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III.—*Notes on the North American Species of Dadoxylon, with Special Reference to Type Material in the Collections of the Peter Redpath Museum, McGill College.*

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(Read May 29th, 1900.)

One or two years before his death, the late Sir William Dawson placed in my hands a large amount of material representing the various species of *Dadoxylon* collected by him during a period of nearly half a century, one typical species from Europe, and several supposed species of *Cordaioxylon*, *Tylodendron* and *Cordaio-Sigillaria*, with the request that I should revise the whole in the light of our most recent knowledge respecting this most interesting group of plants. In the interval, considerable material has come to hand through Prof. C. S. Prosser, from the Permian and Cretaceous of Kansas, and this has been incorporated in the revision, as it was found to embrace several well known forms of *Dadoxylon*, together with other interesting types.

Several considerations combined to give weight to the idea that a revision was not only desirable but necessary. The genus *Dadoxylon* has been known under a variety of names since Withan's publication in 1833.¹ It has been investigated by all the leading paleobotanists of Europe and America since that time, and the abundance of material in America, but more particularly in France, where its remains are to be found in great quantity and often most beautifully preserved, has led to its being one of the best known genera of fossil plants. So ample has been the material, and so perfectly has it been preserved in all its parts, that we now have a fairly accurate knowledge of its internal structure, as also of its external characteristics including the foliage and fruit. Notwithstanding all this however, an examination of the literature of the subject discloses a remarkable degree of confusion as to the plants which properly fall under this genus, their real affinities with existing forms, and their limitations with respect to geological time. This confusion is not only evident in the type material from this part of the world, but it appears in all the writings of various authorities and does not disappear from the most recent

¹ The Internal Structure of Vegetable Fossils.

efforts to untangle the difficulty.¹ Kraus² and Solms-Laubach,³ among recent authorities, have done more than any others to give a clear and systematic conception of the real nature and relations of these plants. Knowlton has also summarised our knowledge of them in such a way as to afford a working basis of considerable value.⁴

Looking at the various descriptions of the internal structure of the stem, one is immediately impressed with the inadequacy of the diagnoses and the too often loose and unscientific way in which the facts are stated, giving no adequate ground for comparison and the accurate differentiation of one species from another. Thus in *D. Newberryi*, one of the most important structural facts is entirely neglected in the description of the species, while in others, the mere statement that a certain detail is more or less like that of another species in which it is poorly or inaccurately described, conveys no accurate conception of the real facts, and forms no proper basis for comparison.

Such looseness is a common fault and appears even in the most recent publications. The explanation is no doubt to be found in the fact that there has been no general revision of all the species on the basis of the stem structure, but one author has copied from another and in such copying there has been no direct reference to the original types for purposes of verification.

The work of Sir William Dawson, extending over half a century, has resulted in the accumulation of a large amount of material from various parts of North America, the greater portion of which formed the basis of published descriptions, but there was also a considerable amount of material which had never been fully determined. This embraced species described only in his notes, as well as others which he had not attempted to describe. There were thus some species without names, and others to which he had assigned specific names. Much of this material has been found to be identical with species already well known, while other portions embraced new species, and in such cases the names employed by Sir William have been retained and are now published for the first time. The accumulation of a particularly valuable collection of type material, presented an opportunity for authoritative revision of the genus, which was not to be neglected.

These considerations seemed to me sufficient to justify prosecution of the work as promptly and as completely as possible, and although it

¹ Proc. U. S. Nat. Mus., 1890, XII., 601.

² Schimper's *Traité de Pal. Veg.*, II., 1870.

³ *Fossil Botany*, 1891, 105.

⁴ Proc. U. S. Nat. Mus., 1890, XII., 601.

has now been brought to a conclusion, it is to be regretted that circumstances so delayed it as to prevent me from completing it during the life-time of Sir William Dawson, and thereby receiving the co-operation and advice of one who had so closely identified himself with these plants.

In the course of my work I have endeavoured to take a complete survey of the literature of the subject. This has not been possible in the fullest sense, since one or two of the more important works have not been accessible. In nearly all cases, however, statements have been verified by direct reference to the original publication, and it thus becomes possible to give a more extended and complete bibliography of the genus and of the individual species than has previously appeared.

A detailed historical summary in this connection is rendered unnecessary by the presentation given by Knowlton, who clearly states the historical basis on which our present views rest.¹ But a brief résumé of the principal phases in our knowledge relating to this interesting group of plants, may serve to bring out somewhat more clearly, the bearings of the present discussion.

Our knowledge of those plants which have been variously known among others, by the names of *Dadoxylon*, *Cordaïtes*, *Cordiaioxylon*, *Araucarites*, *Araucarioxylon* commenced in 1833 with a description of several species of *Pinites* by Witham. In 1847, Endlicher described fourteen species of these plants under the name of *Dadoxylon*. A recognition of the now well known *Araucarian* structure of the stem, led Presl to adopt the name of *Araucarites*, which was subsequently changed to *Araucarioxylon* by Kraus and in a restricted sense, is still retained. In 1850, Unger applied the name *Cordaïtes* to certain leaves from the Palaeozoic formation, and a few years later Geinitz was able to bring under the same designation, various parts of plants which had hitherto been assigned to several separate genera, but which he recognised as belonging to *Cordaïtes*. Grand Eury's investigations of the Carboniferous of the Loire, led to most important results. The great abundance of material which he was able to collect, and the often perfect state of its preservation, joined to the studies which Brongniart had already made of the silicified seeds from St. Etienne, permitted him to obtain a most complete history of *Cordaïtes*. Among other important results reached, he was able to prove that the *Cordaïtes* were gymnospermous plants, and that the problematical *Artisia* or *Sternbergia*, which had for so long been a puzzle to palaeobotanists, was nothing more nor less than the pith of *Cordaïtes*. In the meantime, however, Williamson in England had shown that *Sternbergia* pith belonged

¹ Proc. U. S. Nat. Mus., 1890, XII., 601.

to plants with an Araucarian type of structure, while Dawson in Canada, had shown it to be likewise a feature of the genus *Dadoxylon*, and this led the way for Grand Eury to establish the real connection between this genus and *Cordaitea*; and thus we have come to employ this last name for those woods with an undoubted Araucarian structure, which have been shown to be related to the leaves and fruits for which the name was first employed. Ranging from the Devonian through the Upper Palaeozoic, into the Mesozoic and Tertiary, there are many plants known through their wood, which present many points of similarity to—we may indeed say of affinity with—the Araucarian type, but there are many considerations which lead to hesitancy in regarding them as generically identical, and among these we may consider the distribution in point of geological time. Thus while *Cordaitea* range from the Devonian upwards into the Mesozoic, plants with a well defined Araucarian habit of growth and fructification, range from the Tertiary down as far as the Jurassic, below which they are unknown. In the Palaeozoic also, there are a number of plants known by their wood only, the exact relations of which are matters of doubt—they cannot be referred to *Cordaitea* or with certainty to any other known genus. Kraus¹ has endeavoured to solve the difficulty by referring all such to the genera *Cedroxylon*, *Cupressoxylon*, *Pityoxylon*, *Araucarioxylon*, *Pissadendron* and *Protopitys*, and there are structural grounds for the retention of certain elements of this classification, while admitting the general desirability of the principle of condensation. On the other hand, Felix and others working on the lines of the present acknowledged position of *Cordaitea*, and having reference to the geological distribution of these various plants, have suggested the propriety of confining the *Cordaitea* to Palaeozoic time, while *Araucarioxylon* is reserved for Mesozoic and Tertiary times. Under this ruling *Dadoxylon* becomes a provisional name reserved for all those forms which have no recognised affinity. This idea has been recognised and utilised by Knowlton,² and although there are obvious objections to it, it may nevertheless be regarded as a good provisional basis for further studies. It certainly has the merit of giving a definite line of demarcation between recent types and those of more ancient date, when mere structural resemblances would tend to identify the two. It will also do much toward reducing that endless confusion which comes from a useless multiplication of names for plants which, if not generically identical, are nevertheless closely allied, and as Knowlton very well

¹ Schimper's *Pal. Veg.*, II., 1874, 369.

² *Proc. U. S. Nat. Mus.*, 1890, XII., 601.

points out, the name of *Dadoxylon* does not commit one to a final expression of opinion respecting affinities, but permits transfer to such group, and at such time as may be justified by more ample knowledge. I shall therefore follow this division in the present discussion, and endeavour to harmonise the species diagnoses with it, so far as they are based upon structural considerations, which is our only point of view at the present moment.

The genus *Dadoxylon*, which is now to be discussed as *Cordaïtes*, has its type in *C. Brandlingii* as expressed by Brongniart,¹ who further says, "Ces espèces ont, en effet, la plupart des caractères essentiels du bois des *Araucaria*. C'est-à-dire les ponctuations des fibres ligneuses disposées en plusieurs séries alternantes entre elle, et prenant par pression la forme d'arcoles hexagonales. Cependant il y a quelques différences assez importantes pour qu'on ne puisse pas affirmer que ce sont de vrais *Araucaria*, surtout quand on voit que tant de Conifères actuelles de genres différentes ont, sous ce rapport, une structure sensiblement la même; et par celle raison, je préfère le nom donné par M. Endlicher, en réservant le nom d'*Araucarites* aux plantes qui, par leurs organes de fructification, se rapprocheraient des *Araucaria*."

An examination of various authorities shows some diversity of opinion as to the presence of growth rings in these plants. Knowlton tells us that these woods are "characterised by faint lines of demarcation between the annual rings of growth."² Göppert, in his diagnosis of *C. Brandlingii* distinctly says³ "*ligni stratis concentricis obsoletis*," but in describing *C. ouangondianum* of Dawson, he says "*ligni stratis concentricis distinctis*," a statement borrowed from Dawson. Defining the generic characters of *Araucarioxylon*, Kraus says⁴ "*Lignum stratis concentricis vel obsoletis*." In looking through the various European species of which there are five according to Knowlton,⁵ not one description records the occurrence of growth rings. Grand Eury⁶ bases a grouping of species upon

I Growth rings obscure or obsolete, and

II Growth rings distinct.

He thus agrees with Kraus. Into the latter group he brings *C. Stephanense* and *C. subrhodeanum*, but the absence of figures of the

¹ Tab. des gen. de Veg. Foss., 1849, 76.

² Am. Geol., III., 1889, 106.

³ Kennt. der conif. Holz. der Pal. Form., 1888, 9, 12.

⁴ Schimper's Pal. Veg., II., 1874, 380.

⁵ Proc. U. S. Nat. Mus., 1890, XII., 606.

⁶ Flor. Carb. de la Loire.

transverse section, renders it impossible to ascertain to what extent the growth rings are distinct, and reliance must, therefore, be placed entirely upon the accuracy of the statement made. Referring more particularly to the structure of *C. Brandlingii*, of which we fortunately possess an excellent specimen from St. Etienne, and therefore typical, I find that a very poorly defined ring is observable, but it is to be noted that such rings (Fig. 1) are not of the nature of those common to exogenous trees of higher temperate or sub-arctic regions, but are more comparable with those of sub-tropical regions where there is a constant tendency to continuous growth. Our figure shows that the limits of annual (?) growth are indicated by a very unequal and narrow zone of tracheids which differ from those on either side by their shorter radial diameters. This feature is here of very uncertain value, and in particular regions of the zone it becomes almost obliterated. The zone itself is not more than a few tracheids wide, and the transition into elements of the surrounding structure takes place so gradually, both inwardly and outwardly, that it would be quite impossible to determine which is the inner or which is the outer face, were it not for the general disposition of the vascular elements. Referring now to the various species described by Dawson,¹ I find that in two of his earliest he refers to the obscurity of the growth rings, while in three other cases he mentions them as distinct, and actually founds a species upon their presence (*D. annulatum*). But as appears from the specific diagnosis of this species elsewhere in this paper, this statement is based upon a complete misinterpretation of the structural features presented by the fossil, and the same is likewise true of *D. ouangondianum*. In *D. pennsylvanicum*, which must be regarded as a true *Cordaites* according to our present limitations, growth rings are present and of the general type common to trees of high temperate regions. The summer wood is very narrow, consisting of two to four rows of radially flattened, squarish elements. The termination, and consequent demarcation from the spring wood of the following year, is quite abrupt, the whole appearance being much like that which may be found in some of the living species of *Cupressus* or *Thuya*. It is thus true that of all the species originally described by Dawson, only one of them shows well defined growth rings. The others all conform to that type of obscure rings displayed by *C. Brandlingii* which finds its parallel condition in the genus *Araucaria*. From these considerations it becomes apparent that the descriptions borrowed from author to author without verification, and appearing in the most recent revisions of the genus, are in great need of being recast with respect to a

¹ Foss. Pl. of the Dev. & U. Sil. of Can., 1871, 12, 13.

most important diagnostic feature. Of the eighteen species now entitled to recognition, three show more or less clearly defined growth rings, while in the remaining fifteen, they are obscure or obsolete. It therefore appears that there are fifteen species of *Cordaitea* which conform to the general type of *Araucaria*, while three conform to the type of *Dammara*. This is in strict harmony with the generally accepted view that these plants are of distinctly *Araucarian* affinities but without implying actual connection. Inasmuch, however, as the growth rings are initiated by alternating growth and rest periods which are in turn determined chiefly by climatic conditions, such structural variations are not necessarily indications of relationship, and their chief importance may lie in their indication of varying climatic conditions as operating upon different species of the same genus. Interpreting these considerations in the narrow sense, it would seem as if the genus *Cordaitea* must have included species which flourished under widely different climatic conditions; but interpreted in the broader sense of the *Araucariaceae* as a whole, we are to conclude that the genus as now constituted, embraces in reality what must eventually prove to be distinct genera of the separate types of *Araucaria* and *Dammara* as parallel examples among existing *Araucariaceae*.

All observations agree in the fact of a complete absence of resin canals such as occur in the *Abietineae* on the one hand, and of specialised resin cells such as occur in the *Cupressineae* on the other hand, and in this we observe further agreement with the modern *Araucariaceae*, but as in the latter, all known species show undoubted evidence of the more or less abundant occurrence of resin in the medullary rays, and also in the tracheids of the woody cylinder. The principal occurrence of this material, however, is in the pith, where it is deposited in cells (fig. 8, r. c.), or in the bark where it is developed in connection with specialised resin canals (figs. 2, 6, 7, r. c.) or in special cells. In these respects there is a somewhat close resemblance to what may be noted in *Araucaria*.

The bordered pits constitute one of the most prominent and characteristic structural features of these plants. Some of the species under examination show in a somewhat remarkable manner, the gradual transformation of the scalariform structure into that of the typically bordered pit, and in no case is this exhibited with greater clearness than in *C. Brandlingii* (figs. 9, 10, 11), where a properly selected radial section will show all the gradations from one extreme to the other. This fact is by no means a new one, since so long ago as 1840, Don pointed out that tracheids of *Cycas revoluta* would exhibit scalariform structure at one

end and bordered pits at the other.¹ More recently Williamson has shown that a regular transition from one to the other form, occurs in the wood of Dadoxylon and Dietyoxylon, and he rightly attaches importance to these facts as showing the derivation of pitted structure from scalariform.² At the same time, however, he falls into the error of misinterpreting certain structural features, and is thus led to wrong conclusions upon which he creeds a new genus distinguished from Dadoxylon by details of structure in the bordered pit. It is not my purpose to discuss this aspect of the question at length on the present occasion, but it must be pointed out that the simple pits "without a central pore," which he regards as the essential characteristic of Dadoxylon, have without much doubt originated either in conditions of extreme decay, or in mechanical treatment incident to preparation of the sections, one or both. My own studies have shown several instances where a similar interpretation of appearance could be made, but in every case a more searching examination has always disclosed the true nature of the appearance thus presented. Such structural transitions as have just been shown to occur, are of the greatest interest and importance from a phylogenetic point of view. They are what one might reasonably look for upon the hypothesis that these woods are the most primitive Gymnosperms, and they serve to throw much light upon the origin and relationships of the various vascular elements in the higher plants, both Angiosperms and Gymnosperms.

The typical structure of the bordered pit in these plants is too well known to require explanation or amplification at this time, since it is correctly given in all the diagnoses by leading authorities, but by way of recapitulation, it may be well to state that the pits are generally hexagonal and provided with an oblong or narrowly lenticular, diagonal pore which is three-fourths the diameter of the pit, or more (fig. 11 and 18). When the number of rows diminishes to one, the pits commonly assume a more oval form but remain more or less compressed; and a still further modification appears in the separation of the pits to such an extent that they become round, as may be seen in *Araucaria* where such transitional forms occur. Kraus has employed these facts as the basis of classification,³ distinguishing between certain genera which show on the one hand "*Pori rotundi, vel contiguitate polygoni*," and on the other hand "*Pori compressi, oblongi*."

¹ Jn'l Lin. Soc., 1840.

² M. Mic. Jn'l, 1869, 67-70.

³ Schimper, Pal. Veg., 370.

The peculiar distribution of the bordered pits constitutes one of the most prominent and distinguishing features of the genus, and distinctly allies it to the *Araucariæ*. Unger lays down as a generic character, "*Vasa porosa, poris in series 1—4 spiraliter dispositis*,"¹ which is simply a restatement of Brongniart's recognition that "*les ponctuations des fibres ligneuses disposées en plusieurs séries alternantes entre elle, et prenant par pression la forme d'aréoles hexagonales*." All studies show that the pits are distributed throughout the length of the tracheids, as well as that they regularly occur on the radial walls of *all* tracheids, thus presenting an important contrast to the law of distribution which excludes them more or less fully from the tracheids of the summer wood of the *Abietinæ*.

While these laws of distribution are well recognised as applicable in a generic sense, the various recognised species show great diversity in this respect, and such variations have been taken as an element in diagnosis. The possible value of such data is fully exemplified in the case of *C. Newberryi*, where the pits occur in well defined groups which fall into radial rows. This feature has unfortunately been neglected entirely, by every writer except Prof. Newberry himself, but its importance as a differential character cannot be doubted (fig. 12). It is nevertheless a well recognised fact that the number of rows in which pits occur is such an altogether variable factor within the same individual, as to render it untrustworthy as a differential character except when employed with great caution.² Under these circumstances we can only consider such data as of service in so far as they help to reinforce other characters indicative of specific differences, while at the same time they tend to enforce the idea that one should be very cautious in creating new species unless such can be justified by well defined characters.

The medullary rays require to be discussed from two points of view. The tangential exposure shows the cells to be disposed in one row, becoming 2-seriate in part, and Kraus has employed this feature as a means of differentiation from those other genera in which multi-seriate rays occur.³ In a radial section the rays are seen to be composed of one kind of element only, with the exception of *C. Clarkii*, in which definite tracheids are to be found in addition to the ordinary parenchymatous elements. This is the only species within my observation, which

¹ *Gen. et Spec. Pl. Foss.*, 1850, 378.

² *H. von Mohl, Bot. Zeit.*, 1862, 225; *Kraus, Wurzburger Naturwiss. Zeit.*, V., 1864, 185.

³ *Schimper, Pal. Veg.*, 379.

exhibits this feature, but that it does not necessarily indicate generic divergence is fully established by the parallel case to be met with among the higher Coniferae in *Abies balsamea*.¹ In the parenchyma cells, the upper, lower and terminal walls are thin and not pitted, while the latter are also generally curved as in the Cupressineae and in *Araucaria*. The lateral walls are always furnished with bordered pits which are distinguished from those of the adjacent or underlying wood tracheid by their smaller size and somewhat different details of structure, as well as by their peculiar relation to the ray element itself. These pits are found to differ very materially as between one species and another, with respect to their detailed structure, disposition in the cell and number within the limits of a wood tracheid. That too much dependence cannot be placed upon the stability of these elements of structure as diagnostic characters, is shown in the case of the hard pines, in which group they are utterly worthless; but on the other hand they are of very definite value in the soft pines and other genera of the Abietineae as also in the Cupressineae.² It is therefore reasonable to regard them as of possible importance in the present case.

The structure of the bark has received very little consideration in published descriptions. Two species in the present list —*C. Brandlingii* and *C. hamiltonense*—embrace a thick bark which is well preserved, and in the latter the structural details are so well defined that they will be discussed under the species.

CORDAITES, Unger.

Bib. :—Dana, *Man. of Geol.*, 1875, 349, 371; Nicholson, *Man. of Pal.*, 1879, II., 436, 437, 446, 448, 461, 462; Lesquereux, *2d. Geol. Surv. of Pa.*, 1880, 419, 543; and 1884, 419, 543; Unger, *Gen. et Spec. Pl. Foss.*, Vienna, 1850, 378-381; Lacoe, *Cat. of the Pal. Foss. Pl. of N. A.*, 1884; Dawson, *Q. Jn'l Geol. Soc.*, 1883, 460; Carruthers, *Geol. Mag.*, V., 1868, 8; Williamson, *M. Mic. Jn'l*, 1869, 66; Lesquereux, *U. S. Geol. Surv.*, 1876, 1-16; Lesquereux, *Proc. Am. Phil. Soc.*, 1878, 324; Dawson, *Q. Jn'l Geol. Soc.*, 1874, 215; Williamson, *Mem. Manch. Lit. & Phil. Soc.*, X., 1885-1886, 190; Renault, *Cours de Bot. Foss.*, 1881, Pls. 12 & 13; Brongniart, *Tab. des Gen. de Veg. Foss.*, 1849, 76, 97; Zittell, Schimper & Schenk, *Handb. der Pal.*, 1890, 865, 870; Knowlton, *Am. Geol.*, III., 1889, 106; Knowlton, *U. S. Geol. Surv.*, 1889, 30, 50; Grand'Eury, *Geol. et Pal. du Bass. Houil. du Gard*, 1890, 316; Schimper, *Pal. Veg.*, 1869, II., 380; Dawson, *Geol. Surv. Can.*, 1882, 124-125; Dawson, *Geol. Surv. Can.*, 1873, 15; Grand'Eury, *Flor. Carb. du Dept. de la Loire*,

¹ Penhallow, *Taxaceae and Coniferae*, *Trans. R. Soc., Can.*, 1896, II., iv, 5.

² *Trans. R. Soc. Can.*, 1896, II., iv., 33-54.

1877, 257, 260; Göppert, Die Foss. Flor. der Perm. Form., 1864-1865, 249-259; Göppert, Die Flor. der Sil. Dev. und unt. Kohlenform., 1859, 548-550; Göppert, Die verst. Wälder im nord. Bohem. und Schles., 1859, 7, Pls. 1. & II.; Göppert, Foss. Flor. des Übergangsg., 1851, 252-256; Williamson, Org. of the Foss., Pl. of the Coal Meas., Trans. R. Soc., 1872, IV., 377; Trans. R. Soc., 1876, VIII., 222, Pls. & Figs.; Göppert, Foss. Conif., 1850, 230-236; Engler & Prantl, Gen. Plant, II., 1, pp. 26, 116; Solms-Laubach, Foss. Bot., 1891, 104-122 & 80-84; Witham, Int. Struct. Veg. Foss., 1833.

Transverse.—Pith of the Sternbergia type: the cells large, thin-walled, often resinous. Growth rings when present obscure, rarely somewhat conspicuous. Specialised resin cells and canals wholly wanting except in the bark where they take the form of tubular, branching canals without epithellum, extending in the general direction of the stem axis. Tracheids in regular, radial rows, conspicuously squarish.

Radial.—Elements of the protoxylem spiral and scalariform, and often showing a graduated transition into tracheids with bordered pits. Tracheids with hexagonal, bordered pits throughout, on their radial walls only, in 1-5 rows. Ray cells usually of one kind only; the upper and lower walls thin and not pitted; the terminal walls thin, not pitted, generally curved; the lateral walls with bordered pits.

Tangential.—Medullary rays rather numerous, 1-seriate or often 2-seriate in part.

SYNOPSIS OF SPECIES.

The following synopsis is given provisionally as an aid to identification of the various species, without implying the absolute value of the differential characters.

I.—*Growth rings present.*

1. *C. pennsylvanicum.*

II.—*Growth rings obscure or obsolete.*

A. Ray elements of two kinds, tracheids and parenchyma.

Bordered pits in 2-3, rarely four rows.

Ray cells (tang.) oval or oblong, often narrow.

2. *C. Clarkii.*

B. Ray elements of one kind only.

Bordered pits in groups of 6-13.

Pits on the lateral walls of the ray cells 3-6, chiefly 4 per tracheid.

3. *C. Newberryi.*

Bordered pits in one row, compressed.

Ray cells (tang.) broad, round or squarish.

4. *C. recentum.*

Bordered pits in 1-3, chiefly 2 rows.

Ray cells (tang.) broadly oval.

Ray cells about 31-57 mic. broad.

5. *C. hamiltonense*.

Ray cells about 28-37 mic. broad.

Pits on the lateral walls of the ray cells about 1-4 per tracheid.

6. *C. illinoiense*.

Ray cells (tang.) oblong.

Pits on the lateral walls of the ray cells 1-3, chiefly 2 per tracheid.

7. *C. Brandlingii*.

Ray cells (tang.) oval or round.

Pits on the lateral walls of the ray cells 1-8, chiefly 2-3 per tracheid.

8. *C. materioide*.

Ray cells not determinable.

9. *C. annulatum*.

Bordered pits in 2-5 rows.

Ray cells (tang.) oval or oblong.

Pits on the lateral walls of the ray cells 2-4, chiefly 4 per tracheid.

10. *C. ouangondianum*.

Pits on the lateral walls of the ray cells 4-10, chiefly 6 per tracheid.

11. *C. acadianum*.

Ray cells (tang.) broad or squarish.

Pits on the lateral walls of the ray cells 2 per tracheid.

12. *C. ohioense*.

Ray cells (tang.) oval or round.

Pits on the lateral walls of the ray cells 1-5, chiefly 1-2 per tracheid.

13. *C. materiarium*.

Bordered pits in 5 rows.

14. *C. Hallii*.

CORDAITES BRANDLINGII, (Lindl. and Hutt., Göpp.).

Figs. 1, 9, 10, 11.

Bib. :—Dana, *Man. Geol.*, 1875, 331; Zittell, Schimper & Schenk. *Handb. der Pal.*, 1890, 242, 853, 865; Grand'Eury, *Geol. et Pal. du Bass. Houll. du Gard.*, 316; Unger, *Gen. et Spec. Plant. Foss.*, 1850, ; Knowlton, *Proc. U. S. Nat. Mus.*, 1889, 52, & 1890, XII., 607; Witham, *Int. Struct. of Veg. Foss.*, 1833, 73; Grand'Eury *Flor. Carb. du dept. de la Loire*, 1877, 264; Göppert, *Die Foss. Flor. der Perm. Form.*, 1864-1865, 255; Göppert, *Foss. Conif.*, 1850, 232; Endlicher, *Synop. Conif.*, 1847, 299; Göppert, *Bronn. Gesellsch. d. Nat.*, III., 42; Felix, *Sitzb., d. Natf. Gesell., Leipzig*, 1882, IX., 6; Schimper, *Pal. Veg.*, II., 328; Göppert, *Nachtr. z. Kennt. d. Conif. d. Pal. Form.*, 1888, 12.

Dist.—A widely distributed European species.

Although this species is not enumerated among those specially described by Sir William Dawson, it is represented in his material, and served as his basis of comparison. Moreover, as stated by Brongniart,

"Les espèces-type de ce genre sont les *Dadoxylon Brandlingii* et *Dadoxylon tehichatchellianum*,"¹ and with respect to the former at least, this view has been generally recognised. It is therefore desirable that the histological characters of this species should be passed in review in the present connection.

The material in hand was derived from St. Etienne, France, and may therefore be regarded as typical. Excellent figures of this plant, with respect to its internal structure, have already been given by Zittell, Schimper & Schenk; by Witham and also by Göppert, and with these our photographic figures agree. But in the various descriptions so far given, certain details of importance are not taken into consideration, and these are now embodied in the diagnosis presented here. One of the best descriptions of the plant as already recorded, is that given by Unger to the following effect²:—

"D. ligni stratis concentraticis obsoletis, vasis amplis leptotichis, poris bi-tri-quadriseerialibus contiguus, radiis medullaribus simplicibus aut rarius compositis e cellulis 1-17 superpositis formatis." Some of these details properly belong to the description of the genus, for which we reserve them. To the others we add such as may serve to clearly differentiate this species from the others now under consideration, and at the same time preserve its typical character.

Transverse.—Pith cells about 62 mic. broad, the walls about 16 mic. thick. Tracheids somewhat elongated radially, about 20 x 38 mic., the walls about 6 mic. thick.

Radial.—Ray cells more or less conspicuously contracted at the ends; short, equal to about 1-3 tracheids; the pits on the lateral walls oval or round, narrowly or obscurely bordered, 1-3, chiefly 2 per tracheid.

Bordered pits typically hexagonal, in 1-3, chiefly 2 rows throughout the tracheid, and in the region of the protoxylem showing numerous and striking transitional forms from scalariform vessels; 12.5 mic. broad.

The pith shows characteristic *Sternbergia* structure, the cells flattened vertically.

Tangential.—Rays low, narrow, 15.5 mic. broad; the oblong cells 1, or sometimes 2-seriate in part.

¹ Dict. univ. d'Hist. nat., 1849, 97.

² Gen. et Spec. Pl. Foss., 1850.

CORDAITES NEWBERRYI, (Dn.) Knowlton.

Fig. 12.

Bib. :—Dawson, Geol. Surv. Can., 1871, 14; Knowlton, U. S. Geol. Surv., 1889, 37; Newberry, Jn'l Cincin. Soc. Nat. Hist., 1889, 48-56; Knowlton, Proc. U. S. Nat. Mus., XII., 607.

Dis.—Hamilton Group (Middle Devonian) of Ohio (Newberry); Carboniferous of Ohio (Claypole).

This species was originally described from material collected by Dr. Newberry, who has recorded its occurrence in the Huron Shales on Huron River in Erie County, and about Delaware and at various places in Southern Ohio.¹ In the same year Prof. Knowlton recorded its occurrence in the Carboniferous of Ohio as reported by Prof. Claypole.²

The original description by Sir William Dawson is very inadequate,³ more especially as the characters are comparative with those of *C. Hallii* which is preserved only as an opaque object, and from which, therefore, a correct diagnosis cannot be obtained. The figures illustrating this species are also inadequate, particularly with reference to the general distribution of the bordered pits and the tangential aspect of the medullary rays.⁴ In 1889 Dr. Newberry undertook a revision of the microscopical characters, and called to his aid P. H. (now Dr.) Dudley, who made a very careful diagnosis of the structural characters. This agrees in essential points with my own diagnosis, and requires but little if any modification.⁵

In a radial extent of 17 mm., this species shows no evidence of growth rings. Dr. Dudley says the layers of growth are wide but the limits not conspicuous,⁶ but this seems to us clearly one of those cases in which the rings of growth are so poorly defined as to fall under the designation of obscure or obsolete. The tracheids are conspicuously squarish and somewhat unequal in their two diameters, but the walls are uniformly of about the same width.⁷ In a radial section the ray cells are seen to be of one kind only, resinous and starch bearing. The lateral walls bear oval, bordered pits from 2-3 per tracheid, but chiefly

¹ Geol. Surv. Can., 1871, 14.

² Jn'l Cincin. Soc. Nat. Hist., 1889, 48-56.

³ Geol. Surv. Can., 1871, 14.

⁴ *Ibid*, Pl. I., figs. 7, 8, 9.

⁵ Jn'l Cincin. Soc. Nat. Hist., 1899, 54-55.

⁶ *Ibid*, 54.

⁷ The thickness of the tracheid walls in fossil plants is of no diagnostic value, unless it is clearly unaffected by decay; and even then its value is but slight.

only four. The slit-like orifice is diagonal and nearly the full diameter of the pit. The most characteristic feature is to be found in the peculiar distribution of the bordered pits, which occur in well defined groups of about 6-13, while the groups themselves fall into radial series. These facts were correctly noted by Dudley,¹ but they have been entirely unnoticed by Dawson² and also of Knowlton,³ whose diagnosis of this species is simply compiled from that of Dawson. The character is nevertheless an important one (fig. 12), since it is the one feature which alone, will differentiate this species from all others. In a tangential section, the rays are seen to be numerous, 1-2, more rarely 2-seriate, and varying from 24-55 mic. in width. The oval or round cells are all thin walled. From these facts the following diagnosis may be derived :

Transverse.—Tracheids about 44 x 55 mic., the walls about 12.5 mic. thick.

Radial.—Ray cells resinous and starch bearing, long and narrow, about equal to 3-7 tracheids, the ends conspicuously narrower; the pits on the lateral walls 3-6, chiefly 4 per tracheid, the slit-like orifice nearly the full diameter of the pit.

Bordered pits numerous, round, about 9.3 mic. broad, distributed in radially disposed groups of about 6-13; the orifice diagonal, nearly the diameter of the pit.

Tangential.—Rays of medium height, 1-2, rarely 3-seriate in part; from 24-55 mic. broad, the oval or round cells all thin walled.

CORDAITES CLARKII, Dn.

Figs. 8, 16.

Bib. :—Dawson, Foss. Pl. of the Dev. & U. Sil. Form. of Canada, 1882, 125; Knowlton, Proc. U. S. Nat. Mus., XII., 607.

Dist.—Hamilton Group, Ithaca, New York.

This species was founded upon material obtained from the Genesee shales at Lake Canandaigua, New York, by Prof. H. M. Clarke, and was first recorded by Sir William Dawson in 1882.⁴

The material in my hands shows a well developed pith composed of large, thin-walled cells, many of which contain starch. There is also evidence of an abundance of resin which is apparently contained in specialised cells, but this fact could not be ascertained satisfactorily. In a transverse section the elements of the protoxylem are not specially differentiated from those of the surrounding tracheids which show the

¹ Jn'l Cincin. Soc. Nat. Hist., 1889, 54-55.

² Geol. Surv. Can., 1871, 14.

³ Proc. U. S. Nat. Mus., XII., 606.

⁴ Foss. Pl. of the Dev. & U. Sil. of Can., 1882, 125.

characteristic features of form and distribution belonging to the genus. In a radial distance of 15 mm., there is no evidence of growth rings beyond the occurrence of three vaguely defined zones in which the tracheids appear to have a somewhat shorter radial diameter. There is no such distinction as commonly relates to the differentiation of growth rings. A macroscopic examination of a hand specimen shows that in a radial distance of 22 mm. eight apparent growth rings appear. These vary from 2-4 mm. in width, but their limits are poorly defined and they do not have the sharp terminations commonly met with in properly developed growth rings. A transparent section examined under a low power hand lens, shows no evidence of growth rings, from which we may infer that the appearances presented macroscopically, depend upon features which simulate rings only when taken collectively. This conforms exactly to what may be observed in modern *Araucarias*. The species thus agrees with the characters of the genus in the well defined absence of growth rings.

In a radial section the elements of the protoxylem are seen to be narrow, spiral and scalariform structures which pass into tracheids with bordered pits by a series of gradations. The bordered pits on the radial walls of the tracheids are in 2-4 rows throughout. The medullary rays present the special differential feature of the species. The elements are of two kinds, parenchyma cells and tracheids. The parenchyma cells are usually equal to about three tracheids in length, and their lateral walls are too much decomposed to determine the number and character of the pits. The tracheids are usually long and narrow, interspersed; and on their lateral, upper and lower walls bear numerous crowded and small bordered pits. This feature occurs in no other species brought under my notice, and it serves to differentiate *C. Clarkii* beyond all question. The further question arises as to whether this character is sufficient to separate the plant from the genus *Cordaites*. All the other essential characters are those which belong to *Cordaites*, and the deviation indicated by the occurrence of ray tracheids is still such as may well come within the limits of the genus. This view finds its justification in the parallel case afforded by *Abies*, in which *A. balsamea* stands as a parallel exception to the rule that only parenchyma elements are present.

In a tangential section (fig. 16), the rays are seen to be very variable in height as well as in their detailed structure. In some cases the rays are relatively broad celled and low, and more or less 2-seriate in part. In the higher rays the tracheids are at once distinguishable by their contracted form, and often greater height of the individual element.

They also show bordered pits in section. One tangential section shows very clearly, either a resin canal or a series of resin cells—probably the latter. From these data the following diagnosis may be obtained:—

Transverse.—Growth rings obscure or entirely wanting. The tracheids about 41 x 49 mic. broad, their walls 12.5 mic. thick.

Radial.—Bordered pits numerous throughout the tracheids, in 2-3, more rarely in 4 rows. The elements of the medullary rays of two kinds; the parenchyma cells thin-walled and devoid of pits, about equal to 3 tracheids; the ray tracheids long, interspersed and bearing on their lateral, upper and lower walls, numerous crowded, bordered pits.

Tangential.—Rays very variable, commonly 1-seriate but sometimes 2 seriate in part; the tracheids usually distinguished by their narrow form and pitted walls.

CORDAITES OUANGONDIANUM, Dn.

Bib. :—Proc. U. S. Nat. Mus., XII., 606; Brit. Mus., 1886, 237; Göppert, Nachtr. z. Kennt. d. Conif. d. Pal. Form., 1888, 9; Can. Nat., VI., 165; Jn'l Geol. Soc., XVIII., 306; Acad. Geol., 3d ed., 1878, 534; Dana, Man. Geol., 1875, 271; Pre-Carb. Fl. of N. B., Maine and E. Can., Can. Nat., 1861, VI., 165-166; Quart. Jn'l Geol. Soc., 1862, 306; Zittell, Schimper & Schenk, Handb. der Pal., 1890, 865; Foss. Pl. of the Dev. & U. Sil. in Can., 1871, 12.

Dist.—Middle Devonian of New Brunswick.

The original description of this species, which has been copied by subsequent authorities without question or verification, was contained in the account of the Pre-Carboniferous flora of New Brunswick, Maine and Eastern Canada published in 1861.¹ In the light of more recent studies, this description is found to contain several marked errors which probably resulted from the nature of the material employed. Our own studies show that the transverse section displays no essential divergence from the characters common to the genus as a whole. There is no evidence of growth rings such as form a prominent feature of the original description. At intervals in the section, the structure which has been greatly influenced by decay, has been so far altered by pressure as to form irregular lines of compressed tracheids which have been forced over to one side in the process, as is not uncommon in fossil woods. There has thus been developed a semblance of growth rings, and this is what the original description refers to. A critical examination of these areas, however, does not fail to disclose the true condition which is also suggested by the very irregular disposition, as also by other features presented.

¹ Can. Nat., VI., 165-166.

The radial section shows the bordered pits to be hexagonal in 2-4, chiefly 3 rows. The elements of the medullary rays are all of one kind, and their lateral walls bear from 2-4, chiefly about 4 pits per tracheid. These pits are commonly disposed in radial series.

In tangential section the rays are seen to be 1-2 seriate.

Transverse.—Tracheids about 47 x 56 mic. broad, the walls 9.5 mic. thick. Growth rings none.

Radial.—Bordered pits numerous throughout the tracheids, in 2-4, chiefly 3 rows, about 12 mic. broad. Ray cells equal to about 3-4 tracheids; the lateral walls with oval pits, 2-4, chiefly 4 per tracheid and disposed in radial series.

Tangential.—Rays of medium height, 1-2 seriate in part, the oval cells chiefly about 25-37 mic. broad.

CORDAITES ANNULATUM, Dn.

Bib. :—Quart. Jn'l Geol. Soc., 1886, 146; Knowlton, Foss. Woods & Lig. of the Pot. Form., 1889, 52, and Proc. U. S. Nat. Mus., XII., 1890, 610; Can. Nat., VIII., 1863, 433¹

Dist. :—Middle Carb. of the Joggins, N. S.

The original description of this species in 1863, was derived from a specimen six inches in diameter, which is described as having about fourteen to sixteen growth rings and a pyritised pith about one inch in diameter.¹

A critical examination of the original specimen shows that there is nothing of the nature of growth rings, but as the description states, there are "layers of structureless coal representing cellular tissue or very dense wood." These layers run diagonally to the radial lines in which the tracheids fall, and therefore diagonally to the medullary rays, but sooner or later they curve in such a manner as to often become more or less parallel with them. It will thus be observed that it is quite impossible for them to represent growth rings. The alternating layers of badly preserved wood have been taken for the summer wood of the growth rings, but in following out one of these for a long distance radially, no evidence of growth rings appears. It would thus seem that the statement of the first diagnosis was based upon a misinterpretation of the features resulting from decay localised along diagonal or radial lines. The confusion resulting from this has led recent observers to question if this plant has any real affinity with Cordaites,² but although

¹ Can. Nat., VIII., 1863, 433.

² Proc. U. S. Nat. Mus., XII., 1890, 410.

badly preserved, we may say without hesitation, that enough characters are recognisable to eliminate all reasonable doubt on this point.

Transverse.—Structure much altered by decay, extensive areas being completely carbonised and consolidated to coal. The tracheids are about 34×44 mic. broad, the walls much attenuated by decay.

Radial.—Structure of the rays not determinable.

Bordered pits hexagonal, 9.5 mic. broad, in 2-3, chiefly 2 rows.

Tangential.—The structure is too much altered by decay and pressure to make the details obvious.

CORDAITES MATERIARUM, Dn.

Figs. 13, 14, 17.

Bib. :—Dawson, Rept. on the Geol. Struct. of P. E. Island, 1871, 42; Can. Nat., VIII., 1863, 433; Acad. Geol. ed. 3, 1878, 473; Quart. Jn'l Geol. Soc., XXII., 1866, 96, 127, 128, 141, 145; Quart. Jn'l Geol. Soc., 1874, 215, 216; Can. Rec. Sc., I., 1885, 158; Grand'Eury, Geol. et Pal. du Bass. Houll. du Gard., 1890, 316; Proc. U. S. Nat. Mus., XII., 1890, 608.

Dist. :—Holmes Co., Ohio (Newberry); Upper Coal Measures of Malagash, Pictou, Joggins, Belen and Cambon, N. S.; St. Georges Bay, Newfoundland; Mirimichi, N. B.; Glace Bay, C. B.; Marion Co., Illinois.

The original description of this species, based upon material from the middle and upper coal measures of the Maritime Provinces, was published in 1863.¹ It compares the structure of the wood to that of *C. Brandlingii*, notes the occurrence of a *Sternbergia* pith, and records the occurrence of the plant in the sandstones of the upper coal formation, where it is represented by vast numbers of trunks.

The only notable feature of this species appears in the character of the pits on the lateral walls of the ray cells. These structures show a very narrow border as in the Sequoias, but in many cases this element is so reduced as to become obscure, when the pit is reduced to the condition of a simple, open pore, such as occurs so commonly in many of the soft pines. At first this was attributed to loss of material by grinding, but a very searching examination proved it to be a normal feature. In *C. materioides*, the border is always more prominent, but the pore is nevertheless very wide, and the whole pit bears a marked resemblance to those found in *Sequoia*.

Transverse.—Tracheids 45×75 mic. broad, the walls 7.8 mic. thick.¹ Scattering tracheids show resinous matter.

¹ Can. Nat., VIII., 1863, 433.

¹ The normal thickness of the walls in this genus may be taken as 12.5 mic. Anything less indicates the operation of decay.

Radial.—Ray cells straight, somewhat narrowed at the ends, equal to about 2-6 tracheids; the pits on the lateral walls large, oval, round or oblong, narrowly or even obscurely bordered, 1-5, chiefly 1-2 per tracheid.

Bordered pits numerous throughout the tracheids, chiefly in two, sometimes in 3-4 rows, hexagonal or when more distant, oval, about 12.5 mic. broad.

Tangential.—Rays uniseriate or 2-seriate in part, upwards of 40 cells high, the oval or round cells 17-35 mic. broad.

CORDAITES ACADIANUM, Dn.

Fig. 18.

Bib. :—Can. Nat., 1863, VIII., 433; Acad. Geol., ed. 3, 1878, 473; Quart. Jn'l Geol. Soc., 1866, XXII., 145; Schimper, Pal. Veg., III., 577; Can. Rec. Sc., I., 1885, 155; Knowlton, Foss. Woods & Lig. of the Pot. Form., 1889, 52; Grand'Eury, Flor. Carb. du Dept. de la Loire, 1877, 265; Knowlton, Proc. U. S. Nat. Mus., XII., 608.

Dist. :—Middle Coal Measures, Joggins, N. S.; Port Hood, Mira and Glace Bay, C.B.; Dorchester, N.B.; St. Georges Bay, Newfoundland.

This species was originally described in 1863 from material obtained from the Joggins, Nova Scotia, where it was found in the form of large trees, usually silicified or calcified.¹ It presents no noteworthy features beyond the unusual size of the tracheids in transverse section.

Sir William Dawson's notes include the description of an unpublished species under the name of *C. acadiodes*. A very careful examination of the material shows that this does not present enough deviation from *C. acadianum* to justify its recognition as a separate species.

Large trees, usually silicified or calcified.

Transverse.—The large tracheids are about 62 x 62 mic. broad, the walls 9.5 mic. thick. Scattering tracheids show resinous contents.

Radial.—Ray cells often somewhat abruptly contracted at the ends, equal to 2-5 tracheids; the lateral walls with numerous round or oval pits, from 4-10 per tracheid, chiefly about 6, the border often very narrow, the oblong orifice $\frac{3}{4}$ the diameter of the pit.

Bordered pits numerous, hexagonal, 12.5 to 16 mic. broad, crowded in 2-5 rows.

Tangential.—Rays very variable, ranging upwards of 60 cells high, resinous, more or less 2-seriate throughout, the oval or oblong cells from 17-31 mic. broad.

¹ Can. Nat., 1863, VIII., 433.

CORDAITES OHIOENSE. Dn., n. sp.

Fig. 15.

An undescribed species from New Lisbon, Ohio.

Transverse.—Tracheids 47 x 56 mic. broad, the walls 12.5 mic. thick.

Radial.—Ray cells chiefly short, about equal to two tracheids, straight or somewhat abruptly contracted at the ends; the pits on the lateral walls oval, with a prominent border, apparently 2 per tracheid, but not exactly determinable on account of extended decay.

Bordered pits in 3-4 rows, sometimes 2 rows throughout the tracheid, hexagonal, about 12.5 mic. broad.

Tangential.—Rays numerous, upwards of 25 cells high; broad, about 41 mic., conspicuously squarish, 1 or often 2-3 seriate in part.

CORDAITES MATRIOIDE, Dn., n. sp.

Dist. :—Douglas Mine, Grand Lake, and Mirimichi, N.B.; Port Hood and Mabon, C.B.; Joggins, N.S.

This is an unpublished species embodied in Sir William Dawson's notes. The description there given places particular stress upon the thinner walls of the tracheids—a condition in reality resulting from advanced decay—and the greater number of rows of bordered pits. This latter, together with the number of pits on the lateral walls of the ray cells, really constitutes the point of differentiation from *C. materiarium*, and seems to constitute this a valid species.

Transverse.—Tracheids about 56 x 56 mic. broad, the walls 12.5 mic. thick. Scattering tracheids contain resin.

Radial.—Ray cells straight or somewhat contracted at the ends; the pits on the lateral walls oval, narrowly bordered, 1-8, chiefly 2-3 per tracheid; the lenticular or oblong orifice nearly equal to the diameter of the pit.

Bordered pits hexagonal, in 1-3, chiefly 2 rows.

Tangential.—Rays uniseriate or sometimes 2-seriate in part, upwards of 35 cells high; the oval or round cells 25-31 mic. broad.

CORDAITES ILLINOISENSE, Dn., n. sp.

An unpublished species from the coal measures of Rock Island, Illinois, and from the coal measures of Boonsboro, Iowa (?), the latter being designated in the collection of Sir William Dawson under the provisional name of *D. missouriense*. A third specimen appears in the

collection from Prof. Prosser, as derived from the Chase formation (Permian) of Chase County, Kansas.

Transverse.—Tracheids 47 x 47 mic. broad, the walls 9.3 mic. thick.

Radial.—Ray cells straight or abruptly narrowed at the ends, equal to 3-4 tracheids; the lateral walls show no recognisable structure.

Bordered pits in 1-3, chiefly 2 rows, hexagonal, 12.5 mic. broad.

Tangential.—Rays numerous, 1-seriate or 2-seriate in part, the broadly oval, thin-walled cells 28 mic. broad.

CORDAITES HAMILTONENSE, n. sp.

Figs. 2-7.

An undescribed species from the Genesee shales (Hamilton Group) of Ontario Co., N.Y. Collected by Prof. J. M. Clarke. Material in the collection of Sir William Dawson.

This specimen shows many interesting details of bark structure, which serve to enlarge our knowledge of the general structure of these plants. For the purposes of this description, and as represented by the fossil, but without strict reference to the proper subdivisions of that structure, the bark may be divided into three zones, the inner, middle and outer. In a transverse section the following details appear:—

The inner zone (fig. 2) is composed of isodiametric, thin-walled parenchyma elements. Scattered through this region, but chiefly forming a limiting layer on the outer face, there are numerous resin bearing elements which in the latter situation assume much greater dimensions, but the details of structure of which cannot be satisfactorily determined owing to the alteration of parts. The middle zone (fig. 3) consists of radially elongated, thin-walled elements which simulate cork in their tendency to disposition in radial series. Its radial extent is about equal to or somewhat in excess of the inner zone. Throughout its entire extent, resin canals of simple structure and of variable size, are distributed in large numbers, and in some cases at least, they appear to be derived from the main system of canals forming the outer limit of the first, and the inner limits of the second zone. The outer bark is represented by a broad zone of structure in process of disintegration. This is shown in part in fig. 4, which also includes the outer part of the middle zone.

The outer bark is represented by a broad zone of structure in process of disintegration. This is shown in part in fig. 4, which also includes the outer part of the middle zone.

In a radially longitudinal section, the inner bark consists of vertically elongated parenchyma elements, and it is penetrated throughout by narrow resin cells which accumulate on its outer face, become individually broader and form a zone 2-3 layers thick (fig. 5 and 6). The resin canals appear to be devoid of transverse septa, and are always full of resinous matter in a more or less granular form.

In the middle bark the parenchyma elements are radially elongated as in the transverse section, and the structure is penetrated by numerous resin canals which traverse the tissue in a direction chiefly coinciding with the axis of growth, but as they branch, they often become transverse or partially so. (Fig. 7).

Transverse.—Tracheids very variable, growth rings obscure.

Radial.—Structure of the medullary rays not determinable.

Bordered pits hexagonal, in two rows throughout.

Tangential.—Rays numerous and variable, 31-57 mic. broad; the cells very variable in form and size, thin walled, often broader than high, chiefly 1-seriate, often more or less 2-seriate.

CORDAITES PENNSYLVANICUM, Dn., n. sp.

An unrecorded species collected by Dr. Newberry from the Carboniferous at Pittsville, Pa.

Transverse.—Tracheids 44 x 44 mic. broad, the walls 6.7 mic. thick. Growth rings present, the summer wood about 8 tracheids thick, the tracheids about 12.5 mic. radially, the walls 3.1 mic. thick. Resin passages and resin cells wanting.

Radial.—Ray cells all of one kind, conspicuously but gradually narrower toward the ends, equal to about 3 tracheids; the lateral walls with round or oval pits, about 2-3 per tracheid.

Tangential.—Rays medium, broad, the cells round or transversely oval, variable, 25-31 mic. broad.

CORDAITES RECENTIUM, Dn., n. sp.

An undescribed species from the Permian or Permo-Carboniferous of Prince Edward Island. This was regarded by Sir William Dawson as being closely related to *C. materiarium*, if not identical with it. The characters, however, are such as to mark it off as a distinct species.

Transverse.—Tracheids 47 x 53 mic. broad, the walls much reduced by decay.

Radial.—Ray cells all of one kind, about equal to 2 tracheids; the lateral walls with round pits about 1 (?) per tracheid; the cells conspicuously narrower at the ends.

Bordered pits in a single row, compact, large, compressed and transversely oval or oblong, 15.6 x 22 mic., the orifice very variable from oblong to round, often eccentric, but typically round and central. When distant, the pits are round and smaller.

Tangential.—Rays medium, 1-2 seriate, the very broad cells 41 mic., thin-walled, round or squarish.

In addition to the material thus far described, there are several species from the Prosser and Dawson collections which cannot be brought under *Cordaite*s, but which must fall under other genera in accordance with the classification adopted. These are dealt with in the following descriptions.

CORDAITES HALLI, Dn.

Bib.:—Quart. Jn'l Geol. Soc., 1862, 298, 306; Dawson, Foss. Pl. of the Dev. & U. Sil. Form. of Canada, 1871, 14; Proc. U.S. Nat. Mus., 1890, XII., 606. Middle Devonian of Ontario County, New York.

The material from which the original description was obtained is in a pyritised state and therefore extremely unsatisfactory, inasmuch as such characters as were secured, were derived from an opaque object. As it is impossible to secure better material at present, the original diagnosis is repeated here tentatively.

“Wood cells very large, with five rows of contiguous, alternate, hexagonal areoles. Medullary rays frequent, and with as many as thirty rows of cells superimposed.”

DADOXYLON ANTIQUM, Dn.

Bib.:—Quart. Jn'l Geol. Soc., 1866, XXII., 146; Can. Nat., VIII., 1863, 433; Foss. Pl. of the L. Carb. of Can., Dawson, 1873, 17; Knowlton, Foss. Woods & Lig. of the Pot. Form., 1889, 37 & 52, and Proc. U. S. Nat. Mus., 1890, XII., 611; Acad. Geol. ed. 3, 1878, 473.

Dist.:—L. Coal Measures, Horton, N.S.

This plant represents a type which cannot well be referred to any existing form. It is among the earliest of this group described by Sir William Dawson who stated that it belongs to the type represented by the *Palaeoxylon* of Brongniart, *Pinites* Withami, L. and H.,¹ and the *Pissadendron* of Endlicher.² While it presents several features common to *Cordaite*s, its chief peculiarity lies in the multiseriate medullary rays.

¹ Int. Struct. of Foss. Veg., 1833, 72.

² Schimper, Pal. Veg., 370 & 384.

Transverse.—Tracheids in regular, radial rows, rather uniform, 44 x 47 mic. broad, the walls 9 mic. thick. Medullary rays numerous, 1—several cells wide.

Radial.—Ray cells all of one kind, short, equal to 2-3 tracheids; conspicuously and gradually narrower at the ends; the upper and lower walls thin, not pitted; the terminal walls thin, not pitted, usually curved; the lateral walls with bordered pits about 6 per tracheid, obscure, the slit-like orifice diagonal.

Bordered pits in one row, round and as broad as the tracheid; the orifice lenticular. These structures are for the most part wanting, and when present are very poorly defined.

Tangential.—Rays numerous, large, multiseriate, 2-4 cells wide, high; the cells hexagonal and all very thin-walled.

DADOXYLON PROSSERI, n. sp.

This specimen from the upper part of the Chase Formation (Permian), was obtained by Prof. Prosser from between sections 14 and 15, Cottonwood Township, Chase Co., Kansas, in 1897. The material is very badly preserved, but as it seems to differ from the others of the same formation, it is assigned a provisional name.

Transverse.—Tracheids in regular radial rows, rather rounded, 47 x 47 mic. broad, the walls 12.5 thick. Resin passages and special resin cells wanting. Growth rings none.

Radial.—Ray cells all of one kind, equal to 3-4 tracheids; the upper and lower walls thin and not pitted; the terminal walls thin, not pitted, generally curved; the lateral walls with small, round bordered pits, about 2-4 per tracheid.

Bordered pits round, 12.5 mic. broad, in 1-2, chiefly 2 rows.

Tangential.—Rays numerous, 1-seriate or somewhat 2-seriate in part, the round cells thin-walled, about 25 mic. broad.

DADOXYLON EDVARDIANUM, Dn.

This species from the Lower Trias at Indian River, Prince Edward Island,¹ is represented by badly preserved material from which the original diagnosis was obtained. The material will not admit of any exact confirmation of the diagnosis, which is here repeated provisionally.

"Trunks without distinct rings of growth, and with a central pith not observed to have transverse laminae. Wood cells with one, or rarely two, rows of contiguous, hexagonal areoles. Medullary rays simple, infrequent, with two to ten rows of cells superimposed."²

¹ Rept. on the Geol. Struct. and Min. Res. of P. E. Island, 1871, 45.

² Proc. U. S. Nat. Mus., XII., 1890, 615.

PITYOXYLON CHASENSE, n. sp.

This material was obtained by Prof. Prosser from the Chase Formation (Permian) at Coon Creek, Chase Co., Kansas, in 1897. The structure is fairly well preserved. Its chief feature is to be found in the occurrence of broad rays which bear a small, central resin canal. This feature is exhibited by my sections in tangential section only, probably in consequence of the special condition of preservation. It nevertheless serves to definitely separate the plant from Cordaites, and its affinities are rather with the Pityoxylon of Kraus.¹

Transverse.—Tracheids chiefly in regular radial rows, very variable in size, squarish, about 44 x 44 mic. broad; the walls 12.5 mic. thick.

Medullary rays numerous, chiefly one cell wide, occasionally 2-3 seriate. Growth rings wholly wanting. Resin cells and resin canals not represented.

Radial.—Ray cells all of one kind; straight, equal to 2-4 tracheids; the upper and lower walls thin and not pitted; the terminal walls thin, not pitted, straight or curved; the structure of the lateral walls not determinable, but the pits are probably round.

Bordered pits in 1-3 rows, chiefly 2 rows, round or hexagonal, 12.5 mic. broad, the orifice probably round.

Tangential.—Rays of two kinds.

(1) Uniseriate rays, the cells oblong, 25 mic. broad, often 2-seriate in part.

(2) Fusiform rays, the terminals linear and of the structure of the uniseriate rays; the central tract very broad, nearly round; the cells large, thin-walled, irregular and enclosing a small, central resin passage with large epithelium cells.

CUPRESSINOXYLON CHEYENNENSE, n. sp.

A specimen of the Prosser collection obtained from the Cheyenne (Comanche Cretaceous), east of Stokes Hill, Kiowa and Baker Co. line, Kansas, 1897.

Transverse.—Tracheids in regular, radial rows, rather uniform, roundish, about 62 x 62 mic. broad; the walls 15.5 mic. thick.

Resin passages and special resin cells wanting.

Growth rings apparent, very broad, in a radial extent of 20 mm., two growth rings of an equal thickness of 10 mm. are represented. The summer wood conspicuous, about 3-4 cells thick, the tracheids about 29 x 38 mic. broad, the tangential walls about 15.5 mic. thick.

Radial.—Ray cells all of one kind, straight; the upper and lower walls thin and not pitted; the terminal walls thin and not pitted, straight or

¹ Schimper, Pal. Veg., 370.

curved; the lateral walls showing no structure which has been obliterated by decay; the cells 3-5 tracheids long.

Tangential.—Rays numerous, medium, 1-3 seriate; the cells round, thin-walled, 47 mic. broad.

CUPRESSINOXYLON COMANCHENSE, n. sp.

Collected by Prof. Prosser from the Comanche Cretaceous (?) N. W. of Ashland, Clark Co., Kansas, 1897. The material is badly preserved and some of the details cannot be made out satisfactorily, especially if the pits are 1 or 2 seriate. It bears a very striking resemblance to some of the Cupressinæ.

Transverse.—Tracheids in regular, radial rows, rounded, very uniform, 44 x 44 broad, the walls 12.5 mic. thick. Resin passages and special resin cells

Growth rings prominent, about 10 in a radial extent of 22 mm.; the summer wood thin, composed of 2-4 rows of tracheids, the latter about 22 mic. wide, the walls 12.5 mic. thick.

Resin passages and resin cells wholly wanting.

Worm borrows are frequent and show copious exudation of resin which has often preserved the adjacent structure from decay.

Radial.—Ray cells of one kind only, straight; the upper and lower walls thin and not pitted; the terminal walls thin, not pitted, chiefly curved; the lateral walls with oval, bordered pits about 1-2 per tracheid, the oblong or broadly lenticular orifice nearly as long as the pit; the cells equal to about 4 tracheids.

Bordered pits round, large, 19 mic. broad; in one or sometimes 2 rows, the orifice round.

Tangential.—Rays uniseriate, the cells thin-walled, round, 19 mic. broad.

ARAUCARIOXYLON PROSSERI, n. sp.

One of the Prosser collection from the Cheyenne (Comanche Cretaceous), of the Bluff west of Sun City, Medicine Lodge River, Baker Co., Kansas, 1897.

Transverse.—Tracheids in regular radial rows, squarish, 39 x 42 mic. broad; the walls 6.2 mic. thick.

Resin cells and special resin passages wholly wanting. No evidence of growth rings in a radial extent of 22 mm.

Radial.—Ray cells all of one kind, straight or narrower at the ends, equal to 3-9 tracheids; the upper and lower walls thin, and devoid of pits; the terminal walls thin, not pitted, curved; the lateral walls show no structure through extreme alteration.

Bordered pits not clearly determinable, but probably round and in one row.

Tangential.—Rays numerous, chiefly low; the cells broad, round, about 31 mic. wide.

DESCRIPTIONS OF THE FIGURES.

- Fig. 1.—*Cordaites Brandlingii*. Transverse section showing extent of development in the growth rings. S.W.=Summer wood. x 48.
- Fig. 2.—*Cordaites hamiltonense*. Transverse section of the inner bark, showing (c) the cambium region, (pr.) the ordinary parenchyma and bast structure, (r.c.) the resin canals forming the outer limit. x 48.
- Fig. 3.—. Transverse section of the middle bark in continuation of Fig. 2, showing (r.c.) resin canals, (pr.) ordinary parenchyma tissue. x 48.
- Fig. 4.—. Transverse section of the middle bark (m.b.) and the outer bark (o.b.) which is in process of decomposition. x 48.
- Fig. 5.—. Radial longitudinal section of the inner bark showing (m.r.) medullary rays at their entrance from the wood, (c.) the cambium region and (pr.) the ordinary structure of the parenchyma. x 48.
- Fig. 6.—. Radial longitudinal section of the inner and middle bark in continuation of Fig. 5, showing (r.c.) the resin canals and (pr.) ordinary parenchyma structure. x 48.
- Fig. 7.—. Radial longitudinal section of the outer middle bark, showing (pr.) ordinary parenchyma structure and (r.c.) resin canals. x 48.
- Fig. 8.—*Cordaites Clarkii*. Transverse section of the stem showing (r.c.) resin cells in the pith, vascular elements of the protoxylem (v.), and the ordinary tracheids (tr.) x 48.
- Fig. 9.—*Cordaites Brandlingii*. Radial section showing the structural details in the vascular elements of the protoxylem. x 180.
- Fig. 10.—. Radial section in continuation of Fig. 9, showing passage of spiral into scalariform structure. x 180.
- Fig. 11.—. Radial section in continuation of Fig. 10, showing transformation of scalariform structure into bordered pits of transversely elongated form, and finally into pits of the hexagonal type. x 180.
- Fig. 12.—*Cordaites Newberryi*. Radial section showing disposition of the bordered pits. x 180.
- Fig. 13.—*Cordaites materiarium*. Tangential section showing the general character of the medullary rays of the uniseriate type. x 48.
- Fig. 14.—. Tangential section from the same specimen showing the rays 2-seriate in part. x 48.
- Fig. 15.—*Cordaites ohloense*. Tangential section showing the character of the medullary rays. x 48.
- Fig. 16.—*Cordaites Clarkii*. Tangential section showing the nature of the rays with parenchyma cells and tracheids, which latter appear chiefly in the contracted portions. x 61.
- Fig. 17.—*Cordaites materiarium*. Radial section showing typical character of the bordered pits in two rows. x 180.
- Fig. 18.—*Cordaites acadianum*. Radial section showing typical character of the bordered pits in 2-4 rows. x 180

FIG. 1. *CORDAITES BRANDLINGII*. X 18.

FIG. 2.—*CORDAITES HAMILTONENSE*. X 18.

FIG. 3. *CORDAITES HAMILTONENSE*. X 48.

FIG. 4.—*CORDAITES HAMILTONENSE*. X 48.

FIG. 5.—CORDAITES HAMILTONENSE. X 18

FIG. 6.—CORDAITES HAMILTONENSE. X 18.

FIG. 7.—CORDAITES HAMILTONENSE. X 18.

FIG. 8.—CORDAITES CLARKII. X 18.

FIG. 9.—CORDAITES BRANDLINGII. $\times 180$.

FIG. 10.—CORDAITES BRANDLINGII. $\times 180$.

FIG. 11.—CORDAITES BRANDLINGII. $\times 180$

FIG. 12.—CORDAITES NEWBERRYI. $\times 180$

FIG. 13.—CORDAITES MATERIARIUM. x 48.

FIG. 14.—CORDAITES MATERIARIUM. x 48.

FIG. 15.—*CORDAITES OHIOENSE*. X 48.

FIG. 16.—*CORDAITES CLARKII*. X 61.

FIG. 17.—*CORDAITES MATERIALIUM*. x 180.

FIG. 18.—*CORDAITES ACADIANUM*. x 180.