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CHARLES D WALCOTT, DIRECTOR

THE GEOLOGY OF THE PERRY BASIN IN SOUTHEASTERN MAINE

BY

GEORGE OTIS SMITH and DAVID WHITE

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DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington, D. C., May 27, 1904.

SIR: I have the honor to transmit the manuscript of a report on the geology of the Perry basin, in southeastern Maine, by George Otis Smith and David White, and to recommend its publication as a professional paper.

This report embodies the results of an investigation of alleged coal deposits, made in cooperation with the Maine State Survey Commission. While from an economical standpoint the results are entirely negative, they are none the less important and are of great scientific interest.

Very respectfully,

C. W. HAYES,
Geologist in Charge of Geology.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

THE GEOLOGY OF THE PERRY BASIN, IN SOUTHEASTERN MAINE.

By George Otis Smith and David White.

INTRODUCTION.

EXPLANATION OF THE INVESTIGATION.

The geologic examination of the Perry district, in southeastern Maine, was undertaken at the request of the Survey Commission of the State of Maine. During the 1902–3 session of the Maine legislature an effort was made by petitioners resident in Washington County to obtain from the State an appropriation of $10,000 for coal exploration. The resolve proposed contained a proviso necessitating an additional contribution of $5,000 by individuals or corporations interested. The $15,000 thus procured was to be expended in drilling for coal at the most promising localities. The resolve failed to pass, but the Maine Survey Commission decided that the same results could be accomplished by the expenditure of a small portion of the general appropriation for geologic work in cooperation with the United States Geological Survey.

The authors were detailed by the Director of the United States Geological Survey to make the investigation of the Perry region, under the direction of the Maine commissioners, for the purpose of determining the possibilities of the occurrence of coal in commercial quantities. As will be shown later, the region is especially favorable to geologic work, and a ten-day reconnaissance yielded data upon which definite conclusions can be based. These conclusions are presented in this paper, together with observations incidentally made that have a bearing upon the general geologic problems of the region. It is believed that the results thus obtained in answer to the inquiry as to the occurrence of coal are even more definite than those which would have been reached by the expenditure of the proposed appropriation in extensive drilling operations.

In the preparation of the report the observations and deductions of both authors have been used, but Chapters I and III have been written by Mr. White and Chapters II and IV, with the added descriptions of other localities visited, by

Mr. Smith. A preliminary statement of the results was submitted to the Maine Commission August 5, 1903, and published by it in the daily press of the State on the following day.

STATEMENT OF CONCLUSIONS.

In this paper it will be shown, regarding the geologic relations, that—

1. The Perry formation, consisting chiefly of brownish conglomerates and interbedded lavas, lies in irregular areas in marked unconformity on earlier formations, the youngest of which is probably of a date not later than the oldest Devonian.

2. The formation is estuarine and was rapidly deposited, the materials being derived, without long transport, from rocks immediately adjacent to the area of deposition.

3. The lower beds of the formation are more coarsely and massively conglomeratic toward the north, and the higher beds are accompanied by a larger proportion of intrusive rocks.

4. Since the deposition of the Perry beds there has been no very marked folding and but slight alteration of the sediments, though minor faulting and some cutting by intrusives have occurred.

5. The lavas of the Perry formation are basic as compared with those of Silurian age, which are of a rhyolitic type.

6. The age of the formation is distinctly Devonian, and probably Chemung.

Regarding the occurrence of coal it is found that—

1. The strata of the formation, which are exposed in exceptional completeness, bear no evidence of the presence either of any seam of coal, of whatever thickness, or of any of the usual and more or less characteristic accompaniments of coal seams, such as old soils, Stigmaria clays, leached plant shales, etc., there being no traces of even carbonaceous or black-shale beds or partings.

2. The fossils show that the rocks are of upper Devonian age; i. e., that they were laid down in a period earlier than the deposition of any commercially workable coals yet discovered on any continent. There is therefore no basis whatever for the hope of finding usable coal in any of the concealed parts of the Perry formation.

3. There are no rocks of coal-bearing age under the Perry formation. The youngest of the remaining Paleozoic rocks of the region, beneath and surrounding the Perry formation, are far more ancient than the rocks of the Perry formation. The last drill prospect is shown to have passed through the Perry formation and into the lavas of Silurian age.

4. The reports of coals do not, when investigated, conflict in the least with the foregoing conclusions.

CHAPTER I.

REVIEW OF LITERATURE.

By DAVID WHITE.

The vicinity of Perry has perhaps attracted more attention on the part of geologists than any other portion of eastern Maine. The presence in the Perry basin of the youngest Paleozoic rocks yet definitely determined in the State, the relative proximity of this basin to the coal fields of Nova Scotia and New Brunswick, and the lithologic resemblance between the rocks of the basin and those associated with the coal measures lying farther northeastward are conditions which, since the earliest geologic explorations in the State, have combined to excite interest in this region as one favorably situated for the occurrence of coal. The researches were therefore carried on chiefly with an economic motive.

Geographically and structurally the Perry basin is most closely bound to southern New Brunswick. Accordingly we find its geologic features compared with those of that Province, its formations having been included by the Canadian geologists in their discussions of the upper Paleozoic axis of the Bay of Fundy, with which the Perry basin is continuous.

As early as 1836[a] Dr. Charles T. Jackson, in the service of both Maine and Massachusetts, published numerous details of the geology of eastern Washington County, including descriptions of the eruptives and red sandstones and conglomerates about Perry. The sandstones, described as extending along the St. Croix River from Indiantown to Liberty Point, in Robbinston, were identified as belonging to the coal formation of New Brunswick and Nova Scotia, though, as was explained, until the sequence should be traced across from the Grand Lake (New Brunswick) coal field it remained impossible to fix their exact position with reference to any coal beds assumed to be near. The term "New Red sandstone" was applied[b] to some of these beds along the St. Croix River, and they were correlated with the older Mesozoic of Connecticut and the gypsiferous and coal-bearing series of

[a] First Rept. Geol. Public Lands, State of Maine; Mass. S. Doc. No. 89, March, 1837, pp. 11, 12, 18. First Rept. Geol. Maine, 1837, pp. 17, 18, 97.

[b] First Rept. Geol. Maine, 1837, p. 97.

Nova Scotia. On the basis of this supposed identity of formation Professor Jackson recommended the exploration, by boring or otherwise, for coal, which, if present, he thought should be found between Pembroke and the St. Croix. He says:

"From the observations which we have been able to make it will appear that the sandstone here described is a continuation of that which exists in New Brunswick and in which the bituminous coal of the Grand Lake is probably contained. It will, however, be impossible for me to speak positively on this subject until I have visited that district, for no survey of the region has ever been made. It is, however, an undoubted fact that the sandstone in question is identical with the red sandstone of Nova Scotia which contains gypsum, salt springs, and coal. In a subsequent excursion around Lubec Bay we found a salt spring, which issues from the soil near the junction of this sandstone with the argillaceous limestone rock, above the Lubec lead mines. The New Red sandstone rests directly on the transition limestone at Pembroke. It occurs also at Red Head, Nutters Point, where it is of an exceedingly fine texture and will serve perfectly for the manufacture of hones and fine grindstones for delicate tools.

"If coal really occurs in this sandstone, it should be found between the village of Pembroke and the St. Croix River. In the present state of our knowledge of the country it is impossible to say more respecting the occurrence of coal in this section. It not unfrequently happens that some members of the coal series are wanting, which may possibly be the case here. It is, however, worthy of exploration, and by boring through this rock in a few places the question may be settled at little expense to those who may enter on the task.

"Should no such operations be carried on before the next year, I hope to be allowed to extend my researches to the known coal regions of New Brunswick, on the Grand Lake, when more light may be obtained on this important subject. The numerous irregularities to which our coal measures are subject render it difficult, if not impossible, to trace them without the aid of immediate comparisons of one section with another. No geological observations would imply that the red sandstone in question should not contain coal; for if it should be found equivalent to the New Red sandstone formation of Europe, it will belong to the upper coal series. The occurrence of a salt spring at its junction with the limestone appears to favor this supposition."[a]

The same views are implied in Doctor Jackson's second report[b] as State geologist, made in 1838. Nevertheless, as will be seen later, the correlations on which he based his hope of developing a coal field in this basin, and which were accepted by Gesner, the geologist of New Brunswick, were entirely false and misleading.

For a score of years following the close of Doctor Jackson's survey, the literature, so far as it concerns the Perry formation, relates chiefly to the classification and age of the coal- or copper-bearing red sandstones of North America. This discussion was participated in by the most eminent American geologists of the period.

[a] First Rept. Geol. Maine, 1837, pp. 17, 18.

[b] Second Ann. Rept. Geol. Public Lands of Maine and Massachusetts, Boston, 1838, p. viii.

In 1851 Jackson, though insisting that the red sandstones overlying the Silurian in Maine were of the same age as those in the Connecticut Valley or in New Jersey, suggested[a] that all of the deposits in question might belong in the Silurian system. This proposition was promptly combatted by Agassiz, who urged[b] that the vertebrate remains of the New Jersey red beds should not be regarded as older than the Trias.

In 1859 the current of opinion as to the age of these rocks was turned from a later to an earlier age, apparently by a fossil plant. In that year Prof. W. B. Rogers laid before the Boston Society of Natural History[c] "specimens of the supposed coal-bearing rocks of Maine, in which was an impression closely resembling *Cycloteris hibernica*, so common in Great Britain." Professor Newberry concurred as to the affinities of this species, and Professor Rogers was accordingly of the opinion that the Perry beds were to be correlated with the "Kiltorcan" (Devonian or "Ursa," but regarded by him as lower Carboniferous) of Ireland, the "Albert shales" of New Brunswick, and the Pocono coal-bearing series of the Appalachian region, all being referable to the lower Carboniferous. Later he was disposed to regard the Perry beds as upper Devonian, or transitional to the Carboniferous. About the same time Jackson stated[d] that, although at first disposed to consider the Perry beds as "New Red" or Triassic, he had since come to regard them as Devonian, since he had traced the red sandstones from Perry to Trescott and Machias, where they rest on beds of Silurian if not Devonian age, but that "fossils recently discovered seemed to indicate that his first conjecture, that these rocks are Triassic, was well founded." This was followed by a reiteration on the part of Agassiz[e] that the red sandstone of southern New Brunswick was Triassic, additional proof being cited in the form of a *Calamites* supposed by him to be close to the Triassic *Equisetum columnare*.

In the meantime shafting and boring had been carried on in the Perry basin in the search for coal, and the careful scrutiny of the rocks had led to the discovery of additional fossil plants. Accordingly, when, in 1861, Prof. C. H. Hitchcock entered upon his duties as State geologist of Maine, he called to his aid, in the determination of the vexed Perry question, the services of Prof. J. W. (later Sir William) Dawson, who had already begun the publication of his valuable series of papers on the Paleozoic floras of northeastern America. Hitchcock's report[f] contains the most accurate and detailed description of the geologic features of the basin that has yet appeared, though, as in previous reports, the Perry sandstone was not in all areas

[a] Proc. Boston Soc. Nat. Hist., vol. 3, p. 335.
[b] Loc. cit., p. 337.
[c] Proceedings, vol. 5, pp. 86, 170, 398.
[d] Loc. cit., pp. 396–398.
[e] Loc. cit., pp. 357, 398.
[f] Sixth Ann. Rept. Sec. Maine Bd. Agric., Augusta, 1861 (1862), pp. 247–257, 208.

distinguished from the red shales of the Silurian. The most important part of this report, however, so far as it relates to the prospect of finding coal in this basin, is that giving the results of Dawson's study of the fossils and enumerating or describing seven species of fossil plants found at Perry. In view of the character and distribution of these species Dawson unqualifiedly asserted his conclusion that the beds were of Devonian age, thus confirming his previous views, which were almost simultaneously published,[a] but which had been based on a smaller amount of material.

The conclusions, accompanied by paleontological evidence, first set forth by Sir William Dawson, met prompt and general acceptance at the time by Hitchcock[b] and others, though more precise correlations were not given until later, when, as additional material was discovered and the distribution of the species was better known, his comparison of the Perry flora became more exact. Thus, in Dawson's next papers[c] on the subject, in the following year, he refers the Perry beds (estimated at 1,300 feet) to the upper Devonian and correlates them with the upper member of the "St. John Series" and the upper Devonian of Gaspé. In the next year Dawson[d] had recognized 16 forms in the Perry flora, which he correlated as before, while cautioning explorers of this region "that these rocks strikingly resemble in their mineral characters the lower Carboniferous red sandstones and conglomerates of some parts of Nova Scotia and New Brunswick, and also probably Mesozoic 'New Red sandstones' of these Provinces."

These words of Dawson reflect his embarrassment in correlating the relatively unaltered Perry beds with the lithologically strikingly dissimilar and somewhat metamorphic St. John beds, or "fern ledges," lying farther northeastward in the same basin at Lepreau and St. John, along the Bay of Fundy. This difficulty seems to disappear when he concludes[e] that the beds at Perry "may belong to a Devonian horizon somewhat higher than that of the St. John beds, and that this may possibly serve to account for their comparatively unaltered condition." He reiterates, however, that "the flora of the Perry beds is precisely equivalent to that of the upper Devonian of Pennsylvania and New York, and quite distinct

[a] On the pre-Carboniferous flora of New Brunswick, Maine, and eastern Canada: Canadian Naturalist, vol. 6, June, 1861, pp. 172-175. The collections studied by Dawson were those of the Portland Society of Natural History and a collection made by Mr. Richardson, of the Geological Survey of Canada.

[b] Proc. Portland Soc. Nat. Hist., vol. 1, pt. 1, 1862, pp. 76-78. In this paper Professor Hitchcock points out the fact that the paleontological equivalents of the Perry beds underlie the lower Carboniferous of the Bay of Fundy region, and he calls attention to the consequent conclusion that the Carboniferous does not occur in Maine, and that "we need no longer expect to find beds of coal in Perry."

[c] On the flora of the Devonian period in northeastern America: Quart. Jour. Geol. Soc. London, vol. 18, November, 1862, pp. 296-330, pls. xii-xvii; reprinted in part, Am. Jour. Sci., 2d ser., vol. 35, 1863, pp. 311-319. Descriptions of new fossils. Second Ann. Rept. Nat. Hist. and Geol. Maine, 1863, pp. 402, 404; reprinted in Proc. Portland Soc. Nat. Hist., vol. 1, pt. 2, 1863, pp. 99, 100, pl. ii.

[d] Further observations on the Devonian plants of Maine, Gaspé, and New York: Quart. Jour. Geol. Soc. London, vol. 19, November, 1863, pp. 458-469, pls. xvii-xix. Acadian geology, 1868, p. 513.

[e] The fossil plants of the Devonian and upper Silurian formations of Canada: Geol. Survey Canada, 1871, pp. 6, 11, 68, 71, 85.

from that of the lower Carboniferous," and in his table[a] the sandstones about Perry are put opposite the Chemung of New York and the upper Devonian of Gaspé.

The difficulties met in reconciling a Devonian correlation of the Perry beds with the great section near St. John adopted by the New Brunswick geologists as typical of the Devonian for the southern part of their province seems to have increased as the stratigraphic studies of Prof. L. W. Bailey, Dr. G. F. Matthew, and Prof. C. F. Hartt were carried along the Bay of Fundy to the shores of Passamaquoddy Bay. In the same year in which Dawson's report, just mentioned, was printed we find Bailey and Matthew[b] placing the "Perry sandstone group" "at or near the base of the lower Carboniferous," although, since at Perry and St. Andrews they contain Devonian forms of vegetation, it was thought that they might be of earlier date than the lower Carboniferous of the Kennebecasis Valley. This reference we find reaffirmed in 1880 by Bailey, Matthew, and Ells, who, in discussing the outlying deposits on the shores of the Passamaquoddy Bay, explain that[c] "these are interesting as containing in their lower portions fossils of a Devonian type, while the beds themselves are uncomformably superimposed upon the true Devonian, and otherwise possess the characters of the lower Carboniferous rocks."

The second part of Dawson's Fossil Plants of the Erian and Upper Silurian Formations of Canada appeared in 1882,[d] and among the more exact correlations contained therein we again find the Perry beds placed at the top of the Devonian, on a level with the "*Pterichthys* beds" of Scaumenac, New Brunswick. This conclusion was unqualifiedly stated in all of Sir William's later references to the Perry formation.[e] Nevertheless, the stratigraphers of the Canadian Survey seem genrally to have decided that the stratigraphic tracing of the beds admitted no doubt as to the identity of the Perry with the lower Carboniferous of the Bay of Fundy basin, to which it is very closely similar lithologically; and we find the Perry formation mapped as lower Carboniferous by the Geological Survey of Canada on the detailed geologic sheet embracing this portion of the international boundary.[f]

An important paper relating to the Perry formation was published by Prof. N. S. Shaler in 1886, under the title "Preliminary Report on the Geology of the Cobscook Bay District, Maine."[g] This paper is devoted chiefly to the lithology, stratigraphy, and fossils of the rocks, which he classifies in four groups, three

[a] Foss. Pl. Dev. Upp. Sil. Form., Canada, p. 11.
[b] Geol. Survey Canada, Rept. for 1872, p. 200.
[c] Geol. Survey Canada, Rept. for 1880, pp. 12D, 15D.
[d] Geol. Survey Canada, for 1882, p. 113.
[e] See Geological History of Plants, 1888, p. 107; also, Geology of New Brunswick, Nova Scotia, and Eastern Canada, 1891, Suppl., p. 73.
[f] Geol. Survey Canada, Province of New Brunswick, No. 1 S. W., 1880.
[g] Am. Jour. Sci., 3d ser., vol. 32, pp. 35-60.

of these being below the Perry group, the highest of the latter, the Cobscook, including dark sandstones and shales ("Moose Island Black shale"), probably approximately of the date of the "Ohio" ["Hamilton"] shale. These groups are—

1. A basal series, of unknown thickness, consisting of gneissoid, syenitic, and granitic rocks and some mica-schists, probably of Laurentian age.

2. The "Campobello group," comprising dark greenish, grayish, siliceous, and argillaceous rocks with very little lime and no fossils, over 4,000 feet thick, to be compared with the Cambrian.

3. The "Cobscook series," not less than 4,000 feet of more or less altered sandstones, shales, limestones, ash beds, and intrusives, carrying at points Clinton, Niagara, lower Helderberg, and middle Devonian (?) fossils.

4. The "Perry series," over 2,000 feet of coarse, red conglomerates and sandstones unconformably deposited, of upper Devonian or lower Carboniferous age.

The structure of the basin and the erosion intervals between the groups are discussed at some length, though the red Silurian does not seem at all points to have been distinguished from the Perry, which, with its coarse, red sandstones, conglomerates, and reddish shales, estimated as certainly over 2,000 feet in thickness, he regards as a shore or estuarine deposit distinctly unconformable on the older groups.

Professor Shaler adds:

"If the lower part of the section at Perry should turn out to be upper Devonian or sub-Carboniferous, as seems not improbable, then the evidence will be to the effect that a period of erosion occurred in the interval between the close of the middle Devonian and the formation of the Perry beds. This is especially interesting, as it would seem to show that this portion of the continent was above the sea during a part of the Devonian or of the sub-Carboniferous period."[a]

In the Cobscook group, which is next below the Perry group, Shaler recognizes four faunas: A lower Helderberg, at Orange Bay; a fauna closely related to the Clinton or Niagara, at Dents Point; a Niagara fauna, near Demysville, and the fauna of the "Moose Island Black shales," for which he argues a middle Devonian age. For the latter correlation the age evidence, which is in part merely circumstantial and lithologic, does not appear sufficient. The paleontological evidence on which these age determinations were based will be briefly considered in a later part of this paper (p. 22). In a footnote[b] the author remarks:

"It may be incidentally suggested that the conglomerates and sandstones of the Perry series should be compared with the deposits of the 'Catskill period' of the Hudson district."

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[a] Loc. cit., p. 50.

[b] Loc. cit., p. 51.

Finally, it is interesting to note a conclusion regarding the Perry group more recently presented by Prof. L. W. Bailey, in a paper "On some Relations between the Geology of eastern Maine and New Brunswick," wherein the following statement is made:[a]

"In its fossil flora, so well described by Sir William Dawson, its aspect is undoubtedly Devonian, but to the other rocks of that system, as seen only a few miles to the eastward, along the New Brunswick coast, it bears no resemblance whatever, while, both in the nature of the beds and in their relations to the subjacent formations, it does bear much resemblance to the rocks of the lower Carboniferous system which spread so widely over other portions of the province. For this reason it was, in the survey reports and maps, represented as a part of the last-named system. On the other hand, however, it differs from the latter in the total absence of the marine limestones and gypsiferous beds usually found in connection therewith, and in this respect approaches more nearly a group of coarse sediments skirting the shores of the Bay des Chaleurs, which have been there shown to be unconformably overlapped by the lower Carboniferous or Bonaventure rocks. It is probable that in both instances these coarse red beds, though true Devonian, are to be regarded as representing the most recent portion of that system, and like the Catskill group of New York, which they nearly resemble, constitute a transitional series between the two."

It is thus seen that the conclusions of Professor Bailey and the suggestions of Professor Shaler are in substantial agreement with the correlation first proposed by Sir William Dawson, notwithstanding the consequent difficulties involved in the correlation of the supposed Devonian and lower Carboniferous rocks along the Bay of Fundy between the St. Croix River and St. John.

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[a] Trans. Royal Soc. Canada, vol. 7, sec. 4, 1889, p. 60.

CHAPTER II.

DESCRIPTIVE GEOLOGY.

By George Otis Smith.

CONDITIONS OF GEOLOGIC WORK.

The natural conditions in this coast region may be said to favor geologic mapping. It is true that in the interior portion of the area outcrops may not be everywhere as numerous as the geologist might desire, although in our rapid traverse of the principal roads the rock exposures were found to be sufficiently abundant to serve the purpose of the reconnaissance. Yet the coast line is here characterized by a very extensive development of deep indentations and projecting peninsulas, and along the most of this complicated shore line the very strong tides of Passamaquoddy and Cobscook bays have been effective in sea erosion. Thus sea cliffs have been carved that expose large faces of rock, and in these and in the outlying stacks, ledges, and reefs the rock strata can be easily studied. At the base of the cliffs the rock is in places swept clean by the tide, so that it is often possible to study contacts or dikes in both horizontal and vertical sections.

These favorable conditions prevail especially along the western shore of St. Croix River, where the Perry formation is exposed. Thus the conclusions reached concerning the stratigraphy and structure of this formation are for the most part definite. Rarely is the geology of an area so easily read and the problem to be investigated so readily solved.

In this reconnaissance of the Perry district the greater part of the time was devoted to the Perry formation itself. The shore section was carefully studied from Red Beach as far as the highway bridge at the northern end of Moose Island. The western and northern limits of the area of Perry rocks were determined approximately by road traverses, and at the same time the rocks forming the floor upon which the Perry sediments had been deposited were observed, the reconnaissance extending as far west as Pembroke. For the purpose of obtaining a broader knowledge

GEOLOGIC MAP OF THE PERRY BASIN, SOUTHEASTERN MAINE

BY

GEORGE OTIS SMITH AND DAVID WHITE

Scale 0 1 2 3 miles

1904

JULIUS BIEN & CO. LITH. N.Y.

of the Perry formation the adjacent parts of New Brunswick were also visited and the sections exposed there were studied. In short, the work was planned so as to obtain as much information as possible regarding the stratigraphy, structure, and age of the Perry formation. The older rocks were studied chiefly in their relations to this formation, although some other observations will be recorded in this paper, because of their importance in the interpretation of the geology in other parts of the State.

OLDER FORMATIONS.

The rocks older than the Perry formation are of three classes—the granitic rocks, the Silurian sedimentary strata, and the associated volcanics. These will be described briefly, since some knowledge of them has proved to be essential to the solution of the question under discussion. Especially is this true of the Silurian rocks lying directly beneath the Perry conglomerate, from the fact that coal prospectors have sometimes failed to recognize these as older than the formation in which they hoped to find coal.

GRANITE.

Granitic rocks extend along the St. Croix River from near Calais to Robbinston. At Devils Head there are prominent exposures of granitic rocks. On the northwest slope of this promontory several types of igneous rock occur. In the same quarry opening light-pink granite and a dark-green rock are exposed in parallel sheets. The former is granite of the normal type, containing only a small proportion of biotite, while the latter has the composition of granite, but contains larger amounts and greater variety of the darker constituents, pyroxene being probably present with the hornblende and biotite. Some masses of coarse diabase also occur at this locality and the relations indicate a complex intermixture of several distinct intrusions of plutonic rock, which may, however, represent a common magma.

Farther south, at Red Beach, the granite is uniform in both color and texture. This granite is quarried extensively and the product of the Red Beach quarries has an excellent reputation in the market. Its attractive red color, fine grain, and even texture are qualities that fit it for the best work, since it takes a high polish.

In the town of Robbinston the red granite is slightly different in character. It is of even finer grain, and quartz, orthoclase, and plagioclase constitute almost the whole of the rock. In the specimen collected here a slight amount of chlorite represents the ferromagnesian constituent, which was probably biotite. In texture it approaches graphic granite, the quartz not being a younger constituent than the orthoclase, but in places showing the peculiar intergrowth with that mineral. Both the feldspars are deeply colored with iron oxide, the plagioclase being slightly lighter in tint. It is this coloring matter in the feldspars that gives the bright-red color to the granite of Red Beach and Robbinston, and, as will be shown later, to the Perry sandstones as well.

Age of granite.—The exact age of the granitic rocks is an interesting point for determination. This question has no special importance in this investigation, but its bearing upon the geology of this portion of the State is direct enough to warrant brief mention here.

The granitic rocks that directly underlie the Perry formation in the town of Robbinston were regarded by Shaler as "of presumably Laurentian age." Bailey and Matthew, however, as early as 1872, recognized much of the granite as "intrusive," although there would be difficulty in separating this from the Laurentian granite. The "red syenitic rock" on the east side of the St. Croix River is described as appearing to graduate into feldspathic beds, which are in turn succeeded by "amygdaloidal traps" and sandstones containing *Modiolopsis* and *Lingula.*[a] In a later report[b] by these geologists this "Nerepis granite" is assigned to late Devonian time.

The observations made in connection with the present investigation confirm in part the conclusions of Bailey and Matthew. The red granite at Robbinston is the western continuation of their "Nerepis granite" and in its general appearance also resembles somewhat the "felsites" interbedded with the Silurian sandstone. The red granite and the red spherulitic lava, already described, are similar in composition and in the manner in which the orthoclase is colored. The latter feature probably has little value except as it explains the general resemblance of the two rocks as they are seen in weathered outcrops. In view, however, of their similarity in mineralogic and inferred chemical composition, it seems probable that these rocks are plutonic and effusive representatives of the same magma and are to be correlated in age in a general way. The granitic intrusions thus may not have ceased until later Silurian time, the rhyolitic lava on the north end of Moose Island being a flow from the same magma from which the granite now exposed at Red Beach had been derived. Neither granite nor rhyolite contributed pebbles to the Silurian sediments, but their detritus constitutes the bulk of the Perry conglomerate, as will be seen from the descriptions in the following chapter.

The evidence thus appears to support the conclusion that the red granite of Robbinston as well as the red rhyolitic rocks of Perry and the north shore of Moose Island are of late Silurian or of early Devonian age.

[a] Geol. Survey Canada, Rept., 1872, p. 188.

[b] Geol. Survey Canada, Rept., 1880, p. 22D.

SILURIAN STRATA.

A small area of slates was observed a short distance south of Red Beach. This occurrence, however, is not so favorable for detailed observation as are the larger areas south of Perry, and therefore the extent of the rocks here was simply mapped and their age provisionally considered as Silurian.

The Silurian rocks in the southern part of Perry and in the adjoining town of Pembroke, as well as on the neighboring islands, have been studied by the New Brunswick geologists and by Professor Shaler, who, in a report on the geology of Cobscook Bay,[a] has presented some results of observations made in this very interesting area.

Collections of fossils were made by Professor Shaler: (1) At a point about half a mile south of Balls Mill, on the west side of Whitings, or Orange, Bay; (2) at the head of Leightons Cove; (3) on the east shore of Sewards Neck at Rogers Island and at Reynolds Cove; and (4) at Shackford Head on Moose Island, and at Princess Cove.

From the first of these localities Professor Shaler provisionally lists 33 species of invertebrates, which he interprets as showing contemporaneity with the Lower Helderberg group of New York, although failing to indicate any particular division of that series.

The Leightons Cove fauna, of which he gives a preliminary list of 17 species, he regards as proving a close relation of these beds to the horizons of the Clinton and Niagara in New York.

In the Moose Island material he tentatively identifies 6 species, which are considered by him as supporting a correlation of these rocks with the middle Devonian of Ohio and Kentucky.

The collections of fossils made by Professor Shaler in the Cobscook Bay region have more recently been transferred to the hands of Prof. H. S. Williams, who has been engaged in a special study of the upper Paleozoic faunas of Maine. In response to the request of the chief paleontologist of the Survey, Professor Williams has had the courtesy to review the fossils from the above-mentioned localities and to communicate provisional lists of the species, together with his conclusions as to the age of the fossiliferous beds. In his study of the specimens he has had the assistance of Dr. E. M. Kindle, whose knowledge of and experience in studying Silurian fossils is well recognized.

From the Leightons Cove collection (station 1442) Professor Williams reports 16 species, as follows:

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[a] Shaler, N. S., Am. Jour. Sci., 3d ser., vol. 32, 1886, pp. 35–60.

Fossil invertebrates collected at Leightons Cove, Me.

Species.	Reported range.
Lingula sp.	Cambrian-Recent.
Orbiculoidea sp.	Ordovician-Recent.
Stropheodonta ? sp.	Silurian-Devonian.
Chonetes cf. hudsonicus.	"Becraft."
Dalmanella cf. planiconvexa.	Lower Helderberg-Oriskany.
Dalmanella cf. subcarinata.	Lower Helderberg.
Rhynchotrema formosum.	Lower Helderberg.
Camarotœchia sp.	Ordovician-Carboniferous.
Trematospira cf. simplex.	Lower Helderberg.
Orthonota ? sp.	Silurian-Carboniferous.
Nucula? sp.	Silurian-Recent.
Avicula cf. communis.	Lower Helderberg.
Modiolopsis ? sp.	Ordovician-Lower Helderberg.
Tentaculites elongatus.	Lower Helderberg.
Cheirurus sp.	Ordovician-Silurian.
Beyrichia sp.	Ordovician-Carboniferous.

It is the opinion of both Doctor Kindle and Professor Williams that there are not among them "any purely diagnostic Clinton or Niagara species, and though the orthids and strophodontas and some other things are similar to Niagara forms, they are closer to the eastern type of Lower Helderberg species of the same genera."[a]

From the material from Whitings Bay (station 1440) Professor Williams provisionally lists the following 36 species:

Species collected at Whitings Bay, Me.

Species.	Reported range.
Receptaculites infundibuliformis Eaton.	Lower Helderberg.
Zaphrentis sp.	Silurian-Carboniferous.
Spirorbis sp.	Paleozoic-Recent.
Cornulites cf. serpularius.	Ordovician-Silurian.
Monomerella cf. ovata var. lata.	Guelph.
Leptæna rhomboidalis.	Trenton-"Warsaw."
Stropheodonta cf. Beckii.	Lower Helderberg.
Stropheodonta planulata.	Lower Helderberg.
Stropheodonta cf. varistriata.	Lower Helderberg.
Stropheodonta ? sp.	Silurian-Devonian.
Chonetes cf. hudsonicus.	"Becraft."
Dalmanella cf. perelegans.	Lower Helderberg.
Dalmanella cf. subcarinata.	Lower Helderberg.
Rhynchotrema formosum.	Lower Helderberg.
Uncinulus mutabilis.	Lower Helderberg.

[a] Letter of May 12, 1904, to Dr. T. W. Stanton.

Species.	Reported range.
Atrypa reticularis.	Silurian-Devonian.
Spirifer cf. octocostatus.	Lower Helderberg.
Spirifer cf. perlamellosus.	Lower Helderberg.
Trematospira cf. simplex.	Lower Helderberg.
Nucula ? sp.	Silurian-Recent.
Tellinomya n. sp.	Ordovician-Lower Helderberg.
Cypricardites n. sp.	Ordovician-Devonian.
Ambonychia cf. aphæa.	Niagara.
Conocardium ? sp.	Ordovician-Carboniferous.
Avicula cf. communis.	Lower Helderberg.
Cyrtolites sp.	Cambrian-Carboniferous.
Cyclonema sp.	Ordovician-Devonian.
Loxonema cf. Fitchii.	Lower Helderberg.
Tentaculites elongatus.	Lower Helderberg.
Hyolithes sp.	Cambrian-Carboniferous.
Cyrtoceras myrice.	Lower Helderberg.
Oncoceras cf. ovoides.	Lower Helderberg.
Proetus sp.	Ordovician-Devonian.
Calymene sp.	Ordovician-Silurian.
Dalmanites cf. micrurus.	Lower Helderberg.
? Fish teeth.	Silurian-Recent.

This list, in the judgment of Professor Williams, contains about the same number of diagnostic Lower Helderberg species as were given by Professor Shaler.

The single species which Professor Williams reports from Sewards Neck (Station 1447) is called *Modiolopsis* cf. *undulostriatus*, a Niagara fossil which, he remarks, "is a form that might occur higher."

Professor Williams appends the following very important and interesting correlations and observations:

"Although the species listed from these three localities are not the same throughout, Mr. Kindle and I agree in thinking them to be younger than typical Niagara and more intimately related to the Lower Helderberg fauna of New York and the interior than to any other fauna of the country yet reported.

"There are many species among them which in general characters have both Niagara and Lower Helderberg representatives, with neither of which they exactly agree, but critical comparison favors the Lower Helderberg correlation.

"The *Monomerella* (No. 5 of the Whitings list) is very close to the Guelph species *M. ovata var. lata* Whiteaves,[a] from Durham, Ontario, Canada. Two specimens are in the collection from Maine. In both the Durham, Canada, and the Cobscook, Me., localities, this species is associated with *Cyrtoceras myrice.*

"It is also important to note that no truly diagnostic Niagara species have been detected after careful search. This distinguishes the fauna from that reported from North Haven, in Penobscot Bay, and from each of the faunas of Aroostook County;

[a] Pal. Foss. (Canada), vol. 3, pt. 1, p. 6, pl. viii, fig. 2a.

Me., which have been referred to the Niagara, namely, 'Aroostook limestone,' 'Graptolite shale,' 'Sheridan sandstone,' 'Ashland' shales and limestone,[a] each of which has shown some true Niagara species.

"On the other hand, although the species are not the same throughout, there are enough common forms to associate these Cobscook formations with the 'Squaw Lake limestone' and 'Chapman sandstones' in Aroostook County, and with the 'St. Helens beds' of Canada, as all belong to approximately the same general place in the time scale. The Cobscook faunas seem to me to be somewhat older than the typical Lower Helderberg taken as a whole, and particularly older than the other three eastern faunas above named."

In his preliminary list of the fossils collected by Professor Shaler from Moose Island Professor Williams makes no distinction as to the two or three localities. The species enumerated are as follows:

Species collected at Moose Island, Me.

Species.	Reported range.
Lingula cf. ligea.	Middle-upper Devonian.
Orthis sp.	Ordovician-Carboniferous.
Camarotœchia sp.	Ordovician-Carboniferous.
Atrypa reticularis.	Silurian-Devonian.
Spirifer ? sp.	Silurian-Carboniferous.
Cyrtina ? sp.	Silurian-Carboniferous.
Nyassa subalata.	Hamilton.
Modiomorpha cf. subalata var.	Hamilton.
Murchisonia sp.	Cambrian-Trias.
Beyrichia sp.	Ordovician-Carboniferous.

Professor Williams writes:

"The Moose Island fauna is very perplexing, as it contains nothing which, so far as I am able to see, can be taken as absolute evidence of Devonian. The genera reported are all long-ranging Paleozoic forms, and on account of the distortion of the beds it is impossible to establish with certainty the specific characters of most of them. We have identified *Nyassa subalata* and a *Lingula* as *L.* cf. *ligea*, and a very common fossil as *Modiomorpha subalata.* These are all Devonian, and although I think the fauna is probably Devonian, I would not be surprised to find, on more careful study and on the discovery of more species, that it is Carboniferous. Provisionally, and until further study and full comparison can be made with Nova Scotia, English, Welsh, and European faunas, the first three faunas may be correlated with those of the early Lower Helderberg time, and the fourth fauna may probably be assigned to middle Devonian time, its exact horizon being uncertain."

It will be seen that Professor Williams's opinion regarding the fossiliferous beds on Moose Island differs to an important extent from that based by Mr. Schuchert on the very small collections which were made by the writers at other points on

[a] Williams, H. S., and Gregory, H. E., Contributions to geology Maine: Bull. U. S. Geol. Survey No. 165, 1900, pp. 44-54.

Moose Island, but which probably represent, in part at least, the same series of rocks.

The rocks in which the faunas from the three localities first mentioned were collected were grouped together by Professor Shaler and termed the "Cobscook series," while the rocks supposed by him to be Devonian are named the "Moose Island series." Messrs. Bailey and Matthew earlier described[a] these same rocks under the name of "Mascarene series," which was believed to measure about 2,000 feet in thickness.

As stated above, the Perry formation at the northern end of the basin is in contact with the granite; at the southern end it overlies strata that are believed to belong to the "Cobscook series" of Shaler and the "Mascarene series" of Bailey and Matthew. Closely associated with these sedimentary strata are volcanic rocks which will be described in a later section.

Inasmuch as no sections of the Silurian rocks were measured or carefully studied, only a general description of them can be given here. On the northern part of the Pleasant Point peninsula the more important members of the sedimentary formation are dark-gray flags, which usually show ripple marks and contain abundant impressions of brachiopods. Shales and fine-grained impure limestones also occur in this section, while similar rocks were observed on the western shore of the cove west of this peninsula. The general strike of these rocks is N. 25° to 80° E., and their dip is northwest, at angles ranging from 35° to 75°.

On Birch Point, on the north side of Cobscook Bay, similar ripple-marked flags, shales, and impure limestones occur, striking N. 30° E. and dipping 30° to the north.

In the western part of the area described in this report is a considerable thickness of purple shales, extending from the head of Sipp Bay westward to Pennamaquan River at Pembroke, where they are succeeded by dark, fossiliferous slates and sandstones. The belt of purple shales extends a mile or two up Pennamaquan River, and the shales are remarkably uniform in character wherever seen and show a fairly constant dip to the northeast. Professor Shaler provisionally assigned these purple shales to the Perry formation, apparently upon the basis of color and relations to the beds of the Cobscook series.[b] Bailey and Matthew[c] describe the same rocks, but place them in the next to the uppermost division of their "Mascarene series." That these shales belong to the pre-Perry formation is indicated both by their areal position and stratigraphic relations to the fossiliferous strata at Pembroke and on Cobscook Bay and by their lithologic differences from the Perry rocks. In the Perry section there are no shale beds that can be compared with these, the thickness of which Shaler estimates as over 1,500 feet. The purple shales are finer grained than the Perry rocks, have

[a] Geol. Survey Canada, Rept. 1872, pp. 144–158. [b] Am. Jour. Sci., 3d ser., vol. 32, 1886, p. 49. [c] Op. cit., p. 157.

a different color, and, moreover, show slaty cleavage, a structure not observed in any of the shaly beds in the Perry section. These purple shales do not come into contact with the Perry formation, but dip beneath a mass of volcanic rocks that underlie the Perry formation. Interstratified with these volcanic rocks, however, is a bed of similar purple shale, which lies unconformably beneath the Perry rocks. From these considerations it is believed that the purple shales also are to be included in the series regarded as Silurian.

A small number of invertebrate fossils were collected by the writers in 1903 from several localities in the vicinity of Perry. All these fossils, with the exception of a few fragments from Mr. Farnsworth's yard at West Pembroke, come from the Moose Island series, which, as we have seen, is regarded by both Shaler and Williams as probably Devonian. These small collections were placed in the hands of Mr. Charles Schuchert, curator of paleontology in the United States National Museum, who has submitted a report upon them as follows:

"1. Carlow Island, St. Croix River, Maine:

"Lingula sp. new.
"Whiteavesia sp. new.
"Bollia near B. Clarkei.
"Leperditia of the L. alta type.
"Beyrichia, two species, one of the B. Klödeni type.
"Bythocypris, probably two species.

"This fauna is unmistakably Siluric and beneath the Helderbergian. As all of the species appear to be new, no direct comparison can be made with Appalachian and Interior faunas. In general the aspect of this fauna reminds one of the Medina and Manlius; and while it certainly is not so low as the former, it does not appear to be so high as the latter. Provisionally it should be referred to the Niagaran (i. e., Rochester shale and Lockport limestone of the Interior), as it has nothing in common with the Helderbergian faunas of the Cobscook region.

"2. Inlet south of Little River, 2 miles from Perry village, Me.:

"Lingula sp. new.
"Whiteavesia sp. new.
"Modiolopsis sp. undetermined.

"Apparently the same horizon as at Carlow Island.

"3. North end of Moose Island, 3 miles north of Eastport, Me.:

"Psiloconchoid pelecypod.
"Bythocypris, probably the same species as the one found at Carlow Island.
"Beyrichia, species restricted to this locality.

"This fauna has nothing that can be certainly identified with that of Carlow Island, and yet its characteristics are Siluric. It probably indicates the same age as that of Carlow Island.

"4. A. S. Farnsworth's yard, West Pembroke, Me.:

"Brachiopod, possibly a rhynchonelloid.
"Tentaculites.

"Age uncertain, possibly Siluric.

"5. Pleasant Point, 4 miles northeast of Eastport, Me.:

"A small, distorted, and poor bivalve; may be modiolopsoid."

Although it is possible that none of the localities mentioned above are representative of Professor Shaler's collections, and consequently are not in the lists given by Williams, it appears probable that the specimens from localities Nos. 1, 2, 3, and 5 are derived from the "Moose Island series," as defined by Professor Shaler. The testimony of the stratigraphy, so far as observed by the writers, as well as the correlations made by the Canadian geologists, tend to confirm the assignment of the series to the Silurian.

No attempt has been made to represent on the geologic map the exact distribution of the Silurian strata. They are intimately connected with the volcanic rocks, and detailed study would be necessary to work out the structure. It is sufficient for the present purpose to observe that wherever these rocks are in contact with the Perry formation the relations are seen to be unconformable.

ASSOCIATED LAVAS.

A large proportion of the rocks in contact with the Perry formation are of volcanic origin. In part these are closely associated with the Silurian sediments, but elsewhere the lavas predominate. Doubtless these pre-Perry lavas may include several types, but only those occurring in the southern part of the town of Perry were examined.

South of Gleason Cove these volcanic rocks are exposed both in the railroad cut and along the shore. Two types were recognized in the field, the dark, compact lava, exhibiting flowage texture, and the breccia, in which fragments of similar lava can be seen. Later microscopic study has verified this recognition of the rocks as of volcanic origin and has shown them to be of rhyolitic composition. Quartz and orthoclase are sporadic constituents in the rhyolite, and the fluidal texture in the glassy base, now for the most part devitrified, is conspicuous. In the brecciated phase of lava, fragments of clear glass are included in darker glass. This rhyolite has special interest because of its connection with the drill core mentioned in a later portion of this report. Some coarse agglomerates are associated with the rhyolite.

Farther south, on Carlow Island, there is a red porphyritic rock which appears to be interbedded with the sedimentary strata. This rock extends around the north end of Moose Island to the toll bridge. When examined microscopically it is found to be in large part a spherulitic lava. The spherulites are much altered and brightly colored with a red pigment, probably oxide of iron. Quartz occurs in large grains inclosing the spherulites, while what was probably orthoclase, now altered, forms phenocrysts at the center of a few spherulites. Another phase of this red rock is found to be fragmental and composed of angular particles of quartz, orthoclase, plagioclase, and spherulitic lava.

In the rough and hilly region southwest of the village of Perry more spherulitic lava is associated with a purple shale. The spherulites are readily seen on the weathered surface of the pinkish rock. Under the microscope this rock is seen to be a fine type of spherulitic lava. The spherulites exhibit both radial and zonal structures, and the radial crystallization, in the interior at least, is primary, while the fine quartz and feldspar mosaics in the outer zones may be possibly of secondary origin. There are also some fragments of pink glass, with delicate trichites.

These rhyolitic lavas were termed "reddish felsite" and "felsite porphyry" by Shaler, and their occurrence was described by him as that of extrusive flows with associated dikes. These "felsites" were assigned by Bailey and Matthew to the "Mascarene series," forming division 5 of that series. In addition to recognizing the pre-Perry age of these rhyolitic lavas, which is most conclusively shown by the pebbles found in the Perry conglomerate, it is only necessary to call attention to the marked differences between these rhyolites and the lavas described later as included in the Perry formation.

PERRY FORMATION.

SUBDIVISION.

The Perry formation as exposed in the towns of Robbinston and Perry is divisible into four members. Two of these members consist of sedimentary strata, while the other two are interbedded lavas and associated volcanic breccia. The section may be described thus:

Members of Perry formation.

Upper lava: Green lava with columnar parting and amygdaloidal texture. Includes one bed of conglomerate and sandstone.

Upper sandstone: Coarse red and brown sandstone and conglomerate, with small amounts of shale. Includes one flow of lava near base.

Lower lava: Basaltic lava and breccia. Includes one thin bed of conglomerate near top.

Lower conglomerate: Coarse conglomerate and red sandstone, with thin beds of sandy shale.

The thickness of these members can not be definitely given. The lowest member is evidently the thickest, but probably its thickness varies considerably in different parts of the area. As will be noted later, the Perry sediments were largely shore deposits, so that the distance from the source of the material would control largely the thickness of the beds. In the case of the volcanic members the different lava flows give the impression of being rather more persistent in thickness than might be expected. The faulting in the southern part of the area of course precludes any comparison of thickness in the different parts of the shore section.

OCCURRENCE.

The rocks of this formation are exposed continuously along the shore from Mill Cove, in the southern part of Robbinston, to Gleason Cove, in the town of Perry. A smaller area of the same formation occurs farther south in Perry, on the shore of Bar Harbor, at the northern end of the highway bridge. Another outlier of these rocks occurs on the shore in the northern part of the town of Robbinston.

As shown on the geologic map, the area covered by the Perry formation is about 8 miles long and about 2½ miles wide at its widest part, its total area being about 15 square miles. The Perry rocks occur on the opposite shore of St. Croix River, at St. Andrews, and their occurrence farther west on the Maine coast was reported in the early surveys. The Perry area, however, is doubtless of most importance, not only on account of the flora it has yielded, but also because the formation is apparently more fully represented here than farther east.

The lower conglomerate member occupies the larger part of the area here described. The northern outlier of Perry rocks is north of Hilchins Point, a connected tongue making up the shore of Brooks Cove. In the northernmost portion of this outlier the Perry conglomerate occurs with a dip of 20° to the southeast, while just north of Hilchins Point the conglomerate and sandstone have a northern dip of 30°. The basal beds here and at Brooks Cove are coarse, and at the latter locality especially the conglomerate exhibits its derivation from the red granite of the vicinity; the bowlders of that rock predominate, and the matrix is of an arkose character.

In the larger area the conglomerates predominate in this lowest member, but it appears to be true that the beds are of somewhat finer material in the southern part of the area than in the northern. The sandstone beds are massive and resist well the attacks of the waves, so that a high cliff is a characteristic shore feature. Pulpit Rock is a noticeable mass of red sandstone standing out at a little distance from the cliff, and was pictured in the atlas accompanying Jackson's first report.

Throughout the shore section the rocks of this lower member are characterized by their red color, which varies from a bright brick red to a chocolate brown, although the brighter tints are possibly the more common. While this red color is so marked a feature, it can not be regarded as a safe criterion for the recognition of the Perry formation. The Perry sandstones and conglomerates share this color with older formations, from which they have been derived. So it is that at a short distance the red granite and lava underlying the Perry conglomerate in Robbinston or on the shore of Bar Harbor closely resemble the Perry rocks. The shore detritus from these igneous rocks that is seen along St. Croix River often can not be distinguished from that derived from the disintegration of the red sandstone or conglomerate. Moreover, this close resemblance is not fortuitous, since in the deposition of the Perry rocks it was in fact exactly similar shore detritus from the red granite and lava that made up the bulk of the sediments. The rocks of the Perry formation, therefore, are red because they were largely derived from red rocks, under conditions that allowed relatively little change in the detritus contributed to the basin of sedimentation.

The Perry rocks exposed on the St. Andrews Peninsula, on the New Brunswick shore, appear to belong to this lowest member of the formation. It is evident, however, that here the sandstone and shale are more important than the conglomerate. Such differences in the character of beds of approximately the same age are to be expected in the case of a formation like the Perry, which consists essentially of shore deposits. The Perry rocks occurring in small areas at other points on the shores of Passamaquoddy Bay probably all belong to this lowest member.

The next higher member of the Perry formation is that termed the lower lava in the table on page 28. This volcanic member is exposed from Gin Cove to a short distance beyond the next cove south.[a] These same rocks are also exposed on the shore about half a mile north of Gleason Cove. These rocks are plainly of volcanic nature, the member including sheets of both lava and breccia. The lava exhibits all the characteristics of a surface flow and the succession of flows and sheets of breccia make a striking contrast to the stratified sediments below. The volcanic rocks are evidently conformable with the sedimentary strata both above and below; at one place a thin bed of typical conglomerate occurs, interstratified with the lava flows, and at another some fine-grained red shale occurs, noticeable since it is less arenaceous than any beds farther north. Thus the volcanic member represents simply an interval in the deposition of the Perry sediments, probably only of short duration, when the lavas were erupted; and the occurrence of the thin conglomerate shows that this outbreak constituted only a partial interruption of the processes of sedimentation.

The lavas constituting this volcanic member are different from the Silurian lavas described earlier in this chapter. The Perry lavas appear much fresher and are more readily recognized as the products of volcanic action. Not only do they lack the metamorphism of the Silurian rocks, but they are of a different type. The lava exposed in the vicinity of Gin Cove is a purple basalt. Examined microscopically it is found to consist of plagioclase in fine laths and augite in large ophitic plates. Dark reddish brown iddingsite is present, and probably represents grains of olivine, which must have been an important constituent in

[a] The name Gin Cove is applied on the accompanying map to the cove locally so known, although this usage does not agree with the coast chart, on which this name is given to the next cove southward.

the fresh lava. Magnetite is also abundant. With the exception of this alteration of what was probably olivine, the basalt is fairly fresh for a Paleozoic lava.

The upper sandstone member conformably overlies the basaltic rocks just described. This division of the Perry formation is exposed on the shore north of Frost Cove. Its lowest bed consists of conglomerate and coarse sandstone about 50 feet thick. Above this is a sheet of volcanic rock about 30 feet thick, which is undoubtedly a lava flow, as the rock is compact and shows imperfect parting in its lower portion, while above it is amygdaloidal and exhibits flowage textures. It is followed by a number of beds of sandstone and conglomerate. The sandstone is for the most part thin bedded and the beds are not always continuous for any distance. Small amounts of shale occur interbedded with the sandstone. Some of the sandstone is stream bedded, and in such rock it is noticeable that the flow of the currents depositing the sand is shown always to have been from the northwest. At the top of this upper sandstone member is a conglomerate bed 6 to 8 feet in thickness.

The upper lava member is exposed for a short distance south of Frost Cove and constitutes the remaining portion of this section of the Perry formation. This lava is dark green in color and apparently similar in composition to the basalt of the lower member, but it is not so compact, and possibly may be more andesitic in character. Some phases of the rock have a decidedly muddy appearance and may represent flows containing considerable fragmental material. The lava exhibits both columnar parting and amygdaloidal texture, so that it is readily recognizable as a volcanic rock. At one point this volcanic member includes a few feet of conglomerate and red sandstone, showing again how intimately connected were these volcanic outflows with the processes of sedimentation, the one interrupting the other only for brief intervals. On this account the subdivision of the Perry formation into these four members is somewhat arbitrary, and is helpful only as it serves the purposes of description. The representation of these four subdivisions on the geologic map makes it possible to indicate the general structure of the area.

GENERAL CHARACTERS.

The above descriptions of the rocks of the Perry formation are believed to be sufficient to indicate the general characters of the rocks in which the search for coal has been prosecuted. The more important question of the age of this formation is reserved for another chapter of this report.

Two principal facts should be emphasized in the description of the Perry formation, namely, the difference in character of the sediments in the several parts of the area, and the absence of carbonaceous or clayey beds in the section exposed.

The changing characters of these Perry rocks is an evident expression of the conditions of their deposition. The greater distance of the Gleason Cove locality and St. Andrews Point from the main source of supply caused conglomerate beds at these places to be thinner than at places farther north and west. At this greater distance the sediments consisted largely of sands and silts that formed the sandstones and sandy shales now exposed. These sediments were well sorted, and so active were the shore currents that plainly at no time were the conditions such as to favor the accumulation of fine mud or vegetal matter. It is not altogether surprising, therefore, that fine clays or coaly shales are wanting in the sections of the Perry formation.

Still another important fact remains to be mentioned, and this pertains to the volcanic members of the Perry formation. The lavas interbedded with the sedimentary rocks of this formation differ altogether from the lavas associated with the Silurian strata. These two groups of volcanic rocks may have some points of general resemblance, but to the close observer they appear quite distinct, and their petrographic dissimilarity is especially evident when they are studied microscopically. The distinction between the Silurian rhyolite and the Perry basalt is so marked that there is no possibility of failure to identify each wherever found. This fact was recognized in the field and its application to the purposes of this investigation will be noted in a later section.

STRUCTURE.

The geologic map well exhibits the structure of the Perry basin. In general it may be stated that the rocks of the Perry formation are only gently inclined, 15° to 20° being the maximum dip except for a short distance north of Gleason Cove. Low dips are also characteristic of the Perry rocks as exposed on the St. Andrews shore. The general statement may be made, therefore, that the rocks of this formation are only gently flexed.

The areal distribution of the four members which are distinguished on the geologic map serves to show the general form of the basin so far as the Maine portion is concerned. It is really only the western part of the basin that is preserved on this southeastern shore of Maine. Other edges are found on the New Brunswick shores, but the central portion is beneath the waters of Passamaquoddy Bay. It seems probable, however, that the greater part of the formation is represented in this western part of the basin. The smaller area of Perry sandstone west of Bar Harbor, in the southern part of the town of Perry, has low dips, and the small thickness of rock exposed here shows that outliers of this formation may perhaps occur still farther southwest, and these may later be found to connect this basin with the Machias area of red sandstones described in the early Maine reports.

The heavy sandstones of the Perry formation are plainly jointed. In many places the vertical joint planes have been taken advantage of by surface waters and deep chasms have been thus eroded. These breaks in the cliff are conspicuous, but are plainly the product of erosion, there being no displacement of the strata on either side. In some cases wave erosion has combined with the work of surface rivulets and considerably enlarged these openings. Pulpit Rock was probably separated from the main cliff by erosion of this type.

Faulting has played some part in the development of the structure. In the southern part of the area two faults were observed and their positions are indicated on the map. These faults both have a general east-west trend, and while definitely observed at the shore, their extent farther west was not determined. Their extension, as shown on the map, is based upon observations as to the distribution of the rocks. As may be noticed on the map, two marked offsets in the basal boundary of the Perry formation are in line with these faults. No evidence of faulting was noticed at these offsets and the suggestion is offered that in passing westward the faults become sharp monoclinal flexures, which find expression in the sharp bends in the Perry-Silurian contact.

The more northern of the two faults brings the upper lava member on the north in contact with what is probably the upper sandstone member. The fault plane is vertical and the sandstone, which shows a normal dip to the southeast at an angle of 20°, is sharply upturned until it is vertical or even slightly overturned at the contact with the lava, which is itself disturbed at the line of contact. These relations show the downthrow to be on the north side of the fault, but there is no reason for believing the displacement to be very great.

The other fault strikes N. 70° E. and brings what appears to be the lower lava in contact with the lower conglomerate member. Here again it does not seem probable that the amount of displacement is great, although there are evident indications of disturbance in the vicinity of this fault. The sandstone strata immediately south of the fault have been thrown into sharp folds, and the axes of the folds nearest the fault have a trend parallel to that of the fault plane. A minor syncline next to the fault is overturned and at the fault contact both sandstone and lava are crumpled and crushed.

Further evidence of the disturbed character of this south side of the main syncline is found in the continuance of the steep dips along this shore as far as the mouth of Little River. Here the sandstone has a dip of 50° to the north, while on the opposite shore of Gleason Cove the more prevalent dip of 20° is observed.

Another fault was noted at the head of the long cove south of Gleason Cove. A westward extension of the Perry conglomerate here overlies the Silurian flags, with a low northern dip. A short distance farther north the conglomerate has its dip steepened and is then abruptly cut off by the Silurian lava. At the contact the lava shows a slickensided surface. This fault differs from the two before described in that here the downthrown block is on the south side of the fault. Doubtless other faults exist in this area, but these are the more important ones, the others being too small to be detected in this rapid survey of the section.

CHAPTER III.

PALEONTOLOGY.

By David White.

No fossil remains of animals have yet been recognized in the Perry formation. Fragments of stems or algæ are found in many of the beds that are of sufficiently fine composition to preserve or reveal them, but such beds constitute a very small part of the formation. The plant remains found consist chiefly of broken and waterworn stems, generally so fragmentary and abraded that they can not be identified paleontologically, or used to determine questions of stratigraphy.

PLANT-BEARING LOCALITIES.

The discoveries of recognizable land plants are confined essentially to two localities in different horizons in the lower divison of the formation. Descriptions of these places are given in considerable detail by Dawson in his earlier papers. Most of the fossils from the formation are said to have come from a thin stratum of green, sandy shales[a] outcropping on the right bank of Little River, about one-half mile below the wagon-road bridge at Perry. This thin bed, which is described as a green-shale lens, is stated by Dawson[b] to have been worked out and exhausted by 1863. We were, however, so fortunate in 1903 as to find and to uncover the edge of this lentil and to obtain considerable material, though in excellence if not in variety it is inferior to some of that collected in larger quantity in earlier years by Mr. Jethro Brown, a systematic as well as an arduous collector at Perry, and by Dawson, Hitchcock, Richardson, the Rogers Brothers, and other geologists who visited this region. A second locality is on the Robbinston road about one-half mile north of the Perry post-office, where, near McPhail's house, red sandy shales and red sandstones with land plants occur just above the lava sheet on which the road runs.

[a] This is one of the extremely rare occurrences of green-shale parting, green-shale strata being almost unknown in the Perry formation.

[b] Quart. Jour. Geol. Soc. London, vol. 19, p. 460.

Other plant remains, consisting for the most part of fragments of stems such as have generally been referred to *Psilophyton*, are found at various places in the more southern outcrops, while fragments of algæ are not rare in the less conglomeratic beds along Little River and near the fault north of Gleason Cove.

COLLECTIONS STUDIED.

The task of restudying the old as well as the new collections, necessary to a critical examination of the evidence as to the age of the Perry beds, has been very difficult by reason of the unfortunate dismemberment and dispersal of the earlier collections, which included many of the types. It is believed, however, that in the preparation of the following descriptions the greater part of the Perry material existing in our American museums has been passed in view. Special acknowledgments are due the officers of the Portland Society of Natural History, to Dr. E. O. Hovey and the American Museum of Natural History, to Prof. C. W. Johnson and the Boston Society of Natural History, and to Dr. R. T. Jackson and the Museum of Comparative Zoology of Harvard University for generously placing at my disposal the fossil plants from Perry in these institutions; also to General Manager Evans of the Maine Central Railway, and Mr. Jackson Brown, of Perry, for the contribution of specimens more recently collected by the latter. We are also particularly indebted to Prof. D. P. Penhallow, of McGill University, Montreal, for his courtesy in placing in my hands for examination and comparison typical *Psilophyton* material from the university collections studied and labeled by Sir William Dawson.

DESCRIPTIONS OF SPECIES.

On account of the generally very fragmentary nature of the fossil materials and the equally fragmentary literature on Devonian plants the descriptions and synonymy in the following section are somewhat detailed, a number of the specimens being described individually in order that these rare Devonian types, many of which are at best difficult of interpretation, may be more accurately as well as more frequently recognized and identified.

Concerning the botanical relations and structure of many of the types of this period we have little knowledge. Yet many of the fragments of stems, foliage, or problematic fructifications reveal superficial features and peculiarities of form which distinguish them from the plant types of other geologic times and thus render them characteristic of the period.

TÆNIOCRADA D. White.

Rept. State Paleont, New York, 1902, p 603.

TÆNIOCRADA PALMATA D. W.

Pl II, Fig. 10

Frond small, spreading broadly palmately from the apex of a slender, rounded stipe, deeply dissected, nearly to the base, in divisions 2–3 mm. wide, which fork repeatedly and somewhat divaricately at a moderate angle, at intervals of about 5 cm.; lobes fleshy, smooth, rapidly diminishing in width at each dichotomy; central strand or axis indistinct.

The alga described above is essentially characterized by the palmate arrangement of the rapidly dichotomising lobes at the apex of a stipe. In the specimen figured, Pl. II, Fig. 10, the stipe is concealed for a short distance, when the cleavage of the rock shows its continuation to a length of 3 cm. on the opposite side of the shale fragment. The lobes appear to have been somewhat crowded or fasciculate in the middle of the frond. As indicated by the smooth surface of the impression and a slight slickensiding near the base, the lobes were probably fleshy. In the basal portions there are faint signs of axial strands, but these become indistinct on passing upward. It is possible, however, that better preserved specimens will show this plant to possess well-developed axial strands, thus removing all doubt as to the reference of the species to the genus *Tæniocrada*.

The specimen comes from just east of the fault west of Gleasons Cove, near the mouth of Little River.

PLATYPHYLLUM Dawson.

Foss Pl Erian and Upp Sil Form Can, pt 2, 1882, p 101.

PLATYPHYLLUM BROWNIANUM Dn.

Pl II, Figs 1, 2

1862. *Cyclopteris Browniana* Dawson, Rept Nat Hist. and Geol Me, 1861, p 250, fig 5
1862 *Cyclopteris Browniana* Dn, Hitchcock, Rept Nat Hist and Geol. Me, 1861, p 248.
1862 *Cyclopteris Browniana* Dawson, Proc Portland Soc. Nat Hist, vol i, pt 1 p. 77, pl i, fig 3.
1862. *Cyclopteris Browniana* Dawson, Quart Jour Geol Soc London, vol. xviii, p 320, pl xii, fig 9.
1863 *Cyclopteris Browniana* Dawson, Am Jour Sci, 2d ser, vol xxxv, p 313
1863 *Cyclopteris Browniana* Dawson, 2d Ann Rept Nat Hist and Geol Me, 1862, p 403
1863 *Cyclopteris Browniana* Dawson, Proc Portland Soc Nat Hist, vol i, pt 2, p 100, pl ii, fig 5
1863 *Cyclopteris Brownii* Dawson, Quart Jour Geol Soc. London, vol xix, p. 463, pl xvii, fig 6
1871. *Cyclopteris Brownii* Dawson, Foss Pl Dev and Upp Sil Can, p 46, pl xv, fig 172, p 85
1877 *Cyclopteris Brownii* Dn, Peach, Trans Geol Soc Edinb, vol iii, p. 151.
1883 *Cyclopteris Brownii* Dawson, Can Nat, vol x, No 1, p 10
1888. *Cyclopteris Brownii* Dawson, Quart Jour Geol Soc London, vol xxxvii, p 307.

1882. *Cyclopteris* (*Platyphyllum*) *Brownii* Dawson, Foss. Pl. Erian and Upp. Sil. Can., pt. 2, p. 101, pl. xxiii, figs. 11–13 (?).

1884. *Archæopteris* (*Cyclopteris*) *Brownii* (Dn.) Lesquereux, Coal Flora, vol. iii, pp. 837, 850.

1886. *Palæopteris* (?) *Brownii* (Dn.), Kidston, Cat. Pal. Foss. Pl. Brit. Mus., p. 229.

1888. *Platyphyllum Brownii* Dawson, Geol. Hist. Pl., p. 265.

1889. *Rhacophyllum Brownii* (Dn.) S. A. Miller, N. Amer. Geol. and Pal., p. 139.

1894. *Cyclopteris* sp., Nathorst, Zur. Pal. Fl. d. Arkt. Zone, pt. 1, Lief. 1, p. 13, pl. 1, fig. 12.

Fronds or pinnules large, often 15 cm. or more in length, more or less orbicular, obovate, or ovate, deeply and often broadly cuneate-lobate, sinuate margined, membranaceous; nerves very thin, obscurely if at all fibrous, distant about 2–3 mm. midway of the leaf, and forking four or five times in passing, gently arching, to the margin.

Little is known as to the precise affinities of this interesting species, which was named for Mr. Jethro Brown, the original collector at Perry, the type locality. The small fragments collected in 1903 agree in all respects with that figured in pl. ii, fig. 5, of vol. 1, pt. 2, of the Proceedings of the Portland Society of Natural History, 1863, and which, through the courtesy of the Boston Society of Natural History, we are able to reproduce in Pl. II, Fig. 1. Sir William Dawson, in his later observations,[a] was disposed to regard these fossils as either epiphytic on fern stems or as growing in clusters from rhizomes. The latter view is based on the specimens from Scaumenac, which were erroneously, I believe, identified with this species. As to their fern nature, I would add that in the State paleontological collections at Albany I have seen large cyclopterid pinnules superficially resembling these on the rachis of large petioles taken from the Chemung, near Hancock, N. Y., and probably belonging to *Archæopteris obtusa* (Lx.).

It seems possible, however, that the plant in hand is to be assigned to the Algæ, to which the fragments before me appear to be bound by the characters of the membranaceous lamina and by the thin nerve bands, which are evidently thickened as compared with the intervening lamina, but which, to my mind, do not show indisputable signs of fibro-vascular structure. In this respect they are in exact agreement with the type[b] described by Lesquereux[c] as *Rhacophyllum truncatum*, which was considered by both its author and Sir William Dawson as probably identical with the plant from Perry. I had collected a number of similar specimens from the Catskill of northeastern Pennsylvania, all of which are apparently algoid, but hesitated to refer them to *Platyphyllum* on account of their more dissected fronds, until opportunity was given me, through the courtesy of the Portland Society of Natural History, to examine its collections, in which I found the highly divaricate specimen illustrated in our Fig. 2. I do not, however, regard *Platyphyllum truncatum* as specifically identical with the Perry species, though it is evidently very closely related to it.

[a] Canadian Naturalist, vol. 10, No. 1, 1883, p. 10.
[b] Lacoe collection, No. 19414, U. S. Nat. Mus.
[c] Coal flora, vol. 1, 1880, p. 311, pl. 1, fig. 7.

The nerves of *Platyphyllum Brownianum* fork four or five times at a rather wide angle, as is well shown in Pl. II, Fig. 2, which shows one of the types. The earliest figured specimen,[a] though a mere morsel from the interior of a leaf, reveals an identical nervation. The statement that the nerves fork but once, made in all of Dawson's descriptions, and illustrated in all other figures of the plant, is wholly erroneous. The specimen from Scaumenac, figured by Dawson as *P. Brownianum*, can not, if drawn correctly, be regarded as representing this species, since the nerves, as shown in the figure, are very much closer, rarely forking, and parallel. None of the Perry specimens show nervation of this type in any portion of the frond.

The fronds obtained from the Catskill of Pennsylvania and regarded as gymnospermous in Rogers's Geology of Pennsylvania, 1858, vol. 2, pl. xxii, can not safely be included in *Platyphyllum Brownianum*, though they are evidently closely related and are no doubt congeneric. Comparison of the Pennsylvania figures, which I will designate *Platyphyllum Rogersi*, should be made with our Fig. 2.

The specimen from the Devonian of the west coast of Spitzbergen, figured by Nathorst,[b] agrees so well with the fragments of the Maine plant that, notwithstanding the insufficiency of the material, I hardly hesitate to place it under the same name.

ARCHÆOPTERIS Dawson.

Foss. Pl. Dev and Upper Sil Form Can, 1871, p 48.

ARCHÆOPTERIS JACKSONI Dn.

Pl III, Figs 1, 2, 2a, 3, (4?).

1861 *Cyclopteris Jacksoni* Dawson, Can Nat, vol vi, No. 3, pp 172, 173, figs 9, 9a, 9b.
1862 *Cyclopteris Jacksoni* Dn., Hitchcock, Rept Nat Hist and Geol Me, 1861, p 248
1862 *Cyclopteris Jacksoni* Dawson, Proc Portland Soc Nat Hist, vol i, pt 2, p. 76
1862 *Cyclopteris Jacksoni* Dawson, Quart. Jour Geol. Soc, vol xviii, pp 298, 319.
1863 *Cyclopteris Jacksoni* Dawson, Am Jour Sci, 2d ser, vol xxxv, p 313
1863 *Cyclopteris Jacksoni* Dawson, 2d Rept. Nat Hist and Geol, Me, p 402
1863. *Cyclopteris Jacksoni* Dawson, Quart Jour Geol Soc, vol xix, p 462, pl xix, figs 26, 26a–c
1868 *Cyclopteris Jacksoni* Dawson, Acad Geol., p. 547, figs. 191a, 191b
1891 *Cyclopteris Jacksoni* Dawson, Geol N S and N B, p 546, fig 191
1870. *Cyclopteris (Archæopteris) Jacksoni* Dawson, Nature, vol ii, p 87, fig 3
1871 *Cyclopteris (Archæopteris) Jacksoni* Dawson, Foss Pl Dev. and Upp Sil Can., p 45, pl xv, figs 167–169, p 85.
1871 *Archæopteris Jacksoni* Dawson, Foss Pl Dev. and Upp Sil Can, p 48
1880. *Archæopteris Jacksoni* Dawson, Chain of Life, p 98, fig 89
1881. *Archæopteris Jacksoni* Dn, I C White, Rept. 2d Geol Surv Pa, G5, pp 63, 187.
1882 *Archæopteris Jacksoni* Dn, I. C White, Rept 2d Geol Surv Pa, G6, pp 103, 320

[a] Rept Nat Hist and Geol Me, 1861 (1862), p 250, fig 5
[b] Fossile Flora der arktischen Zone, pt 1, lf 1, pl i, fig 12

1883. *Archæopteris Jacksoni* Dawson, Can. Nat., vol. x, No. 1, p. 307.
1888. *Archæopteris Jacksoni* Dawson, Geol. Hist. Pl., p. 74, figs. 24, 24a, 24b.
1894. *Archæopteris Jacksoni* Dn., Prosser, Bull. U. S. Geol. Survey No. 120, pp. 13, 14.
1895. *Archæopteris Jacksoni* Dn., Dana, Man. Geol., 4th ed., pp. 592, 622, figs. 898, 899.
1897. *Archæopteris Jacksoni* Dn., Dun, Rec. Geol. Surv. N. S. Wales, vol. v, pt. 3, p. 120.
1880. *Archæopteris Halliana* (Göpp.) Lesquereux, Coal Flora, vol. i, p. 305, syn. in part only.

Fronds sometimes of large size, with thick, striate, or rugose-striate, sometimes obscurely transversely corrugated rachis; lateral pinnæ close, relatively short, occasionally attaining a length of over 12 cm., straight or more commonly curving slightly outward, oblong-linear, tapering but slightly, abruptly obtuse, open or oblique, alternate to opposite, with intermediate alternating pinnules, usually not in the same plane, on the main rachis; pinnules varying in size, relatively oblique, broadly imbricated, rather broadly and decurrently attached, narrowly rhomboidal, the lower proximal margin nearly straight or slightly concave for about one-half the length of the pinnule, the inner distal border nearly straight and vertical for about one-third of the length of the pinnule, then gradually curving outward, the upper half of the pinnule being strongly asymmetrically ovate, and more or less narrowly rounded at the apex, and entire or faintly denticulate; nervation thin, from three or four very obliquely decurrent or coalescent basal nerves, forking three to five times at a very acute angle, while passing nearly parallel with very slight but increasing curvature, at about 40–45 per centimeter, to the margin, which they meet very obliquely; fertile pinnæ borne alternately at the base of the frond, short, much reduced, probably without sterile pinnules at their bases, and alternating on the same side with slender rudimentary or laciniate rachial pinnules; sporangia small, apparently brevipedicellate, erect, oblong, or slightly clavate, narrowly rounded at the apex, probably stalked or borne on reduced nervilles near the base of the pinnæ, though seemingly arranged in a single row along the midrib in the distal portion of the pinna.

The more conspicuous characters of the species described above are the closely placed dense and very obtuse pinnæ, on which the rather broadly overlapping pinnules are rather narrow and are somewhat narrowly as well as obliquely rounded at the apex, the inferior proximal margin being long and nearly straight, while the border on the distal side of the base is likewise straight and nearly parallel to the rachis. The nerves are slender, close, parallel, and but gently curved. None of the fragments in our collections show the very large terminal pinnules described and figured by Sir William Dawson as characteristic of the species. The general aspect and features of the species are well illustrated in Pl. III, Fig 1, prepared from one of the original specimens studied by Dawson, now in the collection of the Portland Society of Natural History. This example is typical of the dense arrangement of pinnæ and pinnules, commonly, though not invariably, found in this fern. The rachial pinnules, though not so well exhibited as in one of the fragments collected in 1903, are nevertheless indicated by several small fragments between the secondary pinnæ. The main rachis in this specimen is less rugose, transversely, than in other examples in hand. In Pl. III, Fig. 2, is shown one of the typical fragments of a pinna collected in 1903, the details of the nervation, which suggests the Coxton Narrows specimens of *A. minor*, being given in Fig. 2[a].

The identity of the fructification of this species is still in doubt, but the specimen here figured (Pl. III, Fig. 4) can hardly be other than the same species as that from Scaumenac illustrated by Dawson[a] as *Archæopteris Jacksoni*. It is difficult to discern the position of the sporangia on the pinnules in this specimen, and so to ascertain whether or not they are pedicellate and fasciculate as described for this species by Dawson; but from my examination of the specimen I am disposed to believe that in the upper part of the pinna they may be in a single row along the midrib, which is prolonged in a narrow, upward curved semispinose process, after the fashion of many other species of the genus. This fragment I am, however, disposed to regard as perhaps but a young stage of the form shown in Pl. III, Fig. 5, which, although placed under *A. Rogersi* in deference to the judgment of Dawson, I suspect may belong, like other examples of *A. Rogersi* from Perry—the type locality—to *A. Jacksoni*. In his description of *A. Rogersi*, Dawson pointed out the more elongated, cuneate, and distal pinnules with more nearly parallel nerves, and the transversely rugose rachis as distinctive of the former as compared with *A. Jacksoni*. In leaflets of the latter, said to be the more common species at Perry, the nervation, as shown in Pl. III, Fig. 2[a], does not seem distinguishable from that given by Dawson[b] for *A. Rogersi*. As to the form of the pinnules, it is but poorly described and figured by Dawson; but the pronounced variation in width seen in different portions of the same frond in species of *Archæopteris*, as shown by Nathorst[c] in closely related species, or as may be seen in some of the fine slabs in the Lacoe collection of the United States National Museum, caution us against the specific separation of small fragments of the frond on account of the width of the pinnules. The same series of figures given by Nathorst and the same Lacoe specimens also illustrate the transverse rugosity of the rachis in some fragments, especially those nearer the base of the frond, while the more distal portions may be merely striated. In the example illustrated in Pl. III, Fig. 1, there is but faint indication of transverse corrugation in the rachis, but in some of the fertile examples, and in several of the fragments of larger rachis like that shown as *A. Rogersi*, Pl. II, Fig. 12, there is evident corrugation, though I have not seen any sterile pinnæ or pinnules which are not clearly *A. Jacksoni*, judging from the characters of the leaf form and the nervation.

The distinctions between *Archæopteris gaspiensis* and *A. Jacksoni*, for which Dawson at first mistook the former, are perhaps still less evident The former species

[a] Fossil Plants of Erian and Upper Silurian Formations of Canada, pt. 2, pl. xxiv, fig. 17.
[b] Quart. Jour. Geol. Soc. London, vol. 19, pl. xix, fig. 27b.
[c] Oberdevonische Flora d. Bären-Insel, 1892, pl. v.

was originally described[a] as differing by the broader pinnules and the broader scaly or ramentose petioles, and especially by the arrangement and form of the sporangia, which are larger, more oblong, and are placed in pairs sessile on the midrib. It would seem also that the distinction between *A. Jacksoni* and *A. gaspiensis* is valid according to the characters of the fertile pinnæ, if we accept fertile fragments of the form of *Sphenopteris Hitchcocki* as representing *A. Jacksoni.* We are not yet in a position to determine the interrelations of *A. Jacksoni*, *A. Rogersi*, and *A. gaspiensis.*

It is interesting to note that none of the numerous fertile fragments which Dawson must have had from the same bed and place were referred by him to *A. Rogersi*, since he says the fertile pinnæ of the latter are unknown, though examples like that which I give under the latter species, Pl. III, Fig. 5, do not appear to be very rare. The specimens of the latter type are to be compared with the fertile pinnæ of *A. gaspiensis* figured by Dawson.[b] Incidentally it is perhaps significant, though merely circumstantial, that the fertile pinnæ at Perry which I thus tentatively place under *A. Rogersi* are possibly specifically indistinguishable from those of *A. gaspiensis*, which is described as distinguished chiefly by the absence of the transverse rugosity of the rachis, and as being otherwise difficult of separation, while *A. Rogersi* is recorded by Dawson[c] as associated with *A. gaspiensis* in the Gaspé region, just as it is with *A. Jacksoni* at Perry. I would add not only that some of the sterile pinnules of *A. Jacksoni*, in one of the larger specimens in the museum of the Portland Society of Natural History, have the form and size of *A. gaspiensis*, as figured by Dawson, but also that the specimens from Montrose, Pa., published by Lesquereux[d] as *A. Rogersi*, include fragments which, in my judgment, are hardly distinguishable from the sterile pinnæ of *A. Jacksoni* or *A. gaspiensis.* The fructification of the same fronds in the Montrose specimens seems to agree with that figured by me, Pl. III, Fig. 5, under *A. Rogersi.* It is hardly necessary to remark that the specific differentiation of the American species of *Archæopteris* is at present in a confused condition, which can not be satisfactorily resolved without a careful reexamination of the scattered types. For this reason, pending an opportunity to make such a special study of the American material, I leave the discrimination of the Perry species essentially as proposed by Dawson. The combination by Lesquereux of *Archæopteris Jacksoni* and *Sphenopteris Hitchcocki* with *Archæopteris laxa* (*Cyclopteris Halliana* Göpp.) appears to be unwarranted, the pinnæ of the latter being much more slender and flexuous, while the pinnules are delicate and less imbricated.

Archæopteris Jacksoni is present both in the shale bed on Little River and in the field near McPhail's.

[a] Fossil Plants of Erian and Upper Silurian Formations of Canada, pt. 2, 1882, p. 99, pl. xxi, pl. xxiii, fig. 14.
[b] Loc. cit., pl. xxi, fig. 2.
[c] Loc. cit., p. 100.
[d] Coal flora, vol. 1, p. 307.

ARCHÆOPTERIS ROGERSI Dn.

Pl. II, Fig. 12, Pl. III, Fig. 5.

1863. *Cyclopteris Rogersi* Dawson, 2d Ann. Rept. Nat. Hist. and Geol. Me., 1862, p. 403.

1863. *Cyclopteris Rogersi* Dawson, Proc. Portland Soc. Nat. Hist., vol. i, pt. 2, p. 100, pl. ii, figs. 6, 7.

1863. *Cyclopteris Rogersi* Dawson, Quart. Jour. Geol. Soc. London, vol. xix, p. 463, pl. xvii, figs. 17, 18; pl. xix, figs. 27, 27a, 27b.

1871. *Cyclopteris* (*Archæopteris*) *Rogersi* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 46, pl. xvi, fig. 171, p. 85.

1863. *Cyclopteris Halliana* Göpp., Dawson, Quart. Jour. Geol. Soc. London, vol. xix, p. 462, pl. xix, figs. 28, 28a, 28b, doubtfully identified from Perry, Me.

1871. *Archæopteris Rogersi* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 48.

1879. *Archæopteris Rogersi* Dn., Lesquereux, Coal Flora, Atlas, p. 9, pl. lxix, figs. 9, 9a; text, vol. i (1880), p. 307.

1888. *Archæopteris Rogersi* Dawson, Geol. Hist. Pl., p. 279.

1886. *Palæopteris Rogersi* (Dn.) Kidston, Cat. Foss. Pl. Brit. Mus., p. 228.

Habit of growth resembling that of *Cyclopteris Jacksoni*, but with pinnules more elongated and almost cuneate in form and less densely placed, and with veins more nearly parallel; stipe stout, woody, furrowed longitudinally, and marked with strong transverse bars or punctures.

Not having seen any barren pinnæ in our collection from Perry except such as belong to *A. Jacksoni*, I have here quoted Dawson's diagnosis[a] of *Archæopteris Rogersi*, which was based on specimens from this locality, where it is said to be less common than *A. Jacksoni*. Its distinctive features, as compared to the latter, appear to be a stipe transversely corrugated and not leafy between the secondary pinnæ, and less densely placed pinnæ and pinnules, the latter being also generally narrower and more nearly cuneate.

The species is very inadequately illustrated for diagnostic purposes, and is therefore subject to some confusion, which can be resolved only by the examination of the type material. The two very small fragments of pinnæ figured by Dawson are so insufficient for the basis of a species that it is hoped that additional material from Dawson's hand in the original collections at Montreal may be found in support of the differentiation proposed by him. For reasons stated in my remarks on *Archæopteris Jacksoni* I am slightly inclined to regard *A. Rogersi* as representing narrow and more distantly arranged pinnules of the same species, such as are sometimes found in the upper part of large fronds of *Archæopteris*. This problem must, however, for the present remain unsettled.

The fragment of transversely corrugated rachis shown in Pl. II, Fig. 12, is one of a number of rachial fragments in our collections that are referable to *Archæopteris Rogersi*. In its superficial features it closely resembles the corresponding specimen figured by Gilkinet[b] as *Palæopteris Roemeriana*.

[a] Quart. Jour. Geol. Soc. London, vol. 19, 1863, p. 463.
[b] Bull. Acad. Roy. Belgique, vol. 39, 1875, p. 384.

In its corrugation the Perry rachis agrees well enough with Dawson's description of the original figure of a petiolar fragment, but in the traces of irregularly arranged scars to be observed in one or two examples our specimens strongly suggest fragments of the rachis of *A. gaspiensis*, described by Dawson as having indications of flat scales or ramentum. A similar specimen is in the collection of the Portland Society of Natural History. Since, however, the examination of several slabs of *Archæopteris* from the Devonian of Pennsylvania in the Lacoe collection of the United States National Museum or of the figures of *A. Roemeriana* given by Nathorst in his Devonian Flora of Bear Island shows the occurrence of both smoothly striate and transversely corrugated portions of rachis in the same fronds, I am disposed to regard this character as probably due more or less directly to circumstances of preservation and therefore of little specific value. It is not improbable that the corrugation itself is due to the presence in the cortex of horizontal sclerotic plates, which are expressed in the fossil according to the conditions of preservation, the cortical structure being presumably comparable to that described by Williamson and Scott in *Heterangium*.

Associated with the sterile pinnæ of *Archæopteris Jacksoni* I find several fragments of fertile pinnæ, which, since they do not conform to the characters given by Dawson for the latter species, I provisionally place in the other Perry species of *Archæopteris*, *A. Rogersi*, the fruit of which was unknown to the author of that species. As shown in Pl. III, Fig. 5, which represents an average specimen, the sporangia in this species are oblong linear, obtusely rounded, about 4–6 mm. broad and 2.5–3.5 mm. long, arranged singly or in pairs, with very short pedicels along the the midrib, which extends beyond the sporangia in a slender upward-turned prolongation. The sporangium itself is marked by a narrow longitudinal line, probably corresponding to the nerville. This character of the *Archæopteris* sporangium which has been illustrated by Dawson[a] is susceptible of interpretation as a rudimentary annulus. In one of our specimens the pinnæ and sporangia are smaller and more delicate, being intermediate to those placed by me (Pl. III, Fig. 4) under *A. Jacksoni*. The difference in size is perhaps due to immaturity, since the mode of arrangement on the midrib appears to be that shown in the larger specimens.

As already mentioned in my remarks on *Archæopteris Jacksoni*, it is possible, I believe, that this type of fertile pinna may belong to the last-named species. This supposition is to some extent supported by the relatively greater frequency of this form of fertile pinna in association with *A. Jacksoni* at Perry, by their close resemblance to the fertile pinnæ figured by Dawson[b] under *Archæopteris gaspiensis*, and by the occurrence of *A. Jacksoni* with *A. gaspiensis* in the Gaspé region. The

[a] Geol. Hist. Pl., 1888, p. 128, fig. 55*a*.

[b] Fossil Plants Erian and Upper Silurian Formations of Canada, pt. 2, pl. xxi, fig. 2.

very close relations of the Perry specimen to those from Montrose, Pa., described by Lesquereux[a] as *A. Rogersi* are to some extent corroborative of this view. The fertile specimens from Pennsylvania in the Lacoe collection are of the form here placed in *A. Rogersi.*

In his Devonian Flora of Bear Island, Nathorst[b] seems to regard *Archæopteris Rogersi* as probably referable to *A. Roemeriana* Goepp. It seems not improbable that the fragments from Perry, doubtfully identified by Dawson[c] as *Cyclopteris Halliana* Göppert, are but delicate specimens of *A. Rogersi.*

ARCHÆOPTERIS HITCHCOCKI (Dn.) D. W.

Pl. III, Figs. 6, 6^a, 6^b.

1862. *Sphenopteris Hitchcocki* Dawson, Rept. Nat. Hist. and Geol. Me., p. 251, fig. 6.
1862. *Sphenopteris Hitchcocki* Dn., Hitchcock, Rept. Nat. Hist. and Geol. Me., p. 248.
1862. *Sphenopteris Hitchcocki* Dawson, Proc. Portland Soc. Nat. Hist., vol. i, pt. i, pp. 76, 77, pl. i, fig. 4.
1862. *Sphenopteris Hitchcockiana* Dawson, Quart. Jour. Geol. Soc. London, vol. xviii, p. 298.
1863. *Sphenopteris Hitchcockiana* Dawson, Am. Jour. Sci., 2d ser., vol. xxxv, p. 313.
1868. *Sphenopteris Hitchcockiana* Dawson, Acad. Geol., pp. 514, 518, 534, 552.
1871. *Sphenopteris Hitchcockiana* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 49, pl. xv, fig. 175; also p. 52.
1884. *Sphenopteris Hitchcockiana* Dn., Lesquereux, Coal Flora, vol. iii, p. 837.
1869. *Palæopteris Halliana* (Göpp.) Schimper, Traité. vol. i, p. 478 (syn.).
1895. *Cyclopteris Hitchcockiana* (Dn.) Solms-Laubach, Jahrb. d. K. preuss. geol. Landesanst., 1894, p. 86.

Main rachis large, very rugose, sometimes faintly corrugated transversely, and in fertile portions provided between the secondary pinnæ with very slender, narrow, deeply dissected or laciniate, oblique and recurved rachial pinnules, the dichotomous lobes or nerves of which bear sporangia at their apices; fertile secondary pinnæ, alternate, close, very oblique at the base and curving outward, the lower ones reflexed, tapering slightly, with moderately strong rugose rachises; lowest pinnules reduced to very narrow laciniæ, dichotomizing twice or more, the lobes fertile at the apex, the sporangia being broader than the laciniæ, more distal pinnules reduced to the usually once or twice dichotomous short midrib, and the lateral nervilles immediately forking once or more at a rather wide angle to furnish short pedicels for the sporangia; sporangia in lax or diffuse arrangement, often loosely fasciculate at the apices of the very short dichotomous nerves, 1.8–2.4 mm. long, oblong or slightly clavate, often slightly curved, the maximum width (0.5–0.6 mm.) being at the middle or a little below the obtuse or rounded apex, the base being narrowed and the dorsal surface traversed by a low narrow keel in continuation of the nerville.

The diagnosis given above is based on the counterpart of the original type from Perry, now in the geologic collection of the American Museum of Natural History,

[a] Coal Flora, vol. 1; p. 307. Nos. 16989, 16992, 16995, Lacoe Collection U. S. Nat. Mus.
[b] Oberdevonische Flora der Bären-Insel, 1902, p. 22.
[c] Quart. Jour. Geol. Soc. London, vol. 19, 1863, p. 462.

to whose courtesy, through Dr. E. O. Hovey, I am indebted for the opportunity for its reexamination and illustration. As shown in Pl. III, Fig. 6, the rachises of the lateral pinnæ are hardly in the plane of the surface of the shale, a condition not rare in fertile segments of *Archæopteris.*

A conspicuous and interesting feature of this type is the reduction of the rachial pinnules to narrow laciniæ, at the dichotomous apices of which sporangia are borne, as is shown in Fig. 6 [a]. The lower pinnules of the secondary pinnæ are also unique in that they are reduced to narrow, several times dichotomous laciniæ, bearing sporangia at their apices. This feature is probably responsible for the original reference of the plant to the genus *Sphenopteris.* Higher in the secondary pinnæ the pinnules appear to be further reduced, so that a short midrib dichotomously gives off a few short nervilles, which usually fork once, or perhaps twice, immediately, to form the very short pedicels of the sporangia. It is to this spreading and dichotomously branched habit of the nerves or laciniæ that the plant owes its diffuse aspect.

The sporangia, often seen in foreshortened aspect in the matrix of this specimen, are (Pl. III, Fig. 6 [b]) oblong, sometimes slightly enlarged upward, and generally very briefly pedicellate at the usually narrowed base. The residual substance of the sporangia is thick and carbonaceous, each sporangium being traversed by a narrow, low dorsal keel, which may correspond to a rudimentary ring.

The sporangia of this species are typical of the genus *Archæopteris*, a sterile fragment of which occurs on the same piece of shale. The correlation of *Archæopteris Hitchcocki* with any of the species known by their barren pinnæ is not yet definitely possible, on account of the lack of connection between the barren and fertile at Perry and the failure to discern the fertile species elsewhere in association with corresponding barren pinnæ. But it is not beyond the bounds of possibility that the specimen may represent a lower part of a fertile *A. Jacksoni*, whose fruit would appear to approach it by the position of the sporangia on the apices of forking veinlets.

The reference of *Sphenopteris Hitchcocki* to *Archæopteris* was first proposed essentially by Schimper,[a] who regarded it as the fertile pinnæ of *Palæopteris Halliana* (Goepp.) Schimp., to which he also provisionally referred *A. Jacksoni.* Dawson[b] seriously considered Schimper's views, though he remained unconvinced. Lesquereux, who in 1880[c] accepted Schimper's correlations, later restores[d] the species to *Sphenopteris.*

Schmalhausen[e] is disposed to interpret *Sphenopteris Hitchcocki* as a fruiting form closely related to his *Dimeripteris.* The latter genus, which will be discussed later, will at once be recognized as generically distinct. A striking example of the

[a] Traité paléont. vég., vol. 1, p. 478.
[b] Fossil Plants Devonian and Upper Silurian Formations of Canada, p. 52.
[c] Coal Flora, vol. 1, p. 304.
[d] Op. cit., vol. 3, 1884, p. 837.
[e] Mém. Com. Géol., vol. 8, No. 3, St. Petersburg, 1894, pp. 29, 30.

evils resulting from a too free interpretation of foreign imperfect descriptions and figures is furnished by Piedboeuf's inclusion[a] of *S. Hitchcocki* with *Haliserites Dechenianus*, *Fucus Nessigii*, *Psilophyton*, and *Sphenopteris condrusorum* in his *Sargassum Dechenianum*, supposed to belong to the *Fucaceæ*. By the form and characters of the sporangia and their position at the ends of forking veins *Archæopteris Hitchcocki* appears to be related to the fossil plant from the Devonian of Belgium described by Crépin[b] as *Psilophyton condrusorum*, the *Sphenopteris condrusorum* of Gilkinet.

OTIDOPHYTON D. W., gen. nov.

OTIDOPHYTON HYMENOPHYLLOIDES n. sp.

Pl. II, Fig. 3.

1863. An "Filicites incertæ sedis," Dawson, Quart. Jour. Geol. Soc., vol. xix, p. 464, pl. xvii, figs. 10, 16?

Fragments filicoid in form, with broad, lineate, rachial axis, bordered by rather thick and apparently somewhat fleshy, short, ovate lobes, which are open nearly at a right angle, laterally asymmetrical, slightly upward-pointed, and connate for about one-third of their length, the narrow, rounded sinuses being marked by small, roundish, dense, umbilicate organs about 0.5 mm. in diameter, and joined to the rachis by an oblique, decurrent, and rather thick strand; lamina of the lobes depressed along the rachis and nearly flat except near the slightly apiculate extremities of the lobes, where it appears to be marked, in most cases, at a distance of about 1.25 mm. from the border, by a small slightly depressed low mammilla.

The fragment here described is, like most of the other material from the Perry beds, more or less abraded or macerated, a fact which, in conjunction with the generally granular matrix, renders the interpretation of the impression and carbonaceous residue a matter of much difficulty; yet the salient features are sufficiently clear to make it identifiable for general paleontologic and stratigraphic use. It has therefore seemed desirable to give it a systematic nomenclatural designation, although the determination of the precise nature and functions of the parts are necessarily left to future discovery and research.

The habit of the pinna, Pl. II, Fig. 3, is strongly suggestive of a fern, with short, thick, fleshy lobes united at the base and separated in their distal portions by deep and narrowly rounded sinuses, at the base of each of which the thickened carbonaceous umbilicate impression, sometimes elongated radially and evidently joined by a thick outward curved strand to the rachis, is strongly suggestive of the synangium of *Hymenophyllum*. As will be seen by reference to Fig. 3, there is very good reason for believing that this sinal organ is sporophyllous. In the fragment illustrated it is constant in its occurrence between the lobes. In view of this interpretation it becomes, however, somewhat embarrassing to explain the small mammillate

[a] Mittheil. Naturf. Verein, Dusseldorf, 1887, pt. i, p. 47.

[b] Bull. Acad. Roy. Belgique, vol. 38, 1874, pl. i, fig. 3.

depressions which occur within the apices of the lobes, and are likewise marked by a thickened carbonaceous residue. Other things being equal, these would naturally be taken for fructifications, but in this particular case such an interpretation is quite inadmissible, unless we conceive the plant to possess two distinct types of sporangia borne on the same pinna. It is possible that the one or the other is merely glandular, or that the sinal impressions are those of pedicellate organs or appendages. I am, however, slightly inclined to regard the peripheral traces as possibly glandular.

The specimen in hand does not satisfactorily reveal any definite system of nervation. Several of the lobes on the right hand of the axis appear to be somewhat distantly marked by depressed lines, lying generally parallel to the trend of the lobe and possibly bifurcating once or more, which bend downward near the rachis, but it is not possible to follow them with sufficient accuracy to establish their mode of origin or their precise habit of subdivision. They are probably to be regarded as the true nervation of the fleshy pinnules, although in other portions of the specimen no evidence of nervation is visible.

As compared with other Paleozoic plant types, the fragments in hand appear to resemble none sufficiently closely to indicate near relationship. As to the general aspect of the fragment, embracing a thick rachis bordered by dense fleshy lobes, the example shown in Fig. 3 is slightly suggestive of that from the lower Coal Measures of Missouri, described by the writer as *Brittsia*,[a] in which we have denticulately lobed pinnules or appendages arising from the sinuses between fleshy rachial lobes corresponding in general form and arrangement to that in *Otidophyton*. The latter, like *Brittsia*, also distinctly resembles the fronds described by Renault and Zeiller as *Zygopteris*.[b] This genus differs widely from the type in hand in the position of the sporangia.

From an examination of the figures of the unnamed fern from the Perry beds, published by Dawson[c] in 1863, it appears almost certain that the fragments described as having "dark spots, which are probably remains of fructification" in the sinuses, are referable to the genus, and perhaps to the species, described above, although the lobes are figured as narrower and the nervation is said to anastomose near the rachis.

The fragment illustrated is in general form and aspect somewhat similar to specimens described by authors as young examples of *Archæopteris*. Fig. 3 deserves especial comparison with the bipinnate example of almost exactly similar form from the Devonian of Condroz, illustrated by Crépin[d] as *Palæopteris hibernica*.

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[a] Mon. U. S. Geol. Survey, vol. 37, 1899, p. 98, pl. xlvii, figs. 1-5.
[b] Fl. foss. bassin houill. de Commentry, pt. 1, 1886, p. 77, pl. xxxii, figs. 5-7.
[c] Quart. Jour. Geol. Soc. London, vol. 19, p. 464, pl. xvii, figs. 10, 16.
[d] Bull. Acad. Roy. Belgique, vol. 38, 1874, p. 561, pl. iii, fig. 6.

BARRANDEINA Stur.

Sitzb. K. Akad. Wiss., Wien., math-nat. Cl., 1881, vol. lxxxiv, pt. i, p. 362.

BARRANDEINA PERRIANA (Dn.) D. W.

Pl. II, Fig. 11.

1862. *Anarthrocanna* sp., Dawson, Quart. Jour. Geol. Soc., vol. xviii, opp. p. 329.
1863. *Anarthrocanna Perriana* Dawson, Proc. Portland Soc. Nat. Hist., vol. i, pt. 2, p. 100, pl. ii, fig 3.
1863. *Anarthrocanna Perriana* Dawson, Second Rept. Nat. Hist. and Geol. Me., p. 403.
1863. *Anarthrocanna Perryana* Dawson, Quart. Jour. Geol. Soc., vol. xix, p. 461, pl. xvii, fig. 21.
1871. *Anarthrocanna Perryana* Dawson, Foss. Pl. Dev. Upp. Sil. Can., pp. 27, 85.

Rigid stems marked with broad, slightly irregular, low, flat, nearly contiguous, obscurely lineate ribs formed by the decurrent or appressed narrow bases of petioles or leaves, whose arrangement is spiral, the fracture being more or less oblique.

Under the name *Anarthrocanna perriana*, Dawson published a number of stem fragments of calamarian aspect, the leaf or petiole bases being described and figured as verticillate. From a number of small fragments in hand, one of which (Pl. II, Fig. 11) is illustrated herewith, it appears that the scars are arranged with more or less distinctness spirally instead of verticillately. The scars themselves are mere portions of very obliquely decurrent rachises or leaf bases whose succession in the longitudinal sense forms a slightly irregular low rib. Each leaf lower on the rib appears as if laid on the rib, with the width of which it coincides.

On account of the appressed condition and the mode of origin of the leaf bases the fractures are relatively lower, as regards the spiral, in some cases than in others; so it happens that in some instances they may appear to be verticillate. However, this aspect is, I believe, merely accidental. I am unable to recognize either the presence of nodes or of any enlargements corresponding to nodes such as are described by Dawson, whose figures, indeed, show no such enlargements. The reference of the Perry plant to Göppert's genus *Anarthrocanna* is untenable, since the latter genus includes exarticulate stems bearing verticillate branch scars.

The foliar characters and form of reproduction as well as the internal structure of the American plant are not known. The mode of decurrence of the leaf bases is somewhat similar to that seen in the secondary rachises of stems of *Archæopteris*. It is possible, on the other hand, that some of the supposed leaf fragments described as *Cordaites angustifolius* may have been borne on stems of this type, though it seems more probable that they will eventually prove to be fern stems. In this connection it is important to consult the fragment from the Hamilton of New York, figured by Dawson[a] as "*Cordaites?*", which would seem to be congeneric with the Perry plant. Both types, the New York type in particular, are so similar in their

[a] Quart. Jour. Geol. Soc. London, vol. 18, 1862, p. 318, pl. xvi, fig. 59.

rachial characters to the axis described by Krejči[a] as *Protolepidodendron Duslianum* and by Stur[b] made the type of *Barrandeina* as to require consideration as being generically identical. I have therefore tentatively placed the Maine plant in the genus *Barrandeina*. It should be compared with *B. Duslianum*, pl. v, figs. 3, 4, 5, of Stur's paper on the Flora of the H-h1 stage in Bohemia.

RHACHIOPTERIS Dawson.

Quart. Jour. Geol. Soc., vol. xviii, 1862, p. 323.

RHACHIOPTERIS PINNATA Dn.

1842. Plant ——, Vanuxem, Geol. 3rd Dist. New York, p. 191, fig. 57.
1889. Plant ——, Lesley, Dict. Foss. Pa., vol. ii, p. 657, text. fig.
1862. *Rhachiopteris pinnata* Dawson, Quart. Jour. Geol. Soc., vol. xviii, p. 323, pl. xvi, fig. 60.
1863. *Rhachiopteris pinnata* Dn., Hall, 16th Rept. Regents N. Y. St. Cab., p. 111, fig. 1.
1871. *Rhachiopteris pinnata* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 57.
1880. *Rhachiopteris pinnata* Dn., Lesquereux, Coal Flora, vol. i, p. 332.
1885. *Rhachiopteris pinnata* Dn., J. M. Clarke, Bull. U. S. Geol. Survey No. 16, pp. 28, 33.

RHACHIOPTERIS PINNATA Dn., var. ANGUSTIPINNA D. W.

Pl. IV, Figs. 1, 2, 3.

Bipinnate; axis rigid, irregularly and obscurely costate, irregularly lineate, slightly dilated laterally in passing upward to the bases of the secondary pinnæ; secondary pinnæ distichous, opposite about 4 to 5 cm. distant, at an angle of about 45° with the main rachis, rigid, narrow, of varying length, often seeming to terminate abruptly, strongly decurrent at the base, and conspicuously broadening the main rachis for some distance below the point of union; pinnules little known, very small, apparently somewhat distant, membranaceous, narrow, possibly oblong, irregular in outline, or lobate, not spread in the plane of the rachis.

Although little is known of the foliage of this type, the characters of the rachial portions are so nearly identical with those of the specimen from the Marcellus shale, middle Devonian of New York, made the type of the genus *Rhachiopteris* by Dawson,[c] that it seems not more than varietally separable from *Rhachiopteris pinnata* Dn. The chief distinctions recognized in the variety *angustipinna* lie in the less tapering secondary pinnæ, which are more slender at their bases, and in the absence of a distinct medial depression or pit on the surface of the main rachis between and nearly opposite each pair of lateral pinnæ, such as are shown in Dawson's illustration. Nevertheless, some slight depressions corresponding to those shown in *R. pinnata* are present, though not satisfactorily

[a] Sitzungsber. K. böhm. Gesell. Wiss., 1878 (1880), p. 333.
[b] Sitzungsber. K. Akad. Wiss., Wien., math.-nat. Cl., vol. 84, pt. 1, 1881, p. 362.
[c] Quart. Jour. Geol. Soc. London, vol. 18, 1862, p. 323, pl. xvi, fig. 60. The genus *Rhachiopteris* Dawson, 1862, must not be confounded with *Rhacopteris* Schimper, 1869, or *Rachiopteris* Williamson, 1874, the last being a homonym of Dawson's genus.

clear, in the Perry plant. It is possible that in this species the secondary pinnæ are in four vertical rows, tetrastichous, or that shorter pinnæ or pinnules at the ends of the abruptly terminated lateral rachises alternate with the pairs of secondary pinnæ.

The specimens present very little to indicate the characters of the pinnules borne by the rachises. On account of the coarse, irregularly fracturing nature of their matrix, their extremely delicate lamina, and the projected positions of their leaflets, only small fragments may be shown in definite relation to the rachis. A portion of such a pinnule is seen (Pl. IV, Fig. 3) on the second lateral pinna, which is not uncovered beyond. Its membranaceous lamina is ventrally broadly concave to the thread-like vascular axis. The examination of other specimens, such as that in Fig. 1, appears to show the presence of leaf bases or offshooting nerves at various points of the rachis, which becomes sparsely lineate toward the base. These lateral rachises are themselves marked by a somewhat loose or irregular denser median portion or narrow axis, which is sometimes in relief and sometimes depressed, and hardly exactly parallel with the margins. The latter suggest a thick wing. The aspect of these less dense lateral portions of the secondary rachises, in the presence of such apparently deficient transpiratory leaf surface, suggests that the bordering laminæ of the stem may have been stomatiferous.

An example of a larger secondary pinna, probably belonging to the same plant, is shown in Pl. IV, Fig. 3. Here we have remains of several pinnules still in evidence. I am disposed to interpret these pinnules as generally alternate and not more than 1.5–2.5 cm. distant on the same side. They are so delicate as to be abraded, shriveled, or curled at the borders in all or nearly all specimens I have found so far. In their general mode of division and form they strongly resemble the terminal, thin, recurving, laminar expansions which probably served as leaves in the smoother of the groups of plants referred by Dawson to *Psilophyton.* They represent, I believe, an early or rudimentary form of fern pinnule.

A very interesting phase of the lateral pinnæ is the apparently rapid if not almost abrupt termination of the rachis, either close to its base or at some distance from the main rachis. In some cases this is perhaps due to imperfect exposure of the specimens, though in others it would seem to be due either to rapid reduction of the axis attendant on foliar development or to fragility just above the leaf bases. The relative delicacy of the vascular axis, as compared with the rachises or lamina, illustrated in Pl. IV, Fig. 1, should be borne in mind in this connection. Similar specimens of secondary pinnæ with fragments of similar pinnules, found at a number of Devonian localities and almost certainly belonging to the same genus, have generally, though probably erroneously, been referred to the genus *Psilophyton*. In these fragments we similarly have a smooth, slender rachis with central thickened axis, often depressed or traversing a depression, and a more fleshy and evidently less fibrous wing on either side. So also these branches, and even the leaf bases themselves, often end abruptly in a blunt though not resistant recurved base, to which thread-like or delicate fragments of pinnules, or of the vascular axis of the distally macerated portion of the rachis, seems in some instances to adhere.

The fragments figured by Dawson, or seen in Pl. IV, Figs. 1 and 2, may with interest be compared with the portion of a fern skeleton from the Lenne beds (middle Devonian) of Oben zum Holz, figured[a] by Count Solms-Laubach, and compared with *Sphenopteris condrusorum*. In the Oben form we have opposite branches on the main rachis, which are evidently traversed by a distinct medial axis, while the strongly reflexed lobes of the divaricately forking ultimate divisions of the rachis are suggestive of the portion of a pinnule shown in Pl. IV, Fig. 1. In the regularity of the lateral pinnæ our plant suggests the species last mentioned, which was described by Gilkinet.[b] But while the rachial portions of the two ferns appear to have many points in common, the pinnules of the Belgian examples are distinctly sphenopteroid, more rigid, and regularly disposed, and are comparable to the *Sphenopteris moravicum* of Ettingshausen.[c]

Rhachiopteris pinnata also closely resembles defoliated fragments of *Archæopteris*, with opposite lateral pinnæ. It may, however, be distinguished from the latter by the broadened axis just above the axils of the pinnæ, which in *Archæopteris* are acute, the secondary rachises themselves being more rigid, fibrous, and without the bordering lamina.

RHACHIOPTERIS PUNCTATA Dn. (?).

1842. Plant ——, Vanuxem, Geol. 3rd Dist. N. Y., p. 191, fig. 56.
1889. Plant ——, Lesley, Dict. Foss. Pa., vol. ii, p. 657, text-fig.
1862. *Rhachiopteris punctata* Dawson, Quart. Jour. Geol. Soc. London, vol. xviii, p. 323, pl. xvi, fig. 61.
1863. *Rhachiopteris punctata* Dawson, in Hall, 16th Rept. N. Y. State Mus. Nat. Hist., p. 113, fig. 4.
1871. *Rhachiopteris punctata* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 57.
1880. *Rhachiopteris punctata* Dn., Lesquereux, Coal Flora, vol. i, p. 332.
1884. *Rhachiopteris punctata* Dn., Williams, Bull. U. S. Geol. Survey No. 3, p. 14.
1888. *Rhachiopteris punctata* Dawson, Geol. Hist. Pl., p. 93.
1889. *Rhachiopteris punctata* Dn., Lesley, Dict. Foss. Pa., vol. ii, p. 657, fig. 56.

Fern stems, rigid, with somewhat coarse, irregular, longitudinal ribs, between which the impression is marked by small transverse ridges about 0.75 mm. distant, thus producing the appearance of vertical rows of very coarse punctuations between, and often lapping upon, the impressions of the large vascular bundles.

[a] Jahrbuch K. preuss. geol. Landesanstalt u. Bergakademie, 1894, pl. ii, fig. 1, p. 93.
[b] Bull. Acad. Roy. Belgique (2), vol. 39, 1875, p. 393, figs. 1, 2.
[c] Fossile Flora Mahrisch.-Schles. Dachschiefers, p. 100, pl. iv, fig. 4.

The stems described by Dawson under the above name are, as was admitted by him, probably to be associated with *Archæopteris*. They perhaps represent specimens showing in a more marked phase the conditions of preservation often seen in rachises of the fronds of this genus. It is possible that the peculiar transverse fretting may be due to the presence of horizontal sclerotic plates in the cortex, comparable to those in *Heterangium*.

This species is perhaps of no value beyond indicating for its terrane the presence of some kind of *Archæopteris* whose petiole bases may be preserved so as to show a transversely rugose stem, a fact already recognized at Perry through the occurrence of *A. Rogersi*.

SPHENOPTERIDIUM Schimper.

Traité Pal. Vég., vol. iii, 1874, p. 487.

SPHENOPTERIDIUM sp.

Among the plants placed in my hands through the courtesy of Dr. R. T. Jackson, of the Museum of Comparative Zoology of Harvard University, I find a fragment of pinnule (No. 3,337) which by its form and nervation is very similar to some of the lobes of *Sphenopteridium furcillatum* found by Ludwig[a] and Potonié[b] in the collections from near Herborn, Hesse-Nassau. The terranes containing the latter are referred on nonpaleobotanical evidence to the Silurian; but the evidence of the plants themselves is sufficient to show that the *Sphenopteridium* beds are not older than upper Devonian.

DIMERIPTERIS Schmalhausen.

Mém. Com. Géol., vol. viii, No. 3, St. Petersb., 1894, p. 12.

DIMERIPTERIS INCERTA (Dn.) D. W.

Pl. II, Figs. 7, 8, 8ª, 9.

1862. *Cyclopteris incerta* Dawson, Quart. Jour. Geol. Soc. London, vol. xviii, p. 320, pl. xvi, fig. 44.
1871. *Cyclopteris incerta* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 65.
1884. *Cyclopteris incerta* Dn., Lesquereux, Coal Flora, vol. iii, p. 830.

Very slender stems occasionally forking more or less divaricately, with central axial strand, the lateral portions less dense and often irregularly costate or lax; lateral branches relatively short when fertile, becoming abruptly diffuse by rapid dichotomies at nearly a right angle, the ultimate divisions being very narrow, curved, or reflexed, extremely short; sporangia borne in clusters of 4 to 10 or more at the apices of the ultimate branchlets, sessile, imbricate in subglobular heads, oblong or oblong-lanceolate, about 2.5 mm. in length and about 0.6 mm. in diameter, obtuse and sometimes slightly flaccid; sterile pinnules not definitely known or correlated.

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[a] Palaeontographica, vol. 17, No. 3, 1869, pl. xxiv.
[b] Abhandl. K. preuss. geol. Landesanstalt, n. s., vol. 36, 1901, pp. 20, 21.

The interesting fossils here described and illustrated furnish another example of the incompleteness of our knowledge of many of the older types of land plants. The stems of the form shown by several fragments in Pl. II, Figs. 7, 8, appear to be indistinguishable from others that have commonly been referred to *Psilophyton princeps*, which is recorded by Dawson as occurring at Perry. They are usually very slender, long, somewhat rigid, with central thickened vascular axes, which are often carinate in the impression. These stems or branch fragments often show short, abruptly terminated, branch, or leaf bases, to which adhere short, irregular filamentose remains, presumably branchlets or leaf nerves or fragments of pinnules. By their superficial characters they appear to be inseparable, at least generically, from specimens from Scaumenac labeled by Dawson as *Psilophyton princeps*. The agglomerations or heads of sporangia also appear to be directly comparable to those illustrated by Dawson[a] as *P. robustius*. The resemblance of the last-mentioned species touches also the characters of the rapidly and dichotomously diffuse fertile branchlets and the arrangement of the sporangia.

The specimens from Perry can not, however, be referred to the genus *Psilophyton*, as proposed by Dawson[b] in 1859, even if we allow for some uncertainty as to the true nature and characters of *Psilophyton princeps*, the type of its genus. In the latter we have distinctly spinous or scaly stems, irregularly dichotomous and revolute, as shown by the figures, not circinnate? at the apex. The supposed fruit of the type is comparable in some respects to that from Perry. But from the descriptions and figures given by Dawson there would seem to be ample ground for questioning the congenerity of the species subsequently described as *P. robustius*, *P. elegans*, and *P. glabrum* with *P. princeps*. The more ample illustrations given by Dawson[c] in 1871 aid little in determining the problem, since we have both smooth and spinous stems under the type species of the genus, while the fruiting of the latter shown in his fig. 118 differs not only from that given in 1859, but also, in less degree, from that indicated in fig. 103 of the same work. As Count Solms-Laubach has pointed out,[d] the determination of the generic interrelations of the species described by Dawson as *Psilophyton* requires a thorough revision of the material with a reexamination of the types.

While doubt remains as to the generic identity of the Perry specimens with the type of the genus *Psilophyton*, whatever be their relations to *P. robustius* there is hardly room for question as to the precise congenerity of the plant in hand with the material made by Schmalhausen the type of his genus *Dimeripteris*.[e]

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[a] Fossil Plants Devonian and Upper Silurian Formations Canada, 1871, pl. xii.
[b] Quart. Jour. Geol. Soc. London, vol. 15, p. 478. Canadian Naturalist, vol. 5, No. 1, 1860, p. 2.
[c] Fossil Plants Devonian and Upper Silurian Formations Canada, pls. x, xi, xii.
[d] Jahrbuch K. preuss. Landesanstalt u. Bergakademie, 1895, pp. 73, 76.
[e] *Dimeripteris fasciculata*, Mém. Com. Géol., vol. 8, No. 3, St. Petersburg, 1894, pp. 12, 30, pl. i, figs. 10, 11.

The fragments in hand approach *D. fasciculata* so closely as at first to leave doubt as to the specific distinction between the Perry and the Donetz plants. The specimens shown in Pl. II, Fig. 7, should be compared with pl. i, fig. 11, of the Donetz-Becken flora. But the species is also still more closely bound to the specimen from the Hamilton of New York described and figured by Dawson[a] as *Cyclopteris incerta*. Although I should not have associated it with a rounded stem branching so freely as that illustrated by Dawson as belonging to the latter species, its sporangia are so similar both in arrangement and in form to those shown in fig. 44c of Dawson's plate that I tentatively place it in the same species. The subdivisions shown in 44b represent, I believe, ultimate branch divisions from which the sporangia have fallen. As such they should be compared with our Fig. 8. The curvature of the pedicels uniformly in the same direction in 44c is probably merely accidental. The apparent coalescence in the impression of the sporangia borne on two ramules in the upper part of this figure illustrates a feature common in our species, in which it is probable that in some cases the sporangia of more than one ramule are blended in the branch or head. Dawson's figure fails to show the features of the individual sporangium, and I am not certain whether they agree in all respects with those revealed in the coarse matrix at Perry.

The type of fructification here described seems to have close analogies in other plants described from the Devonian of various regions. In the aspect of the heads, the development of the sporangia from rapidly dichotomizing ramules, and the characters of their sporangia themselves, *Dimeripteris incerta* and *D. fasciculata* are to be compared with the fructification from the Devonian of Bear Island described by Nathorst[b] as *Cephalotheca mirabilis*. Were it not that the sporangial heads in the latter are almost sessile in the proximal angles at the bases of the secondary pinnæ the plants would of necessity be regarded as very closely related species of the same genus. The fructification of the plant in hand also resembles in some respects that described by Vaffier[c] as *Alcicornopteris Zeilleri*, from the lower Culm of Maconnais, or the *Calymmotheca bifida* figured by Kidston[d] from the Calciferous sandstone series of Scotland. However, the plant in hand is very readily distinguished from both of the latter types by the great differences in its rachial development and mode of division.

Several fragments of irregularly lobed, delicate ramules (or pinnules?) in the collection may represent the leaves of *Dimeripteris incerta*. They are, in general, membranaceous laminæ traversed by slender central nerve strands, and are com-

[a] Quart. Jour. Geol. Soc. London, vol. 18, p. 320, pl. xvi, fig. 44.
[b] Kongl. svensk. Vet.-Akad. Handl., vol. 36, No. 3, 1902, p. 18, pl. i, figs. 18-35.
[c] Annales Univ. Lyon, n. s., vol. 1, fasc. 7, 1903, p. 124, pl. vii.
[d] Trans. Royal Soc. Edinburgh, vol. 33, pt. 1, 1887, pl. viii, figs. 1-6.

parable to those described as *Rhachiopteris pinnata* var. *angustipinna*. They also resemble some of the slender, nonpunctate stems erroneously placed in *Psilophyton princeps*. The phases and characters of certain of the ramose stems at Perry will be described more particularly in connection with the supposed Psilophyta from the same place.

None of the sporangia provisionally referred to *Dimeripteris incerta* show the mode of dehiscence. There is, therefore, doubt as to whether the bivalvate or bilobate organs later to be compared with *D. gracilis* represent the generic type of sporangia described above. The coincidental association of the forms described by Schmalhausen as *Dimeripteris fasciculata* and *D. gracilis* in the Donetz beds; the *D. incerta* and fossils of the type shown in fig. 103 of Dawson's plate in the American Devonian; and the similar association of the fasciculate with the bivalvate bodies next to be described at Perry are interesting analogous conditions, if they do not bespeak direct relationship.

DIMERIPTERIS RECURVA (Dn.) D. W.

Pl. II, Figs. 4–6.

1862. *Sphenopteris* sp., Dawson, Quart. Jour. Geol. Soc. London, vol. xviii, opp. p. 329.
1863. *Sphenopteris* sp., Dawson, Proc. Portland Soc. Nat. Hist., vol. i, pt. 2, p. 100, pl. ii, figs. 8, 8a.
1863. *Sphenopteris* sp., Dawson, 2d Rept. Nat. Hist. and Geol. Me., p. 404.
1863. *Sphenopteris recurva* Dawson, Quart. Jour. Geol. Soc. London, vol. xix, p. 464, pl. xvii, figs. 7, 8.
1871. *Sphenopteris recurva* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., p. 53.

Pinnules at the summits of slender-curved or geniculate, closely dichotomous ramules, very small, cuneate or obovate-cuneate, slightly curved upward, very obtuse, dichotomously bilobate, with thin narrowly decurrent lamina; sporangia narrowly obovate, paired or clustered, a little smaller than the lobes of the pinnules, apparently bivalvate.

Among the material collected in 1903 are a number of very small specimens which appear to represent the *Sphenopteris recurva* of Dawson. Pl. II, Fig. 5, shows the common form of the pinnular fragments, and illustrates well the dichotomous division of the pinnules which have in some instances the aspect of empty sporangia. A fragment possibly representing sporangia, and without doubt referable to the same species, is drawn in Pl. II, Fig. 6. I have no clear proof that the sporangia are bivalvate. In Pl. II, Fig. 4, is shown a fragment of a pinna which I believe belongs to *Dimeripteris recurva*.

The reference of these specimens to *Dimeripteris* is based on the apparently close relation of the material in hand to that described by Schmalhausen[a] as *Dimeripteris gracilis*. There seems to be little doubt that they are congeneric, but the reason why *Dimeripteris gracilis*, which I am inclined to think may be identical

[a] Mém. Com. Géol., vol. 8, No. 3, St. Petersburg, 1894, p. 30, pl. ii, figs. 23–25.

with its associate, *Sphenopteris Lebedewi* Schm., is included in the same genus as *D. fasciculata* does not appear to be entirely clear.

Specimens like that in Pl. II, Fig. 6, may be compared with those given by Dawson on pl. ix, fig. 103, of his Devonian and Upper Silurian Flora[a] as sporangia of *Psilophyton princeps*. The latter are also described as bivalvate. I have not been able to associate the fossils here figured with any particular type of stem or rachis and therefore can not say if they are peculiar to the stems from Perry which have been doubtfully identified as *Psilophyton princeps*. The specifically distinct fragment shown under the latter name in pl. x, fig. 118, of Dawson's memoir also deserves comparison with *Dimeripteris gracilis*. The interesting coincidence in finding at Perry two plants apparently corresponding to *Dimeripteris fasciculata* and *D. gracilis* of the Donetz locality has already been noted in my remarks on *D. incerta*. In the development of the pinnules the plant in hand is comparable to *Sphenopteris flexilis* Heer,[b] from the lower Carboniferous of Spitzbergen, while the bivalvate aspect of the large lobes suggests the fragment figured without name by Unger[c] from the Cypridina beds of Thuringia.

SPHENOPTERIS Sternberg.

Vers Fl Vorwelt, vol 1, Tent , 1825, p xv

SPHENOPTERIS FILICULA (Dn.) D. W.

1862 *Trichomanites* sp., Dawson, Quart Jour Geol Soc London, vol xviii, opp. p 329.
1863 *Trichomanites* sp , Dawson, Proc Portland Soc Nat Hist , vol i, pt 2, p 100, pl iv, fig 9
1863 *Trichomanites* sp , Dawson, Second Rept Nat. Hist and Geol Me., p 404
1871 *Trichomanites* sp , Dawson, Foss Pl Dev and Upp Sil Can , p 86
1863 *Trichomanites filicula* Dawson, Quart Jour Geol Soc London, vol xix, p 464, pl xvii, figs 12, 13
1871 *Trichomanites filicula* Dawson, Foss Pl Dev and Upp Sil Can , p 56

Cuneate to broadly ovate pinnules dichotomously dissected, generally at a narrow angle, in skeleton form, the lobes rigid, linear, obtuse, but little wider than the nerves, which are slightly depressed ventrally and very narrowly alate.

Little can be said of this species, which has been recognized in a few small fragments only. Our specimens show a more oblique subdivision of the pinnules, with greater regularity and rigidity in the lobation, and with rather broader lobes, than is shown in the two small figures published by Dawson.

The plant here described agrees so closely with that from the upper Devonian of Bear Island, illustrated as *Sphenopteridium* by Nathorst in the first plate (figs. 16, 17) of the Palaozoische Flora der Arktischen Zone,[d] as to raise the question

[a] Fossil Plants Devonian and Upper Silurian Formations Canada, 1871
[b] Flora Fossilis Arctica, vol 4, No 1, Pl I, figs 11–27
[c] Richter and Unger, Denkschr K Akad Wiss , Wien, math -nat Cl , vol 11, 1856, pt 2, p 99, pl vii, fig 25
[d] Kongl svensk Vet -Akad Handl , vol 36, No, 3, 1902, p 14

whether it is not specifically identical with the latter. It is also comparable to the *Sporochnus Krejči* of Stur,[a] from the upper Devonian (H–h1) of Bohemia. From the characters of the portions of pinnules before me the species appears also to be related to the *Sphenopteris flaccida* described by Crepin,[b] from the Devonian of Condroz and the *S vespertina* of the American Pocono. I find no evidence in support of a relationship of the plant to *Aphlebia*, as was suggested by Dawson.

PSILOPHYTON Dawson

Quart Jour Geol Soc, vol xv, 1859, p 478

? PSILOPHYTON CF. PRINCEPS Dn.

Pl V, Figs 3–7, Pl. VI, Figs 7, 8.

1859 *Psilophyton princeps* Dawson, Quart Jour. Geol Soc London, vol xv, pp 478, 479, 480, figs 1a–1m

1860 *Psilophyton princeps* Dawson, Can Nat, vol v, No 1, Feb., p 34, figs 1a–t

1861 *Psilophyton princeps* Dawson, Can Nat, vol vi, No 3, June, p 175

1862 *Psilophyton princeps* Dn, Hitchcock, Rept Nat Hist and Geol Me, 1861, p 248.

1862 *Psilophyton princeps* Dawson in Hitchcock, Proc Portland Soc Nat Hist, vol i, pt 1, p. 76

1862 *Psilophyton princeps* Dawson, Quart Jour. Geol. Soc London, vol xviii, p 298

1863. *Psilophyton princeps* Dawson, Am Jour Sci (2), vol. xxxv, p 313

1863 *Psilophyton princeps* Dawson, 2d Rept Nat Hist and Geol Me, p 402

1863 *Psilophyton princeps* Dawson, Quart. Jour Geol Soc London, vol xix, p 462.

1868 *Psilophyton princeps* Dawson, Acadian Geol, p 543

1870. *Psilophyton princeps* Dawson, Nature. vol. ii, p 86, figs 1, 1a–1e

1871 *Psilophyton princeps* Dawson, Foss Pl. Dev and Upp Sil Can, p 37, pl ix, x, figs 111–119, pl xi, figs 127–129, 133, 134

1880 *Psilophyton princeps* Dawson, Chain of Life, p 95, figs 87a–c

1888 *Psilophyton princeps* Dawson, Geol Hist Pl, p 64, figs 19a–e

1891 *Psilophyton princeps* Dawson, Geol. N S and N. B, p 543, Supplement, p 71, fig 12

Stems not very robust, irregularly and more or less unequally dichotomous, subgeniculate to straight, usually gently curved between the branches, dilated at the points of division, 2–6 costate when flattened, the costæ rounded and separated by several slightly uneven furrows equaling the costæ in dimensions; branches very open, marked in impressions by an oval depression a few millimeters above the point of origin, fewer costate than the axis, and dividing pinnately to dichotomously or yielding almost abruptly to dichotomous, lax, thin, narrow, recurved foliar laminæ not in the same plane.

The provisional reference, with expressed doubt, of the above-described fragments to the genus *Psilophyton* is based (1) on their generic if not specific agreement with material from New York and Canada referred by Dawson and other paleontologists to *Psilophyton princeps*, (2) on the record by Dawson of

[a] Sitzungsber K Akad Wiss, Wien, math-nat Cl, vol 84, pt 1, 1881, pl ii, figs 1, 2.
[b] Bull Acad Roy Belgique, vol 38, 1874, p 360, pl i, fig 3

the latter species at Perry, and (3) on the examination of specimens from Perry, labeled with the latter name by Sir William Dawson himself, in two collections which have been placed in my hands. Yet I have been strongly of the opinion that none of this material is specifically identical with the plant originally described[a] from Gaspé as *Psilophyton princeps*, and am even doubtful whether the two are congeneric.

The relation of the stem fragments from Perry to the typical *Psilophyton* of Dawson can best be discussed after the description of the former.

The general features so far as exhibited in the material in hand may be readily understood by an examination of the figures of a number of the fragments. In Pl. V, Fig. 3, is shown a not entirely flattened rachis in which the branches, as usual either broken or abruptly terminated, are given off alternately. In its flexuosity and ramification this example is comparable to specimens from Campbellton labeled as *Psilophyton princeps*, though it is not so clearly costate as the latter. In general form this fragment is also remarkably like some of the fragments in the New York State collection labeled by Dawson as *Rhachiopteris tenuistriata*. A possible confusion of *Psilophyton* and *Rhachiopteris* in some species was long ago suggested[b] by the author of both genera.

A fragment with more rigid rachis, shown in Pl. V, Fig. 4, well illustrates the abrupt form of termination of the lateral branchlets, which is so common and characteristic in fossil stems of this type. It also shows the depression or elongated pit in the basal portion of each branchlet. A peculiar character is the rapid fading out or practical vanishment of the branchlets. This is perhaps often due in some of the smaller branchlets to the diminution of rigidity and the almost abrupt transition to the thin, lax, bifurcating lamina, presumably of foliar function, which has been destroyed by erosion. In many cases, however, the seemingly abrupt ending is due in part to rapid ramifications as well as increasing tenuity, the ramification, like the foliation, being not in the plane of the impression, and being usually covered or abraded. This specimen serves to illustrate the costation of the rachis and the decurrence of the rameal strands.

In Pl. V, Fig 5, is shown a rachial fragment of a more slender form which appears to agree with similar fragments recorded as belonging to the above-named species. The ramules are evidently foliate, though largely removed by erosion. Fragments of the lax laminate expansions of the branches, which I interpret as foliar, are shown in Pl. VI, Fig. 8. The aspect of the divisions is comparable to that originally shown by Dawson[c] in *Psilophyton grandis*. The abrasion to which the Perry sediments have been subjected has generally destroyed the more delicate

[a] Quart Jour Geol Soc London, vol 15, 1859, pp 478-480, Canadian Naturalist, vol 5, 1860, No 1, p 2
[b] Fossil Plants Devonian and Upper Silurian Formations Canada, 1871, p 57
[c] Quart Jour Geol Soc London, vol 15, 1859, p 481, figs 2a, 2b

portions of the plants, but the comparison of many of the imperfect fragments with other material from the Devonian of New York shows them to be generically identical.

In order better to illustrate both the branching and the foliar termination in the smoother type of *Psilophyton* I show (Pl. V, Fig. 7) a part of a specimen from Campbellton, New Brunswick, now in the United States National Museum collection, choosing it because it was identified by Dawson as *Psilophyton princeps*. In this example we see no distinct traces of spines or scale-leaves, though traces of obscure and distant punctation (exaggerated in the figure) are rarely observed in small portions of the fragments. The costæ, which are well displayed, are slightly irregular and the furrows are of varying depth. The fragments of divaricately recurved lamina, which terminate the rachises, and which I interpret as possessing leaf functions, are in general typical of a plant form common in the Devonian and are usually regarded as characteristic of *Psilophyton*, though they do not seem to be clear in the original Gaspé figures.

A laminar development similar to that shown in our figure is also found in both the rachial and terminal portions of the specimens illustrated by Stur[a] as *Hostinella hostinensis*. The terminal fragments shown in Stur's pl. iv, fig. 5, of the flora of etage H-h1 are so nearly of the type seen in Campbellton specimens as to leave scarcely room for doubt as to the generic identity of the types. A closely similar mode of division and rachial termination is seen also in the branches shown in fig. 3, pl. vii, of Miller's Old Red Sandstone and referred by Dawson to *Psilophyton*, and in the frond from the Lenne beds cautiously described by Solms-Laubach[b] as a fern skeleton.

Pl. V, Fig. 6, and Pl. VI, Fig. 7, illustrate two small rachial fragments from Perry, which show the peculiar branching in equal dichotomy sometimes seen in these plants. Occasionally the division appears to be unequally trifurcate and, like the example, Pl. VI, Fig. 7, not in the plane of the rachis.

Passing now to the question of the generic identity of the plants in hand, I have to state that none of the specimens in our collections from Campbellton or from New York, to which I have referred, exhibit the distinct spines or spiny scales ("leaves") on stems or branches, the closely revolute ("circinnate vernation") development of the branches, the pitted rhizomes, or the rachial scale-scars described and illustrated in Dawson's original publication of the genus and species. The Campbellton examples are practically smooth. In fact, with the exceptions of examples from Gaspé, the material described by Penhallow[c] as *Psilophyton grandis*, and some specimens from the Hamilton at Mapleton, Aroostook County, Me., I have seen no

[a] Silur-Flora der Etage H-h1: Sitzungsber. K. Akad. Wiss., Wien, math.-nat. Cl., vol. 84, pt. 1, 1881, pl. iv.
[b] Jahrb. K. Preuss. Geol. Landesanstalt, 1894 (1895), pl. ii.
[c] Proc. U. S. Nat. Mus., vol. 16, 1893, p. 113, pl. xii, fig. 12a; pls. xiii, xiv.

specimens in our collections which may without question be referred to *Psilophyton* as the genus seems to have been originally founded by Dawson in 1859.

The confusion as to *Psilophyton* dates back to the supplementary descriptions and figures given by Dawson[a] in 1871, where we find both spiny and smooth stems placed in *Psilophyton princeps* together with two other types of fructification,[b] neither of which appears to be reconcilable with that originally shown in 1859 and 1860.

In order to aid me in gaining a clearer view of the genus, Professor Penhallow, of McGill University, Montreal, has been so courteous as to place in my hands for comparison typical and excellent material from Gaspé and Campbellton, labeled *Psilophyton princeps* by Dawson.

From the examination of these specimens I am convinced that the variety *ornatum* is not specifically identical with the Campbellton smooth type; but since the material submitted does not, unfortunately, include the types of the species and genus, there is still some doubt as to the precise characters of the Gaspé originals. There is, however, I believe, little doubt that the so-called variety *ornatum* represents the original type species of the genus, its varietal discrimination being of doubtful validity. The specimens from Gaspé belonging to this, the spinous plant, are readily distinguishable from those of the few-costate, smooth, and more ramose plant, and clearly show the spines or spine scars, even in the inrolled, somewhat blunt, apical portions. The latter, as shown by No. 3239 of the McGill University collection, are truly inrolled and circinnate instead of revolute, since one of the fragments displays lateral pinnæ also in circinnate vernation just below the apical coil. The aspect of the specimen is filicoid.

The characters of the larger stem fragments of the true *Psilophyton* from Gaspé are well shown in pl. ix of the Flora of the Devonian and Upper Silurian Formations (1871), the spines being not exaggerated either as to length or rigidity in figs. 104 or 110. Those on the smaller divisions of the rachis, such as are shown in Dawson's fig. 100, appear to correspond to the type figures published in 1859 and 1860. Occasionally in the stem impressions the spines are marked by distinct and sometimes distant pits. The fragments of fertile pinnæ from Gaspé lent me by Professor Penhallow, though obscure, seem to correspond to Dawson's fig. 102, and are distinctly punctate and thus referable to the typical species.

The relatively smooth or Campbellton type of plant, referred, erroneously, I believe, by Dawson to *Psilophyton princeps*, is represented in Pl. V, Fig. 7. Its characteristic costation is nearly always in evidence, there being no indication of spines except that furnished by a minute and very distant and obscure punctation, which is difficult to observe in most cases. It is also more lax, branching very freely,

[a] Fossil Plants Devonian and Upper Silurian of Canada, p. 37, pls. ix, x, figs. 111–119; pl. xi, figs. 127–129, 133, 134.
[b] Loc. cit., pp. 37, 89, pl. ix, figs. 102, 103; pl. x, fig. 118.

especially near the apex, which is very delicate (Pl. V, Fig. 7*a*) as well as intricate on account of the frequent divaricate dichotomies. In the specimens of the typical species from Gaspé I have seen none of these divaricate terminal laminar developments which form so constant a feature of the smooth Campbellton plant, and I am consequently inclined to regard this development as somewhat characteristic of a particular group to which the Campbellton plant belongs.

Whether the smooth costate (Campbellton) type is congeneric with the true type of *Psilophyton princeps* (=var. *ornatum*) must be demonstrated by further study and by examination of the types. The former probably represents the genus *Hostinella* of Stur. It is possible that a generic connecting link between them may be found in *Psilophyton robustius*, the rachis of which is punctate though its axis is filicoid. There would appear, however, to be some reasons for regarding the latter as a generically distinct form. It is doubtful whether punctation of the rachis, which may represent an environmental effect, is to be regarded as of generic diagnostic value in such cases. A stronger argument appears to obtain in the similarity in the fructification as described and figured.

To the true *princeps* group, as illustrated in Dawson's original figures and in the spiny stems published in 1871, belongs, as congeneric, the *Psilophyton grandis* of Penhallow from the Genesee of New York, the habit of the stems as well as their mode of division being identical. To the same group should probably also be referred the specimens from the "Old Red Sandstone" of northern Scotland, described by Carruthers[a] as *Haliserites Dechenianus*, though they differ by their closer spines from *Psilophyton princeps*. Specimens of *P. princeps* lent by Professor Penhallow are densely carbonaceous, and seemingly vascular, as, indeed, the type is described to be by Dawson. Yet the comparison is very greatly to be desired of the structure of suitably preserved typical fragments with that of *Prototaxites*, the carbonaceous residue of which might also be dense and of fibrous superficial aspect.

The specimens illustrated by Göppert[b] as *Haliserites Dechenianus* can be referred to *Psilophyton* only on the assumption that they are very erroneously figured. As apparently true Psilophyta, mention should also be made of the stems figured by Salter[c] as *Lycopodites Milleri*, and by Crépin[d] as "*Lepidodendron gaspianum* Dn. ?", from the Devonian of Rouveroy. The union of *Lepidodendron gaspianum* with *Psilophyton*, proposed by some botanists, is wholly unwarranted.

The larger stems of the true *Psilophyton* (var. *ornatum*) from Gaspé are so rugged, bear such long, radiating spines, and approach in aspect so closely to the

[a] Jour Bot, November, 1875, pl cxxxvii
[b] Fossile Flora des Uebergangsgebirge, 1852, p 88, pl ii
[c] Quart. Jour Geol Soc London, vol 14, 1858, pl v, p 75
[d] Bull Soc Roy Bot Belgique vol 14, 1875 pls iv, v

figures of Dawson's *Arthrostigma gracile* as to suggest that they are but the smaller branches of the latter.[a] However, it must be remembered that, notwithstanding the apparently irregular distribution of the spines in the figures, they are described as verticillate, a character which, if valid, precludes any serious comparison with *Psilophyton* or with Göppert's *Drepanophycus spinæformis*,[b] which after all may prove to be generically identical with the type species of *Psilophyton*. For the costate nonspinous type of stems the name *Hostinella* proposed by Stur may be found applicable should their apparent generic distinction be confirmed by the examination of Dawson's originals. The rachises in the Devonian material of what we may provisionally term the *Hostinella* type in Canada and in Maine are less rigid than those of *Aneimites* and *Adiantites* from the lower Carboniferous and lack the strict angularity of the branches of the latter genera at the points of division.

The curved branching stems from Maine should be compared with the fragments from the Devonian of Spitzbergen described by Nathorst in the first part of the Palæozoischen Flora der Arktischen Zone.[c] Also our Pl. V, Figs. 4 and 6, show precisely the characters seen in the stem fragments illustrated in the second part of the work,[d] which described the Devonian flora of Bear Island. The close similarity in features between the original of our Pl. V, Fig. 6, and the examples shown by Nathorst in pl. i, figs. 24–33, of the latter memoir is especially significant in view of the almost equally close agreement between the sporangial heads, *Cephalotheca mirabilis* Nath., attributed to these stems in the Bear Island Devonian, and the fructification from Perry which I have described (Pl. II, Figs. 7–9) as *Dimeripteris incerta*.

The examination of such so-called *Psilophyton* material as I have seen shows the existence in America of two or more groups, represented by several fairly well-marked species which possess stratigraphic value, and which should be carefully diagnosed and illustrated. It is probable also that additional material throwing light on the structure and relationships of these very remarkable early types of land plants will be discovered at some locality The inspection of the material in hand emphasizes the need, as was pointed out by Solms-Laubach,[e] for the revision of the material referred by various authors to *Psilophyton*, together with a thorough reexamination and republication of the types.

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[a] Fossil Plants Devonian and Upper Silurian of Canada, 1871, p 41, pl xiii

[b] Fossile Flora des Uebergangsgebirge, 1852, p 92, pl xli, fig 1

[c] Kongl Svensk Vet-Akad Handl, vol 26, No 4, 1894, pl i

[d] Op cit, vol 36, No 3, 1902

[e] Jahrb K pr geol Landesanstalt, 1894 (1895), p 76

PSILOPHYTON? ALCICORNE D. W.

Pl V, Figs 1, 2

Axis (rhizome?) flexuose, irregularly lineate, branching from one side at right angles at intervals of a few centimeters, the branches greatly dilated at their bases along the axis in a more or less trapezoidal expansion, with rounded sinuses above and below, and immediately emitting an ascending ramule, while the recurving branch at once forks again at a very wide angle to furnish a second ramule close to and nearly parallel to the first; branchlets relatively wide, rather dense, and traversed by a central strand, which sometimes appears in the impressions.

The aspect and general characters of this type of fossil are represented in the figures of two specimens, Pl. V, Figs. 1, 2. It will be seen that in the latter specimen the peculiar system of branching is further carried out. At the apex of the fragment represented in Fig. 1 was a branch similar to those shown lower in the specimen, but this was accidentally destroyed in removing the matrix.

The specimens here described are suggestive of rhizomes from which fronds arise, though they also suggest some algal forms. I tentatively refer them to the genus *Psilophyton*, on account of the similarity in their method of branching to that sometimes seen in stems of that genus. This similarity, as illustrated in a National Museum specimen from the Devonian at Campbellton (Pl. V, Fig. 7), is marred by the degree of complication only, the main branch being less strongly recurved and not forked again immediately. A minor reason for not treating the plant as representative of a new generic type is the occurrence, in the same bed, of fragments agreeing with the plants generally identified as *Psilophyton*. Our example is, however, totally distinct from the rhizome described by Dawson as belonging to the latter genus. Nevertheless, in spite of the difference in general ramification, I am not at present disposed to regard the fossils as representing a new genus.

The species is well marked and easily recognized by the characters of the unique mode of branching, which, so far as observed, is confined to one side of the axis, thus imparting a rhizomal aspect.

PALÆOSTACHYA Weiss.

Steinkohlen-Calamariæ, pt 1, 1876, p 103.

PALÆOSTACHYA ? sp.

Pl IV, Fig 4

The collection of 1903 contains a single small fragment (Pl. IV, Fig. 4) of an axis bearing strong, basally open, or slightly reflexed bracts of lepidophytic aspect, each bearing, at a point just above its base, a slightly oblique sporangiophore supporting two (or four?) short oblong sporangia. The position of the sporangiophore and sporangia appears to justify a tentative and provisional reference of the plant to *Palæostachya*. But it must be noted that the bracts are very thick and decurrently attached at the base, and, especially, that there are no traces either of nodes in the stem, the full width of which is not seen, or of a verticillate arrangement of the scales. Fragments of the kind here illustrated might, if the sporangia were detached, readily be mistaken for *Lepidodendron* or *Lycopodites*, and bear, in fact, a strong resemblance in profile to *Lepidodendron gaspianum*.

BARINOPHYTON D. W., gen. nov.

BARINOPHYTON RICHARDSONI (Dn.) D. W.

Pl IV, Figs 5, 5a, 6, 7, 8

1861 *Lepidostrobus* sp, Dawson, Can Nat, vol vi, no 3, June, p 174
1862 *Lepidostrobus* sp, Dawson, in Hitchcock, Proc Portland Soc Nat Hist, vol i, pt 1, p 76
1861. *Lepidostrobus Richardsoni* Dawson, Can. Nat, vol vi, no 3, June, p 174.
1862 *Lepidostrobus Richardsoni* Dawson, in Hitchcock, Geol Me, 1861, p 248, figs 10, 10a
1862 *Lepidostrobus Richardsoni* Dawson, Proc Portland Soc Nat. Hist, vol i, pt 1, p 76
1862 *Lepidostrobus Richardsoni* Dawson, Quart Jour Geol Soc London, vol. xviii, p 298
1863 *Lepidostrobus Richardsoni* Dawson, Am Jour Sci, 2d ser, vol xxxv, p 313
1863 *Lepidostrobus Richardsoni* Dawson, Proc Portland Soc Nat Hist, vol i, pt 2, p. 100
1863 *Lepidostrobus Richardsoni* Dawson, Second Rept Nat Hist and Geol. Me, p 403
1862 *Lycopodites Richardsoni* Dawson, Quart Jour. Geol Soc London, vol xviii, leaf opposite p. 329
1863. *Lycopodites Richardsoni* Dawson, Second Rept Nat Hist and Geol Me, p 403
1863 *Lycopodites Richardsoni* Dawson, Quart Jour Geol Soc London, vol xix, p 461
1871 *Lycopodites Richardsoni* Dawson, Foss Pl Dev and Upp Sil Can, p 34, pl. vii, fig 81
1880 *Lycopodites Richardsoni* Dn, Lesquereux, Coal Flora, vol ii, p 362

Known by thick, smooth, or irregularly ribbed axes bearing alternate, stout compact, boat-shaped, fertile branches, which are a little distant, not in the same plane on both sides of the axis, of generally lanceolate outline, more or less oblique, strongly concave or hollow ventrally, round-carinate dorsally, slightly incurved at the apex, and which consist of a very thick fleshy keel, broadly carinate in the larger specimens, bearing on either side, on its ventral surface, a row of alternating small, thick, oblong, or oblong-lanceolate, often slightly crescentic, scales or bracts, bracts fleshy at base where coalescing with the thicker midrib, dorsally convex, and more or less distinctly carinate, the midrib sometimes in a depression, and ventrally concave, arching outward, sometimes longitudinally lineate dorsally, slightly broader just above the often twisted base, and provided, within the point of basal dilation, with a small ventral pit or pocket, probably the seat of a sporangium.

The fossils from Perry belonging to the species described by Dawson as *Lepidostrobus* and *Lycopodites Richardsoni* are found to represent a type of supposed fructification which is both interesting and new, though insufficient to show certain essential details indispensable to their proper interpretation and classification. It is not yet definitely ascertained even to what order of plants the new genus here described is referable. Nevertheless certain of its features are so well marked and so striking as to make the type readily recognizable even in small fragments, thus rendering it, as a specialized type of reproductive organ, at once available for stratigraphic purposes. It is hoped that further discoveries in formations of its age may throw light on its vegetative features and its systematic relations.

In the accompanying illustrations and remarks the features presented by the types in hand will be noted, together with such interpretations as the specimens appear to warrant.

The example represented by Pl. IV, Fig. 5, shows portions of a faintly lineate but otherwise smooth axis, on the right of which are three of the boat- or canoe-shaped branchlets that have the general aspect of young fern pinnæ. A better view of the uppermost of these, enlarged to twice the natural size, is shown in Fig. 5a. This exhibits the characteristic form of the pinna (?) and the shape of the dorsally convex lobes or bracts, like the ribs of a canoe, within which, in this instance, the midribs are slightly depressed. The basal union of the bracts with the keel of the pinna or strobilus is not well seen. This specimen, which, together with the two next to be described, belongs to the Portland Society of Natural History, may be regarded, I believe, as a young stage of the fertile plant.

A specimen which appears to represent a more advanced stage of the same species is shown in Fig. 6. Here we see fragments of an axis of slightly greater width than before supporting portions of eight branchlets arranged spirally and not in the same plane, those on the left being revealed by a fortunate cross fracture of the sandstone. This specimen shows that the branchlets or pinnæ, described by Dawson as cones, are not borne in one row on one side only of the axis, as stated in his later descriptions. The branchlets on the right are fractured longitudinally in or near the keel, and the view is therefore lateral and ventral. The greater portions of the bracts are broken away, but the specimen is particularly interesting as showing, in the second branchlet on the right, the pits or pockets at the bases of the pinnules on the borders of the very broad and thick keel. These pits are, I believe, sporangial. It is not certain, however, that they did not contain naked spores, as in certain of the lepidophytes. The details of the scales, which seem to be somewhat pointed at the base, are not well shown in this specimen, though the vascular system is distinctly indicated at numerous points. The branchlets, which should perhaps be called strobili, in this example correspond in size and arrangement to the specimen figured in dorsal or external view by Dawson in pl. xvii, fig. 1, vol. 19, of the Quarterly Journal of the Geological Society of London, 1863.

The fragment of a large branchlet shown in Pl. IV, Fig. 7, represents the form first figured by Dawson[a] as *Lepidostrobus Richardsoni*. It illustrates, in dorsal view, the very thick, broadly carinate, midrib or keel, along which the lobes or bracts, which are close though distinct throughout the greater part of their length, stand like the lobes of a *Pterophyllum*. It is not possible to make out clearly any sporangial pits in this specimen, but I assume that it also represents the fertile plant, in which after the discharge of the spores the bracts, instead of retaining their position in the canoe-shaped strobilus, have spread out nearly in the plane of the keel. The great thickness of the keel argues against the consideration of this specimen as sterile. An imperfect fragment, intermediate in proportions between the specimens last described, is No. 3335 of the fossil-plant collection of the Museum of Comparative Zoology, Harvard University.

As representing perhaps the youngest stage of the fertile branchlets of this plant, I show in Fig. 9 a small specimen which is to be compared with pl. vii, fig. 81a, of Dawson's Fossil Plants of the Devonian and upper Silurian. Even in this little specimen the features of the bracts or lobes, which are comparable to those in Fig. 5, may be seen, while there are also indications of the sporangial pits.

From the foregoing descriptions it will be seen that we have in *Barinophyton* a type of vascular cryptogam in which the fertile specimens consist of stout, apparently smooth axes, carrying alternately, though not in the same plane, short, dense, canoe-shaped branchlets or strobili (pinnæ?), composed of a very thick rachis or keel supporting two opposite rows of alternate fleshy bracts (or pinnules?), each marked at its base by a depression for the protection of the sporangium or spores.

As to whether these fossils represent ferns or lepidophytes I am unable at present to determine. From the mode of attachment of the bracts, their fleshy composition, and the position of the sporangiferous depressions at the base, I am disposed to regard the genus as lepidophytic. In this connection it is of interest to consult *Barinophyton perrianum*, next to be described. Mention may also be made of the faint aspect of ligular pits on the ventral faces of the scales in *B. perrianum*. On account of the coarseness of the matrix the evidence is, however, too obscure for illustration or further description. On the other hand, it is perhaps less difficult to see in the smooth axis and the lateral pinnæ with short, very fleshy rachises, the fertile fronds of a fern in which the thickened, coriaceous, alternating, and somewhat reduced pinnules or lobes partially envelop sporangia at their bases.

It should here be stated that in the material before me I have seen neither indication of dichotomy, as described by Dawson, nor sterile branches of the type shown

[a] Canadian Naturalist, vol 6, 1861, p 174

by him in pl. xvii, fig. 2, of the Quarterly Journal. That dichotomy may, however, occur in this species is rendered probable by its occurrence in another species from the Devonian of New South Wales. A careful comparison of the description and figures published by Prof. W. S. Dun[a] as "*Pecopteris* (?) *obscura*" from Genoa River leaves little room for doubt as to the identity of the latter with *Barinophyton*. In *Barinophyton obscurum* we seem to have almost precisely similar oval, more or less distinctly boat-shaped, "pinnæ," similarly lobed and similarly arranged on a smooth rachis, which, in the largest specimen figured by Dun, appears to be dichotomous. It is possible that the specimen described by Dawson[b] as *Ptilophyton Thompsoni* from the Devonian of Scotland also represents the genus *Barinophyton*.

Barinophyton perrianum D. W.

Pl IV, Figs 10, 10a

Fertile branchlets, small, oblong, 1 cm.–2 cm. long, 5 mm.–8 mm. wide, slightly upturned at the ends, the scales or lobes short, thick, fleshy, ovate, obtuse, or acute, somewhat constricted and twisted at the base, dorsally convex and carinate; sporangia probably relatively large.

The specimens in hand differ from *Barinophyton Richardsoni* by the straighter branchlets or strobili, the narrower keel, and the relatively short, thick, ovate, fleshy scales or lobes. The general features of the specimens are shown in Pl. IV, Fig. 10. On this fragment of shale three of the strobili are compressed laterally so that the two rows of scales are in part superimposed. A portion of the fourth is seen in ground plan, though several of the scales are slightly dislocated in the compressed shale. It will be noted that the keel or axis of the strobilus is alternately lobed, the scales being attached to the lobes. From the examination of the specimens in hand it is not clear whether the scales protected sporangia or naked spores; but it is possible that sporangia of the type shown in fig. 13, found frequently at Perry, may belong to this or the preceding species.

From an examination of fig. 22 on pl. xxiv of the second part of Dawson's Fossil Flora of the Erian and Upper Silurian of Canada, 1882, provisionally referred by him as the fruit of *Arthrostigma*, I am strongly inclined to believe that the specimen from Campbellton there shown is *Barinophyton* and is but slightly different from, or perhaps identical with, *B. perrianum*, whose scales appear somewhat rounded and imbricate in certain conditions of fossilization. The close relation of the Campbellton plants to *B. Richardsoni* was also noted by Dawson[c] in 1883.

[a] Records Geol Survey New South Wales, vol 5, pt 3, 1898, p 118, pl x, figs 1, 2, pl xi, figs 6, 8
[b] Canadian Naturalist, vol 8, 1878, No 7, pp 385–386
[c] Canadian Naturalist, vol 10, No 1, p 11

LYCOPODITES Brongniart.

Classific Vég Foss, 1822, p 9

Lycopodites comosus Dn.

1862 *Lycopodites* sp, Dawson, Quart Jour Geol Soc London, vol xviii, opp p 329
1863 *Lycopodites comosus* Dawson, Proc Portland Soc Nat Hist, vol i, pt. 2, p 100, pl ii, fig 2
1863 *Lycopodites comosus* Dawson, 2d Rept State Geol. Me, p 403.
1863 *Lycopodites comosus* Dawson, Quart Jour. Geol Soc London, vol xix, p 462, pl xvii, fig 14
1871 *Lycopodites comosus* Dawson, Foss Pl Dev and Upp Sil Can, p 35

Stem stout, not observed to branch, densely covered with long filiform leaves.

This species is known to me only by Dawson's description, quoted above, and the figure of a single small fragment published by him in 1863. Its generic determination appears to be somewhat doubtful.

LEPTOPHLŒUM Dawson.

Rept St Geol Me., 1861 (1862), p 249

Leptophlœum rhombicum Dn.

Pl VI, Figs 1–4

1861 *Sternbergia* sp, Dawson, Can Nat, vol vi, No 3, p 175
1862 *Sternbergia* sp, Dawson, in Hitchcock, Rept St Geol Me., 1861, p 248
1862 *Leptophlœum rhombicum* Dawson, Rept Nat Hist. and Geol Me, 1861, p 249, figs. 3, 4
1862 *Leptophlœum rhombicum* Dn, Hitchcock, Rept Nat Hist and Geol Me, 1861, p 248
1862 *Leptophlœum rhombicum* Dawson, Proc Portland Soc. N. H, vol i, pt 1, pp. 76, 77, pl i, figs 1, 2
1862 *Leptophlœum rhombicum* Dawson, Quart Jour. Geol Soc, vol xviii, pp 298, 316, pl. xii, fig 8, pl xvii, fig 53
1863 *Leptophlœum rhombicum* Dawson, Am Jour Sci, 2d ser, vol xxxv, p. 462, pl xviii, fig. 19
1863 *Leptophlœum rhombicum* Dawson, Proc Portland Soc N H, vol i, pt 2, p 100
1863 *Leptophlœum rhombicum* Dawson, Second Rept Nat Hist. and Geol Me, 1862, p 404
1863 *Leptophlœum rhombicum* Dn, Logan, Geol Canada, p 885
1870 *Leptophlœum rhombicum* Dawson, Nature, vol ii, p 86, fig 2
1871 *Leptophlœum rhombicum* Dawson, Foss Pl Dev and Upp Sil Can, pp 36, 85, pl viii, figs 88, 89
1872. *Leptophlœum rhombicum* Dawson, Proc R Inst, vol vi, p 168, fig 2
1873 *Leptophlœum rhombicum* Dawson, Quart Jour Geol Soc, vol xxix, p 369
1878 *Leptophlœum rhombicum* Dn., Etheridge, Cat Australian Foss, p 31
1880 *Leptophlœum rhombicum* Dn, Lesquereux, Coal Flora, vol i, p 460
1880 *Leptophlœum rhombicum* Dawson, Chain of Life, p 98, fig. 90
1882 *Leptophlœum rhombicum* Dawson, Foss Pl Erian and Upp Sil Can., pt 2, p 105
1887 *Leptophlœum rhombicum* Dn, Solms-Laubach, Einl d Palaophytol, p 205
1888 *Leptophlœum rhombicum* Dn, Johnston, Geol Tasmania, p 81 (syn in part)
1888 *Leptophlœum rhombicum* Dn, Schenck, Foss Pflanzenreste, p 64
1862 *Stigmaria* sp, Dawson, Quart Jour Geol Soc, vol xviii, opp p 329
1863 *Stigmaria pusilla* Dawson, Proc Portland Soc Nat Hist, vol i, pt 2, p 100, pl ii, fig 1.
1863 *Stigmaria pusilla* Dawson, Second Rept Nat Hist and Geol Me, 1862, p 403

1863 *Stigmaria pusilla* Dawson, Quart Jour Geol Soc, vol xix, p 460, pl xvii, fig 3
1871 *Stigmaria pusilla* Dawson, Foss Pl Dev and Upp Sil Can, pp 23, 88, pl iii, fig 31
1888 *Stigmaria pusilla* Dn, Renault, Notice sur les Sigillaires, pp 31, 43
1863 *Cyperites* sp, Dawson, Quart Jour Geol Soc, vol xix, p 460
1871 *Cyperites* sp Dawson, Foss Pl Dev and Upp Sil Can, pp 24, 88.
1894 *Bergeria* sp, Nathorst, Zur Foss. Fl. d Polarlander, vol. i, th 1, p 14, pl ii, fig. 8

Trees of small size, dichotomously branching; trunk covered with more or less distinctly marked rhomboidal leaf cushions of relatively large size; leaf cushions or bolsters spirally arranged, nearly contiguous, nearly exactly rhomboidal, the transverse diameter being usually longer, the surface being nearly flat, often more prominent at the proximal angle, which is generally obtuse, the lateral angles somewhat acute, the distal margin being generally concave on either side of the usually slightly acute apex; leaf scar very small, situated a little above the middle of the cushion, oval or ovate, about one-eighth of the width and one-fifth of the altitude of the bolster, narrowly annulate, with a mammillary nerve trace a little above the middle; bolster provided within the distal angle by a slightly depressed, often umbilical, ligular pit, the border of which is radiately corrugated; leaves acicular, slender, attaining a width of about 0.75 mm. and a length of 5 cm. or more, dorsally prominently carinate; fructification not correlated.

Leptophlœum rhombicum was one of the first species to be described from Perry. The salient features of the plant are the relatively large size of the bolsters as compared with the diameter of the stem; and the small oval or ovate leaf scar placed near the center of the nearly flat, very broadly rhomboidal, field. The general aspect of the stems is that of Presl's *Bergeria*, with which Count Solms-Laubach and others have compared this species. In reality the stems seem to present bolsters of the lepidodendroid type, on which are nearly centrally placed leaf scars, probably closely similar to those of *Bothrodendron*. The bolsters, which are nearly contiguous, are generally somewhat tilted with reference to the plane of the stem surface.

In some specimens of this species the cortex is wrinkled so as to produce a slight transverse corrugation. This is most excellently illustrated in the original example $\frac{4304}{1}$ in the geological collections of the American Museum of Natural History of New York. As will be seen in the new drawing of this specimen, Pl. VI, Fig. 1, the bolsters in the upper part of the middle third of the fragment are laterally traversed by shallow and narrow transverse creases. The latter pass through the lateral angles of the bolsters and cross the fields near the leaf scars, which in a few instances they nearly conceal. The creases or wrinkles of the outer cortex are thus regular in occurrence, there being two spaces to the height of each bolster, while the line of fold is sinuate in consequence of the originally curved surface of the bolsters. The result is the production of a nodal effect, though the regularity of the phyllotaxy is clear. It was precisely this nodal aspect, which appears more distinctly when viewed longitudinally, that led Dawson to describe and illustrate this part of the specimen as a *Sternbergia* and to argue for the existence of a *Sternbergia* pith in certain of the Lepidophytes. It is probably a longitudinal contraction of the outer cortex, due to shrinkage of the inner cortex or subcortical tissue. Its uniform periodicity with reference to the height of the leaf scar and the adaptation of the curve to the curvature of the bolsters show that this creasing or transverse corrugation can not be due to chambering of the pith. A close inspection of the type shows the regularity of the leaf scars in the usual quincunxial phyllotaxy throughout. I can find no evidence in the specimen in support of the theory of a chambered pith. In this respect the opinions of Carruthers, Solms-Laubach, and Schenck are well founded. It will be seen that there is slight evidence of zones of foreshortened bolsters, such as are common in several of the Devonian and earliest Carboniferous lepidophytes, as, for example, in Carruthers's *Lepidodendron nothum*, from the Devonian of Queensland, or the large fragment from the Tanner-Grauwacke figured by Potonié[a] as *Cyclostigma hercynicum*.

The general aspect of the bolsters is shown in three specimens illustrated in the numerous publications in which this species was treated by Dawson. These are in close accord with our specimens, as well as with another of the original specimens of Dawson, No. $\frac{4304}{2}$ of the American Museum of Natural History, kindly loaned me for comparison.

Of the detail of the leaf scars little is known, on account of their small size and the coarsely granular composition of the matrix. It is clear, however, that the scar is marked by a very narrow border. The upper margin of the scar is not absolutely distinct, and it is possible that it is slightly indented. No clear indications of parichnoi or appendages have yet been observed. In general the leaf scars would appear to be most directly comparable to those of *Bothrodendron*.

The large size sometimes attained by the bolsters of this plant is shown in the fragment, Pl. VI, Fig. 2. In this the proportional altitude is greater than in most fragments seen. In Fig. 4 is shown a large fragment of stem in which the bolsters are compressed laterally and stretched in the longitudinal sense. This specimen is interesting as showing a rugose, faintly striate, subcortical or subepidermal structure in which the nerve traces also may be seen. It is probable that the narrow subcylindrical impression traversing the fragment represents the central woody axis, the nodal appearance being caused by impression on the underlying bolsters. This phase of the stem finds a corresponding state in certain examples of *Lepidophloios*.

None of the specimens which have come under my notice show indications of

[a] Abhandl. K. preuss. geol. Landesanstalt, new series, vol. 36, 1901, p. 35, fig. 24.

branching or of leafy twigs or cones, such as are figured by Dawson.[a] The original of the figure of a branch published by him I have not seen, but if it is correctly illustrated it precludes the reference of such forms as *Lepidostrobus globosus* to this species, as might otherwise be suggested on the circumstantial evidence of their association in the same bed. I should also add that the leaves or leaf fragments described by Dawson or contained in our collections, on account of their narrow forms, corresponding in width to the leaf scars, and their association in the same bed, are assumed to belong to the species described above. None have, I believe, been found attached to the large bolsters.

In some of the cortical fragments the relief of the bolsters is so slight that they are visible only under proper illumination. The cuticle illustrated by Dawson[b] as *Stigmaria pusilla* appears to represent such a portion of *Leptophlœum rhombicum*, and it is accordingly here included under the same name. The more rounded form of the scars is hardly different from that seen on some of the more distinctly marked fragments of *Leptophlœum* stems.

The species of Palæozoic plants to which *Leptophlœum rhombicum* is most closely related is undoubtedly that described and illustrated by Carruthers,[c] Feistmantel,[d] and others as *Lepidodendron nothum* Unger. The latter plant, while evidently different from Unger's uncertainly defined species,[e] has been regarded by a number of paleobotanists, including Carruthers and Solms-Laubach,[f] as identical with the Perry plant. The concordant characters in support of this union of the two species are certainly both striking and interesting. One has only to compare our Pl. VI, Fig 1, of Dawson's original type,[g] or Dawson's illustration of the same specimen, pl. xxvi, fig. 7, of the Eighteenth volume of the Journal of the Geological Society of London, to be at once impressed with the similarity in the aspect of the stem, including both the normal rhombic bolsters and the wrinkled or foreshortened leaf cushions. This superficial agreement is further reenforced by the cicatricule or ligular scar in the apex of the bolster, as shown in figs. 11, 13, and 14 of Carruthers's plate, or the central leaf scars indicated in [illegible] 10 of the same plate. There is even a close identity in the outlines of the bolsters as shown in figs. 8 and 9 of the cited plate.

Against the actual identity of these species, which was vigorously opposed by Dawson,[h] we have to mention, first, the singular lepidophylloid leaves shown by Carruthers as attached to the stem; and, second, the apparent absence of the interior leaf

[a] Quart Jour Geol Soc London, vol 19, 1863, pl xviii, fig 19
[b] Proc Portland Soc Nat Hist, vol 1, pt 2, 1863, pl ii, fig 1
[c] Quart Jour Geol Soc London, vol. 28, 1872, p 353, pl xxvi
[d] Coal and Plant-Bearing Beds of East Australia and Tasmania, 1890, p 137, pl i, figs 1–4
[e] Denkschr K Akad Wiss, Wien, math-nat Cl, vol 11, 1856, p 175, pl x, figs 4–8
[f] Einleitung d Palaophytologie, 1887, p 205
[g] No $\frac{4304}{1}$ of the collection of the American Museum of Natural History
[h] Fossil Plants Erian and Upper Silurian Canada, pt 2, 1882, p 105

scars from the cushions in which the cicatricules, which I interpret as ligular, are present in the apices. Carruthers and others appear to regard the apical and the more nearly central scars as identical and as indicating mere variation in the position of the leaf scar. Such an interpretation can not be admitted for our American specimens; in fact, the specimens in hand with normal bolsters fail to show the leaf scars at any considerable distance above the center, such examples as Figs. 2 and 3, or $\frac{4304}{2}$ of the American Museum of Natural History being comparable only to fig. 10 of Carruthers's plate, or possibly to the obscure markings shown in one or two of Feistmantel's figures. In the Perry type, Pl. VI, Fig. 1, obscure traces of leaf bases are possibly present, but they are not sufficiently clear for delineation. Nothing of the special form shown by Carruthers is present. The American plant differs also in the absence of carination in the bolsters, such as is shown in fig. 9 of the plate.[a] The Perry plant appears to be also related to the *Lepidodendron australe* of McCoy,[b] with which the Queensland plant of Etheridge, referred to above, is regarded as identical by Etheridge[c] and Kidston,[d] though both of these authors recognize the separation of *Leptophlœum rhombicum*. Both of the Australian stems, which in some cases seem to have been associated, are, I believe, to be referred to the genus *Leptophlœum*. To the same group, if not to *L. rhombicum* itself, is to be referred the fossils from the region of the Ogur, in eastern Siberia, described by Schmalhausen[e] as *Bergeria*.

In the first part of Nathorst's Palaozoischen Flora der Arktischen Zone there is figured as *Bergeria* a specimen from the Devonian of Spitzbergen which, so far as its details are given, appears to conform so completely with *Leptophlœum rhombicum* that it is difficult to regard it as not belonging to the same species.

The type specimens of *Leptophlœum rhombicum* are Nos. $\frac{4304}{1}$ and $\frac{4304}{2}$ of the American Museum of Natural History.

LEPIDOSTROBUS Brongniart.

Prodrome, 1828, p 87

LEPIDOSTROBUS? GLOBOSUS DN.

Pl VI, Figs 5, 5*a*

1862. *Carpolithes sp*, Dawson, Quart Jour Geol Soc London, vol xviii, opp p 329
1862 *Lepidostrobus globosus* Dawson, Quart Jour Geol Soc London, vol xviii, p 298.
1863 *Lepidostrobus globosus* Dawson, Am Jour Sci, 2d ser, vol xxxv, p 313
1871 *Lepidostrobus globosus* Dawson, Foss Pl Dev and Upp Sil Can, p 35
1884. *Lepidostrobus globosus* Dn, Lesquereux, Coal Flora, vol iii, pp 850, 893

[a] Several of the figures in Etheridge's original paper are reproduced in Etheridge and Jack, Geology and Paleontology Queensland 1892, p 196, pl v

[b] Prodrome Paleontology Victoria, dec 1, 1874, p 37, pl ix

[c] Records Geol Survey New South Wales, vol 2, 1891, pt 3, p 119

[d] Jack and Etheridge, Geology and Paleontology Queensland, 1892, p 196

[e] Bull Acad Roy St Petersburg, Mél phys et chem, vol 9, 1876, pp 630, 631, pl xx, figs 5, 6

1863 *Carpolithes spicatus* Dawson, Quart Jour Geol Soc London, vol xix, p 461, pl xvii, fig 15
1871. *Carpolithes spicatus* Dawson, Foss Pl Dev and Upp Sil Can , p 62
1880 *Carpolithes spicatus* Dn , Lesquereux, Coal Flora, vol ii, p 598.
1888 *Carpolithes spicatus* Dn , Schenk, Foss Pflanzenreste, p 99

Small, oblong bodies, consisting of a very broad fleshy axis about 5 mm. in width, traversed by a slender strand; bracts close, very small, about 2 cm. in length, ovate, acute or acuminate, concavo-convex, arching upward above the middle, dorsally broadly carinate; sporangia unknown.

The specimen illustrated in Pl. VI, Fig. 5, is one of only two specimens of this type in our collections. As shown in the enlarged detail, Fig. 5[a], the scales are proportionally very broad toward the base and are pocketed in the flexure. A peculiar feature suggestive of *Leptophlœum* and some forms of *Lepidophloios* is the small axial strand seen in Fig. 5[a]. It is not clear in the specimen before me whether the scales surrounded the axis or were confined to the lateral borders of a flat medial body, but the former appears much more highly probable, and, in fact, such an arrangement must have been present in Dawson's type of the species.

In the absence of knowledge of the definite arrangement of the scales and sporangia it is impossible to determine the exact nature of the fossil in hand. But from the form of the scales and the indications of attendant sporangia I am disposed to regard it as perhaps belonging to *Lepidostrobus*. If such it proves to be, it may eventually be correlated with *Leptophlœum rhombicum*. The bracts have somewhat the aspect of the smallest scales of *Barinophyton perrianum*. It is possible, however, that they are but dense chaffy scales on the rachis of a young fern.

In portions of the specimens the scales arch upward so as to appear like small ovate or roundish bodies on the borders of the axis. To this appearance is doubtless due the description, as *Carpolithes spicatus*, of a specimen [a] which can hardly be other than the same species as the example here figured. I therefore do not hesitate in uniting the species referred to with that from the same type locality very briefly described, without illustration, as *Lepidostrobus globosus*. The aspect of the profile of these specimens suggests that the record of the occurrence of *Lepidodendron gaspianum* at Perry may possibly have been based on a similar fragment.

LEPIDOCYSTIS Lesquereux.

Coal Flora, Atlas, 1879, p 13

Lepidocystis siliqua (Dn.) D. W.

1863 *Carpolithes? siliqua* Dawson, Quart Jour Geol Soc London, vol xix, p 465, pl xvii, fig. 4
1880 *Carpolithes? siliqua* Dn , Lesquereux, Coal Flora, vol ii, p 598
1871 *Carpolithes siliqua* Dawson, Foss Pl Dev. and Upp Sil Can , p 62, 86

[a] Regarded by Dawson as probably the fruit of *Arthrostigma gracile* Fossil Plants Devonian and Upper Silurian Canada, p 62.

Oblong to linear-oblong, 1.5–4 cm. long, 3.5–8 mm. wide or 15 mm. in width when spread out, rounded or truncate-rounded at one end, usually slightly arcuate, obtuse or obtusely rounded at the other end, thinly carbonaceous, minutely granulose.

This species, described by Dawson as *Carpolithes siliqua*, appears to be represented by numerous specimens, the largest of which has nearly the proportion and form illustrated in the figure given by Dawson. The greater number, however, are but about one-half the length of the latter, the width being nearly the same as in Dawson's original. In one of the specimens collected last year and another in the cabinet of the Portland Society of Natural History the sporangium is spread out so as strongly to resemble the specimens described by Lesquereux as *Lepidocystis fraxiniformis* (Goepp.), to which the Perry plant was compared by him. The sporangium wall is relatively thick and destitute of structural features, though, in a few instances, a very fine and faint striation, perhaps due to the cell arrangement in rows, is, under a strong lens, discernible. On account of the coarseness of the matrix it is impossible to differentiate the sporangial contents. A few small megaspores, 0.4 mm. in diameter when flattened, and minutely granulose or obscurely meshed, are found in association. The latter are perhaps indistinguishable from *Sporangites Jacksoni*.

Like the lepidocysts of the lower Mississippian, these specimens vary greatly in dimensions, and, while they seem to be true spore cases, they do not agree in uniformity of size or of form with the species of *Lepidostrobus* in the Coal Measures, and it is not certain that they are referable to any recognized lepidophytic type. On the contrary, it is not impossible that they belong to quite another, and perhaps lower, group of plants.

Lepidocystis inquisitus D. W.

Pl IV, Figs 12, 13, 14

Sporangia small, asymmetrically ovate to oblong, slightly arcuate, 4–8 mm long, 2–3 mm. wide, somewhat wider and more broadly rounded at one end, narrowing a little toward the other end, minutely granular-carbonaceous.

The general aspect and the variation in form of these spore cases are shown in Pl. IV, Figs. 12, 13, and 14. The coarsely granular matrix renders it impossible to discern the characters of the spores. The fossils are rather densely carbonaceous, and this fact, taken with the variation in form, led me at first to think they might be mere waterworn pieces of wood. But they lack traces of the fibrous texture of wood and are not sufficiently thin to represent fragments of cuticle. Moreover, nearly all show the inequality of the ends and the arching. Consequently they are, I believe, to be regarded as sporangia. In general they appear to be of the same nature as the *Lepidocystis siliqua* described above, the chief differences being the much smaller size, proportionally broader form, and more delicate texture. It appears probable therefore that these two species are congeneric. It is possible, however, that *L. inquisitus* may have been derived from some such type as *Barinophyton Richardsoni*.

SPORANGITES Dawson.

Can Nat, vol VIII, 1863, p 454

SPORANGITES JACKSONI D. W.

Pl VI, Figs. 6, 6[a]

Spore masses oblong or elongated, attaining a length of 4 cm. or more, and a width of 1 cm.; megaspores of irregular form, due to compression. averaging about 4 mm. in diameter as flattened, not very rigid, minutely shagreened, and marked by a small mamillate point.

Among the fossils placed in my hands through the courtesy of the Boston Society of Natural History, I have found a portion of an agglomeration of megaspores partially exposed at the edge of one of the rock fragments, No. 6687 of the society's paleontological collections. The removal of a portion of the covering matrix revealed what appears to be two partially overlapping spore masses, as shown in Pl. VI, Fig. 6. They consist of a slightly brownish rock medium, not very densely crowded with the large and somewhat irregularly shaped spores, as illustrated in the enlarged Fig. 6[a]. The spores are very finely shagreened and seem to be marked by a small mamillate point. The thickness of the compressed spore mass in the center was nearly 2.5 mm. From the disposition of the spores and the form of the masses I am disposed to regard the former as practically in place, and the mass as the undisturbed contents of large spore sacs, the full size of which is not shown in these specimens. It is possible that they may have been derived from a lepidocyst of the type of *Lepidocystis siliqua*, though specimens of that species seem in general not so large Such a correlation is slightly favored by the presence of a single similar spore on a shale fragment nearly in contact with an example of the same form. However, it is possible, on the other hand, that the spore agglomeration is of quite different origin. It is not possible from the specimens in hand to ascertain whether spores of more than one kind were contained in the same mass.

The specimens of *Sporangites Jacksoni* are larger and less rigid than those of *Sporangites Huronensis* Dn. of the Genesee shale, or the other megaspores from the Devonian described by Dawson.

The species is named in honor of Dr. C. T. Jackson, the first geologist of Maine.

CORDAITES Unger.

Gen et Sp Pl Foss , 1850, p 277

CORDAITES FLEXUOSUS Dn.

1862 *Cordaites* sp , Dawson, Quart Jour Geol Soc London, vol xviii, opp. p. 329
1863 *Cordaites (Pychnophyllum) flexuosus* Dawson, Proc Portland Soc Nat Hist , vol i, pt 2, p 100, pl ii, fig 4
1863 *Cordaites flexuosus* Dawson, 2d Rept Nat Hist and Geol Me , p 403
1863 *Cordaites (Pychnophyllum) flexuosus* Dawson, Quart Jour Geol Soc London, vol xix, p 462, pl xvii, fig. 9
1871 *Cordaites flexuosus* Dawson, Foss Pl Dev and Upp Sil. Can , pp 44, 85
1880 *Cordaites flexuosus* Dn , Lesquereux, Coal Flora, vol ii, p 544

Leaves lanceolate, acuminate, broad at the base; nerves numerous, parallel, somewhat sinuous and uneven.

In the collections before me I have seen but a single fragment which would appear to be referable to this little-known species, first described from Perry. The specimen in hand, while appearing to represent the form described by Dawson, offers nothing in support of the reference of the fossil to the genus *Cordaites*.

Not having seen the original type, I quote the diagnosis given by Dawson. No other example has, so far as I am aware, been figured or described. The inclusion of this species in *Cordaites* by Dawson was regarded by him as provisional, its true affinities being "quite uncertain."

CORDAITES? ANGUSTIFOLIUS Dn.

1861 *Cordaites angustifolius* Dawson (non Lx), Can Nat , vol vi, pp 170, 176, fig 11c
1862 *Cordaites angustifolius* Dawson, Quart Jour. Geol Soc London, vol xviii, p 318
1863 *Cordaites angustifolius* Dn , Logan, Geol Canada, pp 394, 399, fig 428
1868 *Cordaites angustifolius* Dawson, Acad Geol , pp 534, 546
1871 *Cordaites angustifolius* Dawson, Foss Pl Dev and Upp Sil Can , p 44, pl xiv , fig 163
1880 *Cordaites angustifolius* Dn , Lesquereux, Coal Flora, vol ii, p 544
1882 *Cordaites angustifolius* Dawson, Foss Pl Erian and Upp Sil. Can , pt 2, p 106
1889 *Cordaites angustifolius* Dawson, Trans R Soc Can , vol vi , sec 6, pp 29, 34

Portions of very slender, rather thick, straight or gently curved leaves, 3–5 mm. in width, exceeding 8 cm. in length, regularly lineate with fine, parallel, distinct, longitudinal nerves; apical and basal portions of the leaves unknown.

The fragments which are here provisionally placed under this name appear to conform with the characters of the specimens described and figured by Dawson from Gaspé.

Little can be said of the real nature of the plants included in this species.

Some of them may be fern stems. The species is stated by Dawson[a] in one of his later papers to be of a doubtful nature.

The plants from St. John included by Dawson in the same species represent an entirely distinct type.

CARPOLITHES Schlotheim.

Petrefaktenkunde, 1820, p. 418.

CARPOLITHES CONFINIS D. W.

Pl. IV, Fig. 11.

1871. *Carpolithes?* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., pp. 64, 90, pl. x, fig. 125.

Ovate, about 6 mm. in length and 4.5 mm. in width a little below the middle, asymmetrical, curved slightly to one side, very obtuse, obscurely apiculate, attached by more than one-half its width, nearly flat in the impression, lineate parallel to the border, more strongly marked toward the base.

The fossils above described are tentatively placed in the genus *Carpolithes*, although from the evidently broad attachment irregularly fractured at the base, as shown in Pl. IV, Fig. 11, and from the rather thick substance there would appear to be some reason for regarding them as merely scales, possibly comparable to those of *Barinophyton perrianum*. The broad basal attachment, the asymmetrical form, and the absence of all traces of a border argue against the reference of the type to the genus *Cardiocarpon*.

From a comparison of the details of the figure of a specimen from Gaspé published by Dawson,[b] with doubt as to whether the object was a carpolite or a concretion, I am disposed to regard it as identical with the species in hand.

CARPOLITHES LUNATUS Dn.

1863. *Carpolithes lunatus* Dawson, Quart. Jour. Geol. Soc. London, vol. xix, p. 464, pl. xvii, fig. 11.
1871. *Carpolithes lunatus* Dawson, Foss. Pl. Dev. and Upp. Sil. Can., pp. 63, 86.
1880. *Carpolithes lunatus* Dn., Lesquereux, Coal Flora, vol. ii, p. 598.

Base rounded regularly, apex broadly truncate and mucronate; nucleus surrounded with a narrow margin.

I have seen no specimens representing this form, described by Dawson, as above, from a single specimen found at Perry. From the figure given by the author the systematic position and even the nature of the fossil would appear to be absolutely uncertain. In form and size it closely simulates a bolster of one of the Devonian Bergeria-Lepidodendra.

[a] Am. Jour. Sci., 3d ser., vol. 38, July, 1889, p. 3.
[b] Fossil Plants Devonian and Upper Silurian Canada, pl. x, fig. 125, p. 64.

STEMS—DADOXYLON?

I find in the various collections a number of specimens labeled, apparently by Dawson, as *Dadoxylon* and "stems of *Cordaites*." One of these, in the collection of the Portland Society of Natural History, is the counterpart of the specimen well figured in Dawson's paper on Further Observations on the Devonian Plants of Maine, Gaspé, and New York.[a] It is simply an impression, and promises nothing further regarding the structure of the stem itself. Other examples appear to represent long, straight fragments of striate or lineate stems, one of which has a width of over 3 cm.

These fragments are of little value and I suspect are paleontologically indistinguishable from the material from the Chemung of New York earlier described as *Rhachiopteris cyclopteroides* Dn.[b] The latter species was never figured and is not at present identifiable by the literature. No further description of gymnospermous woods from the Perry beds seems to have anywhere been published,[c] and none of the specimens that have passed through my hands appear to offer sufficient characters for a generic identification.

ADDITIONAL PLANTS.

The following additional plants were reported by Sir William Dawson from Perry, but were not seen by the writer and are not included in the preceding review:

Aporoxylon, recorded,[d] but not figured nor identifiably described.

Calamites sp., entered in the Maine column of the table, Fossil Plants Devonian and Upper Silurian Canada, 1871, page 85; probably by error, since it is not elsewhere mentioned in the literature relating to Maine.

Caulopteris Lockwoodi Dn., of the Devonian at Gilboa, N. Y., is similarly entered in the Maine column only, but is nowhere else mentioned in connection with material from Maine. The entry is evidently an error

Filicites incertæ sedis, published in 1863,[e] belongs to the genus *Otidophyton*, and possibly to *O. hymenophylloides*, though regarded by Dawson as possibly belonging to *Platyphyllum Brownianum.*

Hymenophyllites sp., not recognizably described and not illustrated, appears to have been abandoned after its first publication in 1863.[f] It may be a young fertile pinna of *Archæopteris.*

Lepidodendron gaspianum, reported by Dawson[g] as represented from Perry in

[a] Quart Jour Geol Soc London, vol 19, 1863, p 460, pl xviii, fig 20
[b] Quart Jour Geol Soc London, vol 18, 1862, p 323
[c] Loc cit, opp p 329 Proc Portland Soc Nat Hist, vol 1, pt 2, 1863, p 100 Second Rept Nat Hist and Geol Me, 1862 (1863), p 460
[d] Quart Jour Geol Soc London, vol 18, 1862, pp 299, 307
[e] Quart Jour Geol Soc London, vol 19, p 464, pl xvii, figs 10, 10b
[f] Proc Portland Soc Nat Hist, vol, 1, pt 2, p 100
[g] Canadian Naturalist, vol 1, No 3, 1861, p 174

the collections of the Portland Society of Natural History. I have seen no identifiable specimens. Two small fragments of stem in the latter collection appear to have the remains of leaf cushions, but they do not seem to be spirally arranged, nor do they show scar characters. The vestiges which possibly represent leaves are suggestive of the spines of *Arthrostigma*. One of the fragments resembles, however, that figured by Crépin from the Devonian of Belgium as *Lepidodendron gaspianum* Dn.

"*Megaphyton?*"[a] is not illustrated or sufficiently described for recognition. The genus is ignored in all references to or lists of Perry plants published after 1862.

Psilophyton elegans and *Ps. glabrum*, recorded in 1863[b] as doubtfully identified at Perry, are not afterwards mentioned as occurring in Maine. Without examination of the types or type material it is not possible to determine whether any of the material which is provisionally described in this paper under the head of *Ps princeps* Dawson, but which is shown not to be the true *Ps. princeps*, is really referable to *Psilophyton glabrum*.

AGE OF THE PERRY FORMATION.

Having concluded the critical examination and description of the fossils of the Perry formation, I have now to review the evidence of the genera and species as to the age of the formation itself, and thus to determine whether the beds are really Devonian, as was believed by Dawson and others, or whether, after all, as has been recently supposed by some geologists, they are not a part of the Carboniferous series.

DISTRIBUTION OF THE SPECIES.

Tæniocrada palmata is unknown elsewhere and represents a type of alga, which may have close allies in various periods.

Platyphyllum Brownianum, recorded from the upper Devonian of New York and Baie des Chaleurs, and erroneously from Scaumenac, also appears to be present in the Devonian of Klaas-Billen Bay, Spitzbergen. The remaining species of the genus are upper Devonian, *Platyphyllum truncatum* and *P. Rogersi* being from the Catskill of Pennsylvania.

Archæopteris is primarily a genus of the middle and upper Devonian, though represented in the Carboniferous also, the later species being in nearly all cases characterized by very narrow or lobate pinnules; fructification of the common form, like that of *A. hibernica*, *A. minor*, *A. Rogersi*, has not been found in the Carboniferous. The Perry species of the genus belong to the extremely closely related group represented by *A. hibernica* and *A. minor*, characteristic of the upper Devonian, particularly the Catskill and Chemung, of eastern America.

[a] Canadian Naturalist, vol 6, No 3, p 175
[b] Quart Jour Geol Soc London, vol 19, p 462

Archæopteris Jacksoni, also found in the Devonian at Scaumenac and Restigouche Bay, is closely related to *A. minor* of the Catskill and Chemung in Pennsylvania, and in sterile forms is not readily distinguished from *A. gaspiensis*. *A. Rogersi*, present in the Chemung of New York and at Montrose and Meshoppen in Pennsylvania, is very closely related to *A. Roemeriana* of the upper Devonian of Europe and the Arctic regions. The development and position of the sporangia in *A. Hitchcocki* relate the species intimately to the fructification described as *Sphenopteris condrusorum* from the upper Devonian of Belgium, and, less closely, to the fructification of *A. minor* of the Catskill of Pennsylvania. A plant from the upper Devonian of Belgium having the aspect of that here described as *Otidophyton* has been referred by Crépin to *A. hibernica*.

The peculiar type of plant described as *Barrandeina perriana* is perhaps identical with that from the Hamilton of New York figured by Dawson as "*Cordaites?*", while it is otherwise most nearly comparable to the *B. Duslianum* from Barrande's H-h1 stage. Both the genus *Barrandeina*, to which I have referred the species, and *Anarthrocanna*, under which Dawson placed it, are upper Devonian genera.

Rhachiopteris pinnata is also from the middle Devonian of New York, while *R. punctata*, which is doubtfully recorded in the Perry flora, occurs in the Ithaca shales of central New York and the Chemung at Gilboa, N. Y.

The plant fragment tentatively referred to *Sphenopteridium* seems to have its relatives in the Devonian of the Rhine region and in the basal lower Carboniferous of Europe. I interpret it as representing a group generally characteristic of the lower Carboniferous.

Dimeripteris is known only from the Devonian. *D. incerta*, found typically in the Hamilton of New York, is possibly inseparable from *D. fasciculata* of the Donetz Devonian, while we find a very closely related form under the name *Cephalotheca mirabilis* in the upper Devonian of Bear Island. *D. recurva* likewise seems to have its only near relatives in the Donetz, though it is possibly closely allied to a form illustrated by Unger from the Cypridina beds of Thuringia. It is, however, comparable in some respects to *Sphenopteris flexilis* Heer, from the basal Carboniferous of Spitzbergen.

Sphenopteris filicula, if correctly diagnosed, belongs to a group of species, including *S. affinis* and *S. moravica*, which is, in general, characteristic of the basal Carboniferous. However, a type extremely similar to that in hand, and perhaps specifically identical, has been figured by Nathorst from the Devonian of Spitzbergen. Both closely resemble material from the American Pocono that has been identified with the *S. flaccida* of the Devonian of Condroz. They should be compared also with Stur's *Sporochnus Krejči* from the H-h1 stage (upper Devonian) in Bohemia.

All the species described as *Psilophyton*, with the exception of *elegans*, whose generic reference is doubtful, appear to be Devonian, though *Psilophyton princeps* was also reported by Dawson from beds at Gaspé which are regarded by many geologists as lying below the base of the Devonian. It is characteristically a Devonian genus The specimens which I provisionally place with the smooth-costate group included by Dawson in *Ps. princeps* are by the form of their terminal laminæ most closely bound to the Psilophyta from Campbellton and from the Catskill of New York. The same characters appear in the congeneric *Hostinella hostinensis* from the upper Devonian (H-h1 stage) of Bohemia, and the species of *Psilophyton* of the "Old Red Sandstone" of Scotland. Stem fragments of the smooth *Psilophyton* type are also found in the Devonian of Bear Island and Spitzbergen. *Psilophyton alcicorne* appears to be nearest to the Campbellton material referred by Dawson to *Ps. princeps*, though its real affinities are not known.

The fragment doubtfully referred to *Paleostachya* fails to reveal nodes and the verticillate structure essential to the genus, which is Carboniferous, and has very little stratigraphic value at present.

Barinophyton is a special and very peculiar type, not elsewhere known outside of the Devonian. It is represented by *B. obscurum* in the Devonian of New South Wales, and probably by the plant erroneously described as *Ptilophyton Thompsoni* from the Devonian of Scotland. *Barinophyton Richardsoni* is perhaps present in the Gaspé section.[a] *B. perriana* appears to be present in the Devonian at Campbellton.

The generic characters of the plant named *Lycopodites comosus* by Dawson are not clear, but the general aspect of the fragment as figured is such as is common in the slender branching lepidophytes of the Carboniferous, though species of generally similar aspect are not unknown in the uppermost Devonian. Too little is known of the details of the plant to entitle it to any importance in stratigraphic correlation.

In *Leptophlœum* we have another peculiar lepidophytic type, which appears to combine a bothrodendroid leaf scar with a distinctly lepidodendroid bolster. It is quite distinct from the Bergeria or subepidermal state of *Lepidodendron*. So far as known, *Leptophlœum* is distinctly Devonian. *L. rhombicum* is reported from the middle Devonian of Gaspé and Campbellton, from York River, and the upper Devonian of Queensland. It is present in the Devonian of Spitzbergen and at the so-called Ursa stage of the Ogur region, in eastern Siberia. The remaining species, *L. australe* and *L. nothum* (non Ung.), also occur in the Australian Devonian.

Lepidostrobus globosus is another singular and but little known type which, under the name *Carpolithus spicatus*, is reported from the Chemung of Shamokin, Pa. It is possibly the fertile strobilus of *Leptophleum rhombicum*.

The supposed lepidophytic spore cases described as *Lepidocystis siliqua* seem to

[a] See Fossil Plants Devonian and Upper Silurian Canada, pl xii, fig 154

be most intimately related to a species in the Pocono (basal Carboniferous) of Pennsylvania. *L. inquisitus*, of slightly doubtful generic reference, is unique in form, and may possibly prove not to be lepidophytic

The large oblong sporangial masses described under the name *Sporangites Jacksoni* seem in size and form nearest connected with *Lepidocystis siliqua*. It is not entirely clear, however, that they were similarly produced. The megaspores appear to belong to the *Sporangites* type described by Dawson in several species from the Devonian of North and South America. It is doubtful whether the genus, as composed, is distinguishable from some of the megaspores of the Carboniferous.

The generic reference of both of the species referred to *Cordaites* is somewhat uncertain, although the presence, as low as the Hamilton, of fossil woods of the group commonly known as *Dadoxylon* justifies the assumption that very near relatives[a] of the genus *Cordaites*, if not the genus itself, were present in the middle Devonian. The occurrence of typical foliage of the genus is, in general, characteristic of the upper Carboniferous and lower Permian. *Cordaites angustifolius* is reported from the lower Devonian of Gaspé and Campbellton and from the Marcellus of New York.

Carpolithes confinis seems to be present in the Gaspé section. *C. lunatus*, the characters and identity of which, as described in 1863, from Perry, are very obscure, has not been recognized elsewhere.

CORRELATION.

Of the entire flora described[b] from Perry, *Sphenopteris filicula* and *Lepidocystis siliqua* are types which appear to belong to groups more or less distinctly characteristic of the lower portion of the lower Carboniferous. The fragment described as *Palæostachya?* sp., and the forms earlier published as *Lycopodites comosus* and *Carpolithes lunatus* are too little known or too ambiguous to be at present of stratigraphic value. The correlative significance of *Sporangites Jacksoni*, which has not been found elsewhere, is also as yet undetermined. The remaining species which comprise the main body of the Perry flora are Devonian.

As will have been seen in the foregoing review, the evidence of the geologic distribution, so far as known, of the identical species, of the genera themselves, and of the most nearly related plant forms indicates distinctly and overwhelmingly a Devonian age for the Perry formation. The stratigraphic range of most of the species and their allies strongly points to a place in the upper Devonian, the preponderance of the evidence being in favor of the Catskill-Chemung stage. Allowing for the full weight of the two or three species of close lower Carboniferous affinities, the flora can not at latest be assigned to a stage above the upper

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[a] As *Dictyocordaites Lacoei* Dn., from the Chemung of Pennsylvania.

[b] *Lepidodendron Gaspianum*, a characteristic Devonian plant, unknown in the Carboniferous, and reported from Perry by Dawson, is omitted from the list as insufficiently represented for identification in the Perry material which I have seen.

Catskill as developed in northeastern Pennsylvania and southeastern New York. Compared with the flora of other continents the closest paleontologic affinities of the Perry flora are found in the plant associations of the Donetz and of the Arctic Devonian.

The occurrence of closely related species of *Barinophyton* and *Leptophlœum* together with *Archæopteris* in the Devonian of Australia affords an interesting example of the remarkable intercontinental distribution of the later Devonian plant types.

The conclusions as to the age of the Perry beds recorded long ago by Sir William Dawson are fully corroborated by the study of more extensive material and the discovery of additional plants. The deposition of the strata antedates all known formations of coal in commercial amounts. Small lenticular beds, streaks, or pockets of coal or coaly matter, of local occurrence only, are, in rare instances, found in beds of so great an age as the Perry, but they are always too thin, if not too dirty, to be of use. There is not even the slightest indication of the presence of such beds in the rocks of the Perry basin. The underlying rocks about Perry are still older.

The supposition entertained by some geologists that the Perry formation is identical with the beds regarded as lower Carboniferous at Lepreau, in New Brunswick, in accordance with the arguments and maps published by a number of Canadian geologists, and that, consequently, beds of anthracite coal like that at Lepreau may be found in another series of beds, which is interpreted by them as underlying and older than the lower Carboniferous, is absolutely untenable for two reasons: (1) The beds supposed to be lower Carboniferous at Lepreau, if their age is correctly determined by the New Brunswick geologists, were deposited later than the formation of the Perry beds, and can not represent the same geological period; (2) the series of beds (Lancaster formation) containing the Lepreau coal and supposed to be older than both the lower Carboniferous and the Perry beds are conclusively proved by their fossil contents to be not only of Carboniferous age, but to belong some distance, at least, above the older portion of the lower Carboniferous. The Lepreau coal, being of later date than the age of the supposed lower Carboniferous, can not stratigraphically underlie the latter except as the result of overturn or overthrust. Otherwise the series of beds supposed to be lower Carboniferous must be of far later date.

In view of the facts (1) that no trace of the much younger geological series which carries coal at Lepreau is found in the Perry basin,[a] and (2) that the coal bed at Lepreau is so thin, altered, and dirty[b] that all attempts to mine or use it were long ago abandoned, any further consideration of the possible occurrence of such a bed in the Perry basin is superfluous.

[a] A condition that is most natural, since that series is of vastly later date of formation. If present, it should *overlie* the Perry.

[b] About 36.88 per cent of ash, fide Rept. Geol. Survey Canada, 1878-1879, p. 13D. For further descriptions of the Lepreau bed, see also Rept. Geol. Survey Canada, 1876-1877, p. 345. The bed consists of streaks of carbonaceous shale with interbedded crushed graphitic coal. All efforts to utilize the material as fuel were long ago abandoned.

CHAPTER IV.

ECONOMIC GEOLOGY.

By George Otis Smith.

HISTORY OF SEARCH FOR COAL.

At the time of the publication of Jackson's first geologic report, in the year 1837, interest in the search for coal in this region seems to have already been aroused. It appears that, as geologist to the State, Doctor Jackson, in accordance with the desire of Governor Dunlap, first devoted his attention to the question of the occurrence of Coal Measure rocks, and visited the Perry district at an early date. No special encouragement was offered in his report to those interested in this subject, but the statement is made: "If coal really occurs in this sandstone, it should be found between the village of Pembroke and the St. Croix River."

Prospecting for coal in the town of Perry is said to have begun in 1837 with work by the St. Croix Freestone Company. Ten or twenty years later one Hill, said to have had experience as a miner, who was attracted by what he considered indications of coal, secured mineral rights from the owners of land in the towns of Perry, Pembroke, and Robbinston. The expectation at first seeming to be that coal would be discovered near the surface, a shaft was dug down to the ledge, but it was found necessary to continue the exploration by drilling. The place selected for the location of the prospect was on the north side of Little River, between the shore and the road leading to Gleason Cove. With the somewhat crude type of drill used progress must have been slow and expensive, but it is reported that a depth of about 400 feet was reached. The loss of the drill and later the death of Mr. Hill caused the abandonment of all work.

The interest of geologists in the Perry fossil locality may have helped to keep alive the local belief in the occurrence of coal beds in the red sandstone formation. Another prospect shaft was sunk on the Brown farm, south of Boydens Lake. This is now covered over and the dump overgrown with trees, so that nothing can be learned of the results of the work, except that typical Perry sandstone and conglomerate make up the dump. Operations began again in 1893, when W. F. Trask put down a diamond-drill hole to a depth of 604 feet. This was done for a reorganized company, but again the money procured was exhausted before the work was completed. This drill hole was located close to the old Hill shaft. Little can be learned concerning the strata cut by this hole. The reported statements of the same witness at different times are quite at variance as regards the occurrence or nonoccurrence of coal. It is undoubtedly safe, however, to accept his statement that no coal was found.

Mr. Jesse C. Gleason, of Perry, kindly furnished a piece of the drill core, which came from near the bottom of the hole and was said at the time to be "top clay." Below this it was locally reported that coal was found. This piece of core was of special value to the present investigation from its petrographic character. It is a rhyolitic lava, and is plainly the same rock as the Silurian lava exposed in the shore section. This shows that the Trask drill hole penetrated to the base of the Perry formation and even into the Silurian rocks beneath.

At another locality near Perry, it is reported, coal was actually found in the inclosing rock. The place is on Little River, at the upper dam. When the rock was blasted out in the course of constructing this dam by the Eastport Water Works Company in 1892, a "coal pocket" is said to have been exposed. Our own careful examination of the rock at this place failed to show any traces of coal, and the geologic evidence is strongly against the supposition that any was found there. The rock does not belong to the Perry formation, but, as can be seen from the geologic map in this report, is a part of the Silurian series underlying that formation. The Silurian purple shale is here cut by a dike of dark porphyry of the type described on page 28. What was thought to be coal may have been some dark-colored mineral deposited upon the contact of this dike with the shale, since it is most improbable that coal could occur in such association and in rocks of Silurian age.

It is also reported that coal was found in the glacial drift below this dam, where the trench was dug for the water pipe, but this report could not be verified.

This brief historical sketch of the search for coal is sufficient to indicate how little basis there has been for the belief that coal can be found in the Perry basin. It is unnecessary to consider to what extent this sanguine expectation may have been fostered by some for the sake of possible personal gain, but it is evident that the interest shown by students of geology in the Perry beds has had perhaps a greater influence upon the public mind, causing the residents of Perry and adjoining towns to become unusually well versed in geology. It is unfortunate, however, that the suggestions and inferences favoring the occurrence of coal in this area have been so much more quickly grasped than the counter evidence. In the remaining portion of this chapter the geologic evidence on this economic subject will be presented.

GEOLOGIC DATA.

Brief mention has already been made of two cases in which the reported occurrence of coal is opposed by geologic observations. To serve the purposes of this report, however, it is advisable to cite more fully these geologic data and to explain their application to this subject. It is believed that when the evidence is fully stated the reader will be able to form a definite opinion regarding the possibilities of finding coal in the Perry formation. The fact that during all these decades in which the interest has been maintained in this question so little regard has been paid to certain fairly obvious features of the local geology renders it all important that at this time the geologic data should be explicitly presented.

The character of the Perry formation has been described in a preceding section. The rocks of this formation comprise volcanic products, such as lavas and breccias, and sediments of the coarser type, such as conglomerates and sandstones. Professor Bailey of the Canadian Survey and Professor Shaler of Harvard University have compared the Perry formation to the Catskill of the New York section. This comparison probably expressed not only their belief regarding the age of the formation, but also a recognition of the general resemblance of the Perry rocks to the red sandstones of the Catskill formation. It may be noted that these two formations are not only similar in color, but both are remarkably free from black carbonaceous beds of any kind. In view of the excellent exposures of the Perry beds along the shore it is extremely improbable that any part of the section is concealed. The deep indentations in the coast line cause the same beds to be repeatedly exposed, and therefore a thin stratum that might be concealed in one place would quite likely be shown at another. The fact that no black shales were observed in any portion of the section may, therefore, be taken as strong evidence of the absence of coaly beds in the Perry formation.

As is well known in coal regions, coal seams usually occur in association with under-clays, but no such beds are observed in this area. This absence of fire clays in the section may be regarded as evidence that the physical conditions existing during the time the Perry sediments were being deposited were not favorable to the accumulation of vegetal matter in the form of coal seams. The conglomerates and coarse sandstones, which frequently are cross-stratified, represent sediments laid down in an estuarine basin, where coarse material was contributed by large streams and deposited close to shore. Only rarely did the plant fragments washed down from the land find lodgment in sediments sufficiently fine grained to preserve them as fossils.

Another geologic condition that did not favor coal accumulation was the volcanism that characterized the Perry epoch. Volcanic activity had been a feature in this area during the Silurian period, and was renewed during the time of the deposition of the Perry rocks. From some volcanic center in this vicinity lava flows were erupted, so that sheets of basalt and associated beds of volcanic ejectamenta now occur interstratified with the sandstones and conglomerates.

But perhaps the most conclusive data on this subject of the possibility of the occurrence of coal in the Perry formation are connected with the question of geologic age. The assignment of a Triassic age to these rocks by the first geologists who visited the region, and in later years the correlation of the Perry beds with Carboniferous rocks of New Brunswick, have both served to foster the belief in the possibility of finding coal. The determination of the exact age of this formation, therefore, has become a matter of prime importance. The results of the paleobotanical investigation, as stated in this report, point to the Devonian age of the Perry formation. Rocks of this age are known in certain districts to contain local accumulations of carbonaceous matter, it is true, but such coaly streaks or lenses are thin—rarely a foot in thickness—and of very limited area. Therefore it can be stated that nowhere are rocks of the same age as the Perry beds repositories of commercially workable coal.

There are several instances reported in the Perry region of old coal miners, or self-termed mining "experts," basing very strong opinions upon the fossil plants found at Perry. The similarity of these plants to those associated with the coal at Springhill, Nova Scotia, or with the Pennsylvania coal, has been remarked upon and definite conclusions have been inferred. The identification of Paleozoic plants involves much more critical study than is commonly understood, and little credence should be given to the observations and deductions of those who do not appreciate the complexity of the subject.

Another line of evidence is afforded by the stratigraphy of this area. It will be noticed that all of the prospects and reported occurrences of coal are near the southern border of the area of the Perry formation. The waterworks dam is in fact near the contact with the older rocks, and the rocks in which coal is reported to have been found do not belong to the Perry formation, but are of Silurian age. Both the Hill-Trask and the Brown prospects were located within a half mile of the contact with the Silurian rocks. Such a location, taken in connection with the low dip of the Perry rocks at those points, means that the base of the Perry formation is not many hundred feet beneath the surface. In fact, we have conclusive evidence that in the Trask hole, as stated on a previous page, the drill actually reached this basal contact and penetrated for some distance the underlying Silurian strata. The piece of core termed "top clay" by the driller is in reality a rhyolitic lava. The similarity of this to the lava which occurs interstratified with the Silurian fossiliferous rocks south of Gleason Cove was noticed in the field, and subsequent microscopic study has verified this identification. It is a fortunate as well as interesting fact that the Silurian and Devonian lavas are of such diverse types. On this account there can be no doubt that the Trask drill hole cut all the strata in which there was believed to be any possibility of encountering seams of coal. In fact, it cut even some of the lower beds, including this lava sheet, which is known from its petrographic character to be of Silurian rather than of Devonian age.

CONCLUSIONS.

From all the foregoing facts, therefore, it must be concluded that the belief in the existence of coal in the Perry formation, although maintained for nearly seventy years, is not supported by geologic evidence. The composition of the rocks comprised in this formation, as studied in satisfactory sections, neither shows the presence of any carbonaceous beds nor favors the possibility of their occurrence in concealed portions of the section. This conclusion that coal is not present in the formation is furthermore strongly supported by deductions based upon the Devonian age of the Perry formation, as determined by paleobotanical studies.

Exploration work in these rocks has failed to show the presence of coal seams, and the force of this statement is strengthened by the knowledge that the Trask drill hole reached the base of the Perry formation. Continuation of the work there, or drilling at a locality near the reservoir dam, would simply result in expensive exploration of Silurian rocks in which no one conversant with coal mining would expect to find coal. In fact, a drill hole at the latter locality, though it is reported to have been proposed on the recommendation of an expert, would have resulted only in an utter waste of money.

The assignment of a Devonian age to these rocks may suggest the possibility of finding oil or gas in the Perry area. On this point it need only be stated that the outlook is no more encouraging than that for coal. The occurrence of joints and faults, such as have been described in this report, as well as the presence of interbedded lava flows, are most unfavorable indications, since they preclude the conservation and storage of any liquid or volatile hydrocarbons, even had they originally been present.

The practical deduction to be drawn from the results of the geologic study presented in this report is that further exploration of the Perry basin for coal is unwarranted.

APPENDIX.

COAL IN OTHER LOCALITIES IN MAINE.

By George Otis Smith.

GREENFIELD.

Another locality where coal indications have been reported is the town of Greenfield, the second town east of Oldtown, Me. The rocks exposed in this vicinity differ slightly from the slates seen along the Penobscot River. Red and black slates are the predominant rocks exposed in Greenfield, where the search for coal has been prosecuted. It is in the black slate that what has been termed coal has been found. The black slate is, in places, sufficiently carbonaceous to soil the fingers, a character that immediately suggests soft coal, and the bright glistening surfaces of the rock, as seen in excavations, make it also resemble anthracite coal Near Myra post-office a large shaft has been sunk to a depth of about 20 feet, but in September, 1903, the time of the examination, this opening contained 10 feet of water. The observations possible in the upper portion of the shaft, as well as the examination of the rock which had been thrown upon the dump, were sufficient to give a good idea of the character of the material that is traversed by this shaft. The brilliant luster of much of this rock is plainly the result of crushing and slipping within the rock mass. Similar bright surfaces, technically termed "slickensides," occur in rock of any kind that has been subjected to extreme dynamic action, and in a black rock, like the slate in Greenfield, the resemblance to anthracite coal becomes very strong. It is when these slickensided pieces of slate are broken across, however, that the true character of the rock is seen. The slate is of a dull gray color, and is quite unlike either bituminous or anthracite coal. The rock is full of quartz seams and gashes, which afford further evidence of the crushing to which the slate has been subjected

The resemblance of this material to coal was the basis for the beginning of prospecting in this locality, and this indication was later supported by reports that the coal had been successfully burned in a blacksmith's forge and used in grates. It is unnecessary to consider the source or truth of such reports after examining the black slate to which they refer. The rock is plainly carbonaceous, but, as is shown above, it is not sufficiently so to make the resemblance to coal at all close. For the purpose of thoroughly testing the material, however, a determination of the percentage of carbon in this rock was made in the laboratory of the United States Geological Survey. The loss on ignition in a selected sample of the best material from Greenfield was found to be 9.2 per cent. The remaining 90 per cent of the rock would correspond to what is termed ash in a true coal. This is sufficient to show that the black rock which has been prospected in Greenfield is in no sense a coal, even of the most impure variety, and the geologic examination of the locality affords no warrant for further exploration for coal in the formation exposed there.

FISH RIVER.

It was reported to the Maine Survey Commission that coal had been found on the line of the Fish River extension of the Bangor and Aroostook Railroad. The locality where the coal was said to occur was within the region where Silurian and Devonian strata were recognized at the time of the early surveys of the State, so that there appeared to be a possibility that the Carboniferous might also be represented. Therefore, in accordance with the instructions, a trip was taken over this line and the locality was visited. The examination of the rocks along the railroad was greatly facilitated by the courtesies extended by the officials of the Bangor and Aroostook Railroad.

The strata are well exposed in the fresh cuts of the recently constructed railroad, many of the beds thus exposed probably not being visible in natural outcrops. The formation exposed near the Fish River bridge south of Eagle Lake comprises sandy and shaly beds. These are soft and appear younger than the limestones and other rocks that are exposed both north and south of this locality. The reported "coal" was found to be a 3-inch seam of black material, interbedded with the sandstone and shale. In composition this is simply a shale in which there is sufficient carbonaceous material to give it a black color. It is not coal, and the reports that it had been successfully used in a blacksmith's forge were easily nullified by testing the shale in a hot fire. Pieces of the rock thus treated can be slightly bleached by the action of the fire, but can not be ignited.

This black shale and the associated strata contain fragments of plant remains, a small collection of the best of which was sent to Mr. White for study. His report is as follows:

"The fossil plant material from Fish River consists of small fragments, which, unfortunately, were so triturated and abraded before deposition as generally to obliterate their external characters. Among the specimens are some which appear to represent *Psilophyton elegans* Dawson. Others are doubtfully referable to *Psilophyton princeps* Dawson. The presence of these plants is strongly indicative, though not conclusively demonstrative, of a Devonian age for the beds. No recognizable traces of the genera *Archæopteris* or *Lepidodendron* are noticeable. The absence of these, if the collection is thoroughly made and representative, constitutes negative evidence for a reference to an earlier Devonian stage; but the weight of such evidence is little unless the observations are somewhat ample. The characters preserved in the specimens are, on the whole, such as to leave little room for doubt as to the reference of the Fish River beds to the Devonian."

OTHER LOCALITIES.

At three other localities in the State an attempt was made to verify the reports of the occurrence of coal. The first of these was in the extreme southern part of the town of Penobscot, where some prospecting has been done in a black slate. The rock here is similar to that at Greenfield, but probably contains even less carbonaceous material. The slate is contorted and seamed with quartz, and possesses so little of the appearance of coal that it is strange that it should be considered of any value.

Another region where the occurrence of coal was reported to the commission is Cape Elizabeth. Pieces of coal are said to have been picked up in a plowed field at one place from time to time for a number of years. Unfortunately all of these fragments had been given away or burned, and no others were found in our examination of the field. The country rock, however, at this locality is the same schist that is exposed elsewhere throughout this region. In another part of this town coal is said to have been found when excavations were made for laying water pipes. A piece of this material was seen, and was readily determined as compact black slate rather than coal.

The third locality is Madrid, where anthracite coal was reported to outcrop close to a house. Prof. Leslie A. Lee, State geologist, visited this locality, only to find that the coal was not in place but was fuel that had been left on the property previous to its occupation by the present owner.

Newspaper accounts mention other towns in Maine as promising localities for the occurrence of coal, but in each case the probabilities are that black shale or graphitic slate has been mistaken for coal.

PLATE II.

PLATE II.

Platyphyllum Brownianum Dn.

(Page 37.)

Fig. 1. Original specimen illustrated by Sir William Dawson and now in the collection of the Boston Society of Natural History, through whose courtesy it is here refigured.

Fig. 2. Another example, more deeply dissected. Collection of the Portland Society of Natural History.

Otidophyton hymenophylloides D. W.

(Page 47.)

Fig. 3. Example showing the umbilical impressions at the bases of the sinuses, and indications of obscure depressions, with thickened carbon near the apices of the lobes.

Dimeripteris recurva (Dn.) D. W.

(Page 56.)

Fig. 4. Bifurcating branchlet.

Fig. 5. Fragment illustrating the bifurcation of the small lobes.

Fig. 6. Specimen with more deeply dissected lobes, whose aspect is suggestive of a bivalvate capsule.

Dimeripteris incerta (Dn.) D. W.

(Page 53.)

Fig. 7. Example showing the rapid subdivision of the lamina in different planes, the ramules provided with clustered sporangia.

Fig. 8. Fragment showing fragment of major division with dilated thin lamina of the branch, which is fertile.

Fig. 8[a]. Enlarged four times the natural size, showing one of the sporangia illustrated in Fig. 8.

Fig. 9. Specimen illustrating the rapid subdivision of the ramules in proximity to a branch of considerable size.

Tæniocrada palmata D. W.

(Page 37.)

Fig. 10. Portion of frond showing dissection of the lamina, the lobes of which are traversed by very thin axes of greater density.

Barrandeina perriana (Dn.) D. W.

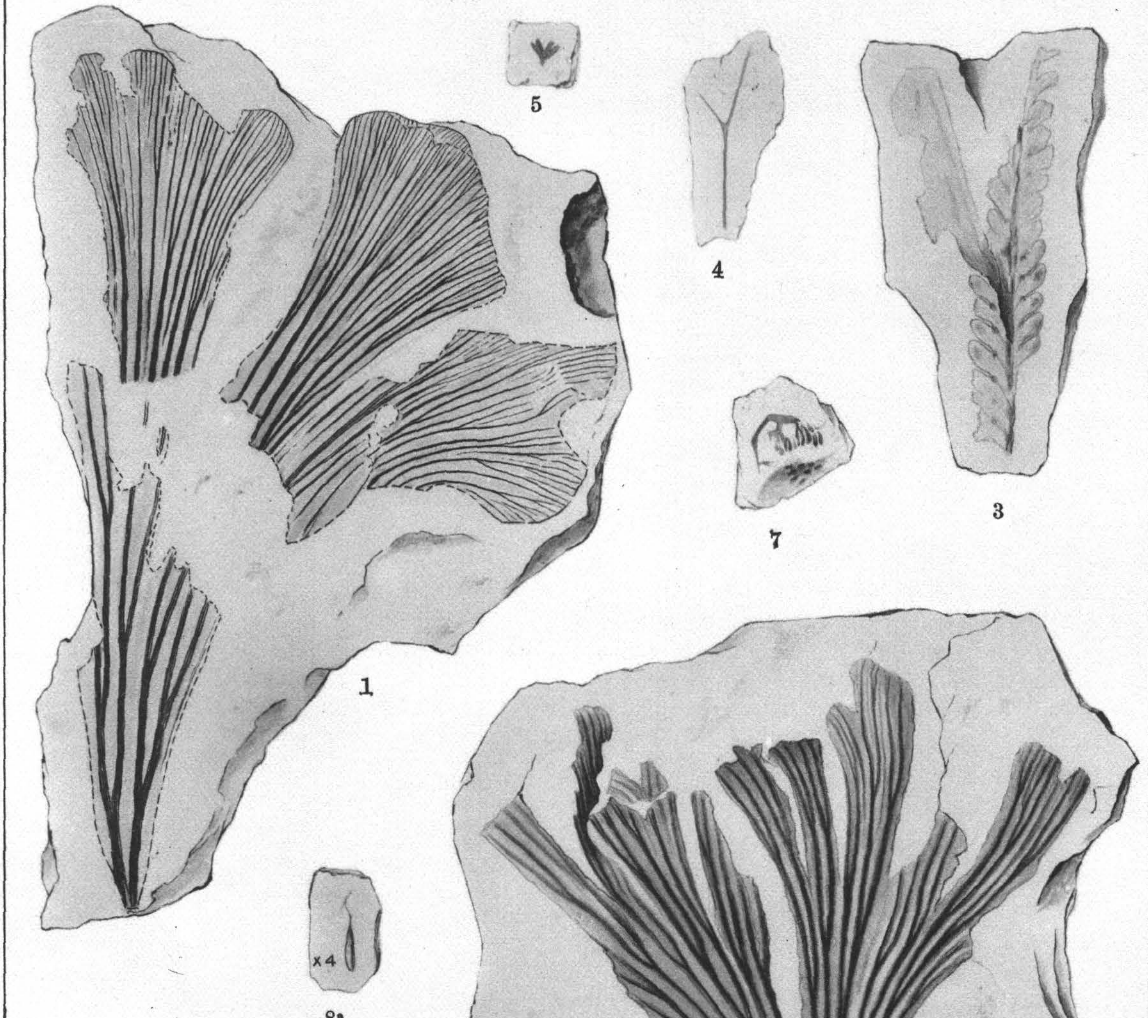
(Page 49.)

Fig. 11. Fragment of stem showing the extremely decurrent petiolar bases descending along the axis in spiral arrangement, though frequently broken back to different levels.

Archæopteris Rogersi Dn.

(Page 43.)

Fig. 12. Rachial fragment showing corrugation of the descending petiolar bases.



FOSSILS OF THE PERRY FORMATION

PLATE III.

PLATE III.

ARCHÆOPTERIS JACKSONI Dn.

(Page 39)

FIG 1 Fragment of frond showing characteristic arrangement and aspect of the pinnæ, the rugose rachis with vestiges of rachial pinnules, and the imbrication of the ordinary pinnules, which in this example are slightly broader than is usual Figured by courtesy of the Portland Society of Natural History, in whose collection the specimen now rests

FIG 2 Fragment of the common type of pinna found in the formation, illustrating the typical rather narrow imbricated pinnules

FIG 2ª Twice the natural size. Pinnule of the example shown in Fig 2 enlarged to show the outline and nervation, which is really derived from a dense primary fascicle descending along the rachis.

FIG 3. Fragments of extraordinarily broad and apically rounded pinnules of the same species

FIG 4 Portion of a fertile pinna of the form described as belonging to the species, but possibly representing an early stage of the fertile pinna of *A Rogersi*

ARCHÆOPTERIS ROGERSI Dn.

(Page 43)

FIG 5 Portion of a fertile pinna showing the fasiculately attached sporangia and the prolonged midrib of the pinnule

FIG 5ª Twice the natural size Detail from Fig. 5 showing the fasciculate arrangement and the thickened neural line of the sporangium

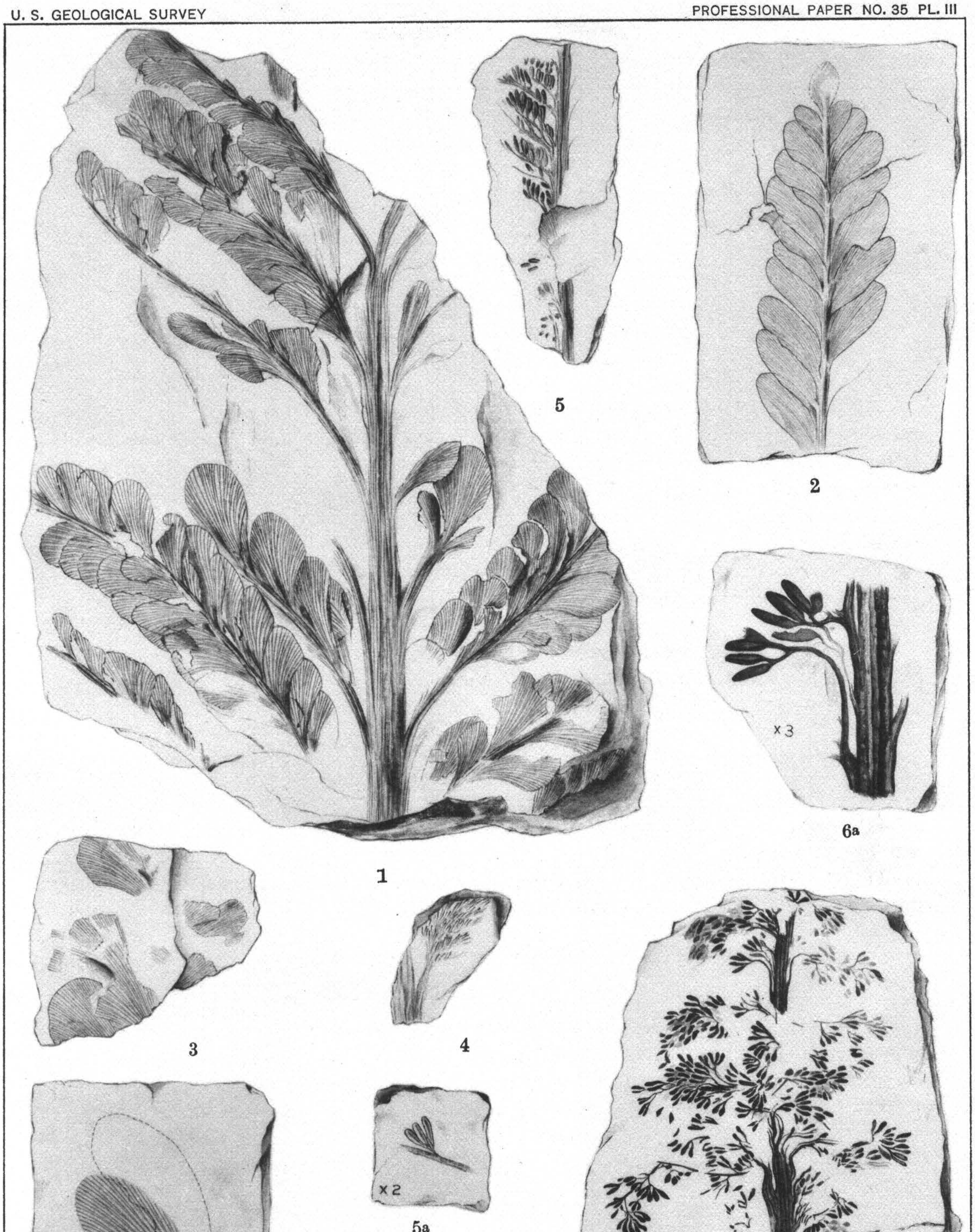
ARCHÆOPTERIS HITCHOCKI (Dn.) D. W.

(Page 45.)

FIG 6. Original type of the species, No $\frac{4329}{1}$ in the fossil plant collection of the American Museum of Natural History, through whose courtesy it is here refigured The specimen shows clearly the sporangial nature of the ultimate divisions, the entire segment being fertile and reduced in lamina

FIG 6ª Three times natural size Showing sporangia attached to nerves of reduced rachial pinnules in the upper part of the specimen shown in Fig 6

FIG 6ᵇ Three times natural size. Showing the arrangement of the sporangia in the peripheral portion of the specimen



FOSSILS OF THE PERRY FORMATION

PLATE IV.

PLATE IV.

Rhachiopteris pinnata Dn. var. angustipinna D. W.

(Page 50.)

FIG. 1. Fragment of the rachis, showing mode of opposite division, the decurrent bases of the subdivisions, and the slender vascular axes of the latter. Vestiges of extremely tenuous laminar appendages, probably representing the leaves of the species, are seen on the larger branches.

FIG. 2. Fragment of a smaller example, showing the dilation at node on the main rachis opposite and between the lateral divisions. This feature also appears, though less distinctly, in Fig. 1.

FIG. 3. Slender branchlet with vestiges of leaves.

Palæostachya ? Sp.

(Page 64.)

FIG. 4. Fragment of axis showing basal portion of scales, in the axils of which appear to be grouped sporangia whose mode of occurrence and probable arrangement are suggestive of *Palæostachya*. One of the bracts, broken in the process of preparation of the specimen, was over a centimeter in length.

Barinophyton Richardsoni (Dn.) D. W.

(Page 64.)

FIG. 5. Fragment of rachis, showing several of the boat-shaped branches or pinnæ still attached, the arrangement being probably spiral. Collection of the Portland Society of Natural History.

FIG. 5[a]. Detail, enlarged twice the natural size, showing the lobes or pinnules of the upper pinna on the right-hand side of Fig. 5. The midribs are somewhat depressed. The depressions at the base of lobes are not well shown.

FIG. 6. Another example showing the pinna in a more advanced stage of development. The apices of the lobes are generally obscure and their full length is not usually clear. In the second branchlet from the base on the right the rachial depressions are shown, the lobes being in part broken away on the side toward the observer.

FIG. 7. Fragment of a full developed or old pinna representing the condition originally figured by Dawson as *Lepidostrobus Richardsoni*. In this example the thick, fleshy rachis is well exhibited, the lobes being apparently attached just within the margin on the ventral surface of the broad wing of the rachis. Collection of the Portland Society of Natural History.

FIG. 8. Elongate and straightened pinnæ probably belonging to the same species and representing a stage comparable to that seen in Fig. 5.

FIG. 9. Fragment of very young branchlet spread out.

Barinophyton perrianum D. W.

(Page 68.)

FIG. 10. Fragments of several pinnæ, the two on the left being in their original position.

FIG. 10[a]. Enlarged twice the natural size. Detail of the lower pinna in Fig. 10, showing the form of the lobes and the depressions or pits, presumably sporangial, at the bases of the latter.

Carpolithes confinis D. W.

(Page 78.)

FIG. 11. Isolated seed, showing striate surface and broad basal attachment.

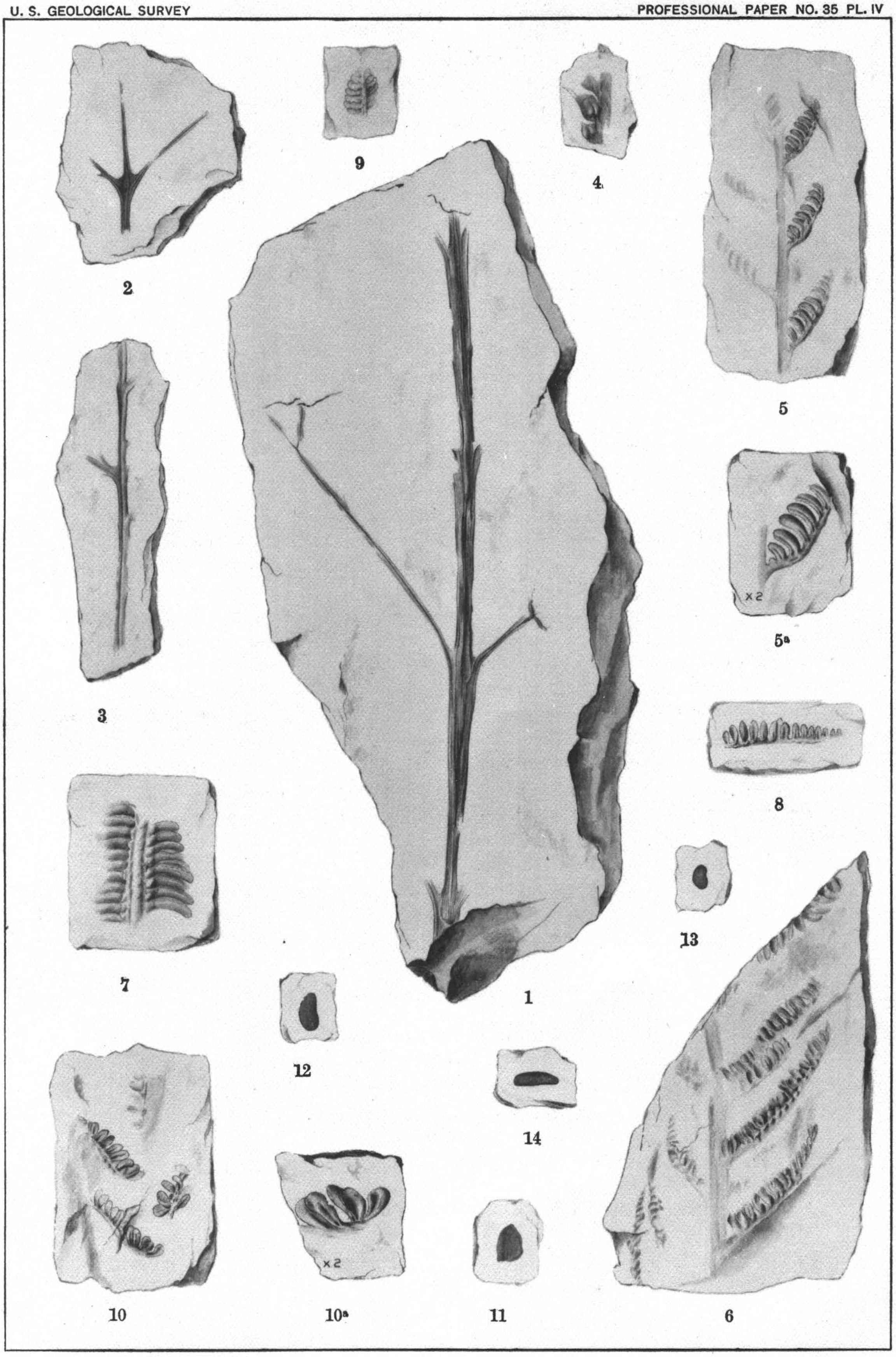
Lepidocystis inquisitus D. W.

(Page 75.)

FIG. 12. Broad form of the sporangium.

FIG. 13. Short-ovate form.

FIG. 14. Elongate form, which, like the others, is slightly crescentic.



FOSSILS OF THE PERRY FORMATION

PLATE V.

PLATE V.

PSILOPHYTON (?) ALCICORNE D. W.

(Page 64)

FIG 1 Example showing the anomalous type of ramification appearing on one side only of the axis A third branch on the right, similar to the upper one in the figure, was originally seen on the specimen, but was destroyed in the process of clearing the matrix from the fossil

FIG. 2 Another example, slightly larger and more complicated, though the primary system is similar to that shown in Fig. 1

? PSILOPHYTON CF. PRINCEPS Dn.

(Page 58)

FIG 3. Fragment showing the ordinary flexuous rachis, irregularly sulcate with one or two somewhat irregular, broadly rounded ridges The abrupt termination of the branches at a little distance from the rachis, as shown in this figure and Figs 4 and 6, is characteristic of this type of fossil.

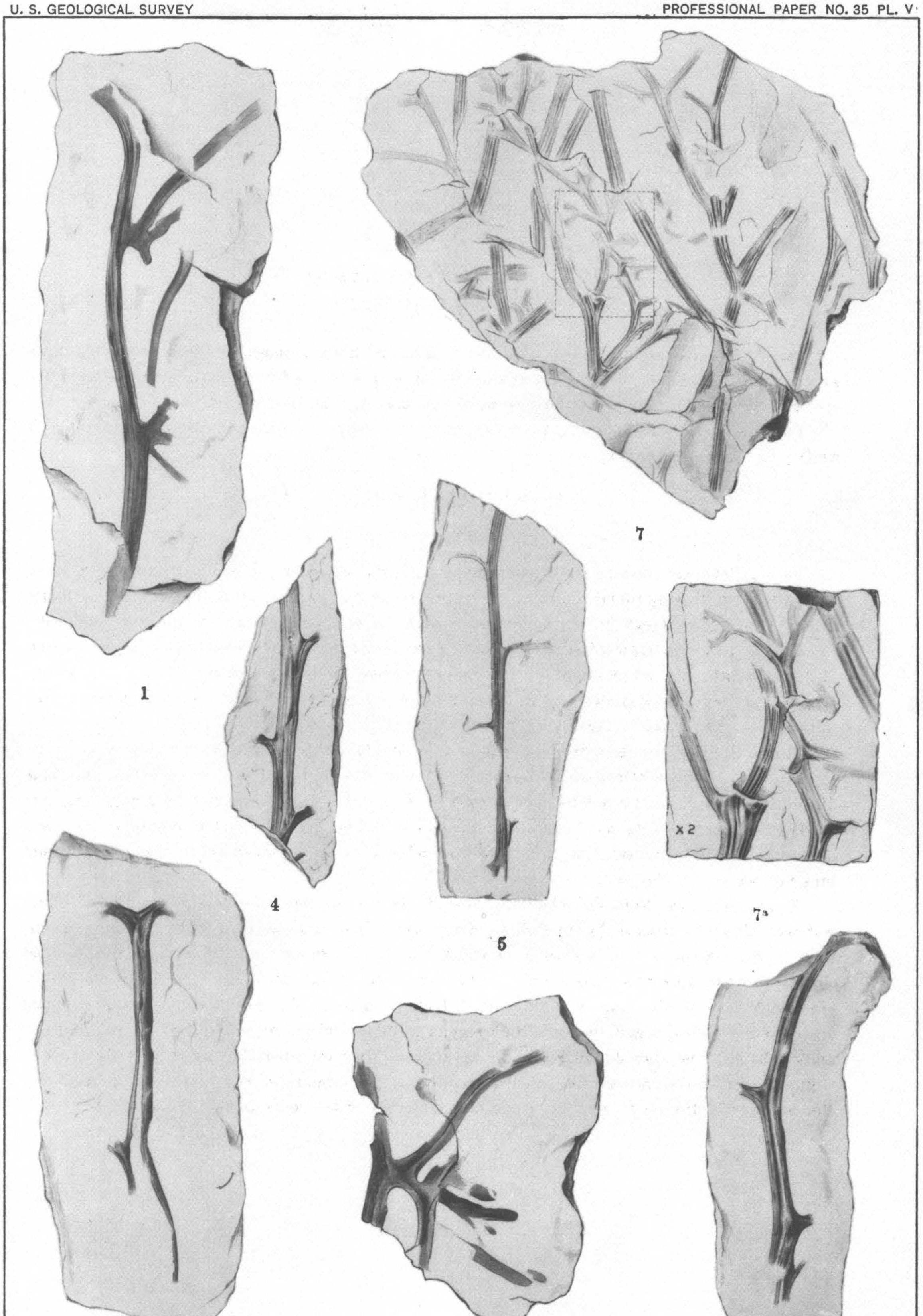
FIG 4 A similar fragment in which the somewhat elongated depressions appearing on the base and just within the terminations of the rameal vestiges are more clearly shown The abrupt terminations are probably due to the almost abrupt change from the rigid axial structure to the thinner and more delicate ramose laminar structure of the foliage

FIG 5. A more slender axis, with fragments of the foliate ramules still attached

FIG 6 Example showing the bifurcation of a rachis at the top, with indications of the immediate dichotomy of each of the subdivisions At the same time the axis curves backward, and the subdivisions are not in the same plane with the parent rachis The abrupt termination in the fossil of the two main subdivisions at the top of the rachis is exactly comparable to that of the lateral branches shown in Figs 3 and 4

FIG 7 Specimen from Campbellton, New Brunswick, in the collection of the United States National Museum, labeled by Sir William Dawson as *Psilophyton princeps* The costation is distinct in the fragments of rachis, some of which show an irregular form of ramification, somewhat similar to that illustrated above under *Psilophyton? alcicorne* A few of the fragments in the specimen shown in Fig 7 are obscurely and distantly punctate. The ultimate divisions of the plant are extremely delicate, and, owing to the irregular mode of division by which they are intermingled and to the fact that they do not lie in the same plane, they are generally very imperfectly exposed.

FIG. 7[a] Twice the natural size Central portion of the original of Fig 7, showing more clearly the costation of the rachis and the mode of subdivision of the tenuous foliar laminæ



FOSSILS OF THE PERRY FORMATION

PLATE VI.

PLATE VI.

Leptophlœum rhombicum Dn.

(Page 69.)

Fig 1. Original type of the species, No. $\frac{1304}{1}$ in the fossil plant collection of the American Museum of Natural History, through whose courtesy it is here refigured. The example shows the normal bolsters in the lower portion, those in the middle being more or less disfigured by a transverse wrinkling of the epidermis, the wrinkles being curved between the points of resistance offered by the lateral angles and the leaf scars of the bolsters, so that in the upper middle the boundaries of the latter are partially obliterated. This transverse wrinkling, which, it will be seen, is apparently of superficial origin, was responsible for the description of this specimen as containing a chambered pith identical with *Artisia*. It will be observed that above the shriveled and wrinkled central portion the bolsters are resuming their normal size and form

Fig. 2 Example illustrating the large size of some of the bolsters, in the apices of which occur the pore-like ligular pits

Fig 3 Fragment of an impression, the relief of the bolsters being exaggerated. In this example the leaf scars are slightly above the middle of the bolsters.

Fig 4 Crushed and slightly macerated specimen in which the surface features of the bolsters are shown near the margins, while throughout the central portion the impressions of the intracortical and subcortical structures only are seen, the superficial tissues having been removed The central strand curving irregularly within the cylinder of the much macerated inner cortex of the fragment probably represents the woody stele of the stem Its nodation is the result of impression on the more rigid rhomboidal cortical tissues.

Lepidostrobus globusus Dn.

(Page 73)

Fig. 5 The specimen agrees in general features with that originally figured by Dawson.

Fig. 5a. Enlarged four times the natural size Showing the curvature of the scales, each of which is traversed by a nerve strand and is convex in the outer portion

Sporangites Jacksoni D. W.

(Page 76)

Fig 6 Portion of the contents of a large, elongated sporangium or possibly of two superimposed sporangia, consisting of a slightly brownish mass more or less crowded with the dark carbonized megaspores The original is in the collection of the Boston Society of Natural History, through whose courtesy it is here described

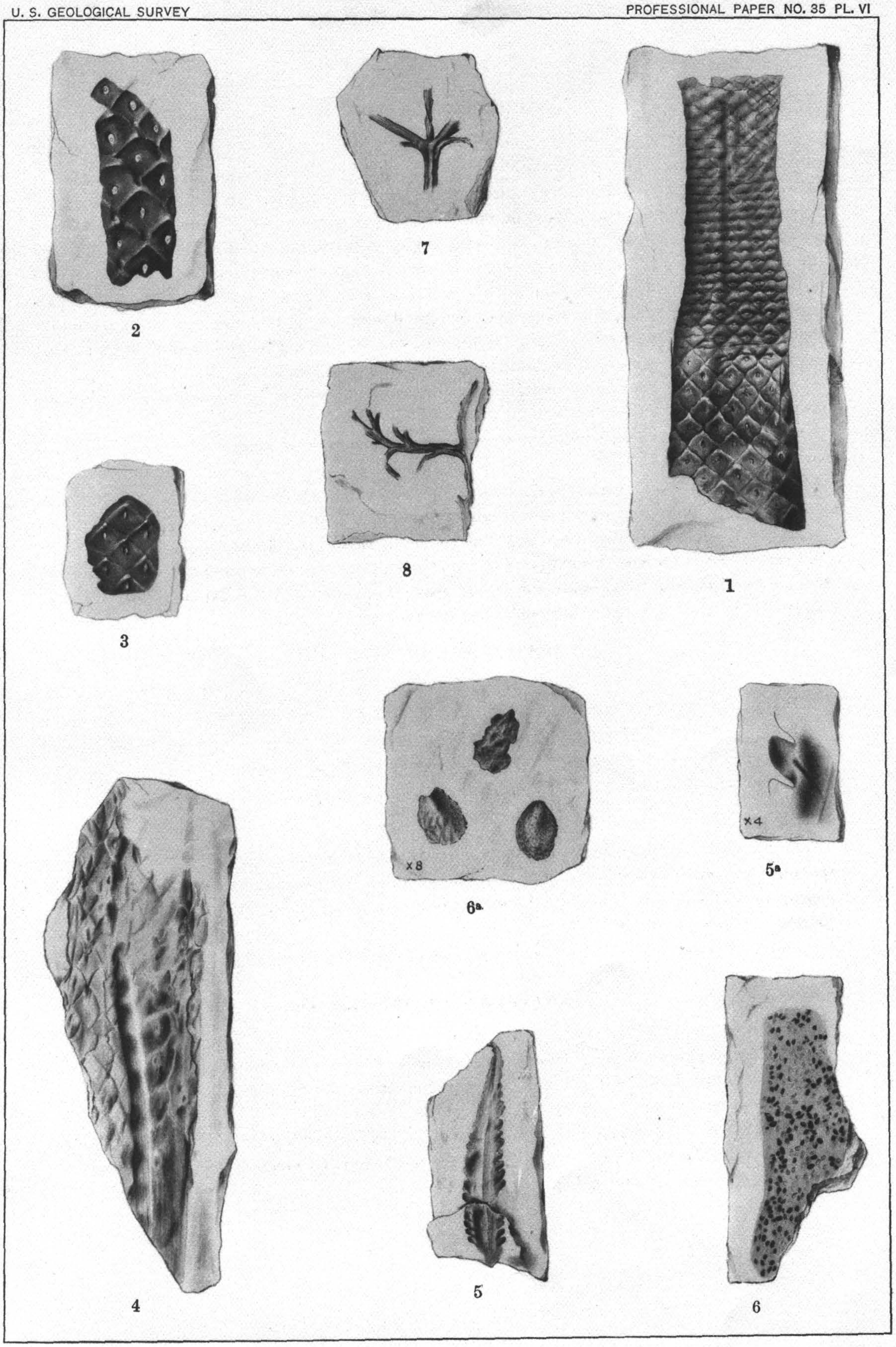
Fig 6a Enlarged eight times natural size Details showing some of the megaspores from the original of Fig 6

? Psilophyton cf. princeps Dn.

(Page 58)

Fig 7 Specimen showing a trituration of the axis, the two subdivisions in the foreground being comparable to that shown in Fig 6 of Pl V, the middle subdivision springing from the back side and lying in a different plane

Fig 8 Fragment probably belonging to the same species, showing the rapid ramification near the periphery of the plant, the branchlets appearing as abruptly terminated, possibly as the result of abrasion of the more delicate laminæ



FOSSILS OF THE PERRY FORMATION

INDEX.

[Black-face figures indicate pages on which detailed descriptions occur, italic figures indicate illustrations, names in italic are synonyms]

O

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY

[Professional Paper No 35]

The serial publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of the United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof The classes numbered 2, 7, and 8 are sold at cost of publication, the others are distributed free. A circular giving complete lists may be had on application.

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