicules do not stand out definitely, as in the case of the hexactinellid sponge spicules, but appear to be imbedded in some membrane. In two instances, anchoring-spicules, like those of Protospongia, project from the base of the mass. I do not know of any monactinellid sponge furnished, as these appear to have been, with long anchoring-spicules."

The sponges of this genus are very rare in the Metis collections, and are obscure and difficult to make out as to their details.

GENUS HALICHONDRITES, Dn.

13.—HALICHONDRITES CONFUSUS, Dawson.

(Fig. 26.)

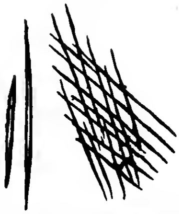


FIG. 26.—*Halichondrites confusus.*
Spicules enlarged.

Oval or irregular masses of small simple spicules, imbedded in patches of pyrite, and without any definite arrangement of root spicules, may indicate the presence of a halichondroid sponge. In the best preserved specimens the spicules appear to be biacerate and more slender and pointed than in the last, and they seem to be in two series, inclined at a very oblique angle to each other. In some specimens elongated spaces, with well-defined margins, are covered with thin films of pyrites, which may have resulted from the replacement or incrustation of a mass of minute spicules, of which traces remain in some places.

It is to be observed in this connection that sponges having originally much keratose or other dense animal matter would naturally aggregate in and around themselves a greater quantity of pyrite than those of a more purely siliceous character.

GENUS STEPHANELLA, Hinde.

Established by Dr. Hinde, London Geological Magazine, 1891, p. 22, to contain some sponge remains discovered by Dr. Ami in the Utica shale at Ottawa, and consisting apparently of groups of very fine radiating spicules. *S. sancta*, Hinde, is the type species. Dr. Hinde regards them as basal spicules of a sponge to which other outer structures which have perished may have been attached.

14.—STEPHANELLA HINDII, s. n.

(Figs. 27, 28 and 29.)

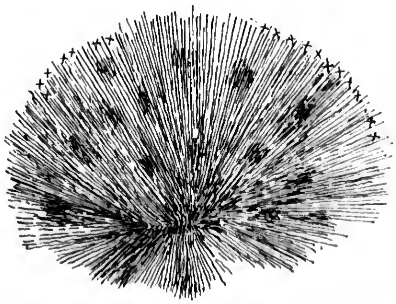


FIG. 27.—*Stephanella Hindii.* Slightly enlarged.

Many fragments of this species have been found from time to time, showing long stout tapering anchoring-rods with masses of long slender simple spicules near them ; but in 1895 for the first time nearly perfect specimens were observed. They consist of discs somewhat larger than those of *S. sancta*, made up of fine straight spicules radiating from a point near one side and rather coarser than those of *S. sancta*, and showing here and there a tendency to be aggregated more densely as if in bundles, but this is not very marked. At and toward the circumference there are occasionally a few very small cruciform spicules which, as they are not confined to one specimen, I regard as probably the remains of an outer or cortical layer. If they are accidental they must be the smaller spicules of disintegrated Protospongiæ entangled in the spicular surface of Stephanella. It seems more likely, however, that they are a part of its structure, in which case it furnishes an example of a sponge with a dense internal skeleton of radiating spicules. Fig. 27 represents a nearly

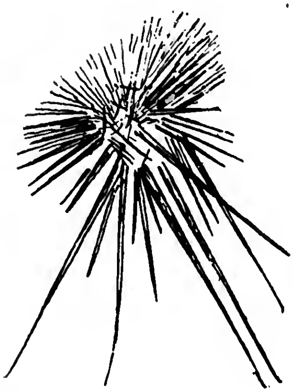


FIG. 28.—*Stephanella Hindii.* **Fragment with anchoring-rods.**

FIG. 29.—*Stephanella ?* **Anchoring-rods and part of the spicules, enlarged.**

complete specimen, and Figs. 28 and 29 disintegrated fragments with the anchoring-roots, which in some specimens are longer and more tapering than in others, though always very stout at the base.

In Dr. Ami's specimens from Ottawa, a few stout anchoring-rods and cruciform spicules are found in the same slabs with Stephanella, but none of them are seen to be attached. I think it not improbable, however, that the former, at least, belong to Stephanella.

INCERTÆ SEDIS.

15. NON-SPICULATE SPONGES.—Pyritous spots of indeterminate form, and showing under the lens only an obscure granular and flocculent appearance are not infrequent on the surfaces of the Metis shales. In addition to these, however, there are two types of these objects of more definite shape, either triangular with a dark space in the centre or oval. The former seem to be flattened hollow cones, the latter possibly flattened sacs. Some of the former show sufficient traces of spicules to connect them with *Protospongia cyathiformis*, while others may be entirely pyritized individuals of *P. delicatula*. In addition to these, however, there are others which, under the lens and when moistened, show indications of simple linear spicules, and more numerous examples which seem to be composed of indeterminate and interlaced fibres reminding one of the tissue of a corneous sponge. None of them have any indications of anchoring-rods. For the present I merely mention them as possibly indicating types of sponges distinct from any of those above described.

16. SPICULATE SACS.—Imbedded in the debris of the larger specimens of Hyalostelia, there are oval flattened patches made up of a dense mass of very small and apparently simple spicules, but presenting no aperture or anchoring-rods. Having found them only in connection with Hyalostelia, I at first imagined they might be some form of ovarian body; but Dr. Hinde doubts this, and is inclined to regard them as distinct organism. One of them is represented in Fig. 30 of about the natural

FIG. 30.—*Spiculate sac*, found with Hyalostelia.

size. If distinct sponges, there may have been some commensal relation between them and Hyalostelia. They are quite distinct from the little masses of broken spicules referred to above in Section IV.

17. MINUTE GLOBULAR OR CIRCULAR BODIES.

Surfaces of an inch or more in diameter are occasionally stippled with minute pyritous spots; when magnified these appear perfectly round and of approximately uniform dimensions. They may either be inorganic discs of pyrite, or may represent flattened organic bodies. In the latter case, they may be germs or ova, or spores, or portions of some complex vegetable or animal organism They recall the little spherules described by Matthew as occurring in the Cambrian of New Brunswick, and named by him *Monadites globularis.* I have not been able, however, to detect any indications of connecting rods or stalks like those figured by Matthew.[1]

VI. OTHER ANIMAL REMAINS.

The most important of these are the little brachiopods referred to above :

OBOLELLA (LINNARSSONIA) PRETIOSA, Billings.

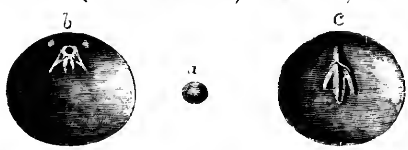


FIG. 31.—*Linnarssonia pretiosa*, Billings. *a*, natural size of medium specimens, *b*, ventral, *c*, dorsal valve.

These are very abundant on the same surfaces which hold the sponges. and are usually replaced by pyrite, though sometimes appearing as mere casts. They often show their interior structures as represented in Fig. 31. They afford for the present the best evidence in relation to the geological age of the deposit, since the species is characteristic of the Sillery, and the genus is a Cambrian rather than Ordovician one in Europe. For this reason I quote here Dr. Hall's description, based on Metis specimens submitted to him some years ago. I may add that Mr. Whiteaves, our best Canadian authority, concurs in referring these shells to Billings's species *O. pretiosa* :

"Shell small, subcircular or elongate transversely. Valves subequally convex, the ventral beak erect, slightly projecting and perforated at its apex. External surface covered with fine concentric lines, faint radiating striæ being visible on the interstitial lamellæ. The interior of the ventral valve bears a subtriangular or U-shaped ridge, the branches of which diverge anteriorly. The thickest portion of this ridge at the union of the branches is penetrated by the foraminal tube. In front of the foramen, and just within the cardinal line, on either side the axis of the shell is a conspicuous tubercle or boss. In the dorsal valve is a median ridge, extending half the length of the valve, and from this two short lateral ridges diverge, taking their origin at one-third the length of the median ridge from the posterior margin."

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[1] Transactions Royal Society, 1889.

ANNELIDS.

Trails and castings of worms are not infrequent in the shales holding the sponges. Some surfaces are covered with what seem to be very minute cylindrical smooth trails of worms, and larger worm-like bodies in pyrite seem to represent casts of burrows or of the bodies of worms. Some of these are a quarter of an inch in diameter and rudely annulated in an irregular manner. There are also a few casts in pyrite of spiral forms like the *Arenicolites spiralis* already mentioned. These burrows and trails are similar to those found in various places at and near Little Metis in the beds of the Quebec Group.

MISCELLANEOUS FRAGMENTS.

Minute fragments, possibly referable to Trilobites, Cystideans and Graptolites, are occasionally seen, though very rarely, and are quite indeterminable.

ALGÆ.

BUTHOTREPHIS PERGRACILIS, Dawson.

(Fig. 32.)

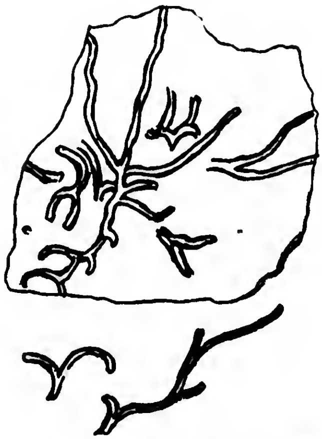

FIG. 32.—*Buthotrephis pergracilis.*

I have nothing to add to the description of this species in the paper of 1889, except that some of the specimens appear to be connected below with a network of slender filaments spread out on the shale, that some of the specimens show indications of a structure of elongated cells or fibres, and that at the extremities of some of the branches there are tufts of rounded masses of granular pyritous matter; but whether these are remains of organs of fructification or attached animal structures, or merely inorganic aggregations, I have not been able to determine.

CHONDORITES METISSICUS, s. n.

Flattened fronds, two to four millimetres broad and the largest eight to ten centimetres long. They are riband-like and smooth, with even edges and fork dichotomously at angles of 40° or more. They show traces of carbonaceous matter but no structure.

In concluding this paper I think it proper to remark on the exuberance of sponge life, both in abundance of individuals and of generic and specific forms on a limited area of muddy sea-bottom of the lower Ordovician or later Cambrian age, evidenced by the collections made at Little Metis, the account of which in this paper is presented as merely the result of recreative excursions in the summer vacation, in a field different from that in which the author is usually engaged.

In a formation usually little productive of fossils, and in muddy deposits, which must have been laid down in water at a low temperature and in the intervals of conditions producing beds of a coarse mechanical character, this abundance of delicate organisms is very unexpected and surprising. We have to observe also that if the sponges in question were, like their modern allies, inhabitants of deep water, there must have been considerable oscillations of level at the time when they lived, as well as much deposition of earthy matters in circumstances unfavorable to marine life, as evidenced in the great thicknesses of barren material intervening between the sponge-bearing layers.

Dr. Hinde has already mentioned the close alliance of many of these Palæozoic sponges with their successors in later formations and in the modern seas, evidencing the great permanence of the siliceous sponges throughout geological time, and the fixation of the mechanical and vital laws of their structure and growth at a very remote period. More especially is this remarkable if we include with them the spicular forms which have been recognized in the Laurentian, Huronian and Early Cambrian rocks. The graptolites belonging to the oceanic waters of the Cambrian and Ordovician have already indicated the paramount importance of giving attention to the general oceanic fauna of these periods, as well as to that of the continental plateaus, and it is possible that in future the sponges may also prove of more value than heretofore in regard to questions of relative geological age.

The results of these observations at Little Metis, in connection with the obscure and unobtrusive character of the fossils, also show how much is in the power of local collectors, having time and opportunity to follow up any discovery by excavation and continued collection. In this way beds for the most part unfossiliferous and presenting few attractions to a passing collector, may be made to yield unexpected scientific treasures.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

Fig. 1.—*Protospongia tetranema.*
Fig. 2.—*P. mononema.*
Fig. 3.— Do Showing *osculum*, partly broken away.
Fig. 4.—*P. tetranema.* Seen in section with root. (All natural size.)

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

Fig. 5.—Crushed specimen of *Protospongia coronata*, encrusted with pyrite. (Natural size.)

Fig. 6.—Smaller perfect specimen of the same. (Natural size.)

Fig. 7.—*P. cyathiformis.* (Natural size.)

Fig. 8.—The same. Young specimen enlarged.

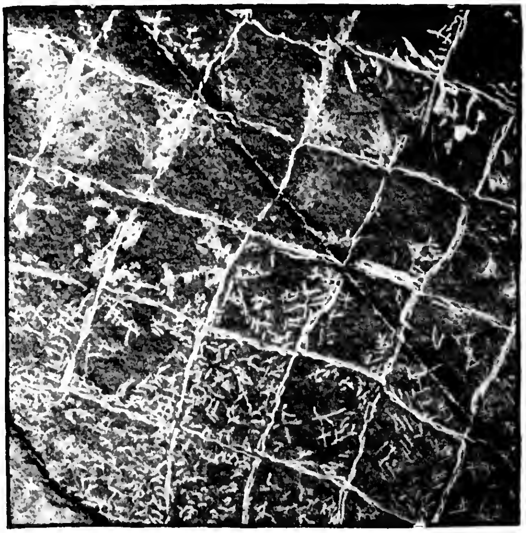

FIG. 9.

FIG. 11.

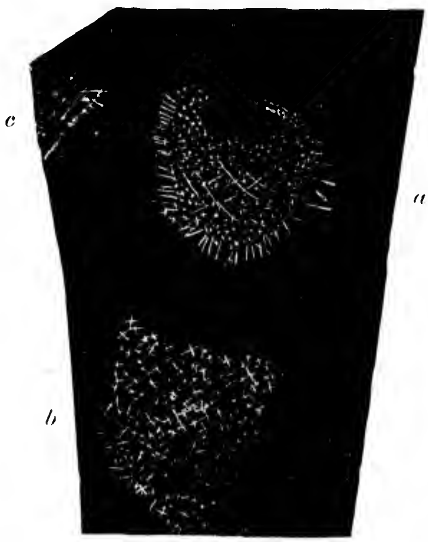

FIG. 10.

FIG. 12.

Fig. 9.—Portion of *Palæosaccus Dawsoni*.

Fig. 10.—Slab with small specimen of *Hyalostelia Melissica* at (a). *Protospongia cyathiformis* at (b) and fragment of *Cyathophycus* at (c).

Fig. 11.—*Acanthodictya hispida*. Fragment of small specimen, partly encrusted with pyrite.

Fig. 12.—Debris of *Protospongia*. (All natural size.)

FIG. 13.

Fig. 13.—Spiral anchoring-rods of *Palæosaccus*, enlarged.