THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FIFTH SERIES.]

No. 65. MAY 1883.

XL.—*On the Affinities of the Genus* Pothocites, *Paterson; with the Description of a Specimen from Glencartholm, Eskdale.* By Robert Kidston, F.G.S.

[Plates IX.–XII.]

Introductory Remarks.

Last November I communicated to the 'Annals and Magazine of Natural History' a short note "On the Affinities of the Genus *Pothocites*, Paterson."

In this was included the description of a specimen, provisionally named *Pothocites calamitoides*, which was collected by Mr. T. Stock from the cement-stone group of the Calciferous Sandstone series, Glencartholm, Eskdale.

In the present paper it is my intention to illustrate and describe all the specimens of this genus which are known to me; the only one previously figured was that originally described by Dr. Paterson; but as there are a few points in his figure which are slightly misleading, I have thought it better to refigure *Pothocites Grantonii*, Paterson, along with the other specimens. This course is also advisable for the purpose of comparison.

The genus was founded by Dr. Paterson * for the reception of a curious fossil collected by him "in a mass of bituminous shale from the coal strata which are exposed along the coast at Granton, and nearly opposite Professor Hope's residence."

In discussing the probable affinities of his plant he says† :— "In taking a general view of this fossil, there are several living genera of plants to which it bears a resemblance, as *Typha*, *Calamus*, *Peperomia*, and *Pothos*. It will not be necessary to describe minutely the resemblance which it bears to either the *Calamus* or *Peperomia*, as it is distant, and does not stand minute examination. The first and last of these therefore, viz. the *Typha* and *Pothos*, it will only be necessary to enter into minute comparison with it.

"It approaches the genus *Typha* in having the reed-like stems, which terminate in a cylindrical head, and that head having one and occasionally two divisions. Although, however, this general description agrees, on more minute examination it will be obvious that it cannot be referred to the genus *Typha*. The pericarp in the genus *Typha* is surmounted with a feathery pappus, and has no scales surrounding the germen. Our fossil may have been a monœcious plant (the upper male part being wanting); but at all events it must have been a tetrandrous plant, from the remains of the four projections, which are represented in the magnified drawing. There is no appearance of there having been any pappus whatever, and therefore it is more likely to be referred to the genus *Pothos*. This class of plants, viz. the genus *Pothos*, is characterized by its spatha being monophyllous, spadix cylindrical, thickly set with flowers, perianth tetraphyllous, berry or capsule tetraspermous, the latter of which is occasionally terminated by four obtuse angles. They belong to the natural order *Aroideæ*. The characters of this class of plants will be found to apply very nearly to our present fossil, making allowance, of course, for the compression it has undergone, and the change of appearance produced by its mineralization.

"The greatest number of the species of the genus *Pothos* are parasitic, and inhabit the vast forests of tropical countries. In some of the species, also, there are truncated fleshy scales on each side of the germen, and which, in the young state, completely cover the male organs of the plant; these are especially conspicuous in *P. acaulis*. The similarity of the

* Paterson, "Description of *Pothocites Grantonii*, a new Fossil Vegetable from the Coal Formation," Trans. Bot. Soc. Edinb. vol. i. p. 45, pl. iii. 1841.

† Paterson, "Description of *Pothocites*, &c.," *l. c.* p. 50.

habitats also favours the idea of it belonging to this class of plants."

Dr. Paterson, in an earlier part of his paper, expresses his opinion that his specimen belonged to the class of parasitic plants.

He also directs special attention "to a slight enlargement of the stem abruptly broken off, very similar, in fact, to what we see in twigs from which the leaves have fallen off, and is evidently to be referred to the remains of a deciduous leaf or spatha"*.

In regard to the *stellate bodies*, situated in longitudinal rows on the spike, he further says †, "When viewed with a lens, these small bodies are seen crowned with from four to five (generally four) ovoid and obtuse projections, with elevated edges; these assume a quadrangular appearance, and give the idea of a germen or capsule, crowned with four or five obtuse angles. The central depression, to which the flowering part of the plant had been attached, is also distinctly to be seen."

The view held by Dr. Paterson that this plant "either belonged to an extinct species of the genus *Pothos*, or to some extinct genus of plants very closely allied to it," was at the time supported by Mr. M'Nab, of the Botanic Gardens, Dr. Greville, and many other gentlemen.

Prof. Henslow, who also examined the specimen, thought it was probably related to *Potamogeton* or *Pothos*. He conceived that the spadix was continuous and not jointed, the apparent joints being the result of compression. He could not see any evidence of ribs, and was "unable to determine the exact nature of the quadrifarious arrangement, whether the parts are calyx-scales, or seed-valves"‡.

In the following description of this specimen some points will be noticed in which, I believe, Dr. Paterson has been deceived by certain appearances in his fossil.

This view as to the affinity of *Pothocites* has been accepted by Mr. Carruthers, Prof. Balfour, and others §.

Prof. Williamson, however, has expressed some doubt as to the systematic position of the plant. In a lecture on

* *L. c.* p. 46. † *Ibid.* ‡ *L. c.* p. 52, *note*.

§ Carruthers, "On Fossil Plants," delivered to the Geologists' Association as Presidential Address, Nov. 5, 1875; "The Testimony of Fossil Botany in reference to the Doctrine of Evolution," Presidential Address, delivered to the Geologists' Association, Nov. 3, 1876; "Notes on some Fossil Plants," Geol. Mag. vol. ix. 1872.

Balfour, 'Introduction to the Study of Palæontological Botany,' p. 66 (Edinb. 1872).

Geikie, 'Text-book of Geology,' p. 732 (1882).

"Primæval Vegetation in relation to Natural Selection and Evolution" he says, "It is also necessary to state further that the Coal-measures reveal some other remarkable stems, the exact relations of which are not yet fully ascertained." Then in a footnote he adds, "This is especially in reference to the *Lyginodendra*, *Nœggerathiæ*, and to the curious *Pothocites Grantonii*, which latter is supposed by some botanists to be a monocotyledonous Angiosperm; this, however, appears doubtful. The genus *Antholithes*, from the Coal-measures, was regarded as a dicotyledonous Angiosperm allied to *Orobanche*; but this idea is now abandoned, and the plant is now referred to the group of Gymnospermous exogens. I expect that further research will lead to some similar change in regard to *Pothocites*" *.

Description of Specimens.

Pothocites Grantonii, Paterson. (Pl. IX. figs. 1–5.)

Pothocites Grantonii, Paterson, Trans. Bot. Soc. Edinb. vol. i. p. 45, pl. iii. (1841).

The full length of the specimen is rather less than $4\frac{3}{4}$ inches; of this the remains of the spike occupy $2\frac{4}{10}$ inches. This latter part consists of two complete segments and a portion of a third. Each internodal portion † of the fruit shows six longitudinal rows of *stellate bodies*, placed on slightly elevated ridges. It is difficult to determine definitely the original number of these vertical elevations, as the specimen is much compressed, and those towards the margins of the fruit are crushed together; but probably there were on the complete circumference ten such elevated ridges, bearing the stellate bodies; of course only five or six are exposed in the specimen. The two marginal rows are imperfectly shown; but the four on the now flattened, once circular surface are distinctly exhibited.

The *stellate bodies* are usually formed of four pointed projections, which radiate from a central depression; but in very rare cases they have five rays (Pl. IX. figs. 3 and 4).

In the enlarged view of these *stellate bodies* given at figure 3 on the plate which accompanies Dr. Paterson's description, the segments of the "quadrangular elevations" are represented as springing from a central tubercle; this is misleading, as no structure of this nature is shown on the fossil.

* W. C. Williamson, 'Essays and Addresses by Professors and Lecturers of Owen's College, Manchester,' p. 229. Macmillan, 1874.

† To the portions between the constrictions of the fruit I have applied the term internodal portions of fruit or spike.

In reality the segments conduct to a central depression. The appearance caused when these minute bodies are viewed with lateral illumination has probably led to this error in the figure. From Dr. Paterson's description it is evident that he recognized the true structure of these little stellate bodies; for he states, "The central depression to which the flowering part of the plant has been attached is also distinctly to be seen."

The appearance of a central column, as represented in his enlarged figure of the little stars, has probably been inadvertently indicated by the drawer of the specimen; but it has unfortunately been frequently copied without any explanation.

The internodal portions of the fruit bear about twelve of these *stellate bodies* on each longitudinal elevation.

I have given enlarged figures of two of these little *stars*, one composed of four, the other of five rays (Pl. IX. figs. 3 and 4).

I cannot distinguish any point to which the supposed "flowering part of the plant" could have been attached.

What appears as a border to the little stars is the upturned edges of the segments, which appear in section as represented at Pl. IX. fig. 5.

The lowest segment of the fruit is almost an inch long by five sixteenths broad, the second about seven eighths of an inch long and slightly narrower than the previous segment; and the third, which is imperfect, is slightly narrower than the second.

The stem to which the spike is attached is finely striated longitudinally.

The small projection from the side of the stem, about three-quarters of an inch below its junction with the fruit, is probably the remains of a branch which bore a similar spike (as will be shown in the description of the specimen from Barnton Pavement-stone Quarry), and does not represent the "remains of a deciduous leaf or spathe," as originally supposed.

The upper left-hand angle of the broken internodal portion is the most perfectly preserved; and it is his part which I have chosen for my enlarged drawing (Pl. IX. fig. 2).

The little "stars" are only shown on those parts of the specimen which have suffered least from pressure.

The specimen is deposited in the museum of the Royal Botanic Gardens, Edinburgh; and my thanks are due to the late Mr. Sadler, the curator, for permission to examine and refigure this interesting fossil.

Loc. From the Calciferous Sandstone series, shore, Granton.

The three following specimens have been already described by Mr. R. Etheridge, Jun.; but as they show some points of considerable value as regards the affinity of the genus *Pothocites*, I give a description of them here in full.

Pothocites Patersoni, R. Eth., Jun.
(Pl. X. figs. 6, 7, 8, Pl. XI. figs. 9 & 10, Pl. XII. fig. 14.)

Pothocites Patersoni, R. Etheridge, Jun., "Note on the Further Discovery of a Species of *Pothocites* (Paterson) in the Lower Carboniferous Rocks near West Calder," Trans. Bot. Soc. Edinb. vol. xii. p. 151 (1874).

Of this plant we have four specimens, representing two individuals. That figured on Pl. X. figs. 6 and 7, and Pl. XII. fig. 14, was obtained by Mr. James Bennie, fossil-collector to the Geological Survey of Scotland, from the black bituminous shale which overlies the oil-shale worked at Raeburn's Pit, near Gunn's Green Toll-bar, about a mile and a quarter north of West Calder.

The specimen, which is represented by the fossil (fig. 6) and the impression (fig. 7), measures in its full length three inches and three quarters. Four segments of this spike are shown; but it is imperfect towards its upper extremity.

This is proved by the central axis extending slightly past the last segment which has been preserved.

From the proportion which the uppermost segment bears to the other segments of the fruit it is probable that there originally were not more than two additional parts in the entire spike.

Of the whole length of the specimen the spike occupies about two inches and three fifths. The basal segment measures four fifths of an inch in length by three eighths of an inch in breadth. The segments decrease slightly in length and breadth as we recede from the base, the fourth being only seven sixteenths of an inch long and a quarter of an inch broad at its base; but it is somewhat narrowed at its apex. This narrowing of the segments at their apices, as will be shown in a specimen presently to be described, is only exhibited in the terminal portions of the fruit; the breadth of the lower segments in all the specimens is almost uniform throughout their entire length.

From the amount of pressure to which this specimen has been subjected, it is a matter of considerable difficulty to determine accurately the number of the longitudinal elevated ridges on each segment; but they appear to have had on their exposed surfaces six such rows, which run continuously through all the segments.

Towards the outer margins of the spike these only appear as dentate longitudinal lines.

Only the two lower segments show the cast of the original plant *in situ* (fig. 6); and although it has suffered much from compression, it stands out in considerable relief. The outer surface is also badly preserved; but still it shows what appear to be the same peculiar *stellate bodies*, so well shown on *Pothocites Grantonii*.

These do not seem to have been observed by Mr. Etheridge; but it is only on a small portion of the specimen, towards the right-hand margin of the basal segment, that they can be deciphered. They are so small that very favourable illumination is necessary for their detection.

The spike, as shown by the impression and the cast, has the general appearance of the longitudinal ridges being crossed by transverse bars, as mentioned by Mr. Etheridge.

The stellate bodies are situated at the extremities of these cross markings, which are connecting-ridges.

From the imperfect preservation of the little "stars," the transverse bars form a more prominent characteristic on this fossil than they do in better-preserved examples.

The little branch to which the spike is attached measures one inch and a fifth in length, and shows two swollen nodes.

The second internode is slightly larger than that next to the fruit. The presence of distinctly marked nodes and internodes, which are even better shown in two of the following specimens than in this one, throws great light on the systematic position of these fossil plants.

Mr. Etheridge, in his description of this specimen, says "that the longitudinal divisions of the cylindrical head were apparently crossed by transverse ridges, which may perhaps be caused by imperfect preservation or some peculiar state of the scattered rounded or quadrangular bodies mentioned by Dr. Paterson."

My examination of this example quite corroborates Mr. Etheridge's views in regard to these surface-markings.

The true nature of these bar-like markings is much better indicated in the Eskdale plant, where they are shown to be merely elevated ridges, extending from one sporangium to another.

Pothocites Patersoni, R. Eth., Jun. *
(Pl. XI. figs. 9 and 10.)

This example is preserved in a similar shale to the previous

* *L. c.* Trans. Bot. Soc. Edinb. vol. xii. p. 151.

specimen, and was also collected by Mr. Bennie from the Calciferous Sandstones at Fell's Pit, near the north-west corner of Briestonhill Moss, about three quarters of a mile north of West Calder.

The cast and impression of this specimen have also been secured. The fossil measures nearly four inches in length; but the spike is very imperfect, and only shows the lowest and a very small fragment of the second segment, which together occupy an inch.

The cast only shows the lowest segment, whose external surface is unfortunately very indifferently preserved; but it still retains a considerable amount of rotundity.

Notwithstanding the unsatisfactory state of its preservation, there are distinct indications of the quadrate bodies. These can be most easily examined by making a wax cast of the impression of the spike.

The lowest segment is nine tenths of an inch long; the sides are straight; the breadth, which is equal throughout, is three tenths of an inch.

The little branch to which the fruit is attached is two inches and three quarters long, very slender, and shows three swollen nodes; this in turn springs from a stouter stem, one inch and three quarters long, which is faintly striated longitudinally and also shows two nodes, from the lower of which the fruiting-branch springs.

On the same slab is the impression of another noded stem (not shown in the figure), whose length is one inch and three quarters, and breadth a little more than the fifth of an inch.

As it is not organically connected with the *Pothocites*, no direct evidence can be drawn from it. Its character, however, is identical with that of the branch to which the fruit is attached; and their association is not without significance.

On the cast of the specimen, where the details of the remaining segment of the spike are best preserved there appear to be four longitudinal rows of little pits, which, of course, on the plant must have been elevations.

Pothocites, sp. (Pl. X. fig. 8.)

Pothocites, sp., R. Etheridge, Jun., "On a new Locality for *Pothocites* (Paterson)," Trans. Bot. Soc. Edinb. vol. xii. p. 162 (1874).

This specimen exhibits little more than a carbonaceous stain on the stone, but is of great interest as being the only one, as far as I am aware, which shows two spikes terminating the extremities of a dichotomous branch. The impression of the plant is about three inches and a quarter long, the stem

occupying about two inches; each of the forks of the dichotomy measures about an inch. The spikes show imperfect longitudinal rows of little tubercular depressions and the usual constrictions which divide the fruit into segments.

We have seen from the description of the previous specimen that the branch bearing the spike arose from another similar but slightly larger stalk. This alone might have given us some insight into the nature of the small projection from the side of the stem of *Pothocites Grantonii*; but in this example its true nature is very clearly explained.

It would appear, then, that there is the greatest probability, if not positive certainty, that the little projection from the side of the stem of *P. Grantonii* is the remains of a branch which bore a similar spike to the one which has been preserved.

From the evidence adduced from this and the last-described specimen, it seems quite impossible to hold any longer the view so often expressed, that the "little projection" is evidently to be referred to the remains of a deciduous leaf or spathe *.

This specimen is also of Calciferous-Sandstone age, and was collected by Mr. James Bennie at Barnton Pavement-stone Quarry, Corstorphine Hill, near Edinburgh.

Pothocites calamitoides, Kidst. (Pl. XII. figs. 13, 15, 16, 17.)

Pothocites calamitoides, Kidston, "On the Affinities of the Genus *Pothocites* (Paterson)," Ann. & Mag. Nat. Hist. Nov. 1882.

This example was collected by Mr. T. Stock from the Cement-stone group of the Calciferous-Sandstone series, Glencartholm, Eskdale.

It is fully seven inches long; of this the spike occupies a little less than five inches and a half, and is, so far as is known to me, the first specimen in which the fruit is shown up to its extremity.

The spike contains eight segments, of which the three basal are about the same size and measure four fifths of an inch long by half an inch broad; the fourth and fifth segments (counting from the base upwards) are about equal to each other in size, but slightly less than those below them. They measure about seven tenths of an inch in length, and are slightly less than half an inch broad.

The succeeding segments decrease in size, the terminal one being only three tenths of an inch long. The upper extremities of the last three segments, but especially of the last two, are narrower than their basal portions; and in the apical one

* Paterson, *l. c.* p. 46.

this is very marked, causing it to have a truncated triangular outline.

The general contour of the other segments is quadrate; their sides are parallel; but the constrictions of the spike at the nodal regions cause a rounding of their angles.

The circumference of each segment has had about fourteen longitudinal rows of sporangia. On the surface exhibited on the fossil four rows are seen to occupy the greater portion of each segment; but on each side, one, or perhaps two, additional longitudinal rows of sporangia are exhibited. These, on account of the flattening of a once circular structure, appear now merely as longitudinal lateral ridges.

The sporangial ridges run continuonsly throughout the whole length of the spike, and do not alternate at the nodes.

On the upper segments of the spike these longitudinal elevations bear little quadrate protuberances with rounded angles and slightly notched sides (Pl. XII. fig. 16). Their outline is ill defined.

On the basal and older segment a few of the characteristic *stellate bodies* are shown. These are not so clearly seen as in *Pothocites Grantonii*, but are quite discernible (Pl. XII. fig. 17).

They are of about the same size as the quadrate bodies mentioned as occurring on the upper segments.

From this similarity in size it would appear that the *stellate bodies* are formed by the *quadrate protuberances* splitting in lines running from their centre to the apices of their rounded angles; and the four segments so divided subsequently become deflexed.

From the facility with which one can trace the development of the *stellate bodies* on this specimen, I am forced to the conclusion that the so-called "four-cleft calyx" is merely the deflected segments of sporangia which have shed their spores.

The sporangia connecting elevated transverse ridges, to which reference has been already made, are very well shown on this example.

The outer surface of the quadrate protuberances is roughened by slightly elongated apiculi.

The stem to which the fruit is attached shows three swollen nodes and is faintly striated longitudinally.

Its upper internode is very short, and measures only three tenths of an inch in length and a little less than two tenths of an inch in breadth. The internode immediately below it measures fully half an inch in length, whilst the lowest is four fifths of an inch long. The fourth internode is incomplete. The stem increases slightly in breadth from above downwards.

One of the most interesting points shown on this specimen is the verticils of leaves which are given off from the nodal regions of both spike and stem. This is shown more or less distinctly at all the nodes of stem and spike except at the lowest node of the stem, where a verticil of tubercles marks the site of the leaves which have fallen off.

The remains of the largest leaf measure half an inch; but more important is their dichotomous structure as exhibited by the leaves at the fourth, fifth, and sixth nodes of the fruit, counting from the apex.

This specimen was presented by Mr. Stock to Mr. John Young, Curator of the Hunterian Museum, Glasgow University. My thanks are due to both of these gentlemen for allowing me to examine and describe this beautiful specimen.

I am also indebted to Prof. A. Geikie, Director-General of the Geological Survey of Great Britain, for kindly allowing me the use of the specimens in the Geological Survey collection while preparing these notes.

From the examination of these five specimens of *Pothocites* it is shown that the plant possessed a segmented fructifying spike or cone. In the only perfect specimen the fruit consists of eight segments. The segments are formed by a constriction which corresponds in position to the nodes of the axis. On the circumference of each internodal portion of the fruit there have been from ten to fourteen longitudinal elevations which bore sporangia; these in the young state appear externally as quadrate bodies, having their angles rounded and a shallow notch on each side. The sporangia open in a definite manner, by a cleft passing from the apices of the angled corners towards their centre; and by the margins of the split sporangia becoming deflexed the so-called calyx-segments are formed.

The spike is also attached to a stem composed of nodes and internodes, which branched in a more or less equal dichotomous manner, and bore, at the extremities of the dichotomous branches, cones or spikes.

The stem also shows traces of longitudinal furrows.

Verticillate dichotomously formed leaves are given off from the nodes of both spike and stem.

From such important structural evidence it appears no longer possible to regard *Pothocites* as a Monocotyledon, and I am inevitably led to the conclusion that *Pothocites* is not the inflorescence of an Aroid, but the fructification of a Calamitaceous plant.

But from the material before us we can, I think, place the genus *Pothocites* in a much more defined systematic position

than merely indicate its nature to have been that of a Calamitaceous plant.

The characters by which we are enabled to show its more particular affinity are the leaves, fruit, and stem.

The foliage is distinctly dichotomous in its structure, as seen in the example from Eskdale.

The furrows on the stem are too indistinct to show whether or not they alternate at the nodes*.

The segments composing the fruit must, however, be regarded as the homologues of the internodes of the stem, so, in all likelihood, the longitudinal ridges of the segments of the fruit represent the furrows of the stem.

In the spike we see that the longitudinal rows of sporangia do not alternate at the nodes, but pass continuously throughout the whole fruit.

In the genus *Bornia*, F. A. Röm. (*Archæocalamites*, Stur), the furrows on the stem do not alternate at the nodes as in ordinary Calamites ; and this well-marked character, possessed by no other carboniferous fossil plant, so far as I am aware, gives it an individuality which cannot be mistaken. Likewise in *Pothocites* we find that the longitudinal elevations which bear sporangia do not alternate at the nodes, but pass continuously throughout the whole length of the spike ; and these ridges, I believe, are simply a modification of the furrows of the stem.

In the genus *Calamites*, where the furrows on the stem alternate at the nodes, we have no reason to suppose that this character would alter, even were they known to produce a *Pothocites*-like cone. But the fruit of the *Calamites* is well known ; and whatever specific differences there may be in the described genera and species of their fructification, they are always of the *Volkmannia* type ; hence it is not at all probable that *Pothocites* belongs to this group of the Calamiteæ.

The dichotomous nature of the foliage is not, however, restricted to the genus *Bornia*.

* It is an unsettled point amongst vegetable palæontologists whether the stems of *Calamites*, in their natural condition, possessed a smooth or a furrowed bark. Some contend that the outer surface of the stem was longitudinally furrowed, others that it was quite smooth, and that the furrows have been imparted by external pressure, or even that the fluted casts, which are of so common occurrence, are merely the internal casts of the hollow stems. But it is generally admitted that when *Calamites* occur as mere casts or impressions they almost invariably show a fluted exterior. Hence, in dealing with fossils in this condition (a condition in which all the specimens mentioned in these notes occur), the furrowing of the stem becomes of generic value, whatever structure the outer surface of the stems may have had when growing.

Stur has described a small *Sphenophyllum* (*S. tenerrimum*, Ett. MS.*) which also possesses dichotomously divided leaves. But this is easily distinguished from *Bornia radiata*, Brongn., by the leaves being much smaller and less regularly dichotomous. The fruit of this plant has also been described by Stur, and consists of a small *Volkmannia*-like cone.

Even on young branches of *Bornia radiata* the foliage is of considerable size. In the *Pothocites* from Eskdale (Pl. XII. fig. 13) we have apparently only the remains of the leaves, little more, indeed, than to show that leaves were given off from the nodal regions of the spike and stem.

For the purpose of comparison I have given three figures of *Sphenophyllum tenerrimum*, Ett. MS. (Pl. XI. figs. 11, 12, and Pl. XII. fig. 18); and as I have been unable to secure good specimens of foliage-branches of *Bornia* (*Archæocalamites*) *radiata*, Brongn., I give a copy of a figure by Feistmantel (see p. 310), which shows both foliage and the fragmentary remains of an undoubted fruit of *Bornia radiata*. This specimen was originally described under the name of *Asterophyllites spaniophyllus*, Feistm.†

Stur figures two other specimens of fruiting branches of *Bornia* (*Archæocalamites*) *radiata*, Brongn.

Both of these are very imperfect, and can only be fully understood from an examination of more perfect specimens.

That on pl. iii. fig. 5‡ represents a *Pothocites* in a very young state: two entire segments of the fruit are shown; but the upper part is hidden by a tuft of leaves.

The foliage arising from the nodal regions of the two segments shows very beautifully its full size and structure. That figured by the same author (pl. iv. fig. 9) is so imperfect that it gives no insight into the nature of the fruit.

To explain more fully the structure of the fruit of *Bornia radiata*, Stur gives two figures (enlarged two diameters) of the fragment of the spike on Feistmantel's original specimen (see p. 311) §.

His latter figure is a corrected drawing of the former; hence with it only we have to deal.

It is so very imperfectly preserved that the original describer remarked regarding it, "a cone-like structure is attached to

* Stur, Culm-Flora, pl. vii. p. 214.

† Feistmantel, O. "Das Kohlenkalkvorkommen bei Rothwaltersdorf in der Grafschaft Glatz und dessen organische Einschlüsse," Zeitschr. d. deutschen geol. Gesellsch. vol. xxv. pl. xiv. fig. 5, p. 498 (1873).

‡ Stur, Culm-Flora, Band i. p. 15, fig. 4, Band ii. p. (23) 129, fig. 9 (1875–7).

§ Stur, *l. c.*

Branch of *Bornia radiata*, Brongn. (*Asterophyllites spaniophyllus*, Feistm.), showing fragment of a fruit and foliage. (Copied from Feistmantel, *l. c.*)

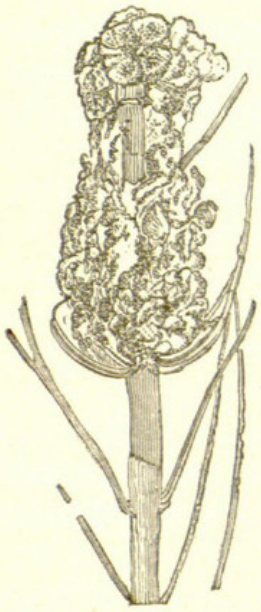
the upper end of the present example, which may perhaps belong to it as a fructification; but, owing to its indistinctness, a closer investigation is impracticable"*.

Stur gives a very full description of his figure of this fragmentary cone of *B. radiata*, of which the following abstract contains the principal points which demand our attention :—

At the base of the spike the remains of a whorl of leaves are shown; in the whorl of leaves immediately below this; one of the leaves reveals its characteristic dichotomous structure. In the middle of the preserved portion of the cone, the presence of a second leaf-whorl is indicated by a single leaf. At the upper part of the cone portion is a "*receptaculum*," so exposed that one is enabled to see its outer surface. He further states that this "*receptaculum*" appears as if "divided into four slightly elevated lappets;" and he supposes that each of the "lappets" corresponds to the position of a sporangium attached below.

* Feistmantel, *l. c.* p. 498.

The upper surface of this "*receptaculum*" is unevenly rough. He further points out that the four "lappets" of the shield are only indistinctly separated from each other, being isolated only at the outer edge, but towards their inner grown together. Their dividing line is indicated by a shallow radial furrow; this, he thinks, may perhaps mark the point of the attachment of the "shield" to a stalk.



Fruit of *Bornia* (*Archæocalamites*) *radiata*, Brongn. (From Stur's 'Culm-Flora,' p. 129.)

Stur also thought it very probable that four sporangia hung from the inner surface of the shield, and that, in consequence of pressure, their presence had caused the four slight elevations or "lappets" on the upper surface.

According to this view, he thought it highly probable that the fruit of *Bornia* included several internodes, and that on the axis, between the leaf-whorls, several whorls of "*receptacula*" were borne; these consisted of a stalked, slightly lappeted shield, bearing on its inner surface four or five sporangia. He also believed the sporangia were (in opposition to recent *Equisetum*) elliptical, flattened, and granulated, about 1·4 millim. long by 0·6 millim. broad. One of the sporangia showed a beak-like projection at one end, which he thought indicated its point of attachment. He goes on to state that the stem, a small portion of which was exposed in the cone, was not jointed.

There are several points in this description which agree entirely with the Scotch specimens. Stur appears, however, to have been misled in some particulars by the imperfection of the example on which his opinions were founded.

We see here again, as in the other figures of this author already cited, the division of the fruit into segments.

The leaf indicating the nodal region, to which reference has already been made, springs from a point a little lower down the axis than the part where the axis is exposed; hence the node is not seen. In plants of this class the presence of a leaf indicates the presence of a node.

In the Eskdale plant this is clearly shown; but one of Stur's figures also shows the same character*.

But the most important structural point of agreement be-

* *Loc. cit.* pl. iii. fig. 5.

tween the Scotch specimens and the plant he so fully describes is afforded by the "*receptaculum*," which he says is "divided into four slightly elevated lappets," with an unevenly roughened surface.

This agrees in every respect with those shown on the upper portion of the *Pothocites* from Eskdale (Pl. XII. fig. 16). Their size also is almost similar.

Whether each of the lobes of the little quadrate bodies represents a sporangium, or the sporangium is four-lobed, I have not sufficient evidence to decide. It is quite possible that the sporangia were arranged in groups of four. It is, however, evident that the "stellate bodies" are formed by an outward radial splitting of the four lappets, the split edges of which eventually become deflexed.

The shield-like structure (quadrate bodies) of Stur is formed by the sporangia (or sporangium), and does not appear to be a peltate expansion to which they were attached as he supposes.

As already indicated, the sporangia are located on elevated longitudinal rows, which I regard as the equivalents of the furrows on the stem. But it must also be noted that the sporangia of contiguous rows stand opposite to each other.

From this comparison of the structure of the fruit, foliage, and stem of *Pothocites* with undoubted fruiting specimens of *Bornia radiata*, their agreement is so complete that it appears to me this genus can only be regarded as the fruit of *Bornia* (*Archæocalamites*) *radiata*, Brongn., or of a closely allied species of the same genus.

In the short description which I originally gave of the specimen collected by Mr. T. Stock at Glencartholm, it was provisionally named *Pothocites calamitoides*. I have since compared it carefully with the original type, and now find that the points I regarded as of specific value cannot be retained as such.

The chief character which induced me to bestow a specific name upon this specimen was the much greater breadth of the segments in proportion to their length, when compared with *Pothocites Grantonii*.

But this diversity is fully explained when we take into consideration the different states of development in which the two specimens occur.

In *P. Grantonii* the fruit appears to have passed maturity and shed all its spores, as indicated by the split sporangia, whereas in the Glencartholm example the lowest segment alone appears to have attained to this degree of ripeness, as only on it the "stellate" sporangia are shown.

In the course of development, we have every reason to believe that during the maturation of the spike the internodes would become elongated; so probably this difference in general outline is only indicative of a different state of development. It agrees with *Pothocites Grantonii* in all other respects.

The absence of nodes on the stem of *P. Grantonii* seems to be entirely due to changes it has undergone during mineralization. The specimen from Barnton Pavement-stone Quarry has also no indication of nodes on the stem; but, from the evidence afforded by the other specimens, there can remain little doubt as to both it and *P. Grantonii* having originally possessed stems similar in this respect to the other examples.

In regard to *Pothocites Patersoni*, Eth., the chief characters on which this species was founded consisted in the absence of the stellate sporangia and the presence of the "transverse bars." I have already mentioned that there are distinct indications of the stellate-like sporangia, and that the degree of prominence of the transverse bars depends greatly on the physical conditions under which mineralization has taken place.

In the plant I provisionally named *Pothocites calamitoides* the transverse bars are very distinctly seen, and associated with them we have the stellate sporangia placed upon their little knob-like extremities.

For these reasons, as well as the evidence afforded by the detailed descriptions of the various specimens, I believe that all these fossils are to be referred to *Pothocites Grantonii*, Paterson, and, further, that this plant is not a distinct and separate species, but the fructification of a species of *Bornia*, Röm., probably of *Bornia radiata*, Brongn. sp.

EXPLANATION OF THE PLATES.

Plate IX.

Fig. 1. Fruit of *Bornia radiata*, Brongn. (*Pothocites Grantonii*, Paterson). The fruit shows two perfect segments and a portion of a third. Each segment has several longitudinal ridges bearing sporangia which have opened. (Nat. size.) From the Calciferous Sandstone series, shore, at Granton.

Fig. 2. Portion of the uppermost segment of the same specimen, showing the arrangement of the sporangia. (Magnified.)

Fig. 3. An open sporangium composed of five rays, from the same specimen. (Magnified.)

Fig. 4. Another sporangium, with four rays. (Magnified.)

Fig. 5. Diagrammatic section (at right angles to the surface) of one of the rays on *Pothocites Grantonii*, Pat., showing that the apparent "*border*" to the rays is caused by an upward turning of their margins.

Plate X.

Fig. 6. Fruit of *Bornia radiata*, Brongn. (*Pothocites Patersoni*, Eth.), showing the fruit attached to a calamitic stem. The spike shows three segments and a portion of a fourth. From the Calciferous Sandstone series, Raeburn's Pit, near West Calder.

Fig. 7. Impression of the same specimen, which shows more distinctly the transverse bars on the segments of the fruit. This example is imperfect, as indicated by a small portion of the axis extending beyond the uppermost segment preserved in the fossil.

Fig. 8. Fruit of *Bornia radiata*, Brongn., showing two spikes terminating the extremities of a dichotomous branch. From the Calciferous Sandstone series, Barton Pavement-stone Quarry, Corstorphine Hill, near Edinburgh.

Plate XI.

Fig. 9. Fruit of *Bornia radiata*, Brongn. (*Pothocites Patersoni*, Eth.), showing the lowest segment. The fruit is attached to a stem composed of swollen nodes and internodes. The fruit-bearing branch springs from another similar but slightly stouter stem. (Nat. size.) From the Calciferous Sandstones, Fell's Pit, near West Calder.

Fig. 10. The impression of the last specimen. (Nat. size.)

Fig. 11. *Sphenophyllum tenerrimum* (Ett. MS.), Stur. From the Calciferous Sandstone series, Raw Camps, East Calder.

Fig. 12. The same. From the Calciferous Sandstone series, Burdiehouse. (In the Hugh Miller collection, Museum of Science and Art, Edinburgh. My thanks are due to Prof. Archer for permission to figure this specimen.)

Plate XII.

Fig. 13. Fruit of *Bornia radiata*, Brongn. (*Pothocites calamitoides*, Kidst.), showing a perfect spike composed of eight segments attached to a calamitic stem. Leaves are given off from the nodal regions of both stem and fruit, some of which show the dichotomous nature of the foliage. From the Calciferous Sandstone series, Glencartholm, Eskdale.

Fig. 14. *Bornia radiata*, Brongn. Enlarged sketch of the impression of the basal portion of the fruit of the specimen from Raeburn's Pit, West Calder, showing transverse bars and node on stem.

Fig. 15. Lowest node of the stem of the Eskdale specimen, showing scars from which leaves have fallen. (Enlarged.)

Fig. 16. Two unopened sporangia, from an upper segment of the spike of the same specimen. (Enlarged.)

Fig. 17. One of the open (stellate) sporangia, from the lowest segment of the same example. (Enlarged.)

Fig. 18. *Sphenophyllum tenerrimum* (Ett. MS.), Stur. From the Calciferous Sandstone series, Raw Camps, East Calder.

Figs. 6–11, 14, and 18 are from specimens in the collection of the Geological Survey of Scotland, Edinburgh.