

ART. XXXVIII.—*On some questions concerning the Coal Formations of North America*; by LEO LESQUEREUX. (Continued from vol. xxxiii, p. 216.

Concluding Remarks on the Fossil Ferns.

THE examination of the fossil ferns of the coal, as far as it has passed under review in the former papers,¹ would apparently authorize the three following conclusions.

1st. That the family of the Ferns was represented, at the coal epoch, by species whose forms are easily referred to very few typical forms. For, if we consider only the figure of the leaves, viz., their contour and nervation, the only part generally preserved in the shales of the Coal Measures, all the species may

¹ Vol. xxxii, p. 193, Sept., 1861, and vol. xxxiii, p. 206, March, 1862.

be comprised in the three sections formerly examined: the *Neuropterideæ*, the *Pecopterideæ* and the *Sphenopterideæ*.

2d. That, from the scarcity of fructified specimens of fossil ferns in the Coal Measures, it would be supposed that most of the species were without fruit. If not, how can we account for the total destruction of the sporanges, either borne on peculiar stems, or attached to the lower surface of the leaves, as we find them in the species of our time?

3d. That the scarcity of large stems that have been or might be referred to ferns would lead us to suppose that, during the formation of the coal, the fern trees were of rare occurrence, at least when compared with the great number of ferns, which, in opposition to arborescent species, can be called herbaceous or shrubby.

These three questions must be considered separately.

1st. If it is certain that characters taken from the form of the leaves and from their nervation are sufficient for a kind of general classification, applicable to the stratification of the Coal Measures, it is true also that this classification fails to give us a clear insight into the true relation and the affinity of our fossil species. To be exact and scientific, an analysis of the ferns must take into account the form and the position of the fructifications; and when these are absent or undiscernable, as is generally the case with the specimens found in the Coal Measures, we are not authorized to believe that all the species, referable by their nervation and the form of the leaves to a common type, are equally related to it, by more essential but unknown characters. Indeed, though the attempt at a classification of the fossil ferns of the coal, from their fructifications, has been till now an abortive effort, the little we know of these fructifications shows a far greater diversity of typical and generic forms than are indicated by the leaves and their nervation. The fruiting leaves of the *Neuropterideæ* are known, from European specimens, only for the genus *Odontopteris*, which, as Mr. Brongniart has remarked, do not bear any relation to ferns of our time. Species of this genus have their spores enclosed in a kind of bladdery sporange, or between the surfaces of the leaflets, which, thus inflated, wrinkled and without any trace of nerves, entirely lose their original shape. American specimens of this species perfectly agree with the beautiful figures that Mr. Gœppert has given of it in his *Genera*. The peculiar shape of the fructifications of this genus is still more remarkable on the fruiting specimens of *Odontopteris Britannica* Gutb., a species which has not yet been found in our American Coal Measures. Its sporanges, placed along a strong rachis and on both sides of it, have the form of an oval-pointed nutlet and rather resemble a raceme of fruit, or rather a branch bearing buds of flowers, of a dicotyledonous

species. Fine specimens of these supposed *Antholites* have been published by Lindley and Hutton, from the Coal Measures of England, and by Dr. Newberry, from our own coal fields. I have found also some small specimens of these peculiar remains at Pomeroy, Ohio, and at Port Carbon, Penn. All these, either naked or bracteated nutlets, appear to be only branches of fruiting stems of some ferns of an unknown type.

The fructifications of the genus *Neuropteris*, which, by the form of the leaves and the nervation, is closely allied to *Odontopteris*, appear to have a far different character. These fructifications, I think, are not known from European specimens; but we have a few from the American Coal Measures, which can be reliably considered as the remains of fruiting parts of some species of this genus. Two of them represent reduced forms of the upper part of a penna of *Neuropteris hirsuta* Lsqx. The leaflets are longer and narrower; the rachis and the medial nerve are flat and broad, and look rather like the branches and divisions of a panicle bearing sporanges. The veins are prominent, granulate, just as if a series of small fruit dots connected together had been placed either along them, or in the narrow space that separates them. If this appearance is real, these fructifications would bear a likeness of position to those of the *Danaeæ* of our time. But not of direction, indeed; for, in this species of our Coal Measures, the nervules are arched and dichotomous or forking like those of a true *Neuropteris*. Another remarkable specimen, preserved in a pebble of carbonate of iron, from Morris Co., Illinois, represents also a branch of a species of fructified *Neuropteris*. In this, the short, ovate, slightly pointed leaflets, about one inch long, and deeply cordate at the base, are attached to the rachis by a short pedicel. They are slightly convex or inflated in the middle, with a narrow margin apparently reflexed, but at the same time flattened all around. The scarcely visible veins are distant and apparently forked once, or the surface, generally quite smooth, is marked by irregular undulate cross-wrinkles, somewhat resembling those of the fructifications of an *Odontopteris*. In this case, the spores appear to be placed in large flakes, covering, except a narrow border, the whole of the lower surface of the leaves, as is the case with the fruit-bearing leaves of some species of *Osmunda* of our time. Thus, in the same genus, there are apparently two far different types of fructifications.

A peculiar specimen of fruiting fern, belonging to the Cabinet of Amherst College, and labelled, Mansfield,? Mass., shows a pinnately divided frond or rather panicle, whose secondary rachis is pinnately subdivided into short branches, bearing numerous groups of fruit dots, placed four by four on each side of a common branchlet. They appear attached to it, each by a very slender pedicel; and, round as they are, with a depressed point

in the middle, they look, at first sight, like the fruit dots placed on both sides of the medial nerve of a *Pecopteris*, whose derma or foliaceous tissue has been entirely destroyed. As no trace of this tissue can be seen, as the pedicels do not resemble veins, but are curved in a peculiar way, and as the fruit dots are at some places scattered and not in regular order, this fossil raceme is more likely the fruit-bearing part of a species whose sterile frond is possibly known with other characters. If it is so, this species would have a relation to the genus *Aneimia* of the living ferns, and thus, it could not enter into any of the three general divisions mentioned above.

The same can be said of *Staphylopteris stellata* Lsqx., of the low coal of Arkansas.² The figured specimen represents a smooth, main stem or branch, pinnately divided into short, thick, horizontal branchlets, each bearing at its extremity a group of four or five oval sporanges, attached to a common receptacle. This species has no affinity whatever with any other fossil remains of ferns, found in the Coal Measures, and thus it is without a place in our general classification.

From a number of fruiting branches of still undescribed fossil ferns, I will only briefly describe another remarkable species recently found at Mason Creek, Morris Co., Ill., by Mr. Even, who has sent, from the same locality, many interesting specimens, beautifully preserved in pebbles of carbonate of iron.³ The specimen shows the upper part of a pinnately divided frond. The divisions are short, (one inch) and comparatively broad, (one-sixth of an inch) linear, obtuse, spreading, decurring in preserving the same breadth on a slender rachis, which, thus broadly winged, looks rather like the primary nerve of a secondary pinna. The veins, emerging in a broad angle from this common rachis, are straight, pretty thick, ascending to the top of the divisions and pinnately branching. The distant simple veinlets, no more than three or four on each side, slightly arched, diverging in a broad angle, bear at their extremity a group of six oval sporanges, placed just on the borders of the divisions. These sporanges, united by their margins around a common receptacle, appear, by this disposition, like small stars with round lobes. Considering only the form of the leaves, this species should be

² Geological Report of the State Survey of Arkansas, ii, 309, pl. 2 fig. 2.

³ A deposit of the same nature, a bank of clay iron ore with pebbles of carbonate of iron, is also found in Southern Ohio, northwest of Marietta. Nearly all the pebbles have as a matrix a piece of fern or of some other fossil plant. As the species are the same both in Illinois and in Ohio, I consider both these strata, from palæontological evidence, as having the same geological horizon. Their place, according to the same evidence, is at or near the level of Coal No. 4, just below the base of the Mahoning sandstone. The most abundant species are *Pecopteris unita* Brgt., *Neuropteris hirsuta* Lsqx., *Pecopteris arborescens* Brgt., *Pecopteris Miltoni* Brgt., *Hymenophyllites hirsuta* Lsqx., *Alethopteris Serlii* Brgt., *Asterophyllites*, *Sphenophyllum*, *Annularia* and *Neuropteris Loschii* Brgt.

placed in the genus *Alethopteris*. But it differs widely from it by its nervation and especially by its fructifications. These would bring this species near the genus *Asterocarpus* of Göppert, or the *Heptocarpus* of Braun, to which it has no affinity whatever by the leaves and the nervation. From examples like this, which, though few in number, are nevertheless every day multiplied by new discoveries, we can admit, I think, for the coal epoch, a far greater diversity of typical forms than could be supposed at first sight and from superficial researches.

2. What is said above is already an answer to the second question concerning the scarcity of fruiting specimens of ferns in the Coal Measures. This scarcity, like the paucity of typical forms in the fossil ferns, is rather casual than real. By careful researches at some places, where the remains of a species are found in abundance, one may generally succeed in finding traces of fructifications. They are especially preserved on specimens found as matrix of iron agglomerations, which have not been exposed to maceration in water for too long a time. This of course confirms the validity of the conclusions arrived at by Prof. Lindley and Prof. Göppert from their experiments on the action of the maceration in destroying or preserving the forms of some species of plants. Most of the species of ferns of our time, under a protracted and continual immersion, have preserved well enough the forms of their leaves with evident traces of their nervation; but they have lost their fructifications. The sporanges have been detached from their supports and destroyed.

It is moreover known that, nearly always, the fern leaves are attached to the shales by their lower surface. Thus, even when the fructifications are preserved, we cannot see them, or we have only an indistinct outline of their form, printed in relief through the carbonized tissue of the leaves. This of course renders the study of the fossil fruiting ferns very difficult.

3. Is the small proportion of fossil remains of true arborescent ferns in the Coal Measures, compared with the great quantity of leaves and stalks or petioles of the same family, a proof that, contrary to the opinion generally admitted, the arborescent ferns were not a predominant character of the vegetation of the coal epoch? If we consider as remains of true arborescent ferns, only those whose bark is marked by large oval cicatrices, left at the base of the fronds, at the point of their parting from the main stem, in short those known under the family name of *Caulopteridæ* or *Protopteridæ*, it is certain that they are very scarce in the Coal Measures both of Europe and of America. In his *Genera*, Mr. Unger counts in the *Protopteridæ* of the coal ten-species only, distributed in five genera. And from these species, five are considered by Brongniart, Lindley and other authors as pertaining to *Sigillaria* or *Lepidodendron*. In his

Tableau des genres, Brongniart enumerates only six species of *Caulopteridæ*; Geinitz in his *Wersteinungen von Sachsen*, four species, three published by Brongniart as *Sigillaria*, and one, a *Megaphyllum*, by Artes; and Gœppert, in his *Fossil Flora des Uebergangsgebirges*, has none. In my examination of the fossil plants of our Coal Measures, I have seen, from the roof shales of the coal, only three specimens of two different species found at Carbondale,^a and one found in Illinois.^b And from the sandstone of the Coal Measures, I have in my cabinet a single specimen from Ohio, and there is another of a different species in the Illinois State Cabinet.^c A few others, like *Sigillaria Cistii* Brgt., from Wilkesbarre, Penn., *Sigillaria discoidea* Lsqx., from Summit Lehigh, Penn., *Megaphyllum protuberans* Lsqx., *Megaphyllum Wilburianum* Lsqx., and *Lepidodendron radicans* Lsqx., from Illinois; these three last figured and described in the Geological Report of that State, may still be referable to this group of plants.

If, on the contrary, we admit with most of the European authors, that the fossil trunks, generally comprised in the genus *Psaronius*, did belong to arborescent ferns, we have to come to quite a different conclusion, concerning the distribution of the vegetation of the ferns at the coal epoch; for these trunks are found in great abundance in some parts of the Coal Measures. But Prof. Brongniart, judging from their internal structure, considers *Psaronius* as a genus related to the *Lepidodendra* rather than to the *Protopteridæ* or ferns. As the *Psaronius* species have their stems generally encased in a thick coat of roots or rootlets, grown and petrified together, the surface of the stems and the cicatrices with which they were originally covered are scarcely to be seen. Nevertheless, among the great quantity of specimens which I have examined in Southern Ohio, I have found a few, the smallest in size, whose uncovered stems evidently bear the long oval scars, the external character of the arborescent ferns.

Now, admitting the species of *Psaronius* as true arborescent ferns, the question of their distribution in the Coal Measures and of the place and importance which they occupied in the vegetation of the coal epoch is still unsolved. Where did they come from, all these trunks of the same genus; all with the same peculiar structure; all horizontally broken in fragments varying from one inch to one foot in length, and thus scattered at some peculiar and isolated localities, where they appear as if they had been heaped by some wonderful and unaccountable agency? I do not know in our Coal Measures of another deposit of petrified trunks of fern trees except that of Shade river, Ohio. It begins at Athens and extends southward as far as Charleston, Va. At least, I have seen trunks of *Psaronius* scattered along

^a Penn. Geol. Rept. p. 869, pl. 13, figs. 1 and 2.

^b Ill. Geol. Rept. ined., pl. 13, fig. 1, under the name of *Caulopteris insignis*.

^c *Caulopteris Worthenii*, sp. nov., Ill. Geol. Rept. ined., pl. 14, fig. 1.

the banks of the Great Kanawha from its mouth to Charleston. The geological horizon of the strata with which they are connected is not satisfactorily determined; though it is certain that their place is not far above the top of the Mahoning Sandstone. They are apparently imbedded in a kind of soft sandstone, which at Shade river is separated by a covered space of 10 feet from a bed of coal 10 inches thick, which I consider as the equivalent of Coal No. 5. I say apparently, because it is not certain that they were originally derived from this bed of soft sandstone or hard clay, exposed on the high water of Shade river, where they are seen in great quantity, heaped in all possible positions and directions, just as if they had been transported and deposited there by a strong eddy. Nevertheless, they do not bear any trace of erosion by water. The fracture is clean and often sharply marked all around their circumference. When they appear eroded, this erosion is evidently due to the process of maceration, at or before the time of petrification. As no remains of this genus are found in connection with the shales of the coal strata, I think that forests of these peculiar arborescent ferns did cover some dry, sandy places of the Coal Measures, in the vicinity of some hot springs perhaps, or under the influence of peculiar atmospheric action. There they may have lived around the marshes, and their prostrated stems have been petrified afterwards by a local influence. I believe that if we could satisfactorily explain the dispersion and the transformation into siliceous of the fossil woods of the Tertiary, whose specimens abound in some parts of Arkansas, Mississippi, &c., this explanation would apply as well to the silicified trunks of the Coal Measures. In any case, and though we know but little about the distribution of the vegetation at the coal epoch, we are authorized to conclude, from the former remarks, that the species of ferns predominant in the marshes of the coal were especially shrubby or herbaceous species of small size, while those of the sandy or dry solid ground were especially arborescent.

Before leaving the *Caulopterideæ* I have still a few words to say of the size of the cicatrices of their bark, compared with the diameter of their stems. These cicatrices, generally distant, placed on the stems in the spiral order two-fifths, are, when found in a good state of preservation, nearly oval or obovate and elongated at both ends, by a somewhat deep furrow. They bear in the middle the mark of a simple fascicle of vessels in the form of a horse-shoe, and the central scar is surrounded by an oval annulus. Of the two specimens formerly mentioned as having been found in the sandstone of our Coal Measures, and whose somewhat flattened stems have preserved their form as well as the cicatrices of the bark, the one, four inches in its greatest diameter, has the scars just one inch broad. In the second, three inches and a half

in diameter, the scars are not quite one inch broad. Now the largest and most remarkable specimen of a *Caulopteris* that I have ever seen and a notice of which has ever been published (*Caulopteris insignis* Lsqx.), shows a piece of bark with a single but entire cicatrice of just three inches in diameter. Admitting that the proportion of the cicatrices to the stem is, in this species, the same as in the former ones, this must have belonged to a trunk of fern of less than one foot in diameter. This agrees well with the size of the trunks of *Psaronius* of Shade river, whose diameter is mostly between four and eight inches, rarely reaching one foot.

The genus *Megaphytum* Art., should, according to Prof. Brongniart's opinion, be united with the genus *Bothrodendron* or *Ulodendron* and referred to *Lepidodendron*, as representing merely a modification of this last genus. Our American specimens do not authorize this conclusion. *Megaphytum protuberans* Lsqx., of the State Cabinet of Illinois, has the cicatrices closely placed above each other, oval, convex, with their top somewhat squarely cut at the point of junction. They bear, near the upper end, the scars of fascicles of vessels, in the form of a horse-shoe; just like the *Caulopterideæ*, but without a marked annulus. These scars were evidently left at the base of large petioles or fronds, and are not cicatrices of leaves or of adventive buds as Mr. Brongniart supposes. It is even evident, from the forms of the cicatrices, which are a little flattened at their base and more elevated at the upper part, that the fronds which were originally attached to them were ascendent and closely appressed upon each other at their base. Moreover, this species has its surface deeply and irregularly striated and furrowed as if it had been covered by rootlets, just like the surface of a *Psaronius*. The cicatrices of *Megaphytum Wilburianum* Lsqx., still more nearly resemble those of a large *Caulopteris*. They are 4 inches broad, round, or square with rounded corners, flattened, with the scars of the vessels placed in the middle, and surrounded by an annulus. From this, it appears evident, that these remarkable stems did belong to a genus of the fern family, bearing two-ranked or distichous fronds. Prof. Geinitz has already admitted the genus *Megaphytum* as intermediate between the *Lycopodiaceæ* and the ferns.

Calamitaricæ.

The species of this group of fossil plants have as common characters: the stems hollow, regularly striated, articulated, with articulations more or less distant, marked by a depressed or circular ring, or by an elevated margin, bearing whorls of leaves more or less united at their base. The five principal genera of fossil plants of the Coal Measures, which have been placed in

this group, *Equisetites*, *Calamites*, *Asterophyllites*, *Sphenophyllum* and *Annularia*, have between themselves no evident and acknowledged relation. Considering the first two of these genera as belonging to the family of the *Equisetaceæ*, Mr. Brongniart has separated from it the last three, placing them with the dicotyledonous gymnospermous plants. The essential reason for this separation is, that species of *Asterophyllites* sometimes bear, in the axils of their leaves, small, flattened, oval, somewhat winged seeds, resembling those of the Yew, and, at the extremity of these branches, a kind of cone containing a pulverulent matter, which this great author considers as pollen. An inflorescence of this kind resembles that of the conifers. If we consider only the more evident characters, viz: the hollow, striated, articulated stems; the leaves more or less united at the base and placed like sheaths around the articulations, this separation appears inadmissible. It is for this reason that most of the European authors have put it aside. Nevertheless, it is evident, from good though small specimens found in our Coal Measures, that, at least, two species of *Asterophyllites* bear, in the axils of their leaves, those small oval or cordate-oval seeds, observed by Mr. Brongniart, and far different from the cones of the same genus which he considered as male flowers. It is certain also, that, from the examination of a great number of these cones, very common at some places in the shales, in connection with branches and large stems of *Asterophyllites equisetiformis* Ll., they contain nothing under their scales but a pulverulent matter, as Mr. Brongniart has seen it. Possibly the flattened seeds, in the axils of the leaves of *Asterophyllites*, could be considered as a kind of tubercles; but I really believe they are true seeds and that all the species of the genus *Cardiocarpum* are referable, if not to the genus *Asterophyllites*, at least to plants related to it. At some places where *Asterophyllites* are abundant, these seeds are seen sometimes in plenty, varying in form from round or oval to cordiform, generally bearing a narrow wing, emarginated at the top, and even broadly winged, as shown by the beautiful specimens figured and described by Dr. Newberry.⁷ They vary much in size, being generally as small as a pea, but sometimes as large as a walnut. If then, as is evident, these fruits belong to *Asterophyllites*, or to plants related to this genus, it is not possible to refer them to *Equisetaceæ*, and so the opinion of Mr. Brongniart is confirmed. But now, the fruits of the genus *Calamites* are still entirely unknown. A single specimen, figured in Sternberg's *Flora*, vol. ii, pl. 14, fig. 1, under the name of *Volkmannia arborescens*, apparently coming from a stem of *Calamites*, has the form of a long ear or cone, bearing whorls of narrow, linear, obtuse, somewhat open leaves, resembling the cones of *Asterophyll-*

⁷ *Annals of Science*, No. 13, (May 1, 1853), p. 152, No. 2.

lites and, as I believe, of the species *Ast. lanceolata* Lsqx., of the *Pennsylvania Geological Report*. The only difference is in the form of the leaves. In our American specimens they are linear, *pointed*, never obtuse as Mr. Sternberg figures and describes them. In my specimens of *Asterophyllites lanceolata* the ears are always attached to a curved, half an inch thick, articulated and striated pedicel, having just the same form as a small branch of *Culamites approximatus* Art. The form of the pedicel, curved upwards, shows that these cones were attached to the side of a large stem and not placed at the top of some branches, and thus explains the reason and the form of large cicatrices, irregularly placed above the articulations of stems of some species of *Culamites*. But species of this same genus have also smaller, round cicatrices regularly placed around their articulations. Though, according to Prof. Geinitz, these scars are left as the point of attachment of some roots, they may nevertheless be only the marks left by fruits like those of *Asterophyllites*. Thus the relation of both genera, a relation so striking, if we consider the other appreciable characters, would be complete. But, even if this affinity of forms was perfectly ascertained, the question concerning the true relative place of these plants would not be settled. For the internal structure of the *Calamites*, as far as it is known, removes them evidently from the *Dicotyledonous* and establishes their relation with the *Equisetaceæ*. It is one of those numerous dilemmas offered for a solution, to the patience and long researches of the Palæontologist.

American specimens do not add much to what was already known of the different genera of this group. I have not seen in our Coal Measures a single trace of an *Equisetites*. I did not even suppose that species of this genus could be found in the Coal Measures. The beautiful specimens figured and described by Geinitz do not leave any doubt on this question.

There is near Carbondale a forest of standing *Calamites* imbedded in a bank of compact, coarse, hard sandstone. Numerous fragments of their stems have been taken out from a tunnel cut in this sandstone. These fragments show nothing but the external surface of the stems. Even the coaly matter which sometimes covers it has disappeared. The species are *Calamites Suckowii* Brgt., *Calamites ornatus* Brgt., which Mr. Geinitz considers as the same species; *Calamites Cisti* Brgt., and *Calamites approximatus* Art. The size of the stem varies from three to six inches, rarely attaining eight inches. A number of them appear to have been crushed upon themselves when still standing, for the bark, or rather the external surface, is often pushed and folded within the stem, all around the circumference. This, of course, proves that the stems of the *Calamites* were hollow cylin-

phyllaceæ of our time. Prof. Geinitz, indeed, has published, in his magnificent work on the fossil plants of Saxony, as fructifications of *Annularia*, (pl. 18, figs. 8 and 9) a beautiful cylindrical long ear with an articulated and striated stem, bearing, at the articulations, whorls of short, linear, pointed leaves, and in their axils round sporanges or fruits. These fruits are undoubtedly of the same kind as those of the fragments described above, and, to my belief, belong to the genus *Asterophyllites*. Against my opinion, still is this fact: that nothing, among our recent ferns, would lead us to suppose that there ever lived species of ferns with whorled leaves. But we see, in the vegetation of the coal epoch, some peculiar features of a far more abnormal and unexplainable character. The question can be decided only by well preserved specimens. And though I have recently seen two specimens of *Annularia sphenophylloides* Ung., the one from Newport, R. I., the other from Illinois, whose appearance did perfectly agree with what I suppose to be the fruit-bearing leaves of *Annularia*, this appearance is not distinct enough to permit a positive assertion. If my supposition concerning the fructifications of *Annularia* should be confirmed, this genus would appear as a link of transition between the *Equisetaceæ* and the Ferns, as the genus *Sphenophyllum* appears to be one between the *Lycopodiaceæ* and the Ferns.