DESCRIPTION OF SOME FOSSIL PLANTS FROM THE GREAT FALLS COAL FIELD OF MONTANA.

BY

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(With Plates LXXXII—LXXXIV.)

In July, 1890, Mr. F. H. Knowlton and Dr. A. C. Peale made a small collection of fossil plants from the Kootanie group of Great Falls, Mont. In July, 1891, Mr. W. H. Weed made an additional small collection from the same locality. These plants have been placed in my hands for determination and description. The object of this paper is to give an account of them. Both collections can be contained in a box of moderate size, so that they can not pretend to be exhaustive.

The specimens show nothing but ferns, conifers, and one Equisetum. The conifers have but few species, and the specimens illustrating each species are few and poorly preserved. They indicate considerable maceration, as if they had been floated in water a long while before they were covered with sediment.

The ferns predominate in the number of species, while the specimens illustrating the species are in several cases very numerous. They are usually well preserved and appear to have been speedily entombed in sediment.

Both Mr. Knowlton and Mr. Weed seem to have failed to find cycads, the other constituent of a typical Mesozoic flora. They, however, exist at the Great Falls locality, for Dr. Newberry, in his excellent paper on the flora of this group,* has mentioned and described several. Besides these a beautiful impression of a cycad, obtained by Mr. R. S. Williams from this field, is figured and described in this paper.

The cycads, however, so far as I can learn, are rare in this flora. Perhaps this is accounted for by the localities in which they grow and by the accidents of preservation. The condition of the fossil conifers found in this field, and their small proportion in the sum total of the Great Falls plants, indicate that the inhabitants of the higher and drier regions were not favored in preservation so much as the ferns, which presumably lived in the marshes and near to the water receiving sediment. Then, too, it is quite possible that additional discoveries may add largely to both the conifers and cycads. Negative conclusions,

* "Flora of the Great Falls Coal Field, Montana." Amer. Jour. Sci., vol. XLI, March, 1891, p. 191.

based on the presumed absence of groups of plants, can not be fairly drawn until it is made certain that no further discoveries can be looked for.

With regard to the age and affinities of this flora, my investigations add nothing to the conclusions arrived at by Dr. Newberry in the paper before cited. These conclusions, which I fully indorse, are that the Potomac group, the Great Falls group, the Kootanie group of Canada, and the Kome group of Greenland are all of the same general age. Dr. Newberry expresses the opinion that the Great Falls strata are somewhat older than those of the Potomac, this being indicated by the absence of angiosperms in the former. This opinion is justified if we take into consideration only the plants found in the Great Falls strata up to this time. But it is possible that, if these beds have not been exhaustively explored, angiosperms may yet be found in them. The strata seem to some extent to show an isolation of forms, and a confinement of them to particular horizons. This would seem to be the case with the cycads. As stated before they do exist in the strata at a particular horizon, or at a particular locality, while in the two collections before me not a single imprint is found. In my collecting from the Potomac beds, I did not discover the angiosperms of modern type that they yield until towards the close of my explorations, long after large collections of plants of older types had been made. The more modern angiosperms of the Potomac are found in the upper beds of the formation, which have been in most places carried away by erosion There are localities in the Potomac of Virginia which show good exposures of thick beds, that abound in impressions of ferns and conifers, but contain no angiosperms. The two near Potomac Run described in Monograph XV of the U. S. Geological Survey; as "Roadside" and "Hillside," have this character. It is noteworthy that *Osmunda dicksonioides*, a plant that seems to be abundant at a certain horizon in the Great Falls field, is found at one of these localities and nowhere else in the Potomac beds. If the age of the Potomac strata had been determined from the fossils of these localities, it would, from the absence of angiosperms, appear older than it is.

With regard to the age of the Potomac itself perhaps a word may be allowed here. It is to be understood that by Potomac is meant the lower member of that formation, as shown chiefly in Virginia. I do not regard this member as all of Wealden age. The period of its deposition seems, if we are to judge by the progress made by the plants, to have extended through the Wealden into the Urgonian, and perhaps to a somewhat later time. It was probably extended throughout the Neocomian. The very remarkable isolation and grouping of the plants of the Virginia Potomac, which seems in a measure to exist in the Great Falls field, and the great differences in the relative abundance of the different types, appear to indicate unstable conditions in the different elements of the flora, and also rapid changes. It is quite possible, then,

that higher types of plants were reached in these strata than in any synchronous with them in Europe.

Returning to the consideration of the constituent groups of plants in the Great Falls flora, we find the ferns decidedly dominant, but different species are by no means equally represented. At the head of the list in number of specimens stands *Aspidium montanense*, a new species. Next to this, and in about the order of naming, come *Aspidium monocarpum*, also a new species, *Thyrsopteris rarinervis* Font., and *Osmunda dicksonioides* Font. These were all apparently abundant. To judge from the character of the rock which bears the imprints, these did not all occur on the same horizon. *Osmunda dicksonioides*, for example, occurs in a material very different from that which shows the imprints of *Aspidium montanense*. .

In this connection I will repeat an opinion expressed before. In determining the age of an unknown group of fossil plants, greater weight as evidence of age ought to be assigned to some plants than to others. These are the plants whose fossils have marked and salient features that permit them to be identified without danger of error. An example of this kind of plant is *Frenelopsis*, especially *F. parceramosa*, of the Potomac flora. When these are fully established and at home in a formation, as would be shown by their general distribution and the abundance of the fossil specimens that they afford, they ought not to be counted simply as units in a sum total to establish a percentage. Their evidence would thus be neutralized by that of other units which are newcomers or belated survivors. This is especially true of floras in a critical stage of evolution, and which contain considerable numbers of newcomers and survivors. The Potomac flora was one of this character, in which Jurassic types were being cast out and Cretaceous ones introduced. If the era of deposition of the Great Falls beds was nearly that of the Potomac, as is most probable, then the flora of the time must have been likewise in an unstable condition.

So far as yet made out, the ferns seem to be the most common plants in the Great Falls flora. The above remarks, owing to the character of this type of vegetation, and to its long persistence with but little change, do not apply to them so well as to many of the forms found in the Potomac flora. *Thyrsopteris rarinervis*, however, is a fern that has a well-marked facies, which is not possessed by many ferns. Its abundance in the Great Falls strata gives it great weight in establishing a resemblance between the Potomac and Great Falls floras.

Equiseta appear to have been very rare in the flora now in question. The few imprints that are found are very poorly preserved, and seem to have been made by fragments that had floated a long time in water.

The two collections yield the following species:

Equisetum Lyelli? Mantell.

Only one imprint was seen that was clearly that of an Equisetum. It occurs in a ferruginous, sandy shale. It is too poorly preserved to

permit positive determination. In size and general character it is so close to *Equisetum Lyelli* that the identification with that species is quite probable. Two or three other imprints of stems occur that may be those of Equisetum, but they are too obscure to be determined even generically.

Aspidium montanense, nov. sp.

Pl. LXXXII, Figs. 1–3; Pl. LXXXIII, Figs. 2, 3 3, 3*a*.

Plant probably arborescent. Fronds large, probably attaining the dimensions of several feet, tripinnatifid or tripinnate. Pinnæ alternate, sometimes nearly opposite. Rachises of all orders strong and rigid. Leaf substance thick and durable. Normal pinnules, or those of the middle portion of the fronds and pinnæ, oblong, slightly falcate, obtuse to subacute, attached by a somewhat widened base, united at the base, inserted under an angle of 45° to 50°. Mid nerves of the pinnules distinct, continued to near their tip, and forking at the summit. Lateral nerves slender, single, arching towards the summit of the pinnules with the basal ones sometimes once forked. The pinnules of the lower part of the frond are lobed or toothed, with lobes and teeth similar in shape to the normal pinnules. Towards the upper or terminal portion of the frond the ultimate pinnæ pass, by continued diminution, through lobed and toothed pinnules into entire ones. Sori in two rows, one on each side of the midrib of the pinnules, obovate in form, attached to the summit of lateral nerve and placed midway in the lamina of the pinnule.

This fern is represented in the collections by numerous well-preserved specimens, which show all parts of the frond. Pl. LXXXIII, Fig. 2, represents the normal pinnules. Pl. LXXXII, Fig. 1, gives the pinnules from the lower part of the frond. Fig. 3 shows dentate pinnæ, passing into pinnules, from the upper part of the frond. Pl. LXXXIII, Fig. 3, shows lobed pinnæ from the upper part of the frond, and Pl. LXXXII, Fig. 2, gives fragments of a fructified compound pinna.

This plant shows considerable variation in the ultimate pinnæ and pinnules taken from different parts of the frond. In the general character of its pinnules it stands midway between two ferns from the Potomac of Virginia. These are *Aspidium fredericksburgense* Font., and *Pecopteris strictinervis* Font. Some of the specimens, taken by themselves, might easily be mistaken for the one or the other of these species. I think that the fern that I reported to Dr. Newberry as *Aspidium fredericksburgense* (see p. 193 of his paper) is a form of the species now described. The fructification is much like that of *Aspidium pinnatifidum*.*

Aspidium monocarpum, sp. nov.

Pl. LXXXIII, Figs. 4–6, 6*a*; Pl. LXXXIV, Fig. 3, 3*a*.

Frond tripinnate. Pinnæ alternate. Pinnules of the lower part of the frond attached by a much widened base, inclined strongly forward,

*U. S. Geol. Survey, Monograph XV, Pl. XXI, Fig. 15*a*.

very slightly falcate, united to a considerable distance from the base, acute to subacute. Mid nerve slender but distinct, splitting into branches at the summit. Lateral nerves single. The ultimate pinnæ, in ascending toward the summit of the frond, pass through pinnæ with ovate acute lobes into those with serrate toothing, and finally into entire pinnules.

Sori, seen only on serrately toothed pinnæ, are very large, single in each segment or tooth, globose or subreniform in shape, attached to a club-shaped receptacle that is borne on the summit of a basal lateral nerve, which is directed obliquely upwards. They occupy the greater portion of the upper half of each segment or tooth. Nerves of the fertile pinnæ in a bundle in each segment or tooth, and splitting up flabellately into branches.

This fern, as shown in the fructification, is a new species. There are numerous good imprints of it, so that its character can be made out pretty well. It occurs in the same yellowish gray sandy shale that carries *Aspidium montanense.* Some of the sterile forms approach so near to some of *Aspidium montanense* that they can with difficulty be distinguished. The fructification, however, is entirely different. The pinnules and segments of this fern have more of the aspect of Cladophlebis than any form of *A. montanense.* They are more acute, more inclined forward, and have a broader base than those of the last-named fossil.

Pl. LXXXIII, Fig. 6, shows a fragment of a compound pinna from the lower part of the frond, and Fig. 6ª a portion of the same enlarged. Fig. 4 gives the ovately and serrately toothed pinnæ or pinnules from the upper part of the frond. Fig. 5 gives the termination of a compound pinna. Pl. LXXXIV, Fig. 3, gives a portion of a fertile compound pinna, and Fig. 3ª a fertile fragment enlarged to show sori and nerves.

Different portions of this fern, if taken alone, could be with difficulty distinguished from several Potomac plants. Some of the serrate toothed forms are exactly like some of the forms of *Pecopteris virginiensis;* some of the ovately lobed pinnæ much resemble some of the forms of *Aspidium heterophyllum.* In size and structure the sori are like those of *Polypodium fadyenioides* of the Potomac strata. The mode of attachment of the sori and the nervation of the fructified forms of *Polypodium dentatum* of the Potomac resemble those features in this fern, but the sori of the Potomac plant are smaller and of different shape.

Aspidium angustipinnatum Font., var. **montanense**, var. nov.

Pl. LXXXIV, Figs. 1, 1*a*.

This fern is represented by six imprints, some of which are well preserved and well characterized. Although somewhat different, it agrees in all essentials so well with *Aspidium angustipinnatum* Font., of the Virginia formation, that I do not think that they should be considered

as distinct species. Fig. 1 shows the normal forms of the specimens. These differ from the Virginia plant perhaps enough to make the Great Falls forms a variety. They do not, however, show any fructification. Most of the specimens are in a ferruginous rock, which is the material carrying the imprints of *Osmunda dicksonioides*. This appears to come from a different horizon from that yielding *Aspidium montanense*. Some of the forms approach pretty closely to some of those of the last-named plant, but the toothing of the pinnules is different. The normal pinnules are long and slender, rather remote, somewhat constricted at base, with the lower side decurrent by a narrow wing, which, in most of the pinnules, unites with the base of the next lower one. The margins show a shallow crenate toothing. The nerves are in the main like those of the Potomac plant. They are single in each crenate lobe, forking about midway their length, and diverging widely in the lobes.

Pecopteris montanensis, sp. nov.

Pl. LXXXIII, Fig. 1, 1*a*.

Frond bipinnate to bipinnatifid. Leaf substance thick, ultimate pinnæ alternate and subopposite. Rachises of different orders strong. Lower pinnules small, united at base for some distance up, spatulate to broadly elliptical in form, subacute, strongly convex in outline on the upper outer margin. Pinnules of the upper part of the frond and terminal portions of the ultimate pinnæ still more united, narrowly elliptical in form. Nerves single in each pinnule and lobe, strong, once forking, with branches widely diverging, the anterior branch ending in the tip of the pinnule or lobe and the posterior one in the upper outer margin.

This small fern is well characterized and seems to be new. As it shows only two specimens its full character can not be made out. For this reason I place the plant provisionally in the genus Pecopteris, as in foliage it is most nearly connected with it. In the form of its pinnules it is much like *Pachypteris ovata* Brongn., but the leaf substance is much thinner and the nerves are different. Fig. 1 gives pinnæ from the lower part of the frond and 1*a* gives several pinnules enlarged to show nervation.

Pecopteris Browniana? Dunker.

Five imprints of small fragments of a fern very near to *Pecopteris Browniana*, and most probably identical with it, occur in the collections. Most of them are in a ferruginous sandy shale of reddish color, which is the material that carries the impressions of *Osmunda dicksonioides*. These differ slightly from those that occur in grayish shale, which are nearer the typical forms. They are, however, imprints of the terminal portions of compound pinnæ, a part of the frond that usually shows much variation in the shape of the pinnules. The pinnules of these are

broader and proportionally somewhat shorter than the normal ones of this fern. All the forms, however, are near enough to *Pecopteris Browniana* to permit their assignment to that species with a high degree of probability.

Cladophlebis heterophylla sp. nov.: Pl. LXXXIV, Fig. 2.

Fronds bipinnate. Rachises stout and rigid. Pinnæ alternate, the basal ones much reduced in size, forming pinnules with a few broad, rounded and shallow lobes. Pinnules united at base, the lower ones of the pinnæ orbicular in shape, the others subquadrilateral, attached by a much broadened base, united at base, falcate, usually very obtuse and remote. Basal inferior pinnule of each pinna larger than the rest, showing three shallow rounded lobes, the lobation becoming less distinct in the upper part of the frond. Nerves not seen distinctly, but apparently forming a bundle that splits up flabellately into branches.

Fig. 2 gives the largest specimen of this fern. The basal inferior pinnules of the pinnæ are quite different from the rest. They are much larger and approximate in form the basal pinnæ, although much smaller than these. The general plan of the nervation, so far as it could be made out, is similar to that of the Acrostichides of the older Mesozoic of Virginia. The shape and size of the pinnules are like those of *Acrostichides microphyllum* of that formation. In the general character of the pinnules it may be compared also with *Cladophlebis parva* of the Potomac formation.

I think that this is the plant reported by me to Dr. Newberry as *Cladophlebis parva*, but the additional specimens show differences enough to separate them. In the absence of fructification, it would go more naturally into the genus Cladophlebis.

In size and the form of its pinnules, it resembles some of the small Gleichenias given by Heer from the Kome beds, and it is quite possible that fructification may be found that will show it to belong to that genus. Only two specimens were found, and its full character, even for the sterile forms, can not be regarded as made out.

Osmunda dicksonioides Font.

Numerous specimens of this fern occur. The imprints are in a ferruginous, indurated shale. They coincide exactly with the Potomac plant. This fossil, to judge from the character of the rock which contains it, occurs at a different horizon from *Aspidium montanense*. It must have been abundant in the Great Falls flora. The fructified form was not seen.

Thyrsopteris microloba? var. **alata** Font.

Two small specimens of a fern closely resembling the Potomac plant, *Thyrsopteris microloba*, var. *alata*, were seen in the collections. The

amount of material is not sufficient to permit positive identification, but in any case this fern is very near the Potomac plant and is of the same type.

Thyrsopteris rarinervis Font.

This fern shows numerous imprints. Some of them are very fine, being much better than any from the Potomac beds. Some of the forms approach more nearly Heer's *Asplenium dicksonianum* than do those of the Potomac fossils. The resemblance was seen in the latter fossils but, as stated, it was not so marked as in some of the Great Falls imprints.

Sequoia ambigua? Heer.

The collections contain three small and poorly preserved fragments of a conifer which is most probably *Sequoia ambigua*. Some of the leaves are preserved and are identical with those of that species. The amount of material does not permit a positive determination.

Sequoia rigida Heer.

There are in the collections four pretty well preserved impressions of a conifer that can not be distinguished from *Sequoia rigida*.

Sphenolepidium virginicum, Font.

Eight impressions of a conifer identical with *Sphenolepidium virginicum* of the Potomac formation were obtained. Most of them are poorly preserved and show a good deal of maceration, as if they had been floated long in water. To judge from the number of impressions of this plant that were found it must have been somewhat common in the Great Falls flora, standing next to *Taxodium ramosum*.

Taxodium (Glyptostrobus) ramosum Font.

This conifer shows twelve specimens. They are the best preserved of the coniferous fossils, giving in most cases the character of the plant quite distinctly. The specimens of it are more numerous than those of any other conifer of the Great Falls flora. It occurs along with the two preceding conifers and with *Thyrsopteris rarinervis* and *Aspidium montanense*, in a sandy shale.

Zamites montanensis sp. nov.

Pl. LXXXIV, Fig. 4.

Mr. R. S. Williams, of Great Falls, loaned Mr. Knowlton a beautiful imprint of a cycad which seems to be new. A drawing of it was made and is given in Pl. LXXXIV, Fig. 4, of this paper.

I have not seen the original, but the drawing gives the character so distinctly that a description can be given from it. The description is as follows: The leaf (compound) is narrowly elliptical in outline and small. It is abruptly pinnate, with a stout rigid midrib. The lower leaflets are lancet-shaped, short, remote, and stand at right angles with

the midrib. In ascending towards the tip of the compound leaf, the leaflets become linear in shape and are more closely approximate, until they touch. They are also nonfalcate, and toward the end of the leaf are obliquely attached to the midrib. The leaflets of the central part of the leaf are longest, giving the elliptical outline. Nerves, three in number, strong, parallel with each other and the margins of the leaflets.

The imprint shows the under side of the leaf uppermost, so that the midrib conceals the insertions of the leaflets. Taking as correct Heer's distinction between Zamites and Pterophyllum,* this imprint does not show positively which of the two it is. It seems, however, to agree best with Zamites and may provisionally be put in that genus. In the form of its leaflets it is quite near *Zamites speciosus* Heer,† agreeing pretty well with some of the features of the smaller forms of that species, but the leaflets are proportionately broader. The basal leaflets also are quite different, and the gradation from these into those higher up is not seen in Heer's plant.

As stated before, it is somewhat singular that neither Mr. Knowlton nor Mr. Weed seems to have discovered cycads. This certainly indicates that they are not generally distributed in the Great Falls strata, but are limited to particular horizons.

UNIVERSITY OF VIRGINIA,
February 10, 1892.

PLATE LXXXII.

Fig. 1. Aspidium montanense, n. sp. Pinnules from the lower part of the frond.
Fig. 2. Aspidium montanense, n. sp. Fragments of a fructified compound pinna.
Fig. 3. Aspidium montanense, n. sp. Detached pinnæ from the upper part of the frond.

PLATE LXXXIII.

Fig. 1. Pecopteris montanensis, n. sp.
Fig. 1*a*. Magnified portion of Fig. 1.
Fig. 2. Aspidium montanense, n. sp. Normal pinnules.
Fig. 3. Aspidium montanense, n. sp. Lobed pinnæ from the upper part of the frond.
Fig. 3*a*. Aspidium montanense, n. sp. Enlarged portion of Fig. 3.
Fig. 4. Aspidium monocarpum, n. sp. Serrate toothed pinnæ or pinnules from the upper part of the frond.
Fig. 5. Aspidium monocarpum, n. sp. The termination of a compound pinna.
Fig. 6. Aspidium monocarpum, n. sp. Pinnules from lower part of the frond.
Fig. 6*a*. Aspidium monocarpum, n. sp. Enlarged portion of Fig. 6.

PLATE LXXXIV.

Fig. 1. Aspidium angustipinnatum Font., var. montanense, n. var.
Fig. 1*a*. Enlarged portion of Fig. 1.
Fig. 2. Cladophlebis heterophylla, n. sp.
Fig. 3. Aspidium monocarpum, n. sp. Showing fertile portion of frond.
Fig. 3*a*. Enlarged portion of Fig. 3.
Fig. 4. Zamites montanensis, n. sp.

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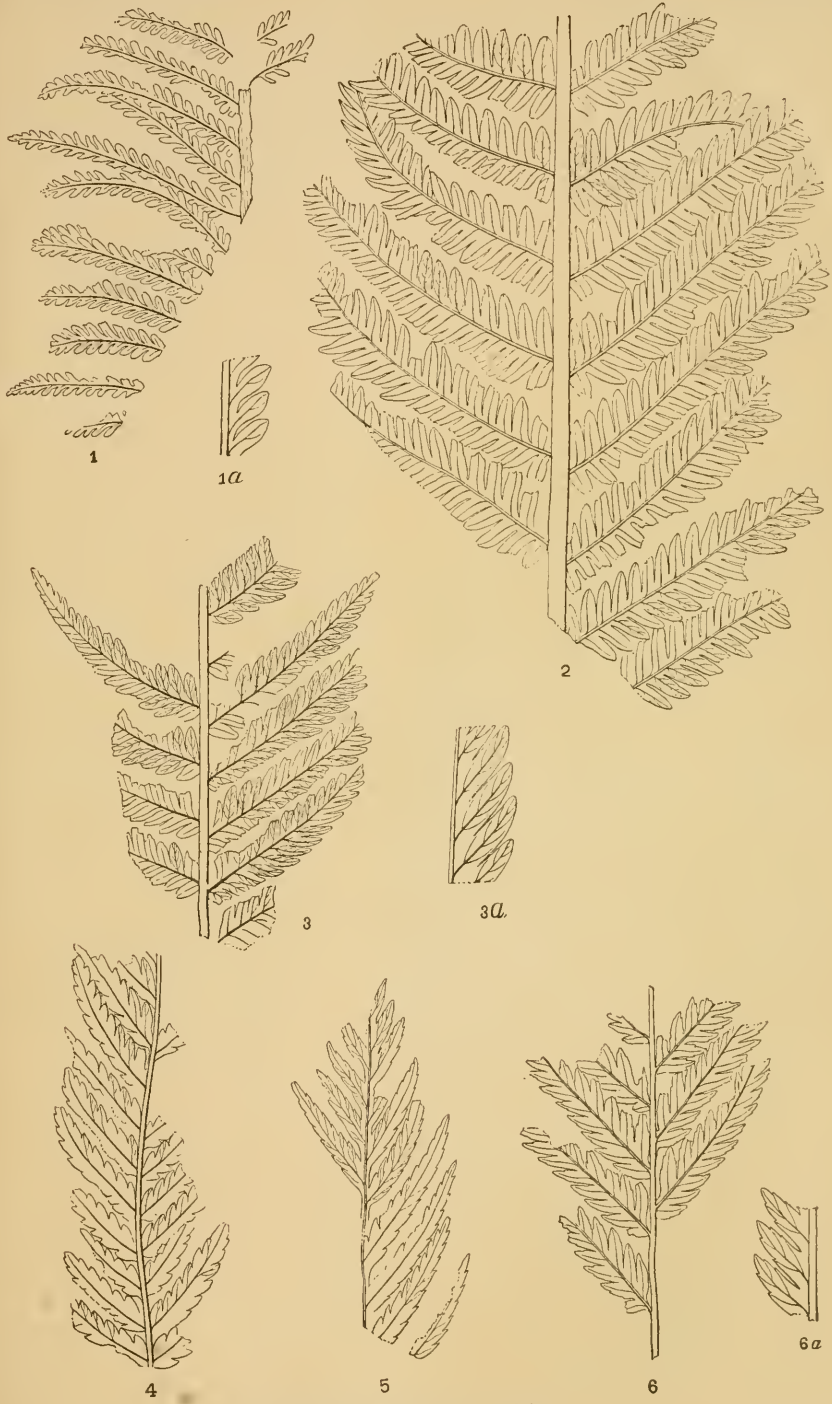
* Flor. foss. arct., vol. III, p. 62.

† Flor. foss. arct., vol. III Die Kreideflora de arctischen Zone, Pl. XIV, Fig. 11.

Aspidium montanense, new species.



1. *Pecopteris montanense*, new species.
2, 3. *Aspidium montanense*, new species.
4, 5, 6. *Aspidium monocarpum*, new species.

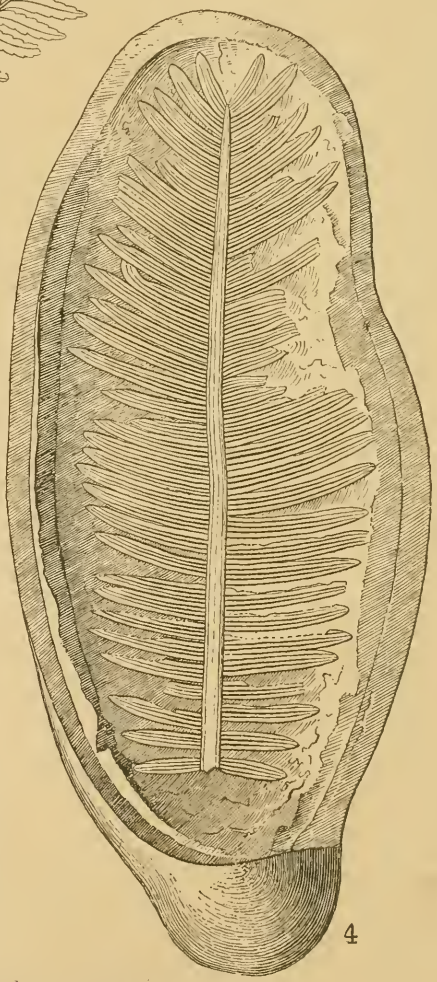
2

1

1a

3

3a



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1. *Aspidium angustipinnatum*, var. *montanense*, new variety.
2. *Cladophlebis heterophylla*, new species.
3. *Aspidium monocarpum*, new species.
4. *Zamites montanensis*, new species.