crag been exposed to the weather for a long period after the ameliorated climate set in we should not have had this interesting record of ice-action, but an undecipherable heap of rock-fragments.

The exceeding abundance of Diatomaceous remains is remarkable. In this respect the deposit is such as might, with some slight modification of external causes, be the equivalent of the famed Lough Mourne and Lough Island; Reavy strata in Ireland; the Raasay, Peterhead, and Mull beds in Scotland; and the Dolgelly earth in Wales. That they have not been detected in the English clays probably arises more from lack of examination than from any dearth of these organisms.

Note.—Mr. J. Wallace Young, of this city, has directed my attention to the presence of titanic acid in the laminated clay, as well as in some of the adjacent rocks. The proportions varied from ·94 per cent. in the clay to 2.93 per cent. in one specimen of felstone. In an examination I have just made of the upper leaf-bed I find it to contain ·80 per cent. of titanic acid.

IV.—On some Fossils found in the Eophyton Sandstone, at Lugnås, in Sweden.[1]

By J. G. O. Linnarsson.

[*Plates XI., XII., and XIII.*]

NO other part of Sweden affords more favourable opportunities for studying the earliest fossiliferous deposits and their relations to each other than Vestrogothia, with its unusually complete, undisturbed, and, in many natural sections, exposed series of strata. Its two lowest principal layers, consisting of sandstone and alum-slate, are to be referred to the Cambrian system, if that system, as proposed by Sir Charles Lyell, Salter, and others, be extended over the "Primordial zone," which is easily distinguished by its organic remains from the overlying Silurian deposits. This sandstone has long been known as the oldest stratum of Vestrogothia above the Fundamental Gneiss. Traces of seaweeds were found in it by our earlier geologists, and caused it to receive the name, still commonly used, of Fucoid sandstone. Deposits of the same period are distributed over large parts of Scandinavia; and Professor Angelin, who, like his predecessors, had found them to be the oldest portion of the whole "Transition formation" of Scandinavia, included them all in his *regio Fucoidarum*, no other Fossil having as yet been found in them. Norwegian authors have proposed the denomination "Sparagmite stage," for the rock prevailing in Norway, which has not as yet afforded any fossils, a term also adopted by Professor Torell.

Until lately few additions had been made to our knowledge of the organic remains preserved in the deposits of the *regio Fucoidarum*.

[1] Translated from the Ofversigt af Kongl. Vetenskaps Akademiens Förhandlingar, March 10, 1869.

Beside the seaweeds, Annelid burrows were found in it several years ago, but nothing was known of the existence in it of any other fossils, and it was generally assumed that very few fossils were to be expected in a layer of an age so remote, and that the rock itself was not capable of preserving, in a sufficiently distinct condition, the remains of such organisms as might have been living at the time of its deposition. Accordingly, until late years, very little attention had been directed to the Fucoid sandstone of Vestrogothia, and I had therefore no great hope of any new discoveries until I succeeded two years ago in finding a *Lingula*. Some time afterwards Professor Torell published his excellent geognostical and palæontological description of all the coeval rocks of Sweden,[1] and of the remarkable discovery made by himself and Dr. J. A. Wallin of a comparatively highly organised plant, the *Eophyton Linnæanum*, Torell, in these oldest deposits.

Since, through these important researches of Professor Torell, due attention has been drawn towards the oldest sandstone of Scandinavia, it becomes desirable to know with accuracy its age in relation to deposits in foreign countries and especially to the English formations, upon which the division into periods of the older Palæozoic time now in use has been founded. At present no certain conclusions can be drawn from the organic remains, these being still so imperfectly known. It is necessary, then, to rely chiefly on the stratification, which can be ascertained with facility and accuracy in Vestrogothia better than anywhere else. Sir R. Murchison, who places the "Primordial zone" in the Lower Silurian system, refers to that system not only the alum-slate of Vestrogothia, which apparently belongs to the Primordial zone, as defined by Barrande from its Trilobite fauna, but also its sandstone layer.[2] Agreeing with Professor Torell,[3] I believe, however, the latter to correspond with the "Longmynd group" of England, which is also considered by Sir R. Murchison as Cambrian, and, according to the classification of Sir Charles Lyell, forms the lower part of the Cambrian system of England. Like the Longmynd formation, the sandstone layer of Vestrogothia reposes on gneiss, which we have every reason to believe to be of Laurentian age. The alum-slate lying above the sandstone completely corresponds with the Lingula-flags, which in England overlie the Longmynd formation. In the alum-slate of Sweden, as in the Lingula-flags of England, two principal divisions are found, the well characterised faunas of which Professor Angelin was the first to distinguish as the *regio Conocorypharum* and *regio Olenorum*. The older of these regions, the *regio Conocorypharum*, is characterised chiefly by the genera *Paradoxides* and *Conocoryphe* (*Conocephalites*), while the genus *Olenus* appears later; thus it is distinctly equivalent to the "Lower Lingula flags" or "Menævian" group of England. The layers which lie above and below the sandstone layer of Vestrogothia being thus equivalent to those which bound the Longmynd

[1] Bidrag till Sparagmitetagens geognosi och palæontologi. Lund, 1868.
[2] Davidson, On the Earliest Forms of Brachiopoda, etc., Geol. Mag. 1868.
[3] Russia in Europe and the Ural Mountains, Vol. i. p. 16.

formation, there is, at least, great probability that these deposits belong to the same period, and that the whole *regio Fucoidarum* is to be regarded as a representative of the lower part of the Cambrian system. If that be not admitted, it must be supposed that the *regio Fucoidarum* has no equivalent in England, and that Sweden is deficient of every deposit from the earlier Cambrian period. For such a supposition, however, no sufficient reason can be afforded. The occurrence of plant-remains cannot be regarded as such, at least so long as nothing corresponding has been known from the Upper Cambrian, and Brachiopods have now been found also in the Longmynd formation. As even the Longmynd formation is said to contain one or perhaps more Brachiopods common to the Lingula-flags,[1] the break between these formations cannot be very considerable, and we have thus additional reason to give to the Cambrian period a longer duration than Sir R. Murchison has assumed. This circumstance and the great dissimilarity between the faunas of the Upper and Lower Lingula-flags has induced some English writers to refer to the Lower Cambrian system not only the Longmynd group, but also the Lower Lingula-flags.[2] Accordingly the *regio Conocorypharum* should also be referred to the Lower Cambrian system. The great geognostical resemblance, however, between the *regio Conocorypharum* and the *regio Olenorum* makes it more suitable, if a tripartition of the system (into a lower, a middle, and an upper stage) be not preferred, to refer them both to the upper division, at least till some closer palæontological relation, than any hitherto shown, shall have been discovered between the former and the *regio Fucoidarum*, or between the Lower Lingula-flags and the Longmynd formation. While thus referring, with Sir Charles Lyell, both portions of the "Primordial zone," characterized by Professor Angelin, to the Upper Cambrian system, I still think that the "Tremadoc group" is to be excluded from that System, and, together with its nearest equivalent in Sweden, the *regio Ceratopygarum* of Professor Angelin, to be regarded as the lowest portion of the Lower Silurian.

The sandstone layer of Vestrogothia belongs as a whole to the *regio Fucoidarum*, but in some other parts of Scandinavia there are deposits of Sandstone also belonging to the younger Cambrian period. Thus in Norway the "Hoejfjelds Kvarts" forms a part of the primordial zone, the stage 2 of Professor Kjerulf.[3] In Oeland, at the base of the alum-slate layer, lies a "calcareous quartz-schist"[4] in which the earliest genera of Trilobites have been found, and which by reason of its fossils has been referred by Professor Angelin to his *regio Olenorum*, but which, with greater show of reason, might be referred to the *regio Conocorypharum*. In Vestrogothia the same forms occur in the lowest part of the alum-slate, to which the quartz schist of Oeland is thus equivalent.

[1] L. c., p. 2.

[2] See Th. Belt, On the "Lingula-flags," or "Festiniog Group" of the Dolgelly District. Geol. Mag. 1867, p. 493 *et seq.*

[3] Kjerulf, Stenriget og Fjeldlæren, p. 212.

[4] A. Sjögren, Anteckningar om Oeland. Ofversigt af K. Vet. Akad. Förhandl. 1851.

On geognostical as well as upon palæontological grounds two divisions may be distinguished in the sandstone of Vestrogothia. In the lower, which is seldom seen in any natural section, the rock is hard, usually thin-bedded; in the upper, which is in many places exposed and has chiefly given rise to the names of Fucoid sandstone and *regio Fucoidarum*, it is softer and often thick-bedded. At the very limits of the adjoining layers the sandstone is of an anomalous composition. At the limit of the gneiss it has the appearance of a conglomerate, and contains also some felspar grains. The uppermost sandstone which lies immediately beneath the lowest alum-slate contains a great deal of pyrites, and sometimes, as at Hunneberg, of clay also. These anomalous portions of the layer are very thin, being hardly more than one or two feet in thickness.

The lower parts of the sandstone, although not overlooked by earlier writers, have, owing mainly to the researches of Dr. Wallin and to Professor Torell's descriptions of the fossils collected by the former, attracted a greater degree of attention, and it was through their works that I was led to make myself acquainted with them.

The Lugnås[1] mountain offers the best opportunity of observing the lower division of the sandstone layer and its contact with the underlying gneiss, that is to say, the line of demarcation between the Cambrian and the Laurentian systems. For that reason this locality has often been visited by geologists, but their views respecting the position of the limit are very different. From the olden time millstones have been quarried on a large scale in many places at the foot of the mountain, out of a rock containing the ingredients of granite and gneiss, but in which the felspar has partially been converted into kaolin. According to some writers, this rock is a weathered granite or gneiss, and as such referred to the Laurentian system, or the "fundamental rocks;" others have believed it to be an arkose formed by the mechanical decomposition of a granitic or gneissose rock and the subsequent cementation of the components. According to this opinion it would constitute the lowest portion of the sandstone, and thus belong, together with the overlying sandstone, to the Cambrian (respectively Silurian) system, or the lowest part of the "Transition formation." Hisinger hesitates between these two opinions; sometimes he names the rock a "rotting" granite or gneiss,[2] but sometimes he says that "the millstone bed may be perhaps properly regarded as a granitic transition arkose separated from the fundamental rock or the gneiss by a thin quartzose layer."[3] Sir Roderick Murchison believes the rock to be a Silurian arkose, constituting the lowest part of the sandstone.[4] But Dr. Wallin, in his detailed and accurate description of the layers of the Lugnås mountain,[5] has clearly shown, that the millstone rock is nothing but a variety of the common gneiss of the district, caused by the partial

[1] Pronounce: Lungnose.
[2] Anteckningar i Physik och Geognosi, Vol. iv. p. 48, 49 (1828).
[3] Anteckningar, Vol. v. p. 67 (1831).
[4] Russia in Europe, etc., vol i. p. 16.* Siluria, 4th ed., p. 347.
[5] Bidrag till kännedomen om Vestgötabergens byggnad. Lund, 1868.

weathering of the felspar, and by no means, as the true arkose, a sandstone-like rock. In visiting the millstone quarries of Lugnås last autumn, I felt convinced, almost at the first glance, of the truth of Dr. Wallin's determination. The mica scales are often seen to be arranged in well-marked laminæ, usually dipping almost vertically, so as to produce a more or less distinct gneissose structure. Besides this the rock (as stated by Dr. Wallin) increases in hardness downwards and resembles more and more the unchanged gneiss of the neighbourhood.

Thus it is above the millstone bed, that the oldest Cambrian deposit commences. The all but horizontal sandstone overlies unconformably the nearly vertical strata of the millstone gneiss. In the quarries its lower division only is exposed. The rock nearest to the gneiss is, as before mentioned, a conglomerate, the sandstone-like cement of which contains larger or smaller rounded fragments of quartz and grains of felspar, the latter sometimes being, as in the millstone gneiss, converted into kaolin powder. In the fourth volume of his "Anteckningar"[1] Hisinger has given a tolerably accurate description of this conglomerate, but he says afterwards, erroneously, that the millstone bed is in immediate contact with a fine-grained sandstone.[2] The conglomerate is usually concreted into one mass with the millstone gneiss, but the limit, as may be expected from the different nature of the rocks, and above all, from their unconformable stratification, is very distinct. As yet no fossils have been found in it.

The thin conglomerate is followed, often without any very distinct line of demarcation, by the main mass of the lower sandstone, which is fine-grained, hard, greyish, and reddens in the air. Except in its undermost parts, its layers are very thin. It is interbedded with thin layers of a greenish-grey shale. Sometimes the sandstone, owing to a greater number of laminæ of mica, assumes a schistose structure. Hisinger and Sir R. Murchison have already described this sandstone and the shale alternating with it ("bluish-grey clay" Hisinger, "greenish-grey shale" Murchison). Dr. Wallin has not only pointed out all its petrographic characters, but also remarked that it contains peculiar fossils, and for that reason, on the suggestion of Professor Torell, he has termed it "Eophyton sandstone," reserving the name of Fucoid sandstone for the upper and softer parts. It is especially in the deep and numerous quarries on the north-eastern side of the mountain that sections of the Eophyton sandstone are exposed, but the limit next the Fucoid sandstone proper is not exposed there and has not been observed in any other place. The thickness therefore has not been ascertained. Dr. Wallin has found it to be at least 30 feet.

It was in this sandstone that Dr. Wallin during the summer 1867 discovered the *Eophyton Linnæanum*, Torell, and in the following year he added the *Arenicolites spiralis*, Torell. Last autumn I visited Lugnås, and collected the fossils I am about to describe. The rock, being very fine-grained, has preserved distinct casts of the

[1] P. 49. [2] Vol. v., p. 67; Vol. vi., p. 60.

plants and animals which lived in, or were swept into, the water where it was deposited, so that the most delicate parts can often be distinguished with accuracy. The knowledge, however, to be gained from the materials hitherto obtained is far from being satisfactory, and the interpretations must often be uncertain. Still I have thought it advisable not to delay publishing my observations, as every contribution that may throw some light on so remote a period, can hardly fail to be acceptable.

Arenicolites spiralis, Torell.—The worm described under this name by Professor Torell, at the last meeting of the Scandinavian Naturalists in Christiana, is one of the commonest fossils, especially in the shale. The spirally curled form, which has given rise to the name, is easily recognized and is very constant. Its relations to the numerous burrows which are found along with it are difficult to decide. The thickness of the burrows—almost the only character to be relied upon—is nearly the same as in the spiral form.

Lingula (?) monilifera, n., Plate XI., Figs. 1 and 2.—Of this species, with the exception of a nearly complete and very distinct cast of the outside of the one valve, Pl. XI. Figs. 1 and 2, I found only a few fragments. The inner parts are not visible in any specimen, and the generic determination therefore cannot be settled; but by the size and the general form, and, above all, by the sculpture of the shell the species is easily distinguished from all the Brachiopods with which I am acquainted. In the cast the apex itself is not visible, and one cannot therefore decide whether it is formed by the dorsal or ventral valve. The shell would seem to have been oval and very much depressed, except near the apex, where the sides are more sloping. The length and breadth are about 22 millimetres. The shell is ornamented with extremely close and fine longitudinal, slightly diverging, raised and beaded lines, of which about five may be counted within the breadth of a millimetre. The lines of growth are apparent only near the front margin. Judging from the thickness of the detached slabs in which this species was found, it would seem to have made its appearance in the undermost layer of the Eophyton sandstone, and may thus be considered the earliest Mollusk hitherto known.

In a slab of schistose sandstone I found a Brachiopod which, in the sculpture of the shell, bears some resemblance to the preceding species, but in other respects, as far as one can judge from the indistinct fragments, is widely different. On the surface of the slab lie two shells, of which the margins only are preserved, and even these but incompletely, the middle part being totally effaced. The contour seems to have been almost circular with a diameter of about 50 millimetres. The shell, like that of *Lingula monilifera*, bears raised, beaded lines, but these lines here seem to be directed towards the centre of the shell; near the circumference their distance from each other is somewhat less than a millimetre. From the general form of the shell this species may most likely be supposed to be a *Discina* or *Trematis*.

Eophyton Linnæanum, Torell,[1] Plate XI. Figs. 3 and 4, and Plate XII.—It is to be hoped that Professor Torell will soon communicate some further observations about this remarkable but as yet not sufficiently known species. In the meantime I may venture upon the following remarks. With the materials I have hitherto obtained it is hardly possible to give a full specific description, and I must therefore confine myself to describing separately some of the specimens collected. In Fig. 3 of Plate XI. is shown a piece of sandstone with two specimens lying parallel and close together. The one to the left agrees, as far as I can recollect, with the specimens exhibited by Professor Torell himself, which I had an opportunity of seeing at the last meeting of Scandinavian Naturalists in Christiania. It is a regularly convex fragment of a stem, of equal breadth throughout, and perfectly straight, 170 millimetres long and about 25 millimetres broad, with a height of about six millimetres.[1] Along its whole length it bears a large number of regular furrows, say 35, the breadth of which is nearly the same as that of the intervening raised ribs. Towards the sides both the furrows and ribs are generally somewhat larger, and especially a few millimetres from the margin one broad and deep furrow is to be seen, besides some ribs raised above the others and at nearly regular distances from one another. These higher ribs are for the most part arranged in pairs and separated by a comparatively broad furrow. Such a pair runs along the middle, and several others are more or less discernable on the right side, this arrangement being less conspicuous on the left side. The smaller ribs and furrows running between the larger are exceedingly fine, and it has not therefore been possible to represent them all distinctly enough in the figure, since even in the original they are to be distinguished only with difficulty. All the ribs and furrows are straight except in the uppermost part (*a*), where those in the middle are gently bent asunder, as though nearly the origin of a branch. On the sides of the stem (*b* and *c*) are to be seen awl-like appendages, the organic connexion of which with the stem is somewhat uncertain.

The specimen on the right hand is depressed and mutilated and not visible throughout its whole breadth, which must have been considerable, the preserved portion being more than 25 millimetres broad. The ribs and furrows are much coarser and much less regularly arranged. On the left side they are comparatively equal and small in size, though coarser than in the former specimen. Further to the right hand the breadth of the furrows is much larger, sometimes amounting even to three millimetres. The ribs are several times narrower than the furrows, the coarser among them being often divided. Even in this specimen they are for the most part straight, but near the left margin the outer ones (*d*) bend outwards, probably where a branch has been given off. Close above this flexion the sculpture is effaced; when the furrows in the upper part again appear, they run quite straight.

[1] Bidr. till Sparagmitetagens geogn. och pal., p. 36, t. ii. f. 3, t. iii. f. 1–3.

[1] In the figure the inner part of the right side appears more depressed than in the original.

Fig 4 in the same plate represents a specimen, somewhat weathered, the outlines of which are therefore not quite distinct. Its visible breadth is about 15 millimetres. In the upper part a branch or a leaf (?) runs out, the base of which forms a ridge obliquely crossing the whole breadth of the stem. Its free portion is bent almost straight upwards, parallel to the stem, but broken so near the base, that its form cannot be conjectured. The longitudiual furrows of the stem are close and narrow, but in consequence of the weathering, not very distinct. In the lower portion they are gently and irregularly bent, then straight, until immediately beneath the oblique ridge they are suddenly bent in the same direction as the ridge; above this they are quite straight. In the appendicular organ no furrows are visible, but that, perhaps, depends partly on the matrix being there more coarse-grained. This specimen agrees in many respects with the right-hand one in Fig. 3, and in order that the conformity between the two in the course of the furrows may be more conspicuous, it has been drawn inverted in Fig. 4*a* by the side of its presumed analogue in Fig. 3. At *d* in Fig. 4*a* as at *d* in Fig. 3 the ribs to the left bend outwards, and close above this point there are no furrows in either specimen, and when these reappear in the upper part they are straight, the right-hand furrows not partaking of the flexion, but running without interruption.—Though probably not belonging to this fossil, a small conical tubercle (*a* in Fig. 4), seems worthy of attention, arising, as it does, in the very margin of the stem, and being surrounded by an annular eminence.

Plate XII. represents a slab which evidently has been long exposed to the air, so that in some places the sculpture is not so conspicuous as in that just described. It contains several larger and smaller fragments of stems. They are all distinguished from the foregoing by their inferior breadth, which is from four to six millimetres. The furrows are in all somewhat conformable and narrow, though for the most part larger than those in the first-mentioned specimen. Some of the stems are depressed, but in some of them the height above the surface of the slab is nearly as great as the breadth; the more convex ones are often angular. The largest specimen has a length of about 100 millimetres. It is divided into two branches of equal size, making an angle of about 40°, and having the same breadth as the common stem. The left branch seems to be somewhat tapering, but that depends no doubt on its gradually sinking in the matrix. Between the branches lies a fragment (*a*) the extremities of which seem to be abruptly cut off at their contact with them. In the axilla of the branches an oblong, irregular, convex mass (*b*) runs out, which, however, shows no trace of structure. The common stem is slightly bent, and has its hinder part sunk in the matrix; but in its continuation there lies a very convex fragment (*c*) of similar form. From beneath the anterior part of this another depressed fragment (*d*) projects with more obscure outlines. Whether they are coherent or not cannot be seen, a formless mass covering the point at which they meet.—Among the other

specimens the following ought to be especially noticed. At *e* a short but large fragment is observed. Its posterior section shows some small cavities disposed obliquely one above the other at nearly regular distances, which may, perhaps, be interpreted as traces of the inner structure. To the right lies a longer and narrower fragment (*f*) which has possibly cohered with another (*g*), of which only a small portion is preserved, in the very margin. Both are there bent, as if they had been united outside the present margin of the slab.—By the side of these lies a specimen (*h*) with deep furrows and sharp ribs. In this, as in some others, the furrows sometimes show a slight trace of a transverse articulation, as if each furrow had consisted of a row of small excavations, but this may have arisen from the weathering of the slab.—At *i* a fragment is seen, which is remarkable for its great convexity and distinctly angular shape.—An irregular raised body (*k*), marked by two parallel rows of tubercles, is probably of organic origin, and is suggestive perhaps of the presence of terrestrial animal life.

Several other slabs not figured contain specimens of *Eophyton Linnæanum*; they give, however, but little information. One of them has almost the whole surface covered with fragments of stems, some of which are branched, but the weathering has made them too obscure to be described.

It seems premature to speculate on the affinities of this fossil, which bears so little resemblance to forms previously known, and ampler materials are no doubt required in order to come to any certain results in this respect. Its organic origin cannot reasonably be questioned, and hardly any doubt can exist as to its belonging to the vegetable kingdom. If it were not of vegetable origin, it could not be interpreted otherwise than as the track of an animal. Such a supposition is contradicted especially by its being branched; a track cannot be supposed to have taken such a form as that shown for instance in Pl. XI. Fig. 4. And even apart from the branching, this interpretation can hardly be maintained if the characteristic furrows be considered, at least I have never seen a description of any tracks with which this fossil could be compared. If the vegetable nature of *Eophyton* be granted, the difficulty of deciding to which group it is to be referred still remains. This difficulty is augmented by the scarcity of fossil plants in the oldest deposits, that might enable us to draw a comparison. From the whole Cambrian and the greater part of the Silurian system no remains of other plants than Algæ have hitherto been obtained. That the *Eophyton* cannot be referred to that class is however evident. Several eminent algalogists have examined the fossil and they have all unanimously and with the greatest certainty declared that it cannot have any affinity with the Algæ. It is then among the vascular Cryptogams and Monocotyledons, that the relations of *Eophyton* are to be looked for. Professor Torell refers it to the latter, and though its phanerogamous nature be not yet fully ascertained, its general habit in many respects reminds us of them. He suggests, however, a near relation to *Cordaites*, a genus referred by several authors

to the *Lycopodiaceæ*. This opinion is founded on the resemblance between the leaves of *Cordaites* and *Eophyton*. It is, however, doubtful, whether the organs interpreted as leaves in *Eophyton* are really such. Judging from the figures given by Professor Torell, they seem to be the same parts which I have described as portions of stems, and which, from their branching not resembling that of compound leaves, their frequent convex shape, etc., I could not regard as leaves. In the restoration given by Dawson,[1] the stem of *Cordaites* has very short joints, and if that be true, there is still less reason to assume a nearer relation between *Cordaites* and *Eophyton*, the stem of the latter, at least in the specimens hitherto found, showing no articulation. Thus, though a great uncertainty still remains as to the place of *Eophyton* in the natural system, it can hardly be doubted that it is of a far higher organization than any plant hitherto known from the oldest deposits.

With regard to the mode of fossilization of the *Eophyton*, it seems probable that the plants immersed in the water made impressions on the mud upon its bottom, and that, after the plants themselves had been dissolved, their impressions were filled with sand. In this manner the fact is to be explained that one specimen often is, as it were, cut off when in contact with another. We must accordingly suppose that the mutilated specimen has made an impression, and that afterwards the other has been laid across and partially obliterated it.

Eophyton Torelli, n. sp., Plate XIII.—Although it is very uncertain whether this species has any nearer relation to the preceding typical species of the genus *Eophyton*, I have thought fit to describe it under the same generic name. Extensive researches into the plant-remains of the Eophyton sandstone are still necessary, before any certain generic characters can be given, and there is therefore reason in keeping them all provisionally under the name *Eophyton*.

Eophyton Torelli is much scarcer than *E. Linnæanum;* at least, I have found it only on one slab of sandstone, some parts of which are represented in Plate XIII.

In Fig. A is shown a stem-fragment about 90 millimetres in length. The foremost half, the breadth of which is 10—12 millimetres, is very convex and distinctly angular, so that four sides are visible. Both the outer sides are almost vertical—in the figure the left side cannot be seen, but it is of about the same breadth as the right. The upper sides are gently sloping and somewhat concave, the left being broader than the right. The hinder part becomes gradually more and more depressed, and consequently the breadth increases, until it attains 19 millimetres. The surface is generally smooth, except that on the hinder part some very faint traces of longitudinal furrows are seen. The most characteristic parts of this specimen are four scales, which seem to be spirally arranged round the axis, but, as far as visible, at unequal distances. The first (*a*), which is placed on the left margin of the depressed portion, is broadly lanceolate and has a length of about 8 millimetres and a maximum breadth of 4

[1] Acadian Geology, second ed. p. 458.

millimetres. At a distance of 15 millimetres, on the middle ridge between the upper sides, another scale (*b*) of about the same shape and size is placed. About 30 millimetres in advance a similar organ (*c*) projects from the upper left hand side, and a fourth (*d*) is seen, as it were, hanging down from the angle of the outer right side. The scale at *c* seems to have been cleft in such a manner that some organ, which had for the most part been destroyed, has been rendered visible.

Of the nature of the objects represented by the other figures, and of their relation to the specimen just described, it is at present difficult to form an idea. In order to draw attention to them, however, I have thought fit to give figures of them. Their presence in the same slab makes it to a certain extent probable that some of them at least belong to the stem described above.

In Fig. B is shown an oblong body strongly convex, with a very wrinkled and rough surface. It might perhaps be conjectured to have been a spicate inflorescence. Its length is 45 millimetres, the breadth about 10 millimetres. From the right side (*a*) two narrow, oblong linear bodies run out, one across the base of the other. Their outlines are very distinct on the outer side, on the inner not quite so much so. Both have along the middle a faint furrow, in the continuation of which is seen a faint threadlike ridge (*b*). A third body of the same form, but shorter and broader, lies at their base. In B′ they are represented somewhat magnified.

In the anterior part of Fig. C a cylindrical body (*a*) is seen, perhaps analogous to *a* in Fig. A. In the posterior part at *b* there are three conical tubercles, arranged in a row, round which the surface of the stone is finely striated.

The objects shown by the portion D of the same slab are for the most part very obscure. On the left side are seen several more or less elevated parts (*a*) marked by faint longitudinal furrows; they are probably portions of a depressed stem. On the right side is seen a broken, cylindrical, wrinkled body, somewhat resembling the one represented in Fig. B, together with some straight linear ribs, while behind them there is a narrow tube, at the side of which lies an oblong body (*b*) that may be compared with *a* in C. Of none of these objects will I venture any interpretation.

Rhysophycus dispar, n.sp.—There occurs in the Eophyton sandstone more frequently than any other, a strange fossil bearing a close resemblance to certain forms described by Hall,[1] Billings,[2] and Dawson,[3] under the generic names of *Rusophycus*[4] and *Rusichnites*. It always consists of a system of linear eminences or ribs, arranged symmetrically and more or less transversely on each side of the middle line. The form most closely agreeing with the descriptions given, especially of *R. bilobatus* (Hall) from the Clinton

[1] Palæontology of New York, vol. ii., p. 23. 24.
[2] Palæozoic Fossils of Canada, vol i., p. 101.
[3] On the Fossils of the genus Rusophycus, Canadian Naturalist, Oct. 1864, 363.
[4] According to the derivation the name is to be written *Rysophycus*, or, with Eichwald (Lethæa Rossica, vol. 1, p. 54) *Rysophycus*.

group, and *R. Grenvillensis* (Billings) from the Chazy limestone of North America, may be considered as the type. It is an oblong body, very convex and broader at one of its ends, which may be called the anterior; it is divided into two symmetrical lobes by a longitudinal furrow, which in the hinder portion is narrow and shallow, but increases forwards in size, so that the front ends of the lobes are completely separated from each other. The width of the whole fossil does not always increase regularly and continuously; the enlargement usually takes place more slowly before the middle and sometimes entirely ceases. Even when the width of the whole increases continuously, the lobes taper before the middle, in consequence of the increasing breadth of the longitudinal furrow. Each lobe has a multitude of close, rather regular narrow ribs, which in the hinder portion meet in the median furrow, forming an angle, the top of which is directed backward. In the middle, where their direction is often suddenly altered, they are almost at right angles with the median line. In the anterior portion, where the ribs of the two lobes do not touch, their projections, if drawn out, would form an angle with the top directed forwards. In consequence of this change in their direction, the ribs are crowded together on the sides and diverge inwards. The dimensions, absolute as well as relative, vary, but not to any great extent. The length I have found to vary between 50 and and 80 millimetres. The greatest breadth is sometimes but little less than the length, but it does not usually exceed two-thirds. The height is greatest in the middle, being sometimes equal to a third of the length. There is no trace of an axis. Hall considers that he has found such an organ in the *R. bilobatus*, but, as stated by Dawson, the supposed stem is undoubtedly nothing but a tube of a worm. Even in the Vestrogothian species such tubes are sometimes seen to issue here and there between the ribs, but never in such a situation as to be mistaken for branches or stems.

The ribs are but comparatively seldom united into such convex bodies as are here described. They are usually extended almost horizontally; sometimes whole slabs are covered with such systems. The ribs are in this case straight or but slightly bent, more nearly parallel with each other and usually almost at right angles with the median lines. The opposite ribs are seldom in contact, and the two halves are therefore entirely separated. Even the approximate ribs of the same lobe are seldom contiguous. Sometimes transitions between this form and the one above described are seen. Thus, in one specimen, the ribs are more crowded and meet at the median line; each lobe is slightly convex, but of the same height throughout its whole length, while the typical form is highest in the middle and sloping both forwards and backwards. The specimens of the horizontally expanded form hitherto collected have a length of from 15 to 80 millimetres; the number of the ribs varies according to the length, but depends also in some degree upon their being more or less crowded. The breadth is between 15 and 30 millimetres, but is in general nearly the same in different parts of the same specimen.

Annelid burrows often have some raised or depressed ribs; sometimes they are seen to wind between the ribs, now over, now under them.

Although the specimens hitherto obtained do not exhibit a complete series of transitions, it is highly probable that the convex and the more horizontally expanded form belong to one and the same species, more especially as Dawson has found two analogous forms of *R. Grenvillensis*.

According to Hall and Dawson the allied American forms always occur on the under side of the strata, where these are reposing on shale, and are thus casts of impressions once formed upon the soft clay. Without doubt the same is also the case with the fossil occurring in Vestrogothia, but I have had no opportunity of directly verifying it.

The genus *Rhysophycus* is still one of the least understood; it has not even been ascertained, whether it be of vegetable or animal origin. Besides, as now defined, it includes objects too heterogeneous. Thus *R. clavatus* and *subangulatus* Hall and *R. embolus* Eichw. seem to have a closer relation to *Arthrophycus Harlani* (Conrad) Hall, than to the other forms referred to *Rhysophycus*. *R. dispar* differs from *R. bilobatus* and *Grenvillensis*, chiefly in the greater regularity of the ribs and of the change of their direction, and in the considerably increased breadth of the longitudinal furrow. In other respects those three species have so much in common, that they must be considered as closely related, and interpreted in the same way. I can find no reason with Hall to refer them to the Algæ. If they were of that origin, we might expect to find a stem or axis. Dawson, who has especially examined the *R. Grenvillensis*, believes the more horizontally expanded form to be the cast of the tracks of some Trilobite, and the convex to be the cast of a hole excavated by the Trilobite for shelter or repose. He therefore alters the generic name into *Rusichnites*. This interpretation does not seem an unreasonable account of the horizontal form, but it does not explain so well the convex form; especially since it is difficult to understand how the ribs could have got the direction they have in *R. dispar*. The further objection that no Trilobites or other Crustacea are found in the lower Cambrian sandstone of Vestrogothia, is of less importance, as from the discoveries already made it is probable that even Trilobites lived when this layer was formed. Salter[1] thinks the species referred to the genus *Rhysophycus* to be short forms of the genus *Cruziana* of d'Orbigny,[2] and there certainly seems to be a great affinity between the two. D'Orbigny simply refers his *Cruziana* to the Articulata; Salter considers it an Annelid tube, somewhat coriaceous. D'Orbigny's name has priority.

On account of its plant-remains the Eophyton sandstone is considered by Professor Torell as probably a freshwater deposit. That this cannot be the case is proved by its also containing Brachiopods. From the frequent occurrence of *ripplemarks* and *rain-prints* it may be supposed to be a shore-deposit.

[1] Bigsby's Thesaurus Siluricus, p. 2.

[2] Voyage dans l'Amérique méridionale, iii., 2, p. 30, pl. 1, f. 1, 2; 1842.—Marie Rouault altered the name to *Fræna*, Bull. Soc. Géol. France, 2 Sér. Vol. vii. p. 729.

The upper division of the sandstone layer, or the Fucoid sandstone proper, is not so poor in fossils as has hitherto been supposed. In an earlier memoir[1] I have mentioned the discovery of a *Lingula* at Djupadalen near Karleby. During the last summer I searched in vain for the same species, but in place of it I collected several specimens of another *Lingula*. Among the specimens obtained not one is quite complete, and they exhibit no decisive generic characters. The rather singular sculpture of the shell however is admirably well preserved, and on that account the species may be named *Lingula* (?) *favosa*. The shell is depressed and has almost the form of a sector of a circle, somewhat exceeding a quadrant; its length is about 5 millimetres, the breadth being about 6 millimetres. The anterior half of the shell bears some sharp lines of growth and a few punctæ, but otherwise it is smooth. Behind the middle there follows a space closely beset with small excavations. At the very apex, which in all the specimens is more or less damaged, the shell seems again to be smooth. The colour, at least outside, is of a whitish blue.

EXPLANATION OF THE PLATES.

Plate XI. Figs. 1 and 2, *Lingula monilifera*, n.
" Figs. 3 and 4, *Eophyton Linnæanum*, Torell.
Plate XII. *Eophyton Linnæanum*, Torell.
Plate XIII. *Eophyton Torelli*, Linnarsson.

V.—On the Formation of Ravines by Recent Drift Accumulations.

By G. Henry Kinahan, M.R.I.A., etc.

IT is not unusual in drift deposits, banked on hill slopes, to find a deep cut occupied by a very minute stream. These cuts or ravines are supposed to be due to the streams; having been excavated by them in the banks of drift. If a ravine of this class is formed in one of the older drifts—namely, the Boulder-clay-drift or the Moraine-drift—it must apparently have been cut by a stream, but much of the drift banked on hill slopes is quite recent; that is formed by meteoric abrasion, and being added to at the present day. In these recent drifts, ravines are of common occurrence, and I would suggest that, instead of the stream cutting its ravine, meteoric abrasion has heaped up the banks, and the only action capable of being done by such a stream, is to keep its channel clear. Such accumulations of drift are very frequent in association with *Maums*, or connecting gaps across mountain-ranges, and there are always ravines in the banks,—yet by no arrangement of the water-supply, could streams be formed that would have the power to excavate them. In the accompanying sketch of Maumgeeha, Yar-Connaught, there is a maum, below which is a recent drift-bank with a ravine and its accompanying stream. None of the surface drainage of the hills on either side of the maum can get into the stream, it being fed by a spring, while the surface drainage of the mountains flows as represented by the arrows, and

[1] Bidrag till Vestergötlands Geologi. Ofvers. af K. Vet. Akad. Forh. 1868.

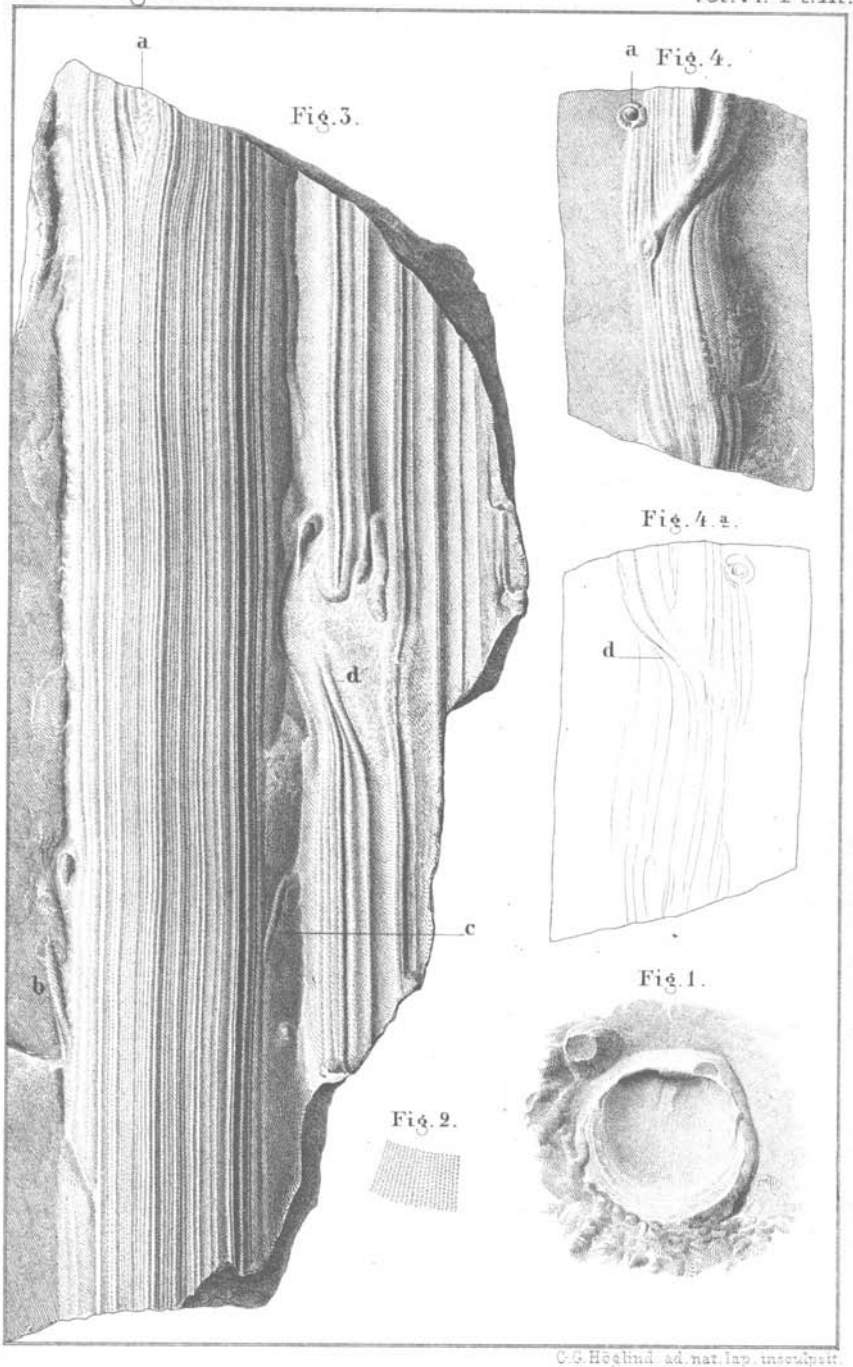
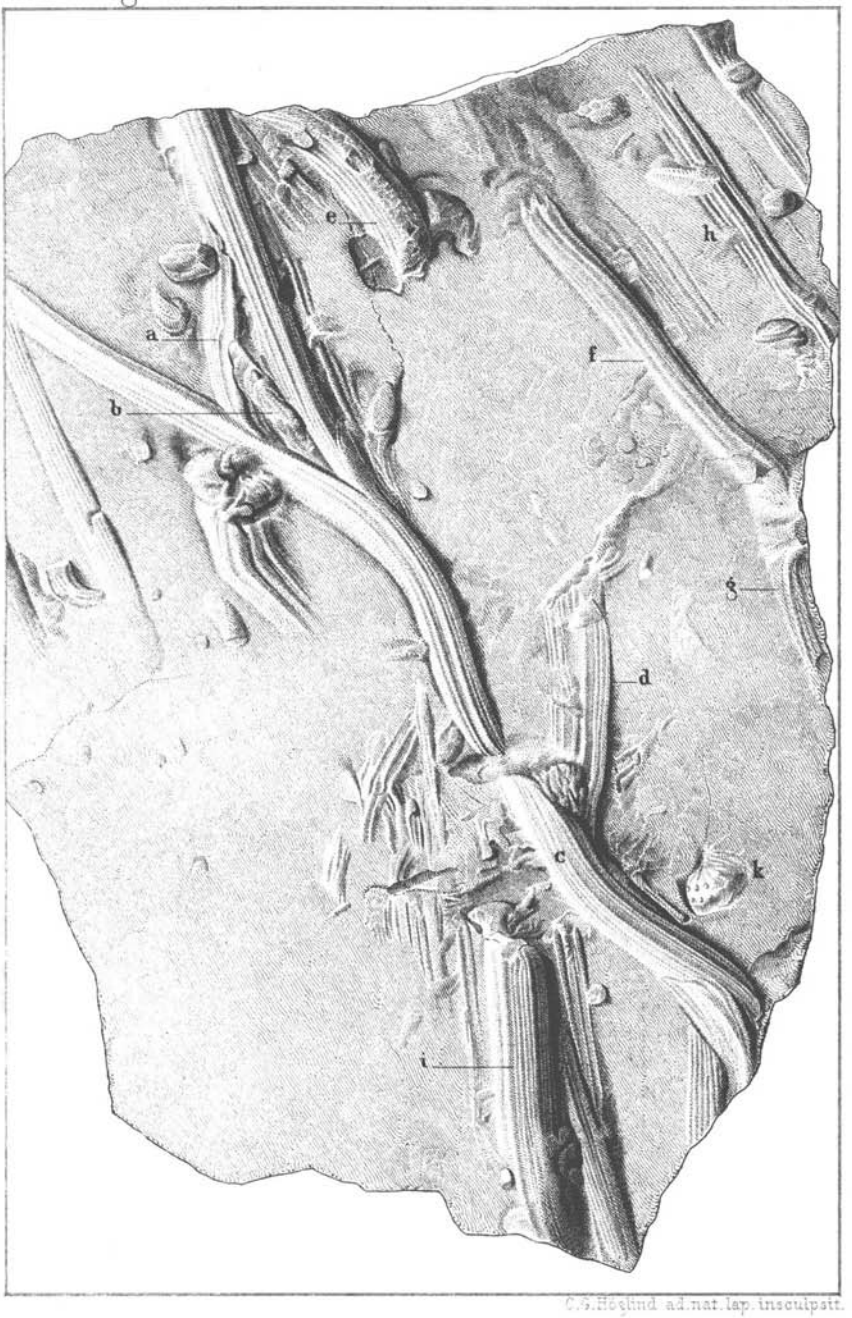
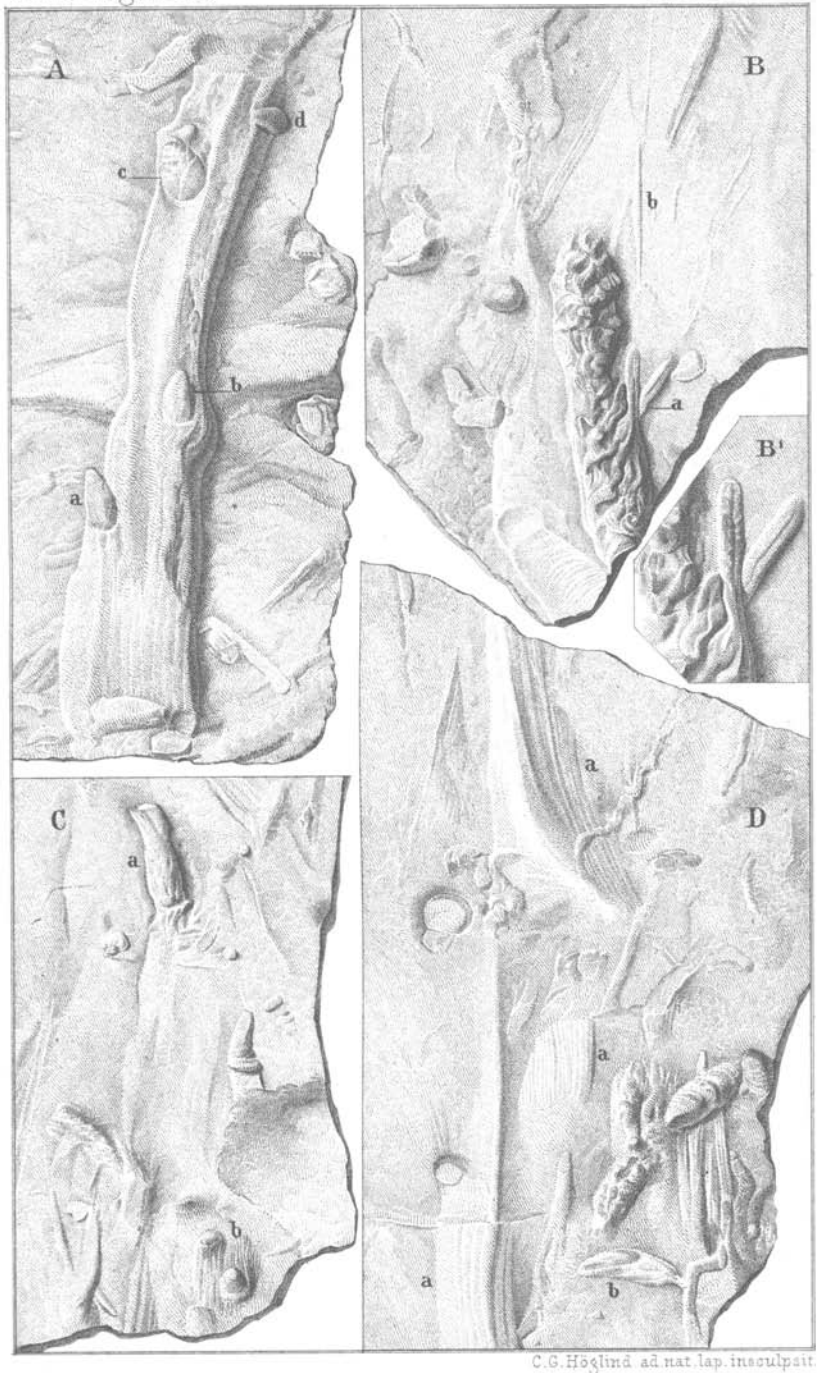


Fig. 1 & 2. Lingula monilifera Linnarsson.
Fig. 3 & 4. Eophyton Linnæanum Torell.



Eophyton Linnæanum. Torell.



C.G.Höglind ad.nat.lap.insculpsit.

Eophyton Torelli, Linnarsson