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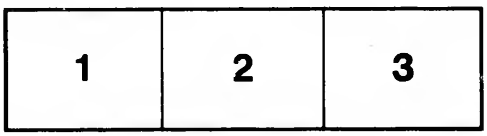

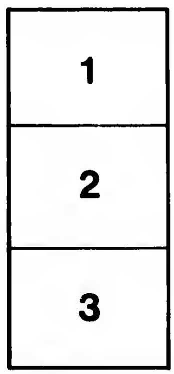

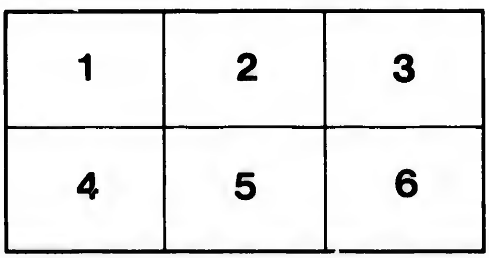

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ON

[*From the* Quarterly Journal *of the* Geological Society *for February* 1879.]

ON THE MICROSCOPIC STRUCTURE OF STROMATOPORIDÆ, etc.

On the Microscopic Structure *of* Stromatoporidæ, *and on* Palæozoic Fossils *mineralized with* Silicates, *in illustration of* Eozoon.

By J. W. Dawson, LL.D., F.R.S., F.G.S., &c.

[Plates III.–V.]

Among the collateral subjects which have arisen in the discussions with respect to *Eozoon canadense,* two of the most important are:—1st, the question of its structural relations with the Palæozoic fossils of the genus *Stromatopora* and allied genera; 2nd, the occurrence in Palæozoic rocks of fossils mineralized with hydrous silicates akin to the serpentine and loganite found in some of the best-preserved specimens of the Laurentian fossil. For several years I have taken advantage of every opportunity to make collections illustrative of these questions, and to subject the specimens obtained to microscopic examination. In this I have been greatly aided by friends who will be mentioned in the sequel, and by the large number of excellent sections prepared by Mr. Weston, of the Geological Survey of Canada, for the late Sir W. E. Logan and for myself. In the following paper I purpose to state the conclusions arrived at as the result of these observations, with such portions as may be necessary of the large accumulations of facts on which they are based.

I. Stromatoporidæ.

1st. *Microscopic Structure.*—The Stromatoporidæ have long been a zoological stumbling-block, and have been referred to Corals, Sponges, Foraminifera, and even to Hydractiniæ. I do not purpose to review these diverse opinions, most of which are undoubtedly based on imperfect acquaintance with the microscopic structure of these curious fossils, but to give an intelligible account of the structure of some typical species, preparatory to the consideration of their relation with *Eozoon.*

The genus *Stromatopora*, properly so called, is founded on the species *Stromatopora concentrica*, Goldfuss, and its allies, which range from the Upper Cambrian to the Devonian inclusive. Avoiding, for the present, complexities arising from the various states of preservation and of weathering, I may refer in the first instance to remarkably well-preserved specimens from the Corniferous Limestone of Ohio, and from the island of Marblehead in its vicinity, which have been placed in my hands by Mr. A. E. Walker of Hamilton, and Dr. Newberry of New York. In these the concentric laminæ and pillars of the fossil are in the condition of opaque calcite, apparently retaining its minute structure and not affected by crystallization; and the interspaces or chambers are occupied by transparent calcite, permitting all the structures to be very well seen, either on polished surfaces or in transparent slices *.

In these specimens about three interspaces and two laminæ occur in the space of a millimetre; and though neither the laminæ nor the interspaces are uniform in thickness, the latter are about twice the width of the former. In some places the laminæ rise into conical or rounded eminences with corresponding depressions; in others they are nearly flat and concentric, this difference being apparently accidental. The laminæ are connected with each other by pillars, which are either round or somewhat flattened (Pl. III. fig. 1). The texture of the laminæ is not spicular, but perfectly continuous and finely granular, as if made up of minute fragments of calcite. When the mass is broken parallel to the laminæ, the pillars appear as minute tubercles (Pl. IV. fig. 5), *but a true exterior surface is smooth.* The laminæ are pierced with numerous round pores about one tenth of a millimetre in diameter. Some of these pass through hollow pillars across one interspace into another; but the greater part pass through the laminæ from one interspace into the next. The laminæ themselves are here and there pierced with horizontal tubes which thicken the laminæ where they pass (Pl. III. fig. 3, *b*); they appear to traverse the laminæ obliquely from one space into another, or from the hollow pillars laterally. They may be called canals. In addition to the ordinary laminæ, some of the chambers or interspaces are subdivided by very thin secondary laminæ. In a few cases these are attached to ordinary laminæ as a sort of inner wall. The ordinary laminæ in the more regular specimens are often of great continuity, extending without interruptions for several square inches.

In some specimens there are a few rounded perforations, less than a millimetre in diameter, which extend vertically through several interspaces. Their walls are densely calcareous. They are often covered up with the growth of the laminæ, and seem to have no connexion with the other parts of the structure. I do not regard them as oscula, but as perforations of some parasitic animal; and I attribute to the same origin certain rounded cavities, similarly walled, in other parts of the mass.

The above is an accurate description of the most common type of *Stromatopora* when, as nearly as possible, in its natural condition. Other species of the genus, as now usually limited, differ principally in the thicknesses and distances of the laminæ, in the number and size of their perforations, and in their more or less tuberculated surfaces. In some species the pores are so numerous that the laminæ appear reticulated; in others the laminæ are so much thickened that the pores appear as tubuli. The pillars also differ somewhat in size and form. In the very numerous specimens which I have examined, I have convinced myself that while the laminæ are always porous they are never spicular, and that the so-called oscula are accidental. They are due either to the causes above referred to or to

* These specimens are associated with a beautiful *Saccammina*, having a calcareous test, which I have described as *Saccammina eriana*.

branches of *Syringopora* and similar corals included in the mass of *Stromatopora*.

It is evident from the above description that the animal matter of *Stromatopora* must have occupied the chambers or interspaces, and must have extended from chamber to chamber through the pores and hollow pillars. Such a structure is obviously that of a rhizopod rather than of a sponge. Further, the arrangement of the laminæ and pillars is very nearly allied to that of *Parkeria* and *Loftusia* as described by Carpenter and Brady, which I have myself studied in specimens kindly given to me by Professor T. R. Jones *. In so far as the hollow pillars and perforated plates are concerned, it has some points of correspondence, though more remote, with *Receptaculites*. The supposed oscula on which has been based a reference of these forms to sponges are certainly not constant. I have seen large masses of the form above described, presenting more than 30 square inches of surface, without a trace of an osculum; and in those specimens where tubular orifices appeared, I have found that they cut like perforations made by a boring instrument through the mass, irrespective of its structure, and that they were lined with continuous calcareous walls different from the laminæ of the fossil. It is scarcely necessary to say, after the above descriptions, that I attach no scientific value to the ingenious and elaborate attempt of Mr. H. J. Carter ('Annals and Magazine of Natural History,' ser. 4, vol. xix. p. 44) to prove that *Stromatoporæ* are skeletons of hydroids allied to *Hydractinia*. The resemblances of *Stromatoporæ* to these hydroids are altogether superficial, and depend on both having a parasitic and concentric habit of growth. In every essential character they differ entirely, and can have no close zoological affinity. In comparison with *Eozoon*, the general appearance and habit of growth are so similar that specimens cannot easily be distinguished by the naked eye, or where the minute structures are not preserved. In microscopic structure the thin laminæ of *Stromatoporæ* correspond to the proper wall of *Eozoon*. The thickening of the walls corresponds to the supplemental skeleton, and the horizontal tubes to the canals, while the interspaces and the pillars correspond to the chambers and connecting walls of the older fossil. The main structural difference is, that while *Eozoon* has a delicately tubulated proper wall of Nummuline type, that of *Stromatopora* has coarser perforations and pores. *Stromatopora* and *Eozoon* may both be regarded as large sessile laminated calcareous Rhizopods; but the former presents a less generalized type than the latter, which combines structures that were usually separated even in the Palæozoic period.

Stromatoporæ of the type above described are abundant in the Corniferous Limestone. They occur throughout the Upper Silurian and are especially abundant and of large size in the Niagara Limestone, where they abound even in those Dolomitic beds that contain

* More recently I have also studied the remarkably beautiful species of *Loftusia* from British Columbia described by Mr. G. M. Dawson, which confirm the resemblance of these specimens to *Stromatoporæ* (see his paper read before this Society, *infrà*, p. 69).

few other fossils. They are also abundant in the Dolomite of the Guelph Limestone; and it is perhaps not accidental that both here and in the Laurentian, fossils of this structure are associated with magnesian rocks. They occur also in the Lower Silurian, though less abundantly; and the oldest specimen I have seen is in the Potsdam Sandstone; and this, its structure not being preserved, may have belonged to *Eozoon* rather than to *Stromatopora*. The Lower Silurian species have usually very thin and continuous walls. In the great Niagara Limestone, as seen at Niagara Falls, the masses of *Stromatopora* occur precisely as *Eozoon* occurs in the Laurentian limestones, and are mineralized with quartz and dolomite, and often almost entirely converted into crystalline masses, though occasionally showing their structure in great perfection.

Certain beds of the Niagara formation, near Hamilton, contain not only *Stromatoporæ*, but multitudes of sponges; and through the kindness of Lieutenant-Colonel Grant, of that place, I have been enabled to examine a number of specimens of these, and to compare them with *Stromatoporæ*. These sponges are all siliceous and spiculate, and belong chiefly to two or three species of *Astylospongia* of Römer, and to *Aulocopina* of Billings, of which his *A. Grantii* is the type. The species of *Astylospongia* present a most regular and beautiful hexactinellid structure, as perfect as that in the sponges of the Cretaceous, showing even the hollow nodes, which have been supposed to be absent in the Palæozoic Hexactinellidæ. *Aulocopina* has a different structure, presenting series of hexagonal tubes built up with interlaced spicules, and giving off bundles of spicules in a radiating manner. These sponges are thus entirely distinct, both in material and structure, from the contemporary *Stromatoporæ*, and there is no link of connexion whatever.

The species included in the genera *Caunopora* of Phillips and *Cœnostroma* of Winchell, and in part in *Syringostroma* of Nicholson, and which may be represented by the *Stromatopora polymorpha* of Goldfuss, have the horizontal canals largely developed in laminæ thickened by supplemental deposit, and traversed by an infinity of minute canaliculi or ramifications of the canals opening at their surfaces. The horizontal canals radiate from central points where they are connected with vertical tubes or groups of tubes penetrating the whole thickness of the mass (Pl. IV. fig. 9, and Pl. V. fig. 10). The whole organism thus becomes divided into a series of vertical systems, which often very much obscure the concentric lamination, and in different states of preservation give very perplexing appearances. They may all be explained by bearing in mind that the horizontal canals, like those of *Stromatopora* proper, pass in the substance of the laminæ, now much thickened, and that at the centres of the systems they descend through the chambers by vertical tubes or groups of tubes which correspond to the hollow pillars of *Stromatopora*.

A great number of specimens of *Caunopora*, *Cœnostroma*, and allied forms, both European and American, have passed through my hands; but I was unable to decide, except inferentially, as to their minute structure, till I was so fortunate as to obtain, through the kindness of Mr. Selwyn, Director of the Geological Survey of Canada, a specimen collected by Professor R. Bell on the Albany River, Hudson's Bay, in rocks of Upper Silurian age. In this specimen the skeleton remains as carbonate of lime, while the canals and tubes are in great part empty, so that their minute ramifications are in the condition of a recent specimen, and can be injected with colouring-matter. The actual structures thus presented are as follows :—

Laminæ thin and obscure. Chambers almost entirely filled with supplemental deposit, traversed by innumerable microscopic horizontal canaliculi, which are tortuous and anastomose frequently. They are connected with systems of radiating canals which terminate centrally in vertical tubes traversing the whole thickness of the specimen, and opening at the surface in round pores visible to the naked eye and placed on the summits of slight eminences. The pores are about 4 millimetres apart horizontally. The upper surface is smooth and does not show the radiating canals, but these are disclosed by erosion or by horizontal fracture. This species closely resembles Hall's *Caunopora incrustans*, from the Devonian of New York; but the pores are more regular and less than half as far apart, and the radiating tubes are more numerous. For the above species I have proposed the name *Caunopora hudsonica* (Pl. IV. fig. 9 and Pl. V. fig. 10).

I have described in a former publication* a fossil preserved in a similar way, but less perfectly, and which has vertical tubes in groups instead of singly; it is from the Galt Limestone of Ontario, and belongs to the genus *Cœnostroma*, as limited in the sequel. I would propose for it the name *C. galtense*.

The structures in *Caunopora* and *Cœnostroma* are unquestionably, at first view, more akin to those of sponges than are those of the typical *Stromatoporæ*, as the vertical tubes may be taken for oscula, and the extremities of the fine tubes for the incurrent pores. On the other hand, the solidity of the calcareous walls and supplemental thickenings is at variance with such a view; and in many respects they more nearly resemble *Eozoon* than any of the Palæozoic fossils with which I am acquainted. The canal-system in both is, indeed, so much alike that it would not be easy to distinguish it, except that *Eozoon* wants the continuous vertical tubes and possesses a true nummuline wall.

The minute structures of such species as the *Stromatopora nodulata* of Nicholson (*S. sanduskyana* of Röminger, Pl. V. fig. 11), connect the true *Stromatoporæ* with the species of the genus *Cœnostroma*; and these, by confluence of the separate tubes, pass into those of the genus *Caunopora*.

Of the species separated by Nicholson in the genus *Syringostroma*, that which he has named *S. columnaris* is a very peculiar type. It is penetrated vertically by what seem to be solid columns, and which, on microscopical examination, prove to result from upward bending and fusion of the laminæ along certain vertical lines. The effect is obviously to give much additional strength to the skeleton. Between

* 'Life's Dawn on the Earth,' p. 160.

the columns the laminæ are supported by pillars as in *Stromatopora*. They are also penetrated by horizontal canals which ramify radially, and are connected with vertical tubes as in *Cœnostroma*, to which this form is very closely allied; I have seen only one species from the Corniferous Limestone, specimens of which have been kindly given to me by Dr. Newberry and Mr. Hinde of Toronto.

Dictyostroma of Nicholson includes species in which the connecting pillars are formed by upward bending of the laminæ themselves in conical points. The only species described by Nicholson (*D. undulatum*) is from the Niagara formation of Louisville, Kentucky. I have, however, seen an imperfectly preserved specimen with this structure from the Black-River Limestone of Port Claire. Mr. Hinde has sent me another from the Corniferous of Port Colborne. These seem to be different from Professor Nicholson's species in the distance between the laminæ, which is much less than in the coarsely constructed species which he has described. The laminæ are porous in these specimens; but I have seen no vertical tubes or oscula.

The species *Stromatopora compacta*, from the Trenton Limestone, described by Billings, and which is not uncommon, does not appear to belong to this group of organisms. It consists of very minute hexagonal tubes with extremely thin walls and well-developed tabulæ, which, from their strong development and continuity, give in some specimens an appearance of concentric lamination. The species seems to belong to the genus *Stenopora*, but its cells are excessively minute. Corals of the genus *Fistulipora*, with small tubes imbedded in a cellular cœnenchyma, may readily, in certain states of preservation, be mistaken for *Stromatopora*.

Stromatoporæ seem not unfrequently to have overgrown corals of different species; and, in the case of *Syringopora*, the tubes of these projecting through the mass often simulate oscula. Mr. Hinde informs me that, in the case of one species, this association is so common that it suggests the idea of a case of "commensalism."

As connected with *Stromatopora*, it may be well to remark that some misapprehension still appears to exist respecting *Archæocyathus*, a fossil of the Cambrian rocks of Mingan, Labrador, and of which several species have been described by Billings. Of these the only one I have studied is *A. profundus*. This is certainly a calcareous, chambered organism, with pores connecting the chambers, and must have been the skeleton of a Rhizopod. The other species have similar structures. It is true, however, that on treating them with acids, Billings obtained siliceous spicules in the matrix, which I have myself examined. I regard them as having belonged to lithistid sponges of the genus *Trichospongia* of Billings, accidentally associated with the *Archæocyathus*.

Some specimens of *Stromatopora* present remarkable lines of growth, caused by the appearance of two or three layers of smaller cells at intervals of seven or eight interspaces (Pl. IV. fig. 4). The preservation of these without the intervening portions may, in some cases, account for the abnormally wide interspaces sometimes seen in imperfectly preserved specimens. I have not been able to satisfy myself whether these lines of growth are of specific value. In one specimen from the Devonian of Iowa, a *Stromatopora* of this type presents large vertical tubes which extend from one growth-line to the next, but are sparsely distributed through the mass, and not connected with radiating tubes as in *Caunopora.*

Another interesting structure, seen in a species from the Corniferous Limestone, usually, though perhaps incorrectly, identified with *S. concentrica*, is the division of the pillars at their summits into branches (Pl. III. fig. 2), so as to support at many points the layer above, which in this case is thin and not much strengthened with supplemental deposit.

2nd. *State of Preservation.*—*Stromatoporæ* have apparently always been calcareous when recent. They are sometimes preserved in the state of calcite with the chambers either filled with the same material or with silica. Sometimes they are entirely silicified, or the laminæ and pillars are silicified and the chambers filled with calcite. Occasionally the chambers are filled with dolomite or the whole structure is dolomitized.

A specimen of the type of *S. concentrica* from the Devonian or Upper Silurian of James's Bay is now before me, and affords a good illustration of modes of preservation in silica. In some places the laminæ and pillars have been silicified, while the chambers are filled with limestone. When weathered or treated with acid, those portions show the whole structure very clearly, including the perforations of the laminæ and the hollow pillars (Pl. IV. fig. 7). Other portions have the chambers also filled with silica, the laminæ being distinguishable by their less transparent and porous character. In these portions the laminæ and pillars have usually been first coated over with minute crystals of quartz. A layer has then been deposited of chalcedony with botryoidal surfaces, and finally the remaining cavities have been filled with crystalline vitreous quartz. In the greater part of the specimen, however, the chambers have been filled with silica, while the laminæ have remained as calcite, and those portions, when weathered, present the appearance of thick structureless laminæ separated by thin spaces and penetrated by numerous round holes representing the pillars. Portions in this state might be mistaken for a coral of the type of *Fistulipora*, but in certain aspects they present that lobated amœboid form which is so characteristic of similarly preserved specimens of *Eozoon.*

In specimens of *Stromatopora* from the Niagara Limestone, it not unfrequently happens that certain layers or groups of layers are silicified, while others alternating with them remain as calcite. In this case, when the specimens are weathered, they present distant concentric layers very different in appearance from the actual structure.

As with other fossils, crystallization plays strange freaks with *Stromatoporæ*, reducing them to such a condition that, but for the partial preservation of portions here and there, they might be mistaken for inorganic bodies. This is well seen in the abundant *Stro-*

matoporæ of the great dolomite-beds of the Niagara Limestone. Of these many are entirely reduced to crystalline masses of quartz or dolomite, except small portions at the surface, while others have become hollow and resemble cavities lined or filled with crystals. In the Upper Silurian dolomite of Guelph, in like manner, there are specimens which have been converted into a granular dolomite, in which, however, the laminæ and, in some cases, the canals are more or less apparent.

The study of *Stomatoporæ* in these different conditions throws great light on the appearances presented by *Eozoon* in various states of preservation, and forms a guide to the interpretation of these, which should be before the mind of every one who desires to form correct opinions on the subject.

Since writing the above, I have seen the remarks of Dr. Nicholson on the calcareous nature of *Stromatopora*, and Zittel's observation of the occasional calcification of the spicules of siliceous sponges, as reported in the 'Geological Magazine' for January 1878. It had not occurred to me that any one acquainted with *Stromatoporæ* would doubt their calcareous nature; but Nicholson has sufficiently disposed of such doubts by the consideration that the *Stromatoporæ* are found silicified only in beds in which corals and shells have suffered the same change. Nor had it seemed necessary to refer in this connexion to the replacement of siliceous spicules with calcite. It is, or should be, well known from the behaviour of siliceous spicules with alkalies, and when heated, that many of them are not purely siliceous, but contain animal matter. This, with the more soluble character of their silica, enables them to be changed or removed without affecting the siliceous matrix. Hence in the siliceous sponges from the Niagara Limestone the spicules are sometimes opaque and granular in appearance, or have disappeared altogether, or have been replaced with calcite or with iron pyrite. These changes are, however, rare, and have no bearing on the calcareous nature of *Stromatopora*.

3rd. *Classification of Stromatoporidæ.*—It is not my purpose to enter into any revision of the numerous species of this family, or to attempt to summarize the work which has been done with reference to the American species by Hall, Winchell, Nicholson, Billings, Röminger, and others. It may, however, be useful to state the results at which I have arrived with reference to the leading generic forms.

1. *Stromatopora* (Goldfuss, 1827).—In the original definition by Goldfuss the genus is characterized as exhibiting "alternating strata of a solid and porous character." The porous strata in this definition are the real laminæ, the solid strata are the filled-up chambers; and according as one or the other is preserved, we have in this type thin laminæ connected by pillars, or thick laminæ perforated with round holes and separated by vacant spaces. The typical species is *S. concentrica* of Goldfuss, and the genus may be held to include all the species with thin or moderately thick laminæ connected with solid and hollow pillars and perforated with minute pores, or having

a reticulated texture. *Stromatocerium* of Hall is a synonym. The genus ranges from the Upper Cambrian to the Devonian inclusive, and it is not easy to separate the species which have been described.

2. *Caunopora* (Phillips, 1841).—The typical species, *C. placenta*, is defined by Phillips as "amorphous," composed of concentric or nearly plane masses perforated by flexuous or vermiform small tubuli and by larger straight subparallel or radiating open tubes, persistent through the mass. This definition includes those species with simple tubes giving origin to radiating tubuli passing through the thickened laminæ. *Cœnostroma* (*Caunopora*) *incrustans* of Hall is a typical American species, as is also *Caunopora hudsonica* above referred to.

3. *Cœnostroma* (Winchell, 1867).—This genus, as defined by its author, includes those species in which the radiating tubes diverge from the surfaces of little eminences raised in the concentric lamellæ; but, as Hall has well remarked, the presence or absence of eminences is a trivial character. The real distinction should be based upon the absence of the central simple radiating tubes, which in these species are represented by a group of more or less divergent ascending tubuli, so that the surface of the last layer presents eminences not with a single large pore at the summit, but with several small pores diverging from their sides. My *Cœnostroma galtense* above referred to and Hall's *Caunopora* (*Cœnostroma*) *planulata* are typical forms. I have been obliged to reverse the generic names as used by Hall, in the twenty-third Report of the Regents of New York, in the manner above stated, as Phillips's name certainly applies to the species with *single* vertical tubes.

Stromatopora nodulata of Nicholson (Ohio Report, vol. ii.) probably belongs to this genus.

4. *Syringostroma* (Nicholson, 1875).—This genus is defined by the author as composed of concentric laminæ and vertical pillars which are so thickened and so amalgamated with one another as to leave nothing but the most minute rounded cells. Laminated tissue traversed by numerous large irregularly disposed horizontal canals. The species *S. densa* included under this genus in the Ohio Report is undoubtedly to be referred to *Cœnostroma* as above defined, being a species with the vertical tubes small and the radiating tubes very large. The species *S. columnaris* has, however, a very special character in the apparent want of vertical tubes, and in the coalescence of the laminæ along certain vertical lines, giving solid columns terminating in imperforate or microscopically perforate tubercles at the surfaces.

5. *Dictyostroma* (Nicholson, 1875).—In this genus the upper surface of each lamina is developed into conical points which support the lamina above instead of pillars. The laminæ have horizontal canals, and the upper surface is apparently solid, though, no doubt, minutely perforate; the irregular oscula referred to by Nicholson are probably accidental. *D. undulata*, Nicholson, is the typical species; but I think we may add to these several others in which

the thin laminæ extend upwards in conical forms instead of pillars, and in some of which the laminæ are thin and apparently destitute of the horizontal tubes.

It is not impossible, though the specimens in my possession are not sufficiently perfect to render this certain, that *Labechia conferta* of Edwards and Haime, from the English Wenlock, may be allied to this or the last genus.

[The above descriptions of Stromatoporidæ were written before the publication of Nicholson and Murie's excellent memoir in the Journal of the Linnean Society, which reached me only a few days before the proof of the above pages. Their descriptions of the structures, and views as to the classification and affinities, agree in the main with those above given, and where they differ deserve careful consideration. They do not seem to have met with so good examples of the hollow pillars and perforated laminæ as those I have described, nor to have so distinctly observed the relation of the horizontal canals to a supplemental deposit of calcareous matter. In their comparison with *Parkeria* too much importance is, I think, attached to the arenaceous character of that fossil—a character which we find in living Rhizopods associated with forms not dissimilar to those which are calcareous. It is also not improbable that some Stromatoporidæ are built up of microscopic calcareous grains. *Loftusia* likewise presents points of comparison of some importance; and the Carboniferous species of that genus described and figured by Dr. G. M. Dawson (see p. 69) is especially instructive. In the memoir in question the genus *Syringostroma* of Nicholson is divided into *Stylodictyon* and *Pachystroma*, *Stromatocerium* of Hall is retained as a separate genus for some peculiar Stromatoporidæ of the Lower Silurian, and a new genus (*Clathrodictyon*) is formed for vesicular species without pillars. The separation of forms contained in *Syringostroma* I have myself suggested above; and I think the grounds for retaining *Stromatocerium* and adding *Clathrodictyon* may be sustained. The authors should, however, I think, have retained *Cœnostroma* of Winchell, and placed in it some forms which they have distributed in other genera. The new facts stated respecting *Labechia* are important with reference to that somewhat problematical fossil.]

The geological distribution of the American Stromatoporidæ known to me may be stated as follows, though the species, no doubt, require some revision :—

Potsdam formation	Stromatopora, sp.
Trenton formation	Stromatopora rugosa, *Hall.*
	Dictyostroma ? sp.
Niagara formation	Stromatopora concentrica, *Goldfuss.*
	Cœnostroma constellatum, *Hall.*
	Caunopora hudsonica, n. sp.
	Dictyostroma undulatum, *Nicholson.*
Guelph formation	Stromatopora ostiolata, *N.*
	Cœnostroma galtense, n. sp.

Corniferous formation	Stromatopora granulata, *Nicholson.*
	S. mammillata, *N.*
	S. Hindei, *N.*
	S. perforata, *N.*
	S. ponderosa, *N.*
	S. substriatella, *N.*
	S. tuberculata, *N.*
	Syringostroma columnare, *N.*
	Cœnostroma densum, *N.*
Hamilton formation	Stromatopora nux, *Winchell.*
	S. cæspitosa, *W.*
	Cœnostroma monticulifera, *W.*
	C. pustulifera, *W.*
Chemung formation	Stromatopora expansa, *Hall.*
	S. erratica, *H.*
	S. alternata, *H.*
	Caunopora incrustans, *H.*
	Cœnostroma solidulum, *H.*
	C. planulatum, *H.*

II. Palæozoic Fossils associated with Serpentine and other Hydrous Silicates.

Fossils having their cavities and pores infiltrated with hydrous silicates are much more abundant in Palæozoic limestones than is usually imagined. In some instances serpentine itself is found to have been concerned in such infiltration; while in other cases the infiltrating hydrous silicates are found to approach to pollyte, fahlunite, and other minerals which have usually been regarded as products of decomposition or metamorphism, but which, as Dr. Sterry Hunt has justly remarked, cannot reasonably be referred to such an origin when they are found filling the pores of Crinoids and other fossils in strictly aqueous deposits. In this case they must surely be the results of original deposition in the manner of glauconite; and, as we shall find, they sometimes appear to be strictly the representatives of that mineral, which occurs under similar conditions in other parts of the same formations.

1. *Serpentine of Lake Chebogamong.*—Mr. Richardson, of the Geological Survey, has observed, north of the Laurentian axis, on the Saguenay River, certain rocks which appear to be similar in mineral character to the Quebec group of Sir William Logan, and occupy a geological position intermediate between the Laurentian and the Trenton formation. Among these he describes a band of serpentine associated with limestone at Lake Chebogamong, which lies about 200 miles to the N.E. of Lake St. John, in a little-explored region. Among the few specimens which Mr. Richardson was able to bring back with him was one of extreme interest—a specimen apparently from the junction of the limestone and serpentine, and containing a portion of a tabulate coral, of which some of the cells are filled with a mixture of serpentine and calcite, and some with calcite. The serpentine seems to have been weathered; it has a granular, uneven appearance, and under the microscope shows patches with fibrous structure like chrysotile. There are also whitish serpentine veins, fringed with chrysotile or a mineral re-

sembling it under the microscope. The cell-walls of the coral are perfectly black and opaque, and probably carbonaceous. The coral found thus mineralized was examined by Mr. Billings, who had no doubt of its nature, though uncertain as to its generic affinities. After careful study of it, I am disposed to refer it to the genus *Astrocerium* of Hall, and it is not distinguishable in structure from *A. pyriforme* of that author, a species very common in the Upper Silurian limestones of the region in which the specimen occurs. The genus *Astrocerium* is specially characteristic of the Niagara formation; and though Edwards doubts its distinctness from *Favosites*, I think there are constant points of difference, especially in the microscopic characters of the cell-walls, which entitle it to be separated from that genus. In such specimens of *Astrocerium* as are well preserved, the walls of the hexagonal cells seem to have been of corneous texture, with minute corneous spicules instead of radiating septa. They have pores of communication, and there are also occasional larger pores or tubes in the angles of the cells. The tabulæ are very thin and apparently purely calcareous. This accounts for the singular fact, mentioned by Hall, that the cell-walls are sometimes entirely removed, leaving the tabulæ in concentric floors like those of *Stromatopora*. I think it likely that the typical species of *Astrocerium* may have been inhabited by Hydroids, and may have been quite remote from *Favosites* in their affinities.

The formation in which the serpentine and limestone of Lake Chebogamong occur is described as consisting of chloritic slates, in some places with hornblende crystals, dolomites, and hard jaspery argillaceous rocks. Upon these rest conglomerates and breccias with Laurentian fragments, and also fragments of the rocks before mentioned, and on these lie the limestone and serpentine. The serpentine has been analysed by Dr. Hunt, who finds it to contain chromium and nickel, and in this respect to be similar to that of the Quebec group, and not to that of the Laurentian*. The fossil would give evidence of a much later date than that usually attributed to rocks of the character above stated; but it is quite possible that there may be two series of different ages in the region, the lower being Lower Silurian or perhaps older, and the upper of Upper Silurian age. If the serpentine belongs to the newer formation, its association with a coral of the genus *Astrocerium* would of course be quite natural. If it belongs to the older formation, and the overlying limestone to the newer, the serpentine in the latter may be a *remanié* silicate derived from the older rocks and mixed with the limestone at their junction.

2. *Serpentine of Melbourne.*—The serpentines of this place belong to a great series of more or less altered rocks extending through the province of Quebec, and referred by Sir William Logan, on stratigraphical grounds, to his Quebec group, equivalent to the Arenig or Skiddaw series of England †. In ascending order these rocks at Melbourne present first a thick series of highly plumbaginous schists

* Report of Geological Survey of Canada, 1870–71.

† Hunt, however, holds that these rocks are in part Huronian.

or shales, with thin bands of limestone holding fragments of Lower Silurian corals and crinoids. These pass upwards into a thick series of slaty rocks characterized by the prevalence of a shining crystalline hydro-mica, and known as nacreous or hydro-mica slates. They are associated with quartzose bands, and also with lenticular layers of crinoidal limestone. Parallel with these beds and, according to Logan's observations, overlying them, is the series containing the serpentine, which is associated with layers of limestone and nacreous slate, and also with brecciated and arenaceous beds, probably originally tufaceous, with beds of anorthite, steatite, and dolomite, and also with red slates, the whole forming a miscellaneous and irregular group, evidently resulting from the contemporaneous action of igneous and aqueous agencies, and affording few traces of fossils. The serpentines, which occur in thick and irregular beds, are different in colour and microscopic texture from those of the Laurentian system, and also present some chemical differences, more especially in the presence of oxides of nickel, chromium, and cobalt, and of a larger percentage of iron and a smaller proportion of water*.

These serpentines are undoubtedly bedded rocks and not eruptive; but they may have originated from the alteration of volcanic materials†. They appear, shortly after their original deposition, to have been broken up, so as in many places to present a brecciated appearance, the interstices of the fragments being filled with limestone and dolomite, which themselves are largely mixed with the flocculent serpentinous matter, and traversed by serpentinous veins sometimes compact and sometimes fibrous. Besides the very impure limestone thus occurring in the serpentinous breccia, there are also true layers or beds of limestone and dolomite included in or near to the great serpentine band. No well-preserved fossils have been found either in these beds or in the brecciated serpentine; but on treating the surfaces of slabs with an acid or making thin slices, fragments of organic bodies are developed which well illustrate the manner in which serpentine, whatever its origin, may be connected with the mineralization of such fragments.

It is to be observed here that the irregular bedding of the serpentine, and the apparent passage on the line of strike into dolomite and red slate, might accord either with a purely aqueous and oceanic mode of deposition like that of glauconite, or with deposition as beds of volcanic sediments, afterwards altered and partly redeposited by water. The association with ash rocks and agglomerates would, how-

* Under the microscope the Laurentian serpentines are usually homogeneous and uncrystalline, but with the structure of netting veinlets which I have elsewhere called septariform. The Melbourne serpentines usually present a confused mass of acicular crystals or a fibrous structure, and, where structureless, polarize more vividly than those of the Laurentian.

† Sandberger (Essay on Metallic Veins) quotes many German chemists to the [illegible] that "olivine rock and the serpentine formed from it always contain cop[illegible] nickel, and cobalt." This origin might thus apply to the serpentines in the Quebec group in Canada, but not to those of the Laurentian, as I have already urged on other grounds in my reply to Hahn, in the 'Annals and Magazine of Natural History,' 1876, vol. xviii. pp. 32, 33.

ever, tend rather to the latter view, as would also the chemical characters of the serpentine already referred to; but the association with fossils mentioned below tends to show that at least a part of the mineral is an ordinary aqueous deposit. It is also to be observed, with reference to the superposition of serpentine on fossiliferous Lower Silurian rocks, that a similar relation is affirmed by Murray to occur in Newfoundland, where massive serpentines overlie unaltered fossiliferous rocks of the Quebec group*.

No fossils have been found in the compact serpentine, but only in the limestone paste of the brecciated masses and in the limestone bands interstratified. The limestone of the breccia contains not only angular fragments of serpentine but disseminated serpentine and small veins of the same mineral. Its fossils are limited to small tubular bodies, crinoidal joints, and fragments, apparently of *Stenopora*, very imperfectly preserved. The tubular bodies may be portions of *Hyolithes* or *Theca*. Their interior is usually filled with dolomite; their walls are in the state of calcite; and they are incrusted with an outer ring of serpentine. In some instances the calcareous organic fragments are seen to be filled in the interior with serpentine. The crinoidal fragments are in a similar condition, the serpentine having apparently surrounded them in a concretionary manner after the cavities had been filled with dolomite. Fragments of calcite, dolomite, or older serpentine included in the limestone, and of no determinate form, are enclosed in the new or *remanié* serpentine in like manner, and in some cases this newer or coating serpentine was observed to have a fibrous structure. The serpentine thus coating and filling fossils and fragments is of a lighter colour than the serpentine of the fragments themselves, and in this respect resembles that of the small veins traversing the limestone. Such traces of fossils as exist in the layers of limestone are similar to those in the breccia, but not, so far as observed, coated with serpentine.

It would thus appear that, contemporaneously with the original deposition of the serpentine, thin bands of limestone were laid down, with a few fragments of crinoids, corals, and shells; that subsequently, but perhaps within the same geological period, and while the deposition of serpentine was still proceeding, portions of the surface of the serpentine were broken up and imbedded in limestone; that the fissures of this limestone were penetrated with serpentine veins, and its few fossils coated with that mineral, which also forms flocculent laminæ in the limestone.

The mode of deposition of this Palæozoic serpentine is thus considerably different from that of the Laurentian, which forms layers intimately interstratified with great limestones, and also nodules, concretionary grains, and fillings of fossils in these limestones. This difference in mode of occurrence is, no doubt, connected with the difference in composition of the two varieties of the mineral already noticed. In both cases, however, the serpentine has been so depo-

* Bedded serpentines also occur in unaltered Silurian dolomites at Syracuse in New York (Hunt, Chem. and Geol. Essays, p. 310).

sited that it could take part in the mineralization of marine organic remains.

The condition of the fragments of Silurian fossils in the limestones associated with the nacreous or hydro-mica slates is of interest in connexion with this subject. The shining laminated mineral associated with these fossils has been regarded from its chemical composition as a hydro-mica. Under the microscope, however, it shows a want of homogeneity which suggests the presence of two or more silicates, or the association of crystals of hydrous mica with minute grains of siliceous matter of some other kind. Though now highly crystalline, it must originally have been a fine sediment, since it fills the finest cells of *Stenopora* and *Ptilodictya*. Nor can its present state have been produced by any extreme metamorphism, as the undistorted state of these fossils amply testifies. Further it is interesting to observe that though the hydrous silicate is little magnesian, the fossils themselves are not infrequently converted into dolomite. In these fossiliferous beds there are also tabular crystals, apparently of anhydrous mica, little groups of crystals of tremolite, cavities filled with quartz, and crystalline grains of a mineral having the microscopical characters of olivine; and these have been developed or included in the mass without injury to the structures of the most delicate corals.

Similar appearances are presented by limestones from other parts of the Quebec group, of which a great series of slices has been prepared by Mr. Weston under the direction of the late Sir W. E. Logan, who, in his later researches in this group of rocks, gave much attention to the microscopic fossils in the more altered beds, as a means of determining their ages. Besides large series from Melbourne and its neighbourhood, I have examined slices from Stanford, Farnham, Cleveland, Bedford, Orford, Arthabaska, Point Levi, Rivière du Loup, and other places, in most of which Lower Silurian fossils occur associated with hydrous silicates.

The fossils above referred to occur in rocks undoubtedly of Lower Silurian age, and regarded as altered or metamorphosed members of the Quebec group. In the unaltered representatives of these rocks at Point Levi and the island of Orleans there occur considerable quantities of a true glauconite, which has been analyzed by Dr. Hunt, and which is without doubt an original deposit in the sandy and argillaceous beds in which it occurs, which in many cases are precisely similar to Cretaceous greensands. Dr. Hunt's analysis shows that this glauconite contains alumina, iron, potash, and magnesia, and thus approaches to the Laurentian loganite. In the forms of its little concretions it resembles the serpentine grains in the Laurentian limestones; and like modern glauconite it has moulded itself in organic forms. Some of these are spiral or multilobate, as if casts of minute univalve shells or of spiral and textularine Foraminifera*. Others are annular or are arcs of circles, and some pre-

* Ehrenberg has found casts of rotaline and textularine Foraminifera in Lower Silurian beds in Russia; and such forms occur in Upper Silurian limestones in Nova Scotia.

sent a delicate fibrous or tubulated appearance, as if they had moulded themselves on porous shells or very minutely-celled corals, spicules of sponges, &c. Shreds of corneous Polyparies, perhaps of Graptolites, abound in the matrix, but are not connected with the glauconite grains. Unfortunately there are no *Stromatoporæ* in these beds, otherwise we might have an almost precise recurrence of the relations of serpentine with *Eozoon* in the Laurentian*.

Another appearance which may be mentioned in this connexion occurs in certain beds of Utica Slate in the vicinity of the trappean mass of Montarville, and converted into a hard sonorous rock. In one of these are stems of crinoids which have retained their external form, while the calcareous material has been entirely removed and replaced by a soft green crystalline mineral whose physical and microscopical characters are those of chlorite, and which in any case may be regarded as one of those hydrous silicates sometimes termed "viridite."

3. *Limestone of Pole Hill, New Brunswick, and of Llangwyllog in Anglesey.*—In a paper in the Transactions of the Royal Irish Academy, and subsequently in 'Life's Dawn on the Earth,' I noticed a remarkable limestone discovered by Mr. C. Robb, of the Geological Survey, at Pole Hill in New Brunswick, and believed to be of Upper Silurian age. It is composed of fragments of crinoids and shells, the cavities of which are finely injected with a hydrous silicate of alumina, iron, and magnesia, the composition of which, according to Dr. Hunt, approaches to that of the pollyte of Von Kobell, and also to that of a hydrous silicate described by Hoffmann as filling the cavities of specimens of *Eozoon* found in Bohemia. It has also some resemblance to the loganite which mineralizes the *Eozoon* of Burgess, in Canada. At the same time I mentioned a specimen of limestone of similar character which I had found in the McGill-College collection, and which I supposed to be from Wales. It is labelled "Llangolloc," and belonged to the collection of the late Dr. Holmes, of Montreal. Professor Ramsay, to whom I have applied for information as to the locality, kindly informs me that the name is probably "Llangwyllog," that the place so named is in Anglesey, and that limestone of Lower Silurian or Cambrian age occurs in its vicinity.

A portion of this specimen was submitted to Dr. Sterry Hunt, from whose analysis it appears to be of similar character with that of Pole Hill, and like it injects in the most beautiful manner the pores and cavities of crinoids, shells, and corals†. The limestone containing this silicate is of subcrystalline texture, with occasional bright cleavage-faces which belong to crinoidal fragments. Its colour, owing to the included silicate, is dull olive, and it shows occasional small deep green and reddish specks. Its aspect is so waxy, that at a little distance it might be mistaken for an impure serpentine.

When examined with the microscope, the flocculent olive-green silicate is seen to penetrate the mass exactly in the manner of the

* Report of Geological Survey of Canada, 1866.

† As the analyses of these specimens by Dr. Hunt have not been published

serpentine in ophiolite, and it has a polariscope appearance approaching to that of serpentine; while greenish by reflected light, it appears reddish when seen in thin slices with transmitted light. It penetrates the finest pores of crinoids, and at the same time fills the cavities of shells and the cells of corals. The larger fillings of this kind give the deep green spots above mentioned, while the red spots are apparently caused by the partial oxidation of the iron of the mineral. In one shell, apparently a small *Orthoceras* or *Theca*, the dark green filling has cracked in the manner of *Septaria*, and the fissures have been filled with carbonate of lime. In some places the mineral has penetrated the pores of shells of Brachiopods or crusts of Trilobites, producing a tubulated appearance not unlike the proper wall of *Eozoon*.

From the characters of the fragments, I should imagine that this limestone is Lower Silurian rather than Cambrian. It affords an excellent instance of the occurrence of hydrous silicates infiltrating organic fragments, and it deserves the attention of collectors having access to the locality. A curious point of coincidence of this limestone with some of those in the Lower Silurian of Canada is the occurrence of a few bright green specks, probably of apatite or vivianite, giving on a small scale that association of phosphates with hydrous silicates which we find on the great scale in the Laurentian.

The above facts I intend to be supplementary to my papers on *Eozoon* and on the graphite and phosphates of the Laurentian already

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in England, or in such a manner as to be readily compared with each other, I reproduce them here:—

	Pole Hill, New Brunswick.	Llangwyllog, Wales.
Silica	38·93	35·32
Alumina	28·88	22·66
Protoxide of iron	18·86	21·42
Magnesia	4·25	6·98
Potash	1·69	1·49
Soda	0·48	0·67
Water	6·91	11·46
	100·00	100·00

In the Llangwyllog specimen the silicate amounted to three per cent. of the whole, the remainder being carbonate of lime with a very little siliceous sand and fine clay. In the Pole-Hill specimen the silicate amounted to about five per cent., the remainder being limestone with a few quartz grains.

It will be seen that these two silicates, evidently deposited from solution in such a manner as to fill the finest organic pores, are remarkably similar in composition; and the fact that they closely resemble Hoffmann's mineral found in Bohemian *Eozoon*, and also the loganite filling the Burgess *Eozoon* (Quart. Journ. Geol. Soc. vol. xxi. 1865), gives them additional interest.

published in the Journal of this Society, and as illustrative more especially of the affinity of *Eozoon* with its successors in function, the Silurian *Stromatoporæ*, and of the abundant occurrence of serpentine and other hydrous silicates in association with fossils in the Lower Silurian as well as in the older Laurentian.

III. Imitative Forms resembling Eozoon.

It is easy for inexperienced observers to mistake laminated concretions and laminated rocks either for *Stromatopora* or for *Eozoon*, and such misapprehensions are not of unfrequent occurrence. As to concretions, it is only necessary to say that these, when they show concentric layers, are deficient altogether in the primary requirements of laminæ and interspaces; and under the microscope their structures are either merely fragmental, as in ordinary argillaceous and calcareous concretions, or they have radiating crystalline fibres like oolitic grains. Laminated rocks, on the other hand, present alternate layers of different mineral substances, but are destitute of minute structures, and are either parallel to the bedding or to the planes of dykes and igneous masses. In the Montreal mountain there are beautiful examples of a banded dolerite in alternate layers of black pyroxene and white felspar. These occur at the junction of the dolerite with the Silurian limestone through which it has been erupted. Laminated gneissose beds also abound in the Laurentian. Still more remarkable examples are afforded by altered rocks having thin calcite bands, whether arising from deposition or from vein-segregation. One of these now before me is a specimen from the collection of Dr. Newberry, and obtained at Gouverneur, St. Lawrence County, New York. It presents thick bands of a peculiar granitoid rock containing highly crystalline felspar and mica with grains of serpentine; these bands are almost a quarter of an inch in thickness, and are separated by interrupted parallel bands of calcite much thinner than the others. The whole resembles a magnified specimen of *Eozoon*, except in the absence of the connecting chamber-walls and of the characteristic structures. A similar rock has been obtained by Mr. Vennor on the Gatineau; but it is less coarse in texture though equally crystalline, and appears to contain hornblende and pyroxene. These are both Laurentian, and I consider it not impossible that they may have been organic; but they lack the evidence of minute structure, and differ in important details from *Eozoon*. Another specimen from the Horseshoe Mountain in the Western States (I regret that I have mislaid the name of the gentleman to whom I am indebted for this specimen) is a limestone with perfectly regular and uniform layers of minute rhombohedral crystals of dolomite. The layers vary in distance regularly in the thickness of the specimen from two millimetres to one, and must have resulted from the alternate deposition in a very regular manner of dolomite and limestone. These are but a few of the examples of imitative structures which might readily be confounded with *Eozoon*, or which, if resulting from organic growth, have lost all decisive evidence of the fact.

Perhaps still more puzzling imitative forms are those referred to by Hahn, which occur in some felspars, and which I have found in great beauty in certain crystals of orthoclase from Vermont. They are ramifying tubes resembling the canal-system of *Eozoon*, and are evidently a peculiar form of gas-cavities or inclusions. Similar appearances are, however, often presented by the more minute and microscopic varieties of graphic granite, in which the little plates might readily be mistaken, in certain sections, for organic tubulation.

In the present state of knowledge, it is perhaps more excusable to mistake such things for organic structures than to deny the existence of true organic structures because they resemble such forms. Those who have examined moss-agates are familiar with the fact that while some show merely crystals of peroxide of iron or oxide of manganese, others present the forms of *Vaucheriæ* or *Confervæ*. So if one were to place side by side some fibres of asbestos, spicules of *Tethea*, and coniferous wood, preserved, like some from Colorado, as separate white siliceous fibres, they might appear alike; but, even if thoroughly mixed together, the microscope should be able easily to distinguish them. I have specimens of fossil wood, collected by Hartt in Brazil, which have been mineralized by limonite in such a manner that no one, without microscopic examination, could believe them to be other than fibrous brown-hæmatite. Such difficulties the micro-geologist must expect to find, and by patient observation to overcome.

EXPLANATION OF THE PLATES.

Plate III.

Fig. 1. Vertical section of *Stromatopora* from the Niagara formation, showing the laminæ and pillars, without supplemental matter, × 20.

2. Vertical section of *Stromatopora* from the Corniferous Limestone, showing pillars ramifying and thickened at the ends, and laminæ without supplemental matter, × 20.

3. Vertical section of *Stromatopora* from the Corniferous Limestone, with much supplemental matter, but showing unthickened laminæ at *a a*, also horizontal canals at *b b*, × 20.

Plate IV.

Fig. 4. Vertical section of *Stromatopora* from the Corniferous Limestone, × 2, showing lines of growth. *a a*; *c*, vertical section of part of the same, × 20; *d*, surface of lamina, × 20, showing solid and hollow pillars.

5. Portion of lamina of another specimen, × 20, showing large pores and bases of two pillars.

6. Portion of another specimen, × 20, showing hollow and solid pillars and a pore at *a*.

7. Portion of silicified *Stromatopora*, weathered, and showing laminæ and pillars in relief, × 20.

8. Portion of *Stromatopora* resting on a tabulate coral and showing acervuline cells at base, × 2.

9. Vertical section of *Caunopora hudsonica*, showing vertical tube and horizontal canals, × 20; *a*, horizontal section of part of the same, showing canals and canaliculi; *b*, vertical section, more magnified.

Plate V.

Fig. 10. Horizontal section of *Caunopora hudsonica*, showing canals radiating from a central tube, × 20.

11. Vertical section of *Cœnostroma nodulata*, Corniferous Limestone, showing canals and concentric laminæ, with much supplemental matter, × 20.

12. Horizontal section of the same, showing large radiating canals, × 20.

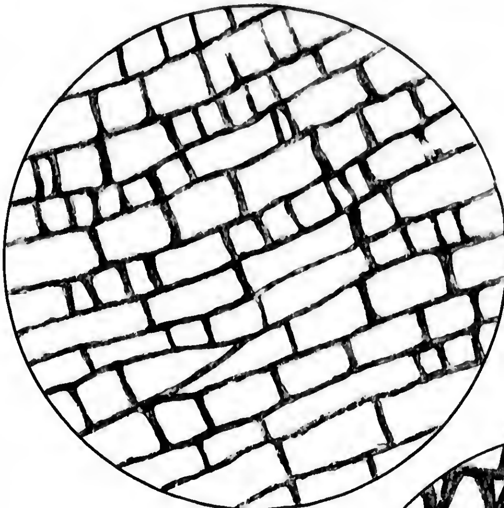
DISCUSSION.

Prof. DUNCAN expressed his belief that many different forms were united under the one head of *Stromatopora*, and that the confusion was often due to the mode of mineralization. He called attention to a *Smithia* on the table, which, by destructive mineralization, had assumed a deceptive resemblance to *Stromatopora*. He thought this had been the case in some of Mr. Lonsdale's specimens. The tubules in the laminæ of *Stromatopora* certainly had much resemblance to the tubules of *Millepora*. Some of the specimens on the table seemed to have openings like calices; as they opened into the cœnenchyma they could not be corals. The cross tubules excluded them from Polyzoa. They showed no true supplemental skeleton or nummuline layer like *Eozoon*, and so he doubted their Foraminiferal character. With regard to the mineralization, he had some years before received specimens of fossils from Canada, which Dr. Dawson's description had recalled to his mind.

Mr. CHAMPERNOWNE described the tubular structure which he had observed in some of the Stromatoporidæ from Devonshire, both in the horizontal and vertical sections, and felt certain that the group contained many different forms. He had never seen Eozoonal structure in the Devonshire fossils.

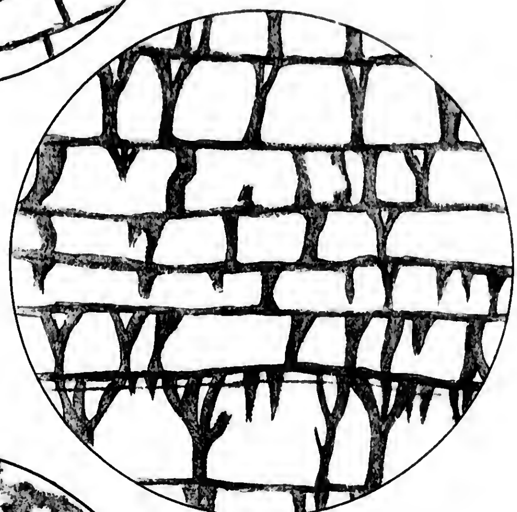
Dr. MURIE stated that some specimens which he had seen resembled the Hexactinellidæ, and he thought they represented sponges, not precisely Hexactinellids.

1.



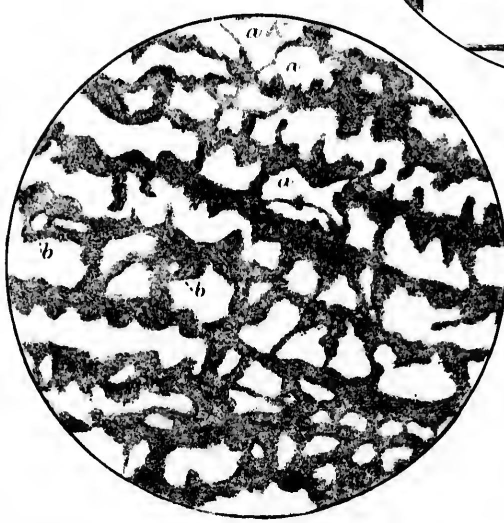
x 20

2.



x 20

3.



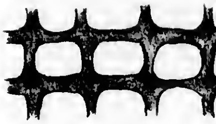
x 20

H Olson lith.

Mintern Bros imp

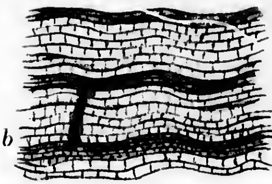
STROMATOPORIDÆ.

4c.



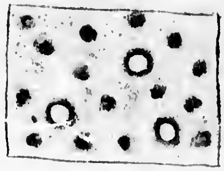
× 20

4.



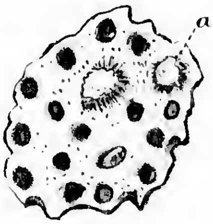
× 2

4d.



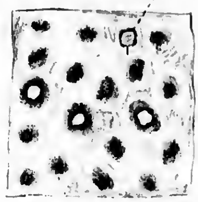
× 20

5.



× 20

6.

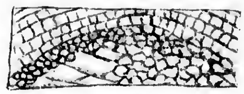


× 20

7.

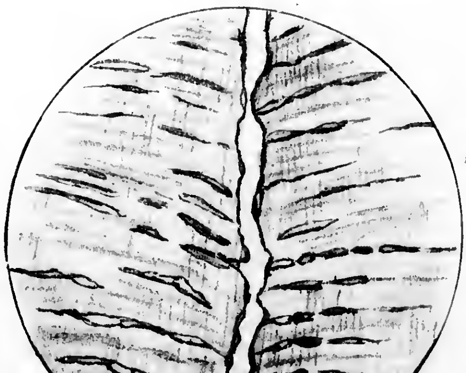
× 20

8.



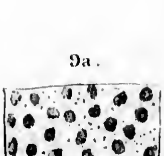
× 2

9.



× 20

9a.



× 50

9b.

× 50

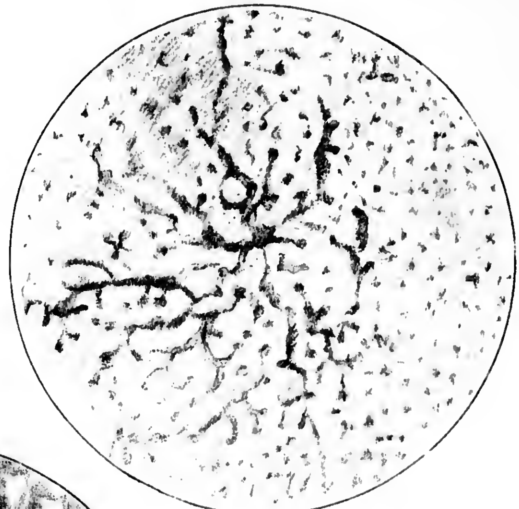
H Olson lith.

Mintern Bros imp.

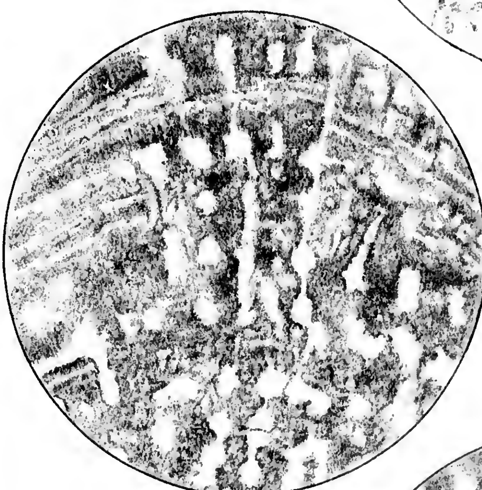
STROMATOPORIDÆ.

10.

× 20



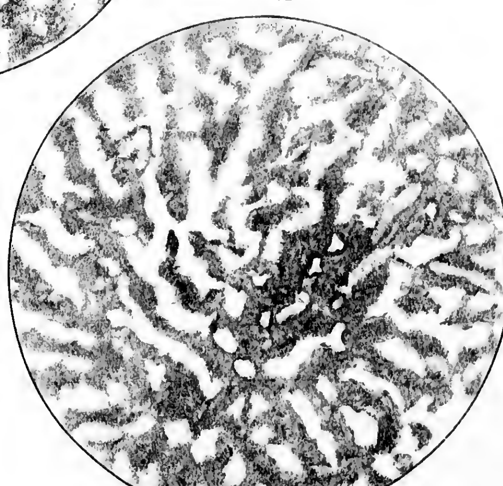
11.



× 20

12

× 20



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