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THE CRETACEOUS FORMATION OF THE BLACK HILLS AS INDICATED BY THE FOSSIL PLANTS

BY

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WITH THE COLLABORATION OF

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ILLUSTRATIONS.

THE CRETACEOUS FORMATION OF THE BLACK HILLS AS INDICATED BY THE FOSSIL PLANTS.

By LESTER F. WARD.

GENERAL REMARK.

The Black Hills are an object lesson in geology. An isolated spur or outlier of the Rocky Mountains, but separated from the main range by valleys and plains of considerable width, they seem to stand alone as a landmark of the Great Plains, presenting from a distance a dark and frowning aspect, which has given them their name. Their elliptical form, the granitic nucleus of the central portion, and the series of successively higher formations that concentrically surround this nucleus, imbricated over one another and stretching away in all directions with diminishing dip, have been too often described to require redescription here.

The history of the discovery of the Black Hills has also often been written and need not be repeated, and we are therefore in condition to proceed directly to the consideration of the specific problems in hand, and may confine our attention almost exclusively to the one formation named in the title of this paper, viz, the Cretaceous. Indeed, the limitations of our subject enable us to leave out of account that part of the Cretaceous formation itself which has received the largest amount of attention from other writers, viz, the marine shell-bearing deposits which occupy its upper portion. These, not having thus far yielded any fossil plants, will be treated in this paper only in relation to the lower beds, and we are restricted to those deposits which lie between the Fort Benton shales above and the marine shell-bearing Jurassic formation below.

I. HISTORY OF OUR KNOWLEDGE OF THE CRETACEOUS OF THE BLACK HILLS.

The great exploring expeditions of Lewis and Clark, 1804–1806; of Maximilian, Prince of Neuwied, 1832; of Nicollet, 1839; and of Audubon, 1843, which so enriched our knowledge of the Great Northwest, all followed the valley of the Missouri River so closely as not to penetrate the Black Hills, and only vague mentions are to be found in the reports of these expeditions of a dark object looming up in the distance. But it was otherwise with the important expedition with which the name of John Jacob Astor is so intimately connected and which has been made famous by the eloquent pen of Washington Irving.[1] This expedition was made in 1811, under the immediate direction of Mr. Wilson P. Hunt. Its object was entirely mercantile and not at all scientific, yet many of the facts that were recorded in Mr. Hunt's notebook and by other members of the party and worked into the narrative twenty-five years afterwards, have a true scientific value—even to some extent a geological value. It is at least true that the exploring party left the Missouri River at the mouth of the Cheyenne, followed that river up some distance, crossed over to the valley of the Little Missouri, and from there skirted the northern limits of the Black Hills proper, and passed on to the Big Horn region. The greater part of the narative is taken up with descriptions of the mountains, the native Indians, and the wild animals that were met with. But soon after leaving the Missouri River the party encountered a fossil forest, which is described in the following terms:

> These plains, however, had not always been equally destitute of wood, as was evident from the trunks of trees which the travellers repeatedly met with, some still standing, others lying about in broken fragments, but all in a fossil state, having flourished in times long past. In these singular remains the original grain of the wood was still so distinct that they could be ascertained to be the ruins of oak trees. Several pieces of the fossil wood were selected by the men to serve as whetstones.[2]

There is no probability that these fossil trunks belonged to the Cretaceous formation, certainly not to the Lower Cretaceous, and they were probably the same as those now known to exist in the valley of the Little Missouri, especially in the vicinity of Gladstone, which are usually referred to the Fort Union group.

The approach of the party to the Black Hills is graphically described, but there is so much that is fanciful in the description that the scientific man must depend upon his own judgment as to what the facts were upon which these high-sounding accounts were based. To those who are acquainted with that country now it is not difficult to do this, and therefore the following description, perhaps the first that was ever made of the Black Hills, still possesses a scientific interest independent of the classic language in which it is couched:

> The Black Hills are chiefly composed of sandstone, and in many places are broken into savage cliffs and precipices, and present the most singular and fantastic forms; sometimes resembling towns and castellated fortresses. The ignorant inhabitants of plains are prone to clothe the mountains that bound their horizon with fanciful and superstitious attributes. Thus the wandering tribes of the prairies, who often behold clouds gathering round the summits of these hills, and lightning flashing, and thunder pealing from them, when all the neighboring plains are serene and sunny, consider them the abode of the genii or thunder spirits, who fabricate storms and

[1] Astoria, or Anecodotes of an Enterprise beyond the Rocky Mountains, by Washington Irving, in two volumes, Philadelphia, 1836.

[2] Loc. cit., Vol. I., p. 246.

tempests. On entering their defiles, therefore, they often hang offerings on the trees or place them on the rocks, to propitiate the invisible "lords of the mountains," and procure good weather and successful hunting; and they attach unusual significance to the echoes which haunt the precipices. This superstition may also have arisen, in part, from a natural phenomenon of a singular nature. In the most calm and serene weather, and at all times of the day or night, successive reports are now and then heard among these mountains resembling the discharge of several pieces of artillery. Similar reports were heard by Messrs. Lewis and Clarke in the Rocky Mountains, which they say were attributed by the Indians to the bursting of the rich mines of silver contained in the bosom of the mountains.[1]

There is probably considerable literature relating to the Black Hills which antedates the middle of the present century, resulting from various hunting and trapping expeditions and to some extent from early attempts at settlement of the country around their base; also from occasional gold hunting and prospecting parties that penetrated some distance into the interior. But such literature, if it exists, must be contained in the popular journals and newspapers and could scarcely be found by the most systematic search. The only mention that I have met with belonging to this class is one which very intimately concerns the subject of this paper, and is, upon the whole, somewhat remarkable. It is contained in the prose writings of Edgar Allen Poe, and occurs in The Thousand-and-Second Tale of Scheherazade. The poet, as all know, was in the habit of supporting much of his imagery by means of footnotes, purporting to be drawn from facts, and often embodying true scientific information. In this characteristic production occurs the following paragraph:

Leaving this island, we came to another where the forests were of solid stone, and so hard that they shivered to pieces the finest-tempered axes with which we endeavored to cut them down.

To this statement he appends a somewhat elaborate footnote, describing three fossil forests. One of these is in Texas, and the description is credited to Kennedy; another is the celebrated fossil forest near Cairo, in Egypt, of which he takes a rather extended account from the Asiatic Magazine. Following the first of these accounts by Kennedy and preceding the longer one relative to the Egyptian forest, he interpolates the following brief but highly significant paragraph:

This account, at first discredited, has since been corroborated by the discovery of a completely petrified forest near the head waters of the Chayenne, or Chienne River, which has its source in the Black Hills of the Rocky chain.[2]

It may never be known when, where, or how Poe came into possession of the data for this statement, but it seems altogether certain that the fossil forest referred to is none other than the one that I visited in 1893, in company with Professor and Mrs. Jenney, and from which the specimens of wood were collected which are further mentioned in this paper (infra, pp. 552, 642).

[1] Loc. cit., Vol. I., p. 253.

[2] The Works of the late Edgar Allan Poe, with Notices of His Life and Genius, by N. P. Willis, J. R. Lowell, and R. W. Griswold; in two volumes; Vol. I, Tales, New York, 1850, p. 139.

Our knowledge of the Black Hills, in so far as it is based on scientific reports, all bears a later date than any hitherto quoted. The important expedition of Lieutenant Warren, made in the year 1855, did not reach the Hills proper, for, as he says, "The routes traversed led over the Great Plains between the Missouri, the Platte, and the Shyenne, and nowhere entered the mountains." But the party was in full view of the Black Hills, and Lieutenant Warren makes the following remark with regard to them: "The Black Hills of Nebraska are believed to be composed of primitive rock, and are the eastern portion of the great mountain belt." Dr. Hayden accompanied this expedition, and his report follows that of Lieutenant Warren.[1] A map accompanies the report, showing much more fully than had any earlier map the numerous streams that have their origin in the Black Hills. Many fossils were collected on this expedition, some of them Cretaceous, which were fully described by Hall and Meek.[2]

This was the first of a series of similiar expeditions conducted by the United States Army, each of which made new inroads into the unexplored country. The report of the Secretary of War in 1858 contains Lieutenant Warren's later results, including expeditions in 1856 and 1857.[3] In these reports Lieutenant Warren gives a historical account of the whole country explored. The Black Hills were penetrated from the south as far as Inyankara, where the expedition was obliged to return on account of hostile Indians and insufficient force. Besides giving a tolerably clear description of the geographical position of the Black Hills, Lieutenant Warren makes a number of allusions to the geology, in which the Cretaceous formation is recognized.

Dr. Hayden accompanied each of the expeditions, and his report (pp. 676–747) constitutes the first really scientific contribution to the geology and natural history of the Black Hills. The section of the Cretaceous, however, given on page 681, does not come from the Black Hills, but from points near the Missouri River. Nevertheless, in view of its early date, it may be worth while to quote so much of it as refers to formation No. 1, afterwards known as the Dakota group:

> Yellowish and reddish friable sandstone, with alternations of dark and whitish clays. Seams and beds of impure lignite, fossil wood, impressions of dicotyledonous leaves; *Solen*, *Pectunculus*, *Cyprina*, etc., Lower Cretaceous.

The reference to fossil wood and lignite is significant, as is also the expression "Lower Cretaceous."

Fossil plants were collected from this horizon and referred to Dr. Newberry, who did not, however, determine them specifically, but referred them to thirteen genera, several of which are extinct. Two

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[1] Explorations in the Dacota Country in the Year 1855, by Lieut. G. K. Warren; Washington, 1856. Senate Ex. Doc. No. 76, Thirty-fourth Congress, first session.

[2] Mem. Am. Acad. Arts and Sci., new series, Vol. V, 1853, pp. 379ff.

[3] Message from the President of the United States to the two Houses of Congress at the Commencement of the Second Session of the Thirty-fifth Congress; Vol. II; Washington, 1858. House of Representatives, Ex. Doc. No. 2, pp. 620ff, 671ff.

of these genera, Credneria and Ettingshausenia, are characteristic of the Cenomanian of Europe, and from these and other facts Dr. Newberry argues that the beds can not be Triassic, but must be Cretaceous (see pp. 683–684).

These several reports were republished verbatim in 1875.[1]

By permission of the Secretary of War Dr. Hayden published certain of these results in the Proceedings of the Academy of Natural Sciences of Philadelphia for 1857,[2] and with the assistance of Mr. F. B. Meek, who determined the molluscan remains, he considerably extended these observations in a paper immediately following the last.[3]

In the first of these papers, speaking of formation No. 1, as seen near the mouth of the Judith River, Dr. Hayden says:

> Although the formation of which I am about to speak has already revealed many important facts, the organic contents of its strata differ so materially from those of any other with which I am acquainted in the Northwest, that we are unable to fix with certainty its position in the geological scale (p. 116).

The second paper contains considerable introductory matter of a geological character, with sections of the various strata in which the fossils were found. On page 128 is given a vertical section of the entire region, from the Carboniferous to the Miocene. The description of Cretaceous No. 1 is identical with the one already quoted, except that in place of the words "Lower Cretaceous" the following is substituted: "This bed is not positively known to belong to the Cretaceous system."

On page 125 the authors make the following important statement relative to their formation No. 1·

> The deposits above alluded to (at the mouth of Judith River) as probably on a parallel with beds seen near the mouth of Big Sioux River on the Missouri—forming No. 1 of the Nebraska section—are characterized, as stated in one of our former papers, by a group of fossils remarkably distinct from those occurring in any of the higher Northwestern formations, and there remains some doubt as to whether or not they are older than Cretaceous. The presence of the genus *Baculites* would seem to establish the fact that they belong to the Cretaceous epoch; while the occurrence in the same hand specimens with these remains of *Baculites*, of a species of *Hettangia*—a genus of bivalves, not known to occur in the Old World in newer formations than the Lias—would, on the other hand, indicate that these beds are older than Cretaceous. For the present, however, we express no decided opinion on this point, but content ourselves with the remark that we are inclined to think that they hold a position near the base of the Cretaceous system and are probably on a parallel with the Neocomian of the Old World, though they may be older.

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[1] Engineer Department, U. S. Army. Preliminary Report of Explorations in Nebraska and Dakota, in the Years 1855–'56–'57, by Lieut. G. K. Warren. Reprint. Washington, 1875, pp. 1–125, 1 map.

[2] Explorations under the War Department; notes explanatory of a map and section illustrating the geological structure of the country bordering on the Missouri River, from the mouth of the Platte River to Fort Benton, in lat. 47° 30′ N., long. 110° 30′ W., by F. V. Hayden: Proc. Acad. Nat. Sci., Phil., Vol. IX, 1857, Philadelphia, 1858, pp. 109–116.

[3] Descriptions of New Species and Genera of Fossils, collected by Dr. F. V. Hayden in Nebraska Territory, under the direction of Lieut. G. K. Warren, U. S. topographical engineer; with some remarks on the Tertiary and Cretaceous formations of the Northwest, and the parallelism of the latter with those of other portions of the United States and Territories, by F. B. Meek and F. V. Hayden; loc. cit., pp. 117–148.

Furthermore, under the head of "Conclusions," on page 133, they say:

Although the weight of evidence thus far favors the conclusion that this lower series is of the age of the lower Green Sand, or Neocomian of the Old World, we yet want *positive* evidence that portions of it may not be older than any part of the Cretaceous system.

In a subsequent paper, published one year later,[1] the same authors extend these considerations to include their researches in the Black Hills, and this may be regarded as the first scientific treatment of the geology of the Black Hills. Relative to their formation No. 1, they say in this paper:

It will be remembered, we have in all our published papers, when speaking of that portion of the Nebraska section composing No. 1, expressed doubts respecting its age. We placed it provisionally as the basis formation of the Cretaceous series, but at the same time stated it was not positively known to belong to the Cretaceous system (p. 44).

They proceed to reproduce the passage last quoted, and add:

Although we have little direct additional evidence at this time in regard to the age of this series, as we have always understood it, we now know that from beneath its lower beds, around the base of the Black Hills, there rises a series of very similar strata, as may be seen by the foregoing section, separated from its base by no well-marked line of demarcation, and containing many fossils closely similar to those considered characteristic of the Jurassic system of the Old World. At the same time we have failed to recognize amongst these fossils any forms peculiar to the Cretaceous epoch, or even very nearly analogous to species common in rocks of that age. . . .

Inasmuch, however, as numerous leaves beyond a doubt belonging to dicotyledonous trees, closely analogous to the oaks, willows, and other existing forest trees, are known to occur in No. 1 along the Missouri, near the Big Sioux, and in northeastern Kansas, and we have a *Baculite* from similar beds, apparently of the same age, near the mouth of Judith River, on the upper Missouri—while we also learn from the letters and notes of our deceased friend, Mr. Henry Pratten, that he saw a species of *Baculite* in formations presenting the same characters, and seeming to occupy the same position, along the Platte above Fort Laramie, we think we hazard little in viewing at least a considerable portion of No. 1 as belonging to the Cretaceous system.

Another fact favoring the opinion that No. 1, even down as low as we have provisionally carried it in the Black Hills section, probably belongs to the Lower Cretaceous, is the occurrence at its base of a bed containing *Ammonites* and *Ostrea*, along with *Unio*, *Planorbis*, and *Paludina*; an association of fossils which, in that position, carries the mind rather to the Wealden than to older formations.

The occurrence of these forms at this horizon also leads us to suspect that a considerable portion of the estuary beds at the mouth of Judith River, above Fort Union, in regard to the age of which we have been so much puzzled, may be, as first suggested by Dr. Leidy, a representative of the Wealden, and, as we were then inclined to suppose, belong to our No. 1. . . .

Since we know that there is a similar group of beds at the base of No. 1, as we

[1] Descriptions of New Organic Remains collected in Nebraska Territory in the year 1857, by Dr. F. V. Hayden, Geologist to the Exploring Expedition under the command of Lieut. G. K. Warren, Top. Eng. U. S. Army, together with some remarks on the Geology of the Black Hills and portions of the surrounding country, by F. B. Meek and F. V. Hayden, ibid., Vol. X, Philadelphia, 1859, pp. 41-59.

now understand it, near the Black Hills, containing a mingling of fresh-water and marine fossils, although we are not sure any of them are specifically identical with those found near the Judith, we are inclined to think our first views in regard to these Judith River formations will prove to be correct, or in other words, the beds from which the saurian remains described by Dr. Leidy were obtained, will yet prove to be a part of the series we include in No. 1 of the Black Hills section. This view receives additional support, too, from the fact that the Judith River fresh-water or estuary formations were often seen much upheaved and distorted, while around the Black Hills the Tertiary deposits appear to lie undisturbed upon the upheaved older rocks, in such a manner as to indicate that the last period of disturbance among the strata of this region occurred after the close of the Cretaceous epoch, but previous to the deposition of the Tertiary (pp. 45, 46).

From all this it is perfectly clear that both Meek and Hayden originally regarded the Dakota group as true Lower Cretaceous, i. e., as lying below the Cenomanian of Europe. Their argument seems to have been in the main in the direction of proving that it could not be lower than Cretaceous, i. e., that it could not be Jurassic or Triassic. It is true that the fossil plants, as already indicated by Newberry, pointed to a Middle Cretaceous age, and not long afterwards quite large collections of plants were made and studied by Heer and others, who were disposed to place the beds still higher.

But it is also true that the determinations of Meek, Hayden, and Leidy, based entirely on the scanty animal remains, and pointing to the Lower Cretaceous, Neocomian, or Wealden, related to beds in which there were very few if any vegetable remains, and which lay below the plant-bearing horizon. The plant beds consist of dark brown, highly ferruginous sandstone, often becoming clay ironstone, and these still constitute the typical Dakota sandstone. Now the lower beds holding the animal remains do not conform to this description, but are rather light colored, coarse sandstones with only occasional yellow ferruginous bands. They have a considerable thickness, and there is no antecedent improbability in their belonging to a lower horizon.

The next important paper was published four years later by Dr. Hayden,[1] but was read July 19, 1861, and is little more than a re-elaboration of the subjects treated in the papers already quoted from. In this paper Dr. Hayden continues to refer to No. 1 as Lower Cretaceous.

Dr. Hayden accompanied, as geologist, the expedition in charge of Col. William F. Raynolds to explore the head waters of the Yellowstone and Missouri rivers, in the years 1859 and 1860. His report was long delayed, but appeared in 1869.[2] This expedition did not, of course, purport to explore the Black Hills, nevertheless they were entered at various points and are dealt with more or less extensively in this report.

[1] On the Geology and Natural History of the Upper Missouri: Trans. Am. Phil. Soc., Vol. XII, new series; Philadelphia, 1863, pp. 1-218, 1 map.

[2] Geological Report of the Exploration of the Yellowstone and Missouri rivers, by Dr. F. V. Hayden, assistant, under the direction of Capt. (now Lieut. Col. and Bvt. Brig. Gen.) W. F. Raynolds, Corps of Engineers, 1859-'60; Washington, 1869.

One paragraph relates exclusively to Dakota No. 1, and has more than usual interest in the present connection:

In the vicinity of the Black Hills, as well as in several other localities, which will be alluded to hereafter in their proper places, are a series of doubtful beds, between the well-marked Jurassic and the Cretaceous. These rocks are quite variable in their character, sometimes composed, for the most part, of a loose material, clays and grits; again of compact concretionary sand or limestones. But few organic remains have as yet been found in these beds, although the most diligent search has been made, and those are quite uncharacteristic, so that their position remains in doubt. I have therefore ventured to call them beds of transition, or passage between the close of the Jurassic period and the dawn of animal life in the Cretaceous. The locality where the following section of these doubtful beds was taken is near the source of the Little Missouri, upon the northeastern side of the Black Hills (pp. 45–46).

A section of the beds follows in harmony with this statement.

Dr. Hayden continued his explorations during the subsequent years, and in 1867 was begun the series of official reports made by him as Geologist in Charge of the United States Geological Survey of the Territories. The first of these annual reports, which related to the Territory then embraced in Nebraska, was for the year 1867. Only a small edition of this report was published at the time, and the same is true of the two subsequent ones for 1868 and 1869; but in 1873 these three reports were republished in a small volume, and it is in this form that they are now usually quoted.[1] In the first of these reports the Black Hills are scarcely treated, but the general section is reproduced unchanged from earlier publications. In the report for 1868 the Black Hills receive special treatment; their geographical position is carefully indicated, and their topographic features described. The geology is also dealt with, and the following passages should be specially noted:

The geological structure of the Black Hills may be mentioned briefly in this connection. The nucleus or central portion is composed of red feldspathic granite, with a series of metamorphic slates and schists superimposed, and thence upon each side of the axis of elevation the various fossiliferous formations of this region follow in their order to the summits of the Cretaceous, the whole inclining against the granitoid rocks at a greater or less angle. There seems to be no unconformability in these fossiliferous rocks from the Potsdam inclusive to the top of the Cretaceous.

From these facts we draw the inference that prior to the elevation of the Black Hills, which must have occurred after the deposition of the Cretaceous rocks, all these formations presented an unbroken continuity over the whole area occupied by these mountains. This is an important conclusion, and we shall hereafter see its application to other ranges, and also to the Rocky Mountain Range taken in the aggregate (pp. 69–70).

In the report for 1869 Dr. Hayden goes more fully into the geological formation, and this report throws great light on the position of the lowest Cretaceous beds:

I believe that a thin remnant of this belt extends far south to New Mexico, but it is often so obscured, or so easily concealed, that I have been continually in doubt in

[1] First, Second, and Third Annual Reports of the United States Geological Survey of the Territories for the Years 1867, 1868, and 1869, under the Department of the Interior; Washington, 1873.

regard to its existence. Coextensive with all the mountain ranges is a large series of beds above the Jurassic belt which belong to the Cretaceous period, the upper and middle portions of which are everywhere indicated by characteristic fossil remains, as seen on the Missouri River, where they were first studied by Mr. F. B. Meek and the writer. The Cretaceous rocks present five well-marked divisions, Nos 1, 2, 3, 4, and 5, or Dakota group, Fort Benton group, Niobrara division, Fort Pierre group, and Fox Hill beds. On the Lower Missouri No. 1, or Dakota group, is characterized by several species of marine shells and a profusion of impressions of deciduous leaves; but along the margins of the mountain elevations I have never been able to discover a single specimen of organic remains that would establish the age of the rocks. I only know that there is a series of beds of remarkable persistency all along the margin of the mountain ranges, holding a position between well-defined Cretaceous No. 2 and Jurassic beds, and in my previous reports I have called them transition beds, or No. 1. They consist of a series of layers of yellow and gray, more or less fine-grained sandstones and pudding stones, with some intercalated layers of arenaceous clays. In almost all cases there is associated with these beds a thin series of carbonaceous clays, which sometimes becomes impure coal, and contains masses of silicified wood, etc. On the west side of the Black Hills they assume a singularly massive appearance, nearly horizontal, 200 to 250 feet thick, and are called Fortification Rocks. Here also occurs a thin bed of carbonaceous clay. On the eastern slope of the Big Horn Mountains I observed this same series of beds in the summer of 1859, holding a position between Cretaceous No. 2 and the Jurassic marls, with a considerable thickness of earthy lignite, large quantities of petrified wood, and numerous large uncharacteristic bones, which Dr. Leidy regarded as belonging to some huge saurian.

There are very few points of resemblance between these beds and those which form the Dakota group, as seen in Kansas and Nebraska.

All the evidence therefore that I have had to guide me in regard to these beds along the margin of the mountain ranges has been their position (pp. 113–114).

Dr. Hayden's reports for the years 1870–1873 relate chiefly to the Great Plains and other parts of the Western country, and we find no additional matter bearing directly upon the Black Hills until the appearance of Captain Ludlow's report of the military expedition of 1874, which again penetrated this region. The geologist of this expedition was Dr. N. H. Winchell, and his report follows immediately that of Captain Ludlow.[1]

Professor Winchell gives numerous sections of the strata of the Black Hills at different points, but is very cautious with regard to their correlation with other beds, and I find no indication that he differs from the views expressed by Dr. Hayden with regard to the position of the Cretaceous strata, but he does not make use of the sections of Meek and Hayden. The legend of the map does not contain any of the general geological terms, such, for example, as Cretaceous, and the beds which were referred to the Dakota group by other authors are here simply called "Dakota sandstone." They are not represented as extending entirely around the hills, but are put down in patches along the eastern and western sides and at the southern extremity, with

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[1] Report of a Reconnaissance of the Black Hills of Dakota, made in the summer of 1874, by William Ludlow, Captain of Engineers, Bvt. Lieut. Col., U. S. Army, Chief Engineer, Department of Dakota. Washington, 1875. Geological Report, by N. H. Winchell, State Geologist of Minnesota, pp. 21–66, 1 map.

large intervals of uncolored regions. It is evident that Professor Winchell did not observe any subdivision of these beds.

This brings us, in chronologic sequence, to the most important geological survey that has been made of the Black Hills, even down to this date, viz, that of Newton and Jenney, in 1875, the geological part of which was, unfortunately, not published until 1880.[1]

The manuscript of this report was prepared somewhat promptly, and Professor Jenney's portion, relating to the mineral resources, was published by Congress in 1876, as Senate Executive Document No. 51, of the first session of the Forty-fourth Congress, but the geological report and the rest of the manuscript remained unpublished for four years, when it appeared as above, having been revised and edited by Mr. G. K. Gilbert. In the biographical notice of Dr. J. S. Newberry the origin of the expedition is stated in the following language:

> In 1875 the Secretary of the Interior applied to Professor Henry, the head of the Smithsonian Institution, requesting him to suggest a geologist to take charge of an exploration of the Black Hills, Dakota, for the purpose of ascertaining the extent and value of the gold deposits discovered there. This request was, by Professor Henry, referred to me, and in accordance with my nominations Mr. W. P. Jenney was appointed geologist and Mr. H. Newton his assistant. The purely geological work of the expedition was for the most part performed by Mr. Newton, and the report now committed to you for publication is the result.

Professor Newton's report on the geology had long been completed and appears to have been in nearly perfect form at the time of his death in 1877. It forms the first part of the volume, occupying 220 pages, and the report is accompanied by an atlas containing three maps. The colored geological map is far more complete than any previous map of the Black Hills and shows, as none of the former ones had done, the remarkably symmetrical character of their geological relations. It shows first that there is a narrow ring of Potsdam sandstone, then a wide belt of Carboniferous limestone; next an encircling trough, aptly compared by Professor Newton to a moat, of red sandy gypsiferous clays, in which is included a purple limestone terrace, all of which is supposed to be Triassic, and to be the equivalent of the "Red Beds" of more southern regions. Skirting this is a very narrow border of highly fossiliferous light-colored Jurassic clays or marls. Then come the foothills, which consist of Cretaceous sandstones and shales referred by Professor Newton to the Dakota No. 1 of Meek and Hayden's section. These slope back to the dark shales of the Fort Benton group, which are succeeded by higher Cretaceous beds that extend to the plains and pass under the Bad Lands of the White River formation.

We are of course concerned here only with the Cretaceous, and strictly speaking only with the lowest member recognized by Professor Newton. In his report he takes up the several subdivisions of the Cretaceous in

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[1]Report on the Geology and Resources of the Black Hills of Dakota, with Atlas, by Henry Newton and Walter P. Jenney. Dept. Int., U. S. Geog. and Geol. Surv. Rocky Mountain Region, J. W. Powell in Charge. Washington, 1880.

their descending order, but uses the numbers of Meek and Hayden. He therefore begins with No. 5 (the Fox Hills group), and deals respectively with this, with No. 4 (the Fort Pierre group), No. 3 (the Niobrara group), and No. 2 (the Fort Benton group), concluding with No. 1 (the Dakota group), under which he includes all that series of rocks which lie between the black shales of the Fort Benton and the Jurassic beds.

The description of this formation is taken almost literally from the numerous memoirs and reports previously published by Meek and Hayden, and is as follows:

Yellowish, reddish, and occasionally white sandstone, with at places alternations of various-colored clays and beds and seams of impure lignite; also silicified wood, and great numbers of leaves of the higher types of dicotyledonous trees, with casts of *Pharella? Dakotensis*, *Trigonarca Siouxensis*, etc. (p. 174).

It will be observed that under localities quoted Professor Newton does not even mention the Black Hills, but proceeds immediately to characterize the formation as observed in the Black Hills in the following language:

Black Hills.—Prominently developed, forming the capping rock to the foothills that surround the Hills on all sides, appears with its characteristic composition—coarse yellow or red sandstones with discontinuous variegated clays. At places a considerable thickness of very soft and fine white sandstone appears at the base. Elsewhere considerable portions are of hard, dense quartzite. No animal fossils were found, but many remnants of plants—in no case more than mere coaly fragments.

Thickness, 250 to 400 feet.

The rim of Cretaceous strata which encircles the Hills dips outward on all sides or away from the axis of upheaval. The strata begin with the foothills that border the outer edge of the valley. The Dakota sandstone, resting conformably upon the Jura, forms the capping rock of the foothill ridge, and dips outward at various angles from 10° to 40°. Just as the Cretaceous encircles the outcrop of the underlying Jura and Trias, so the different overlying groups of the Cretaceous—the Fort Benton, the Niobrara, the Fort Pierre, and the Fox Hills—succeed each other in regular order, forming a series of concentric ridges that decrease in altitude as the distance from the Hills increases (p. 175).

This description is further reinforced by the following more special characterization:

Taking up the groups now in order, the first to describe is the Dakota. Typically it is a coarse sandstone, generally conglomeratic, yellowish in color, and stained red in places by the oxidation of the iron contained in its nodules. Sometimes the sandstone is white in color and uniform and fine in texture, and in several places large portions of the formation consist of intensely hard, glassy, and compact quartzite, white or brownish in color, and having the density, toughness, sharpness, and conchoidal fracture of typical flint. The quartzitic development was especially observed at the southern end of the Hills, where the Dakota expands into a plateau, and in the region north of Warren Peaks, but it is not confined to those localities (p. 176).

The general relation of these beds to those underlying them in the Black Hills is admirably shown in two sections on pages 140 and 141 of that volume, which are reproduced below as figs. 117 and 118.

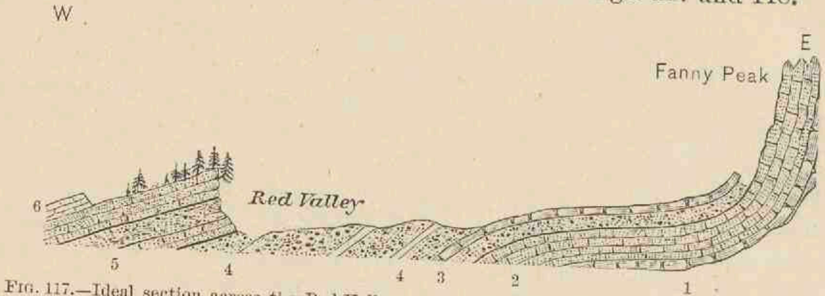


FIG. 117.—Ideal section across the Red Valley at Camp Jenney, showing the foothills at the left and Fanny Peak at the right. (1) Carboniferous limestone; (2) Red sandstone (Carboniferous); (3) Purple limestone (Red Beds); (4) Red clays with gypsum (Red Beds); (5) Jura; (6) Cretaceous.

Upon the geological map accompanying this report have been based all subsequent ones, and very few additions have been made. It is reproduced here with very little change except as regards towns, railroads, etc., resulting from the settlement of the country since that date, and may serve as a general index map of that region (see Pl. LIII).

FIG. 118.—Ideal section across Red Valley on Amphibious Creek.[1] (1) Carboniferous; (2) Red sandstones and clay (Red Beds); (3) Purple limestone (Red Beds); (4) Red clay with gypsum (Red Beds); (5) Jura; (6) Cretaceous sandstone capping the foothills.

After the appearance of this report a long interval elapsed before any further special discussion of the geology of the Black Hills took place, during which time the country was being rapidly settled and the more important locations were being seized upon as sites for towns, while an agricultural population was gradually encroaching from without. A State school of mines was established at Rapid City and, in addition to mining interests, some local attention was being paid to geology.

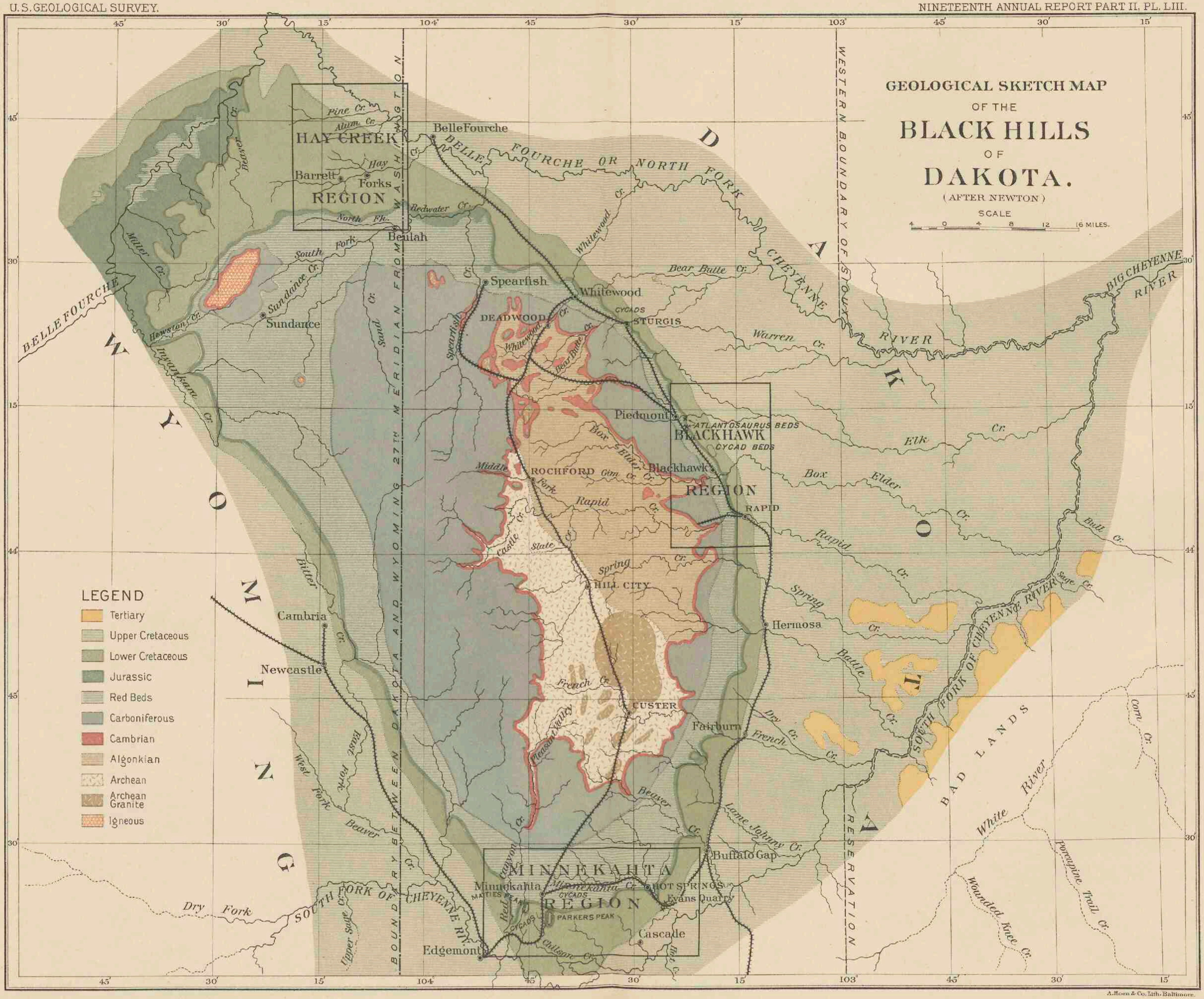
In the year 1888 two papers, by F. R. Carpenter and W. O. Crosby, appeared on the geology of the Black Hills, the priority of which I have not been able to determine.[2]

Each of these papers is an important contribution, and that of Mr. Carpenter contains a map in which the drainage and all the important

[1] Amphibious Creek is the name given in the Geology of the Black Hills to the stream now called Beaver Creek, which in cutting through the rim forms the canyon known as Buffalo Gap. It is unfortunate that the name should have been changed, as there are several other Beaver Creeks in the Black Hills, and the Board on Geographic Names would do well to restore it.

[2] Notes on the Geology of the Black Hills, by Franklin R. Carpenter; Preliminary Report of the Dakota School of Mines upon the Geology, Mineral Resources, and Mills of the Black Hills of Dakota. Rapid City, 1888, pp. 11-52.

Geology of the Black Hills of Dakota, by W. O. Crosby: Proc. Bost. Soc. Nat. Hist., Vol. XXIII, pp. 488-517. Read March 7, 1888.



A. Hoen & Co. Lith. Baltimore.

towns are shown, as well as the general geology. Some considerable advance is made in the knowledge of the geological formations, but it relates principally to the lower beds. The Cretaceous assumes importance only in connection with the discussion of the age of the uplift, which was formerly supposed to be entirely post-Cretaceous; but evidence is adduced in these papers to show that much of the material, even of the lowest Cretaceous, is derived from the older and more central deposits, which must therefore have been elevated at an earlier date. Nothing is here said about subdividing the Dakota group of Newton, and the matter remained in all respects in its original form.

In the summer of 1889 Professor Van Hise, of the U. S. Geological Survey, and Mr. C. W. Hall made a "vacation trip into the Black Hills of South Dakota," and at the meeting of the Minnesota Academy of Natural Sciences on December 3 of that year Mr. Hall read a paper before that academy, an abstract of which appeared in its proceedings of that date.[1] So far as this abstract shows their investigations were confined almost exclusively to pre-Cambrian strata, and the Cretaceous is not mentioned.

In this rapid survey of the history of the discovery of the Cretaceous in the Black Hills and of the Dakota group in general, I have been obliged to leave out of account a series of events connected with the subject in a general way, but without relation to the Black Hills, consisting in the tracing of the Dakota group across the plains from Minnesota to Kansas, the discovery of an immense flora and its elaboration at the hands of Heer,[2] Newberry,[3] and Lesquereux,[4] accompanied by an animated discussion as to the age of the Dakota group.

After numerous mistakes, due to conclusions drawn from insufficient material, to the infancy of the science of fossil plants, and to preconceptions based upon Old World geology, a general consensus was at

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[1] Bulletin of the Minnesota Academy of Natural Sciences, Vol. III, No. 2. Proceedings and Accompanying Papers, 1887–1889, Minneapolis, 1891, pp. 185–186.

[2] Les Phyllites Crétacées du Nebraska, par MM. les Prof. J. Capellini et O. Heer: Mem. Soc. Helv. Sci. Nat., Vol. XXII, No. 1, Zurich, 1866, 22 pp., 4 pl. Sur les plantes fossiles du Nebraska, par Osw. Heer: loc. cit., pp. 11–22, Pl. I–IV.

[3] Notes on the Later Extinct Floras of North America, with Descriptions of some New Species of Fossil Plants from the Cretaceous and Tertiary Strata, by J. S. Newberry: Ann. Lyc. Nat. Hist., Vol. IX, New York, April, 1868, pp. 1–76.

Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States; Department of the Interior, U. S. Geol. and Geogr. Surv. Terr., Washington, 1878, 4°, 26 pl.

[4] On some Cretaceous Fossil Plants from Nebraska, by Leo Lesquereux: Am. Jour. Sci., 2d ser., Vol. XLVI, July, 1868, pp. 91–105.

Contributions to the Fossil Flora of the Western Territories, Part I; The Cretaceous Flora, by Leo Lesquereux: Rept. U. S. Geol. Surv. Terr., F. V. Hayden, Geologist in Charge, Vol. VI, 4°, Washington, 1874, 136 pp., 30 pl.

A Review of the Cretaceous Flora of North America, by Leo Lesquereux: Eighth Ann. Rept. U. S. Geol. and Geogr. Surv. Terr., for the year 1874, F. V. Hayden, U. S. Geologist, Washington, 1876, pp. 316–365, pls. i–viii.

Contributions to the Fossil Flora of the Western Territories, Part III; The Cretaceous and Tertiary Floras, by Leo Lesquereux: Department of the Interior; Rept. U. S. Geol. Surv. Terr., F. V. Hayden, Geologist in Charge, Vol, VIII, 4°. Washington, 1883. Description and Enumeration of Species of the American Dakota Group Formation, pp. 25–107, pls. i–xvii.

The Flora of the Dakota Group, A Posthumous Work, by Leo Lesquereux, edited by F. H. Knowlton: Mon. U. S. Geol. Survey, Vol. XVII, 4°, Washington, 1892, 400 pp., 66 pl.

last reached which placed the Dakota group into substantial correlation with the Cenomanian of Europe. This view, based almost exclusively on the fossil plants, had become so firmly established that it resulted in a general feeling that Dr. Hayden, Mr. Meek, and others had made a great mistake in referring any of the beds embraced in their Cretaceous No. 1 to the Lower Cretaceous in any sense other than that they were the lowest Cretaceous beds represented in North American geology, and the opinion had come to prevail that there was no Lower Cretaceous in the Rocky Mountain region.

But simultaneously with the latter part of this period investigations in British America, on the Queen Charlotte Islands, in California, in Texas, and in Virginia had led to the certainty of the existence of true Lower Cretaceous beds in each of those regions, and had brought to light the Kootanie, the Queen Charlotte group, the Shasta group, the Comanche series, and the Potomac formation. I had myself been engaged in the study of the Lower Cretaceous flora of the United States, and especially of the Potomac formation, since the year 1885, and had examined a number of the Lower Cretaceous areas in other parts of the country. In 1883 I visited the Great Falls of the Missouri in company with Dr. C. A. White, and I observed that the rocks in that region which Dr. White, in harmony with the tradition of the time, referred to the Dakota group were entirely different in character from the well-known brown sandstone which yields the flora of that group, and I even dared to suspect that such a vast thickness of these beds as is displayed on the Upper Missouri could scarcely all belong to the Dakota group. In 1888, or thereabouts, Mr. R. S. Williams made a collection of fossil plants at the town of Great Falls, which were referred to Dr. Newberry for determination and were described by him in the year 1891.[1] He found them to agree in all essential respects with forms of the Kootanie, as made known by Sir William Dawson, and thus was established the true Lower Cretaceous age of these deposits. Subsequent discoveries have only confirmed this conclusion, and considerable additional evidence has been brought to light. Collections made by Knowlton, Peale, and Weed were elaborated by Professor Fontaine,[2] and in 1895 I visited the region myself and made a much larger collection than any of the previous ones, chiefly from Cascade County, some 25 miles southeast of Great Falls, between the Little Belt and High Wood Mountains, from coal mines in the same formation. This collection has also been studied and reported upon by Professor Fontaine, but his report is not yet published. Suffice it to say that all this material agrees in supporting the conclusion reached by Dr. Newberry as to the substantial identity of this flora with that of the Kootanie beds of British America.

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[1] The flora of the Great Falls coal field, Montana, by J. S. Newberry: Am. Jour. Sci., 3d series, Vol. XLI, March, 1891, pp. 191-201, pl. xiv.

[2] Description of some fossil plants from the Great Falls coal field of Montana, by William M. Fontaine: Proc. U. S. Nat. Mus., Vol. XV, Washington, 1892, pp. 487-495, pls. lxxxii-lxxxiv.

A somewhat careful study of the flora of the Amboy clays and of beds of practically the same age on the shores of the Chesapeake Bay and across the State of Maryland to the Potomac had led me to the conclusion that these deposits also lie below the line which should properly separate the Upper from the Lower Cretaceous. Investigations in Alabama and other Southern States had further shown the virtual identity in age of the Tuscaloosa formation and the Amboy clays. The Comanche series had yielded a few fossil plants, which proved to be at least as old as the oldest Potomac beds.[1] All these results, taken together, had led me to believe that the true Lower Cretaceous was really very widespread, and that it would be found in many parts of the West where it had not hitherto been suspected to exist.

In the investigation of the Potomac formation in Maryland the subject of fossil cycads had necessarily become prominent, and I arrived at the conclusion that all the trunks of this character that had been discovered in Maryland are derived from the older beds, which I call the Basal Potomac. Professor Cragin had obtained a fragment from Kansas which certainly belongs to a cycad trunk and which he described as *Cycadeoidea munita* in 1892.[2] He supposed that this fragment came from the Cheyenne sandstone, but after having visited the locality I am satisfied that this could not have been the case, and, taking all the evidence into account, I am inclined to believe that it had weathered out from the base of the true Dakota group, perhaps from the Reeder sandstone.[3]

I mention the cycadean trunks because it was through these that my interest was first attracted to the Black Hills. In February, 1893, the Smithsonian Institution received a letter from Mr. F. H. Cole, at Hot Springs, South Dakota, a dealer in specimens, inclosing photographs of certain petrifactions found in that vicinity, which he said had been called "cycads." The letter and photographs were referred to me on the presumption that these objects were of vegetable origin. I at once perceived that they were fossil cycadean trunks closely resembling those collected by Tyson in 1860 in the iron-ore clays of Maryland and named by Professor Fontaine *Tysonia marylandica*, and, therefore, also similar to the forms found by Mantell and others in the early part of the century in the Purbeck beds on the Isle of Portland and at other points in the south of England. Being greatly interested in the discovery, I recommended that the owner of the fossils be requested to send on a specimen for examination. The request was complied with, and the specimens proved to be all that I had expected. I therefore made the further recommendation that negotiations be entered into

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[1] Notes on some fossil plants from the Trinity division of the Comanche series of Texas, by William M. Fontaine: Proc. U. S. Nat. Mus., Vol. XVI, Washington, 1893, pp. 261-282, pl. xxxvi-xliii.

[2] Contributions to the palæontology of the Plains, No. 1, by F. W. Cragin: Bull. Washburn College Lab. Nat. Hist., Topeka, Vol. II, No. 10, 1889, pp. 65-68.

[3] See Mr. C. N. Gould's paper in Am. Jour. Sci., 4th series, Vol. V, March, 1898, pp. 173, 174.

with a view to the purchase of the collection of six specimens, which were offered for sale. This recommendation was also adopted; the collection was purchaséd, and arrived in May, 1893.[1]

Hot Springs is located on the Red Beds in the valley of the Minnekahta Creek, or Fall River, and it would have been natural to suppose that the cycad trunks had come either from these or from the Jurassic which borders it had it not been stated that they were found "on a high hill." My interest was, of course, strongly aroused to know the stratigraphical position of the beds in which they occurred, and therefore early in September I made an expedition to the region for the purpose of determining it if possible. I had previously corresponded with Mr. F. H. Cole, of Hot Springs, from whom the specimens had been purchased. I had also written to Professor Jenney, who was then at Deadwood, and who kindly consented to join me on my arrival and aid me in the investigation. After considerable search and some difficulty the locality was at length found. The details of this expedition are given below (p. 552).

The general resemblance of these cycad trunks to those that have been discovered in various parts of the world in beds below the Middle Cretaceous raised the suspicion in my mind that these deposits might be older than the plant-bearing Dakota. I learned while there that Professor McBride had been in that region studying the cycads, and that he had collected some and taken them to the State University of Iowa, at Iowa City. In October of that same year he published a description of a species which he called *Bennettites dacotensis*.[2] Professor McBride, and also Professor Calvin, State geologist of Iowa, who had examined the region, presented papers on this subject before the Iowa Academy of Sciences in December, 1893, the latter especially discussing the geological position of the cycads.[3] Professor Calvin shortly after published the results of his investigations in a communication to the American Geologist.[4] Professor Calvin's principal object seems to have been to fix the position of the cycad beds relatively to the well-recognized formations above and below, and it was not, of course, difficult for him to show that they lay between the Fort Benton shales and the marine Jurassic. The idea that this thick formation, amounting in some places to 400 feet, should itself be susceptible to subdivision does not seem to have occurred to him, and after considerable discussion of these more general relations, in which he seems to realize that he is giving a great breadth to the subject, he concludes in the following language:

> Returning finally to the main object for which these observations were undertaken, it is clear that *Bennettites dacotensis* McBride belongs to the Cretaceous period,

[1] See Science, Vol. XXI, No. 543, June 30, 1893, p. 355.

[2] A new cycad, by T. H. McBride: Am. Geologist, Vol. XII, October, 1893, pp. 248-250, pl. xi. Reprinted in Bull. Lab. Nat. Hist., State Univ. Iowa, Vol. II, No. 4, 1893, pp. 391-393, pl. xii.

[3] See Science, Vol. XXIII, No. 570, January 5, 1894, p. 10.

[4] Am. Geologist, Vol. XIII, No. 2, February, 1894, pp. 79-84; also published in the Proc. Iowa Acad. Sci. for 1893, Vol. I, pt. 4; Des Moines, 1894, pp. 18-22.

and the evidence is practically conclusive that the exact horizon at which the individuals of the species were imbedded is represented by the uppermost layers of the Dakota sandstone.

I was wholly unaware of the work that Professors McBride and Calvin were doing, and had overlooked the article of the former in the American Geologist for October. On my return from the Black Hills I proceeded to elaborate the results that I had reached, but having much else to do I did not complete the paper until after the middle of February, 1894, when I sent it on to the Journal of Geology, in which it soon after appeared.[1] The substance of that paper will be given under the next head.

In all that I said in this paper Professor Jenney concurred, as we were together during the entire investigation, and I sent him the manuscript when completed. The sections were made after mutual consultation, and in the field, and were reproduced in the article without change. The diagrammatic sections are my own, and are based upon the data collected. As stated in that article, we were not satisfied with the evidence furnished by the cycads alone or by the cycads and the fossil wood, but proceeded to discover beds containing fossil plants, both in the lower portion and also in the upper. These two classes of plant-bearing beds differ fundamentally, and the nature of the plants from the lower beds made it practically certain at a glance that they could not belong to the plant-bearing Dakota group. But I was not satisfied to rest the case upon my own judgment as to these plants. I therefore referred them to Professor Fontaine, whose thorough familiarity with the older Potomac flora and Mesozoic plants in general has made him the leading authority on the subject. His report upon the collection is published in this article, pp. 259–260. The concluding paragraph of that report is as follows:

It will be seen from this account that the plants, so far as one can judge from such imperfect material, indicate a Lower Cretaceous and Neocomian age, with rather more resemblance to the Kome than Potomac phase or grouping, but it is by no means certain that the Potomac grouping is not nearest to that here shown.

I also referred the fossil wood to Professor Knowlton, and his report immediately follows that of Professor Fontaine, and is in entire harmony with it as regards the Lower Cretaceous age of the specimens. Indeed it would naturally seem to point to a still earlier period, although it can not be said to prove this.

The specimens from the upper beds were indentified by myself, and are fully described and figured below (p. 702–709, Pls. CLX–CLXXII). There is no reason to suppose that they do not represent the true Dakota group, and the line between the Upper and Lower Cretaceous must fall somewhere between the cycad beds and the upper plant beds

[1] The Cretaceous rim of the Black Hills, Jour. Geol., Vol. II, No. 3; Chicago, April–May, 1894, pp. 250–266.

above the quarry sandstone. Nothing has happened since that paper was published to modify the following statements which it contained:

It thus appears that the flora of the beds above Evans quarry is distinctly that of the Dakota group, while all the plants found below that horizon as distinctly indicate a Lower Cretaceous age. The force of this evidence is to my mind irresistible, and it is safe to predict that if any other paleontological evidence is ever found it will confirm this conclusion. The question still remains as to where the dividing line is to be drawn. Between the cycad and fossil wood horizon and that of the Dakota leaves there are some hundred feet of sandstones and shales. Sixty to seventy-five feet of this consists of the massive or heavy-bedded building stone, which in places becomes flinty and very hard. As the thin shaly layer which separates this from the leaf bed may be safely put with the latter into the Dakota proper, and there seems no reason for separating the similarly constituted layer that intervenes between the cycad horizon and the base of the sandstone from the one upon which it rests, the question is narrowed down to that of the position of the quarry sandstone. That question I will leave to the stratigraphical geologists (p. 263).

Professor Todd, State geologist of South Dakota, in 1894 still continued to place the Dakota group between the Jurassic and the Fort Benton, and to indicate the earlier Cretaceous as "absent."[1] He does not do this in ignorance of the results at which I had arrived, but reproduces my sections (pp. 63–71), speaking of one of them as "particularly valuable both for its completeness, and the careful discrimination and measurement of the strata." Commenting on these sections, Professor Todd says:

A point of special interest should be mentioned here, namely, that numerous specimens of cycad trunks have been found at various points. Those which have been quite carefully studied and described by Mr. L. F. Ward (Journal of Geology, 1894), of the United States Geological Survey, and Professor McBride (American Geologist, 1894), of the Iowa State University, were collected in the southern part of the Hills, southwest of Minnekahta and southeast of Hot Springs. Specimens also have been found several miles north of Rapid City, and in a ravine southwest of that place. They all seem to be traceable to the lower layers of the Dakota sandstone, and Mr. Ward, partly for this reason, strongly suspects that the lower layers of the so-called Dakota formation may be older than that period (pp. 71–72).

This is certainly a very mild statement of my position; and my language was intended to express something much more than a strong suspicion as to the Lower Cretaceous age of these deposits.

But whatever doubts there may have been then, they have all been set completely at rest by subsequent events. During the summer of 1894 Professor Jenney, while operating in the coal-mining district of Hay Creek, Crook County, Wyoming, in the northwest portion of the Black Hills, but within the Cretaceous rim, found fossil plants in great abundance associated with the coal. True to his instincts as the type of a scientific collector, he proceeded to collect these plants, and, as a pure labor of love, he obtained during the summer and sent to Washington by official mail one of the finest collections that has thus far been

[1] A preliminary report on the geology of South Dakota, by J. E. Todd, State Geologist: South Dakota Geological Survey, Bulletin No. 1, Sioux Falls, 1894, p. 22.

made from any part of the West. They were sent direct to me, and my interest in them, as may well be imagined, was intense. I received them for the United States Geological Survey, and when they had all been unpacked and duly recorded I sent them to Professor Fontaine for determination. He gave them his painstaking attention, and prepared the able report which I embody in this memoir (pp. 645–702, Pls. CLX–CLXIX).

It is needless to anticipate this report further than to say that the plants completely demonstrate the Lower Cretaceous age of the Hay Creek coal field. Professor Jenney was good enough to make a careful study of the stratigraphical relations of the numerous beds in which the plants occur, representing a large number of horizons, which were fully shown in careful sections. At my request Professor Jenney has furnished extensive notes upon his work there, which are embodied in this paper, and he has also kindly furnished a map of that region. All these data together will, I trust, render the whole subject clear to the geologist.

In a revision, which I made in 1894, of the genus Cycadeoidea of Buckland, which genus probably embraces all the fossil cycadean trunks thus far found in America, I described from notes and sketches made by Professor Jenney a new species of that genus, which I called *C. Jenneyana*.[1] The description there given was of course very meager, and is completed in this paper (pp. 627–632, Pls. CXXI–CXXXII).

This species was made known to me by Professor Jenney, who had long been aware of the existence of the two large trunks at the State School of Mines at Rapid City. He had been to the pains to inquire into the source of these and had learned that they were collected many years before, about 10 miles northwest of Rapid City, by a gentleman named Leedy. Being exceedingly anxious to ascertain whether this locality also lies in the Cretaceous rim of the Hills, I went to Rapid City early in August, 1895, where I joined Professor Jenney, and we proceeded to the locality and made a thorough examination of the general region. A more complete account will be found under the description of the Blackhawk region (infra, pp. 560–563), and I need only say here that, as we expected, the beds yielding this specimen lie above the Jurassic, and the cycads were associated with the heavy sandstones which constitute the lowest Cretaceous deposits. These beds are therefore substantially the same, in their stratigraphical relations, as those yielding the other cycads and fossil plants already referred to. Numerous other specimens had been collected and carried away by persons who desired to profit by them, and not one could be found by our party. Some of these, as will be shown, were subsequently obtained by purchase. A great amount of fossil wood occurs in that locality, a good collection of which was made.

[1] Fossil cycadean trunks of North America, with a revision of the genus Cycadeoidea Buckland: Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, pp. 75–88. (*C. Jenneyana* is described on p. 87.)

From Rapid City I proceeded to Hot Springs, where I obtained considerable additional material, some of it from localities already described, but the remarkable trunk which I call *Cycadeoidea excelsa*, and which is described below (p. 637), was collected in an entirely different locality, which is fully indicated in connection with the description of the species, and its location on the map is given as exactly as the data will permit.

In both my visits to the Black Hills, in 1893 and 1895, I saw large numbers of fossil cycads at various places, mostly in the hands of dealers in specimens, who held them for sale, often at moderate prices, but others were seen in heaps of stones along with specimens of ore, coal, building stone, and other products of the country, often symmetrically arranged in pyramidal forms, at railroad stations and elsewhere.

As the funds at my disposal were limited, I was able to purchase only such as appeared to me to represent distinct species, although I was aware that, not having as yet described the species, I might easily be mistaken in the matter, and that doubtless many new species existed which could have been easily obtained by anyone who had the means.

Well knowing the fate of most of such material, which usually gets into the hands of private individuals making no pretensions to science and who wish such specimens merely as curiosities, but who hold them in high esteem and are unwilling to part with them, or in most cases are so situated that no scientific man ever sees the specimens again, I was glad to learn that Professor McBride had himself secured a large number of specimens for the State University of Iowa, where I hoped they would soon be taken up and submitted to thorough scientific study.

But even after he had secured all he desired great numbers remained, and when, the following year, Prof. O. C. Marsh approached me on the subject and manifested a special interest in these objects, I gladly imparted to him all the information in my possession relative to the best means of securing them, including the names and addresses of dealers who had them for sale, the prices at which they were held, and the localities from which they had been collected, so far as these were known to me. I greatly hoped that with the resources at his command, Professor Marsh would rescue from oblivion and insure to science many of these interesting paleontological treasures.

I heard nothing further from Professor Marsh until on March 18, 1898, I received a letter from him stating that he had obtained a large collection of cycads from the Black Hills and requesting me to come to New Haven and describe them. As the present paper was then already in an advanced stage of preparation and the descriptions of those in my hands were already written and would be included in it, it seemed to me that the opportunity should not be lost of embracing under the same head all the new material that might be accessible. I therefore immediately consulted with the Director on the subject and received orders to proceed at once to New Haven and take all necessary notes on Professor Marsh's collection.

This work was performed from the 22d to the 31st of March. This collection consisted of 87 specimens, and notes were taken upon each of these and the more important of them were fully described. Having with me the descriptions of all the other cycads, I paid special attention to characters which could not be observed in the specimens already described, either because these were too perfect to show any internal structure or from defectiveness of any kind. All variations that the new material indicated from the specimens previously taken as types of species already identified were also carefully noted, with a view to the correction and expansion of the characters. All the new species were of course very carefully dealt with.

In addition to these notes Professor Marsh placed a photographer at my disposal and all the more important specimens were photographed, often from various points of view, for purposes of illustration. All these notes and illustrations appear in their proper places, embodied in the descriptions of the species.

While at New Haven, engaged on this collection, Professor Marsh informed me that two additional invoices were soon expected from the Black Hills, and that he wished me to include these also, if possible, when they arrived. But I could not then wait for them and returned to Washington. On May 20 he telegraphed me that the first invoice had arrived, and on May 31 he similarly notified me of the arrival of the second invoice. The two invoices contained 39 specimens, which, added to the 87 specimens previously received, constitutes a collection of 126 cycadean trunks and fragments.

As nearly all of the first large collection had been obtained from the Minnekahta region, very close to where the original types were discovered, and as these two new invoices were from the Blackhawk region, from which so few cycads had been thus far made known, it was especially important that these should be included in this report, and therefore, at a risk of considerable delay, I undertook their elaboration, which was accomplished in a little over a week, viz, from June 6 to June 13, and this included the work of photographing the important specimens. All the data thus secured are embodied in the descriptions below and constitute a very material increase in our knowledge of the cycadean vegetation of the Black Hills Cretaceous.

Nearly all the specimens in the Yale collection were reported either from the Minnekahta region or from the Blackhawk region, and but very little additional information accompanied the collections. The last invoice from the Blackhawk region was accompanied by data specifying the location of the specimens somewhat in detail, giving distances and direction from Black's ranch, but this embraced comparatively few specimens. The first invoice contained one specimen which was said to have been found between 2 and 3 miles west of Sturgis, South Dakota, a wholly new locality.

With the exception of a small collection obtained by Professor Marsh from Mr. Stillwell, in Deadwood, and reported by him from the Minnekahta region, all of these large collections which Professor Marsh secured were made by Mr. Henry F. Wells, of Sturgis, one of Professor Marsh's trusted collectors of fossil vertebrates, who had been induced to turn his attention to a search for cycads, and whose skill as a collector readily enabled him to locate the cycad beds and obtain quantities of specimens which had been overlooked by more superficial observers. I was certain that Mr. Wells must have covered a considerable area in his explorations beyond that which I had myself seen or that other collectors had visited, and as the work of determining the species proceeded I was more and more impressed with the importance of a fresh survey of the cycad regions, with a view to more exact correlation of the different beds with each other, and a more satisfactory determination of the stratigraphical position of the cycad beds in general. I felt that if I could secure the guidance of Mr. Wells to all these localities this result could be accomplished, and I corresponded with him upon this subject. He expressed a willingness to accompany me to all the localities at any time that I might designate.

I was unable to bring this about until the early part of October, 1898, when, by previous arrangement, I met Mr. Wells at Sturgis, and we devoted eight days to this work, with very satisfactory results. We first visited the new locality between two and three miles west of Sturgis, where specimen No. 1 of the Yale collection was obtained by Mr. Wells. He had found it on a low spur of the foothills, which had dropped or slipped down from the high cliffs to the westward, and was entirely out of position. A second imperfect specimen had been found by him near the same spot, and still lay on the surface. Mr. Wells stated that he had explored the cliffs from which these materials had fallen, but had thus far been unable to find any cycads in position. We then proceeded to the Blackhawk region and went over all the ground covered by his explorations, and later to the Minnekahta region, which was examined in the same way.

The more special results of this expedition, including geological sections, will be given under the Minnekahta and Blackhawk regions, respectively, but some of the general conclusions arrived at from this examination, which was much more thorough than any that I had previously given to the question, may properly be stated here. It is well known that these Cretaceous sandstones form the foothills surrounding the Black Hills, and that they present more or less of an escarpment facing the central core of the hills and separated from the higher and more interior uplift by a broad valley occupied by the Red Beds, which surround the Hills. As a matter of fact, however, the lower part of the escarpment is almost always occupied by beds that are lower than the Cretaceous, the base itself consisting of a greater or less thickness of the Red Beds themselves, succeeded by the whole thickness of the Jurassic, which may amount to 150 feet. Upon this lie the Cretaceous sandstones, which, should they be all represented, would form a cliff more than 300 feet higher, sometimes making a total of nearly 600 feet above the lowest part of the broad encirling valley.

At one time, of course, all these materials extended over the area now occupied by this valley and they have been carried away by the general process of denudation. This process, however, was somewhat peculiar in consequence of the large amount of gypsum contained in the Red Beds, which, as soon as exposed, rapidly disappeared, resulting in a systematic undermining, as it were, of the cliffs, which gave way along an irregular border and either sank or slipped down so as to occupy at different periods positions much lower than that from which they came. The further influence of lateral denudation, forming deep canyons in the sides of the external wall, resulted in the final formation of a large number of narrow spurs or low sloping ridges, often containing the remains of the original cliffs, practically unchanged, after having sunk down to lower positions and still remaining easily identifiable with the cliffs from which they had fallen. The present position of these cliffs, therefore, is no indication of their true position, and although this can usually be determined where large masses have held together, this can not be done in case of loose materials that cover the slopes. Here rocks from all positions in the Cretaceous series lie mingled together and cover the ground to considerable depth, occupying horizons topographically much lower than the base of the Cretaceous. Sometimes these spurs are reduced to small mounds, isolated in the red valley, and cycadean trunks have been found far out in the middle of the valley on such mounds and ridges. Being of a character much more durable than even the hardest of the sandstones, they remain intact wherever they may happen to be, and some have been found lying on top of the Red Beds themselves, all traces of their original matrix having disappeared.

This accounts for a fact that had long puzzled me, viz, the occurrence on many of the cycad trunks of a coating of lime or calcareous matter, often turning one side of them pure white and being very firmly cemented to the rock and difficult to remove. This had led some to suppose that the cycads came out of the calcareous limestone of the Jurassic. As a matter of fact it proves nothing, since the greater part of the cycads that have thus far been found have lain in a position many feet below the base of the Cretaceous, often upon the Jurassic limestone, but usually associated with vast quantities of sand rock, which had accompanied them in the general settling down of the strata to which they belonged.

It is easy to see from all this how very difficult it is to determine the true position of the cycad beds, especially as they are never found adhering in a natural way to the rock in which they were originally embedded, but are always washed out and found lying in all positions, indicative of more or less transportation, or at least local displacement. This is not affected by the fact that nearly all the specimens that Mr. Wells has found that were overlooked by other collectors were more or less buried in the ground, only small parts projecting sufficiently for him to recognize their character. The materials in which they were buried were as heterogeneous as those on the surface, and it would often require many feet of excavation to reach the original bed upon which these loose materials rested.

There are, however, a few facts which may be taken as constituting evidence as to the position of the cycads.

First, a few specimens have been found, if not actually in place or precisely where they grew, at least high up on the original cliff, and it is clear that their position must have been at least as high as that in which they lay.

Second, the cycads and the fossil wood are almost always closely associated, although the latter is much more abundant. Both being silicified, the conditions which would preserve the one would also preserve the other, and therefore it seems probable that both occur at pretty much the same horizon. There are a few cases in which the fossil wood has actually been found in place; that is, as erect trunks in position and prostrate logs projecting from the original cliffs. The fossil wood is not found at all horizons, but only within a certain limit of elevation, and it is not believed that the cycads have a wider vertical range than the wood.

Third, both the fossil wood and the cycads, even on the lowest slopes at which they occur, and however far below their original position, are usually associated with a certain general class of rocks whose character is sufficiently distinct to make it possible to ascertain their original position, and this is the same class of rocks in which the fossil wood is found when seen in place.

All three of these classes of evidence combine and harmonize in fixing the position of the cycad bed, which is always the next important series of rocks that underlie the hard quartzitic sandstones that occupy the uppermost strata, with a thickness of from 75 to 100 feet. The cycad and fossil wood bed consists of softer sandstones separated by thin beds of shale and is not usually over 50 feet in thickness, but may possibly be 75 or 100 feet at some localities.

It may be as well to mention here that on this expedition I took considerable pains to examine the relation of the Cretaceous to the Jurassic, and especially to the uppermost member of the latter, which contains the "Atlantosaurus beds." I visited the original bed from which bones were first taken, at the foot of Piedmont Butte, and was fortunate in finding Mr. George R. Wieland engaged in taking up the bones of a large animal. This spot is 1 mile due east of the town of Piedmont. I measured the bed and found it 54 feet in thickness, and the particular horizon at which the bones were then being excavated, and which had itself a thickness of about 6 feet, was about 40 feet below the top of the Jurassic or base of the Cretaceous. It is a dark clay shale and at this point rests upon heavy beds of white sandstone. It was impossible to decide, either here or at any other point I examined, whether there is unconformity between the Cretaceous and the Jurassic. The particular bed in question is about 100 feet above the bed of Elk Creek and has an elevation above sea level of about 3,400 feet.

As will be seen later, this bed is therefore about 300 feet below the cycad horizon, and cycads actually occur 4 miles southeast of that place.

The Atlantosaurus beds, as thus described, are exceedingly characteristic of the Jurassic of the Black Hills. In my first paper in the Journal of Geology[1] they were accurately described as occupying the uppermost 50 feet of the Jurassic, although at that time I had no idea that these constituted the Atlantosaurus beds. During the present expedition I examined them at every point where the cycad beds were studied and never failed to find them, with almost exactly the same character and nearly the same thickness. In many places fossil wood occurs in a very fine state of preservation near the summit of these beds and in contact with the Cretaceous, while lignite is the form taken by the wood when it is preserved in the clay shales immediately below. They are the same as No. 5 of Professor Jenney's section of the Hay Creek region, the Beulah clays, of which he gives a full account in his notes published in this paper (infra, pp. 568-593), and many of the features which I have here mentioned were observed and recorded by him.

When all the facts above stated are taken into consideration the difficulties in the way of measuring sections in this region become apparent. It is obviously impossible to reach any reliable conclusions by attempting to make sections of the fallen and disturbed materials that occupy the slopes on the sides toward the broad valleys. In most cases it is impossible to say where the Red Beds end and the Jurassic begins or to find the line between the latter and the Cretaceous. In order to measure a section in such a region it is therefore necessary to find a slope which is not adjacent to a broad valley; that is to say, to find some deep canyon a cross section of which will have the form of the letter V and upon the sides of which there has been no opportunity for the slow undermining of the cliffs and the resultant covering up of the slopes by the materials that have come down from above, but in which there has been a rapid and natural denudation, at all stages of which the materials liberated have been carried away, leaving the surfaces exposed. Such exposures are not easy to find, and often are not deep enough to embrace the entire thickness of the beds which it is desirable to measure. The section measured by Professor Jenney and myself in 1893, on the slope of Red Canyon, was an unusually favorable one, and as will be seen, I was able on this occasion, in a few cases, to find other suitable places and to make sections illustrating each of the general regions.

II. THE MINNEKAHTA REGION.

As it was this region which yielded the first cycads, through which my attention was drawn to the general subject, it seems natural to treat it first. I include in it all the southern portion of the Black Hills which has thus far yielded any fossil plants, and this is embraced in a rectan-

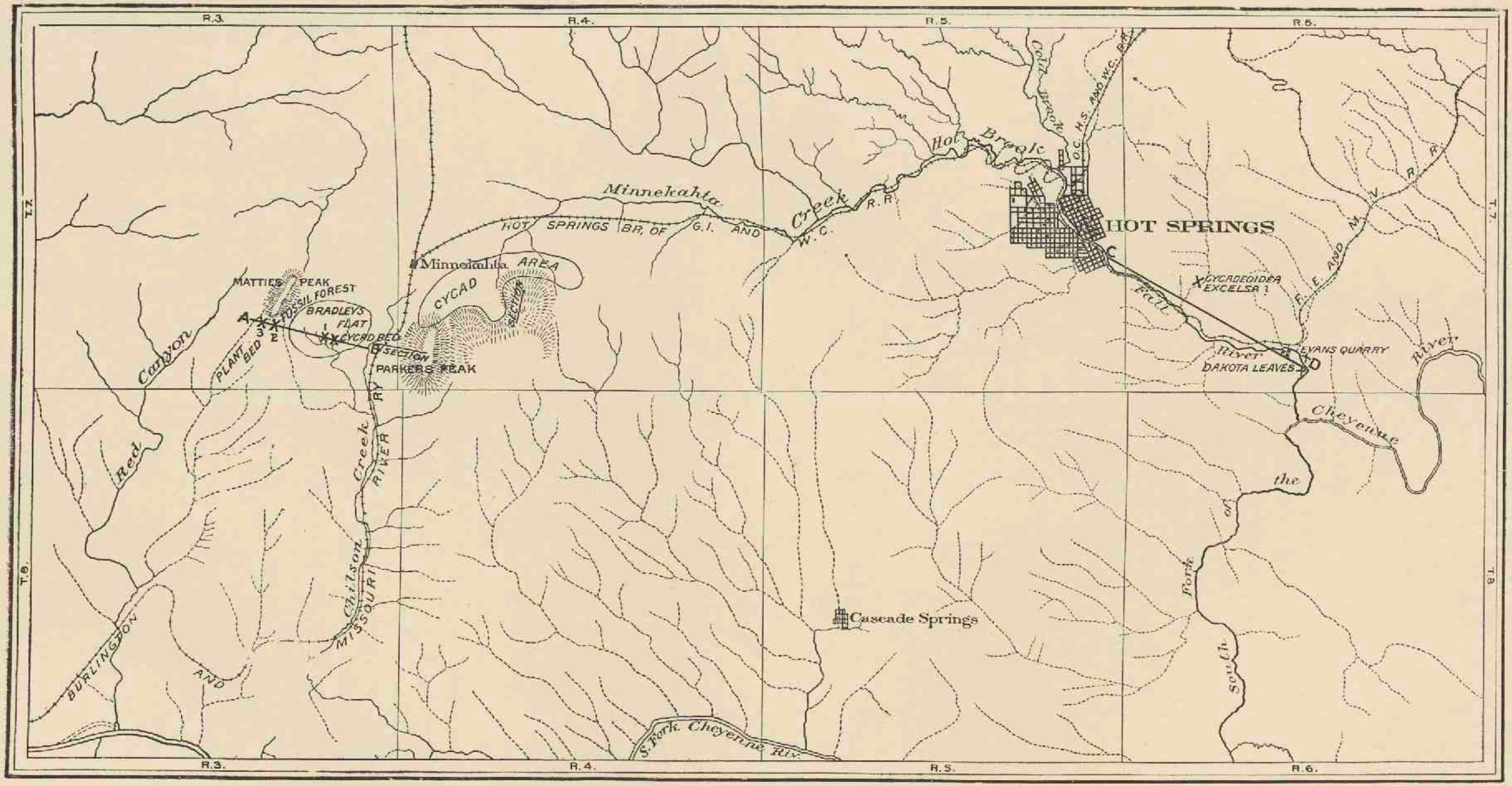
[1] Jour. of Geol., Vol. II, No. 3, April-May, 1894, p. 255 (cf. No. 7 of section No. I.)

gular area having Edgemont for its southwestern corner and extending eastward to the Evans quarry, which lies near the middle of the area north and south. The accompanying map of this region (Pl. LIV), which I have had expressly prepared, embraces townships 7 and 8 S., range 3–6 E., lying wholly in Fall River County.

It nearly all lies within the valley of the Minnekahta River, or, as it is now more commonly called, Fall River. The immediate area within which the first cycads were found is very near the divide between this stream and Red Canyon, while the actual slope on which the most of them occurred is that of a small tributary of Chilson Creek which falls into the Cheyenne between Edgemont and Cascade Springs.

When I visited this region in 1893 for the purpose of determining the exact location of the cycads purchased of Mr. Cole, as above described (p. 512), I proceeded directly to Hot Springs and arrived there on the 5th of September. Professor Jenney met me there from Deadwood, by arrangement. I also found Mr. Cole and arranged with him to accompany us to the locality. An outfit was secured and the 6th and 7th were occupied in making this investigation. The locality itself was on or near the horse ranch of Messrs. Payne and Arnold, and we secured the services of Mr. Payne, who was perfectly conversant with all that region, and he took us immediately to the spot. It is about 3 miles southwest of Minnekahta Station on the Burlington and Missouri Railroad, about 1½ miles west of the bed of the small stream above mentioned, on the foothills formed by the Cretaceous sandstones. We made a somewhat extended examination of the country round about. A mile or more to the northwest of the cycad locality we found the divide between that stream and Red Canyon. Another branch of the first-mentioned stream comes into it from the west, and lies to the south of our area, which is therefore on a southeast slope and near an abrupt descent into a canyon. From this point northwest to near the crest of the divide, the highest point of which is called Matties Peak on the township plat of the General Land Office, the slope is moderate and nearly uniform. At the foot of this crest and about 1½ miles northwest of the cycad locality occurs an extensive fossil forest. The wood is all completely silicified, and consists of prostrate trunks of various sizes and lengths and an abundance of smaller fragments, many of which are scattered about on the sloping plain a long distance below the actual horizon at which they were petrified. At that horizon many still remain, apparently undisturbed, and in one place a trunk over 20 centimeters in diameter was seen projecting several feet from beneath the massive sandstone ledge.

To the south of Matties Peak is a saddle, beyond which the crest of the divide is lower, and here the forest is seen to the best advantage. The most prominent object is a silicified log over 75 centimeters in diameter and 25 meters long, lying where it fell, which may not have been at a very remote date. It had broken away from its roots at the surface of the ground, leaving portions of the stump still exposed, and the entire



MAP OF THE MINNEKAHTA REGION OF THE BLACK HILLS, SOUTH DAKOTA.

root could probably be exhumed. Over the area of ground beyond the present trunk, where the upper limbs and branches would naturally have been, great numbers of fragments and splinters were scattered, clearly indicating that many of these branches must have remained attached when the tree fell.

It will be noted that all this is within the drainage of the Cheyenne River, and therefore it corresponds perfectly with the location of the petrified forest described by Edgar Allen Poe, as quoted above (p. 529), viz, "Near the head waters of the Chayenne, or Chienne River, which has its source in the Black Hills of the Rocky chain." Of course it is possible that there are other fossil forests that would answer this description, but I know of none, and the chances of its being this identical spot are increased by the necessity that it should occur in a geological formation in which petrified forests are to be looked for. It could not, therefore, have been in the Red Beds below nor in the Fort Benton above, and the area is restricted to the Lower Cretaceous. It is therefore scarcely possible that he could have referred to any other than the forest under consideration. A large amount of silicified wood also occurs at the cycad locality itself, and there is reason to suppose that the horizon is practically the same. The whole of this region, including the entire crest of the divide and the area extending to the bottom of the canyon of the cycad bed and far to the southeast, consists of the series of hard sandstone that were treated in the Black Hills report as constituting the Dakota group.

The great improbability that the cycads could have lived in Dakota time, or contemporaneously with the flora of the Dakota group, led me to suspect that these beds were below that horizon, and I resolved not to leave the field until all the evidence on this point that was attainable had been examined. In the immediate vicinity of the fossil forest and cycad bed there were no evidences of plant remains of any other class. The crest above the fossil forest consists of hard, chiefly massive sandstones, which may be traced far around the Hills, and form the upper part of the abrupt escarpment above the soft Jurassic and the Red Beds. On the inner face of this escarpment it was therefore possible to observe a great thickness of the Cretaceous in a limited area; and passing over this crest a little to the southwest of the fossil forest we entered the first lateral canyon which leads into Red Canyon on the west, so named because in it the Red Beds are well exposed. The escarpment here is more or less overgrown with timber, and although the slope is very steep it was possible to work on any part of it. From the summit of Matties Peak to the bottom of the valley was, by careful measurement, over 500 feet, but considerably over 200 feet of this was occupied by the Jurassic, distinctly marked off from the Cretaceous, while at the very bottom the Red Beds were reached. Above the Jurassic there were about 275 feet of Cretaceous deposits, and on different parts of this slope good exposures occurred, showing considerable variety. It was in these exposures that the search for fossil plants was made, and in one of them it was successful. This occurred 60 to 75 feet above the Jurassic, and in a number of places imperfect plant remains were found, chiefly in a soft pink and gray sandstone.

Matties Peak rises some 75 feet above the fossil-forest horizon, and the plant bed now under consideration is about 125 feet below that of the fossil forest. The plants occurred partly in shales and partly in hard sandstone. They consist chiefly of ferns, and have a facies totally different from that of the well-known flora of the Dakota group. They are all carefully described and figured below, and their affinities would of themselves be sufficient to make the Lower Cretaceous age of the bed that yielded them altogether certain, and it was upon these more than upon the cycads or fossil wood that I rested the case in the article above quoted.

The following is the section measured at this place, with a brief description of each bed, giving its thickness in feet. The diagram which follows will serve to make the matter still clearer.

SECTION OF MATTIES PEAK.

	Feet.
Dakota of Newton, 275 feet.	
13. Massive pinkish sandstone approaching a quartzite locally	75
12. Grayish white sandstone with silicified wood and cycads	30
11. Pinkish and yellowish soft sandstone	75
10. Clays with indications of coal	20
9. Soft pink and gray sandstone with ferns and other plants	25
8. Reddish, pinkish, and yellowish brown massive cross-bedded sandstone	50
Jurassic, 220 feet.	
7. Olive gray clay and sandstone shales, including the Atlantosaurus beds	50
6. Light red soft sandstone	60
5. Olive gray clays and gray sandstone shales	40
4. Olive drab clay	20
3. Yellow sandstone shales	20
2. Olive drab clay	30
Red Beds (Trias).	
1. Red marls, conformably exposed at bottom of canyon	20

This section may be represented diagrammatically as follows:

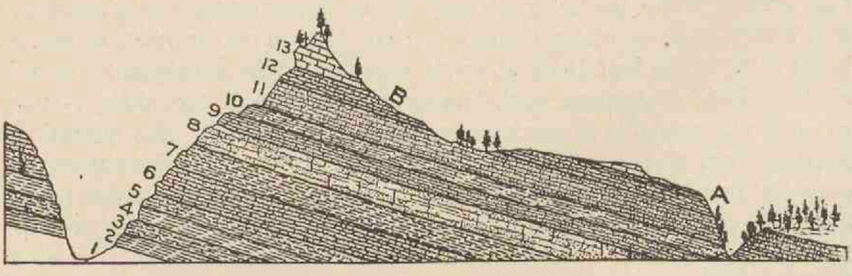


FIG. 119.—Section across the divide between Red Canyon and Chilson Creek. 1, Red Beds; 2-7, Jurassic. 9, Plant bed; 12, A, Cycad bed; B, Fossil forest; 13, Equivalent of Quarry sandstone in section at Evans quarry (see infra, p. 560).

As already stated, this region lies very near the divide between the Minnekahta Valley and the Red Canyon, but is really on the slope of Chilson Creek, which makes down into the Cheyenne River a long way to the east. At the time I visited this place in 1893 I was under the impression that the valley to the east of the cycad beds drained northward into the Minnekahta Valley, and so stated in my article. But this is a mistake, for it is not until we reach the Minnekahta station, at the junction of the two railroads, that we find the beginning of the Minnekahta drainage. A number of small streams from the west, north, and south unite a little way to the eastward and form the Minnekahta or Fall River, whose course is nearly eastward to near Hot Springs, a distance of about 15 miles. It flows chiefly over the Red Beds, and the Cretaceous escarpment lies to the south, forming a conspicuous east-and-west ridge, with a high point at its western end known as Parkers Peak.

On my visit to this region in October, 1898, in company with Mr. Wells, I went carefully over all the ground on which he had obtained his specimens. They all came from a region surrounding the original spot which I examined in 1893, and from which so many of the earlier specimens had been obtained, but Mr. Wells found that there was an area, irregular in outline and more than a half mile square, over which cycads were strewn, though by no means evenly, as they occurred in groups at different points, more or less separated from one another. This area is all within what is called Bradleys Flat and occupies most of the eastern portion of it. There are three spur ridges running out in a southeasterly direction from the main axis, parallel to the line of my section. The central one is that on which the original cycad bed is situated, and cycads were found over nearly the whole surface of this ridge, but chiefly on its southwestern slope, a larger number having been obtained from above the original locality than anywhere else. The most southwesterly ridge yielded cycads only on its northeastern slope, i. e., facing the principal localities of the central ridge. On the most northeasterly ridge cycads were more rare, but were sparingly distributed over the whole of its lower portion, and it was on this ridge that they extended farthest up the slope to the northwest, i. e., in the direction of the main axis.

It was evident from a careful examination of these ridges, especially along the slopes of the deep ravines that separate them, that this whole area must be regarded as out of place geologically and as occupying its present low position by reason of having settled down in the general process of denudation. The disturbance, however, was not so great as in most cases of the kind, and many of the rocks seem still to remain adhering together in a broad sheet, with occasional ledges in which relatively they have never been disturbed, and even outcrops of the hard quartzitic masses belonging at the top of the highest ridges were found normally overlying the softer sandstones in the same relative position in which they may be seen on the crest of the divide 1½ miles farther to the northwest. In the diagrammatic section, Fig. 119, the dip is purposely exaggerated to represent this late tilting of the strata.

I had long been aware that fossil cycads had been found on the south side of the broad valley to the southeast of Minnekahta station. A specimen which I saw in a pile of stones at the station was said to have come from this region, and I was told that others had been found there. Mr. Wells, learning these facts, had explored the country in that direction and had obtained a considerable number of specimens, one of which is No. 5 of the Yale collection, which differs from all others in being completely turned to white flint (see infra, p. 603). The various localities at which Mr. Wells secured the specimens were visited by me, in company with him, and proved to be of exceptional interest from a geological point of view. The south side of the general Red Bed valley, extending a distance of 6 or 8 miles from Parkers Peak eastward, consists of a series of high hills, separated by deep ravines, opening into the valley from the south. Toward the western end of this series these canyons have a more and more northwesterly course, the last one opening out at the north end of Parkers Peak, which is nearly 100 feet higher than the rest and is crowned by the quartzitic rocks that overlie the softer sandstones. No cycads have been found, to my knowledge, on or around Parkers Peak, but at the foot of several of the high ridges to the east of it they occur and the localities were carefully examined by me. The greater number of the cycads of this region, however, were not found near the base of these high ridges but at a considerable distance to the north of them, either on very low ridges extending out into the plain, or on isolated knolls that occur at intervals over a considerable part of the broad valley itself. These knolls consist of the same soft sandstones that belong at the top of the highest hills on the south, and are merely remnants of the materials that were carried away by the process of denudation when the valley was excavated. They are all, therefore, entirely out of place and their position can only be judged by the nature of the rocks with which they are associated. In fact, it was here that a considerable number of specimens were found embedded in the red soil at the bottom of the valley, in the general vicinity of which there were scarcely any remains of the sand rock. Others were deeply entombed in the pure white sand of the Jurassic, and still others lay upon the white calcareous shell rock of that formation and were incrusted with a coating of lime.

It seems probable that these heavy cycad trunks may not have been transported any great distance, and the theory that they have rolled down the slopes of the adjacent hills, at least within any recent period, is completely disproved by the great distances at which they occur from the foot of the hills, often with lateral ridges between. In all probability their original position was not far from vertically over their present one. It is certain that they belonged to the southern range of hills, because they occur much nearer to the south than to the north side of the valley. It must therefore be supposed that the hills and cliffs along the south side formerly extended over the spot where the cycads now occur, and as some of them were found quite close to the foot of these hills this whole region may be regarded as a cycad-bearing area. This area occupies a position to the east and southeast of Minnekahta, distant from 1 to 3 miles from the station, and covers a space of nearly two miles square.

The second of the high spurs to the east of Parkers Peak seems to have furnished the larger number of specimens, and they were found on three sides of this hill around its base. I was therefore specially desirous of making a section of this hill, but owing to the difficulties which I have already explained (supra, p. 549), it was impossible to find any point on the north or northwest sides at which this could be done. It was clear that the Red Beds occupied the lower part and that the whole of the Jurassic was to be found on the slope, but the sandstones from above so deeply covered the flanks of the ridges that the relative thickness of these beds could not be determined. Fortunately, however, a deep gorge had been cut into the side of this projecting ridge, having a southwesterly course and opening out into the canyon between this and the next one on the west. This gorge furnished much better conditions for the measurement of a section, and this was accomplished with considerable success. The hard quartzitic sandstone which forms the highest bed is not present on these ridges and the softer sandstones extend entirely to the summit. The following is the section:

SECTION OF SPUR EAST OF PARKERS PEAK.

	Feet.
Cretaceous, 208 feet.	
7. Rounded summit and slopes at top of ridge, consisting chiefly of soft yellowish or reddish sandstones and thinner sandstone and clay shales, with abundance of fossil wood. This is probably the source of the cycads also	88
6. Nearly vertical ledge of light-colored sandstones	48
5. Slope, mostly covered, consisting of coarse sandstones and clay beds	72
Jurassic, 130 feet.	
4. Olive-gray clay and sandstone shales, including the Atlantosaurus beds	60
3. White sandstone ledge	10
2. Yellow sandstone	20
1. Light-colored rocks, much obscured, probably limestones	40
Red Beds to bottom of canyon	50
Total	388

Parkers Peak is the only one of this range of hills which retains the cap of quartzitic sandstones, and it accordingly rises about 100 feet above the summits of the several more eastern ridges. Its top forms a sort of mesa or elongated table with a north and south trend, and its western face rises directly above the sources of Chilson Creek and is nearly in line between the very similar ridge called Matties Peak 4 miles to the westward, which forms the divide between this valley and Red Canyon, and which was the subject of my first section. The great cycad beds of the Minnekahta region lie between these two high points, and I therefore thought it very desirable to obtain a section of Parkers Peak. This was attended with many difficulties and the section is not as satisfactory as could be desired, but is as nearly accurate as it was possible to make it.

SECTION OF PARKERS PEAK.

	Feet.
Cretaceous, 310 feet.	
8. Hard sandstone ledge, partially quartzitic	100
7. Steep slope, mostly covered, but consisting of soft sandstones corresponding to and probably constituting the fossil wood and cycad bed	75
6. Vertical cliff of soft pinkish and white sandstones	60
5. Slope, mostly covered, of alternating sandstones and clay shales	75
Jurassic, 135 feet.	
4. Olive-gray clay and sandstone shales, including the Atlantosaurus beds	60
3. Other Jurassic beds, mostly obscured	75
Red beds exposed, 100 feet.	
2. Grass-grown slope with occasional red patches indicating Red Beds	50
1. Red beds in the valley to bottom of Chilson Creek	50
Total height of Parkers Peak to bed of Chilson Creek	545

Some 10 miles east of Minnekahta station the broad Red Bed valley gradually closes in to form a canyon narrowing eastward, through which the small stream known as Hot Brook, having its source in numerous thermal springs, passes. This at length unites with several other branches and forms what is there known as Fall River, on which the town of Hot Springs is located. Here the course of the drainage bends southward and breaks through the high ridge on the south, forming a "gap" through the foothills nearly parallel to Buffalo Gap, 15 miles northeast of that point. Its course is here southeast, and where it enters the hills and forms a deep canyon it affords an excellent section through the Cretaceous sandstones, with a length of some 4 miles, to where it enters the Fort Benton clays and ultimately emerges upon the plain and joins the Cheyenne River.

The electric-light plant for the town of Hot Springs, some 5 miles distant from it, marks the termination of the Dakota strata, and Evans quarry, which is just above this point on the left bank of the stream, yields very fine building stone from a massive stratum nearly 60 feet thick, containing no organic remains. But immediately over this building-stone stratum occur shales and sandstones in which dicotyledonous leaves had previously been found by Professor Jenney. It was in consequence of this that he had assumed that the cycads were from the true Dakota group yielding dicotyledonous leaves. But it soon became apparent, on visiting the region, that this was not the case and that the equivalent of the cycad bed was some distance below the quarry sandstone, which is virtually the equivalent of the massive sandstone forming the crest above the fossil forests.

We made a careful measurement of this section and it was published in my article. In my second visit, in 1895, I could find no reason for any essential modifications in that section, and I therefore reproduce it here without change. The quarry sandstone dips very rapidly to the southeast, so as to come down to the bed of the stream at the electric-light plant and to constitute the rock over which a fine cataract flows at this point and through which the water has worn deep longitudinal grooves. Immediately over these rocks there is a bed, some 6 or 8 feet in thickness, of dark clay and argillaceous sandstone shales, with carbonaceous matter and some impure coal. In this bed was found a great abundance of more or less comminuted vegetable matter, with short fragments of culms of reed-like plants, which it has not been possible to determine. There also occur, in certain of the shales, a few tolerably well-preserved dicotyledonous leaves, some of which have been determined, and were sufficient to prove beyond a reasonable doubt that this stratum belongs to the true Dakota group. A small collection was made near the cataract over the hard sandstone on the right bank of the stream, above the electric-light plant.

This bed was easily followed to the quarry, where it constitutes the overlying mass which it is necessary to remove in order to uncover the workable sandstone below. At this point the bed also contains layers of soft white sandstone of considerable thickness. Large blocks of this had been thrown down and lay strewn at the foot of the quarry. On the surfaces of these, and more or less scattered through their mass, were impressions of dicotyledonous leaves of Dakota types. The shales were also found in place above the quarry, and some of these yielded very good specimens. No fossil plants were found in any bed below this layer. For a long distance on both sides of the canyon the quarry sandstone forms the crest of the ridge, constituting a more or less abrupt escarpment of from 25 to 75 feet.

Higher up the stream the beds below the quarry sandstone come into view, consisting of softer sandstones, argillaceous shales, and carbonaceous layers, with impure coal seams, all highly charged with gypsum. These finally come down to the bed of the stream and are ultimately seen resting upon the Jurassic clays, which in turn overlie the Red Beds. Some distance below Hot Springs the Cretaceous can be seen at the summit of the cliffs with the whole thickness of the Jurassic below them and the Red Beds at the base. These latter, at and about Hot Springs, are overlain by heavy beds of conglomerate, probably of Pleistocene age.

The following is the section as measured below Hot Springs:

SECTION AT EVANS QUARRY.

Fort Benton.

11. Grayish black clays with layers of ferruginous concretions, extending to the south fork of the Cheyenne River—contact conformable.

Dakota of Newton, 339 feet.

	Feet.
10. Pink sandstone, mostly thin-bedded, with ripple marks and fucoid-like impressions	30
9. Soft black shales, with traces of carbonized plant remains and some fragments of fossil wood	15
8. Pink and gray sandstone	30
7. Clay shales and sandstones, the latter sometimes white, all plant bearing, much comminuted vegetable matter, matted beds of swamp plants, and well-preserved dicotyledonous leaves of Dakota types, determinable	10
6. Black clay full of carbonaceous matter, with locally 6 inches of impure coal	4
5. Quarry sandstone, massive, light pink, soft, weathering iron-brown	60
4. Soft yellowish and reddish sandstones	100
3. Drab-colored clays with carbonized vegetable matter and gypsum crystals, interbedded with yellow sandstones	30
2. Soft yellow and reddish sandstones with some clay layers	60

Jurassic.

1. Olive-gray, drab, or bluish clays with reddish and yellowish sandstones, to base.

This section may be represented diagrammatically as follows:

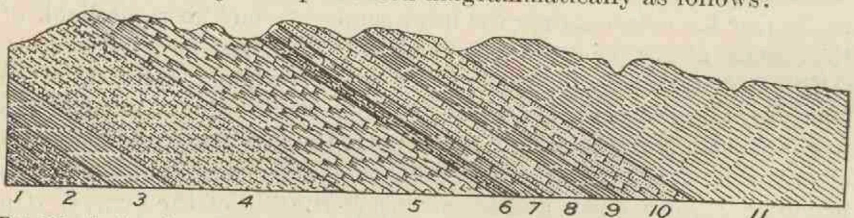


FIG. 120.—Section through Minnekahta Canyon. 1, Jurassic; 3, Equivalent of plant bed in section No. 1; 4, (Upper portion) Equivalent of cycad bed in section of Matties Peak; 5, Quarry sandstone; 7, Dakota leaf bed; 11, Fort Benton.

It will be seen by a comparison of these sections that they are in substantial agreement, although no effort was made to make them so. The upper member, No. 13, in the section of Matties Peak (supra, p. 554) probably represents the quarry sandstone of this section, which was considerably thicker at that point, 15 feet more being found, exclusive of erosion; but these rocks were often much harder, and no quartzitic rocks were seen in the quarry. On account of the débris thrown down from the quarry and other obstructions, it was not possible to examine the next member below with as much care as was desirable in view of the fact that it seems to be the equivalent of the cycad and fossil-forest horizon; i. e., No. 12 of that section corresponds to the upper 30 feet of No. 4 of the present one.

III. THE BLACKHAWK REGION.

In a letter which I received from Professor Jenney, dated August 28, 1893, he gave me the first intimation that cycadean trunks had been found in other parts of the Black Hills than the Minnekahta region. In that letter he says :

I learned from Professor Carpenter, formerly of the School of Mines at Rapid City, that there is a fine cycad in the collection of that institution. The specimen was found lying on the surface near Piedmont, South Dakota, a small station on the Fremont and Elkhorn Railroad, some 18 miles north of Rapid City and nearly 50 miles northeast of Hot Springs. Professor Carpenter tells me that this cycad may have been derived from either the Jurassic or Dakota. Near by are the "Atlantosaurus" beds in the Jurassic, from which Prof. O. C. Marsh obtained many bones of a new species of "Atlantosaurus." Fossil bones, Professor Carpenter (who first discovered these fossils) tells me, are very abundant in the Piedmont locality. It would appear that the cycad-bearing beds, whatever age they may be, encircle the Black Hills, so it is probable that other specimens may be found.

Being much interested in this statement, I wrote him at once with regard to it, and his next letter, dated September 22, 1893, contained the following additional information:

I find that the two specimens of cycads at the School of Mines are in all probability of a different species from those found at Hot Springs. The specimens may belong to one individual. One is the dome-shaped termination of a trunk about 15 inches in diameter; the other appears to be a fragment of the trunk. Compared with the Hot Springs variety, the trunk of this is taller, more cylindrical, and the markings of the leafstalks rudely pentagonal, seven-eighths to 1 inch in diameter, sometimes irregularly four-sided, not rhombic like those we found. I can not learn the exact horizon at which these cycads were found. Some person brought them to Rapid City, where for months they remained in a vacant lot until noticed by the dean, who removed them to the School of Mines. So it is not at all certain that they were originally derived from the same or equivalent beds as those yielding cycads at Hot Springs.

In a third communication, dated October 8, 1893, on the same subject, after having examined the specimens at the School of Mines and made outline sketches of their general form and also of the form and size of the leaf scars, which he kindly inclosed to me, Professor Jenney further states :

Now about the cycad specimens at the School of Mines. After some detective work I have learned that the man who found them is now living in Florida. I have written him to ascertain the exact locality. I hope in a few weeks to have a camera and will then photograph the specimens. I inclose a rude outline sketch with measurements of these specimens at the School that will show you the shape; also a sketch showing the variations in shape in the leafstalk cells. These specimens differ from the Hot Springs species in having a more cylindrical and much taller trunk, free fron excrescences or branches, and in the shape and arrangement of the leafstalks, which are in the School specimens imperfectly trigonal, quadrilateral, or pentagonal, and frequently strongly winged on two opposite angles. The arrangement of the leafstalk pits on the trunk is not so symmetrical in the concentric spiral lines as exhibited in the Hot Springs species. The leafstalks in the School specimens can be seen passing entirely through the outer bark of the cycad, a distance of 5 to 6 inches, terminating at the pith-like core. It would be possible to break them out in prismatic pieces of flint, the exact cast (?) of the original leafstalk.

Still later, October 21, he adds:

I have continued my detective work on the cycad specimens at the School of Mines and have at last traced them back to the man that found them, now at Keuka, Florida. In 1877 Mr. J. M. Leedy, of Rapid City, found the cycads in the foothills some 6 or 8 miles north of Rapid City. They remained at his ranch for a long time and were taken to Rapid City for exhibition at a fair held in Liberty Hall; were not returned, but at the conclusion of the fair were thrown out in a vacant lot near the hall, remaining there several years until removed to the School of Mines. Mr.

Leedy states that he found the specimens north of Box Elder Creek, on the divide between that stream and Elk Creek, and east of the railway (Fremont and Elkhorn), so they would be much nearer Rapid City than Piedmont. I will visit the locality soon and try to find more specimens at the same horizon.

Some negotiations were entered into for the loan of the specimens to the United States National Museum, but Professor Jenney's connection with the State School of Mines terminated about that time, and as I intended to visit the Hills again I did not press the matter further then.

As already stated (supra, p. 545), I stopped at Rapid City in the summer of 1895, when on my way to Oregon, Montana, and California, arrriving there August 19. I proceeded on the same day to the State School of Mines in company with Professor Jenney, and through the kindness of Dr. V. T. M'Gillycuddy, president of the State School of Mines, I was permitted to examine the specimens about which so much had been said. In the meantime I had described the species[1] and named it *Cycadeoidea Jenneyana* for Professor Jenney, my description being based on his notes. President M'Gillycuddy very generously consented to the loan of the specimens to the United States National Museum, and arrangements were made for their shipment to Washington, where they arrived in due course of events and were here on my return from California in the fall. They are thoroughly described and illustrated below (pp. 627, 628, Pls. CXXI-CXXV).

The problem was to ascertain the exact locality from which these specimens had been taken, and we spent the rest of the day in making careful inquiries of the citizens of Rapid City and of all persons in that vicinity who were in possession of any information on the subject. We succeeded at length in finding Mr. Gilbert Getchell, a citizen of Rapid City, who, although he does not seem to have first found the specimens, stated that he accompanied Mr. Leedy at the time that the specimens were brought in, visited the spot with him, and assisted him in loading them into the wagon. He offered to accompany us as our guide and felt sure that he could show us the exact spot. On the next day a party consisting of Professor and Mrs. Jenney, Mr. Getchell, and myself proceeded to Blackhawk, a station on the Fremont and Elkhorn Railroad, 7 miles northwest of Rapid City, and there obtained a conveyance in which our party visited Black's ranch, about 2 miles nearly due north of the station. It was less than half a mile north of the house on Black's ranch where the cycads lay when Mr. Getchell first saw them. Not only this spot but the whole region to the north and northeast was thoroughly explored. No cycads were found, every fragment having been carefully gleaned by other parties, as explained above, but an abundance of silicified wood occurred at nearly all points and even at the place where the cycads were.

The locality is on the left bank of a ravine which has a southward course and runs past the ranch house. It is a little level opening

[1] Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, p. 87.

below a wooded hill. On the hillside, immediately above, fossil wood was more abundant than at any other point. The rocks consist of brown sandstones similar in all essential respects to those of the cycad locality in the Minnekahta region. The level area on which the cycads lay is far below the top of the Jurassic, and the sandstones have all settled down through erosion of the looser materials from a considerably higher position.

The above is all that was known of the occurrence of cycads in the Blackhawk region prior to Mr. Wells's discoveries. His last two invoices to Professor Marsh contained 39 specimens from that region, viz, Nos. 88–126 of the Yale collection, and these were described by me in June, 1898. In the National Museum there are 4 specimens from there. If to these we add the two large trunks that belong to the State School of Mines, South Dakota, we have a total of 45 specimens from the Blackhawk region, which are treated in this paper.

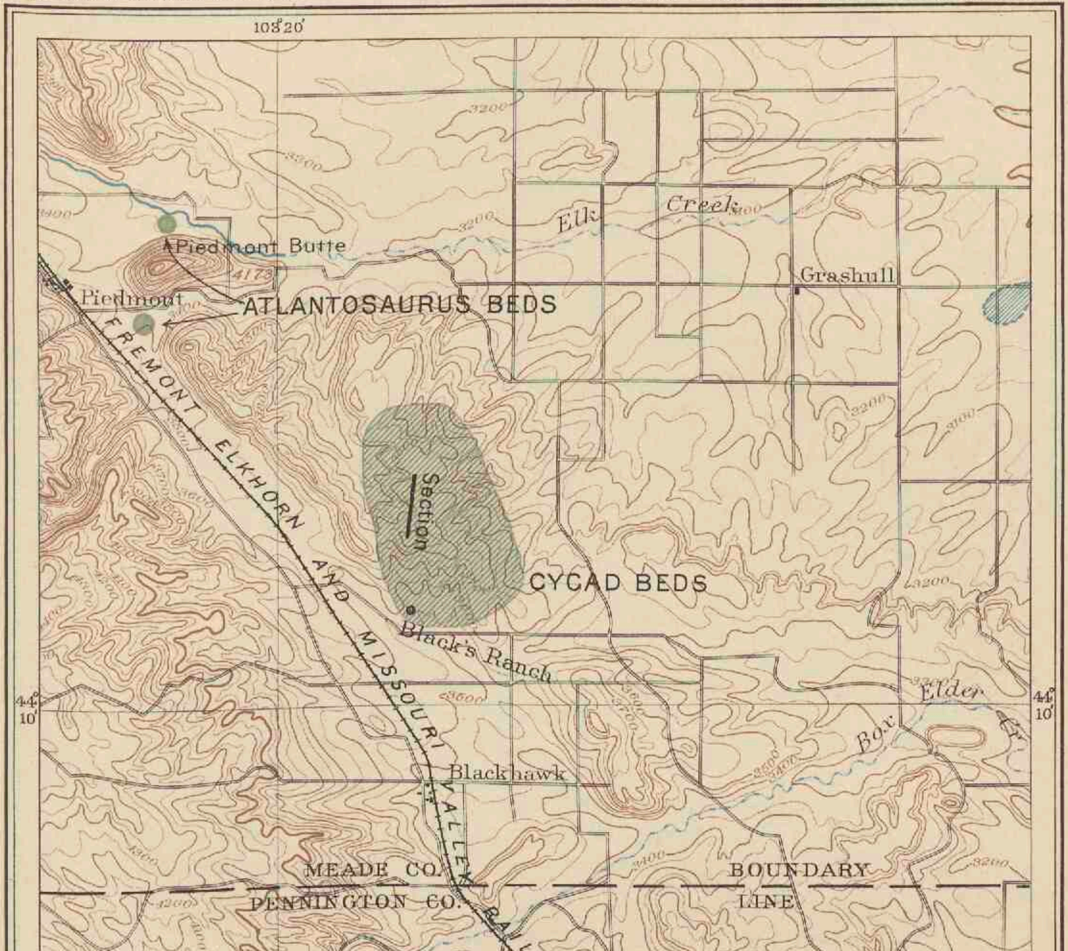
As, on the occasion of my visit to Black's ranch in 1895, none of my party had been able to discover any additional specimens, I was exceedingly curious to know where Mr. Wells had obtained so large a number. The labels on the specimens showed nothing beyond the fact that they had been found in the Blackhawk region. Professor Marsh had, however, at my suggestion, impressed Mr. Wells with the importance of giving more specific localities for the cycads, but so late in the day that it was only in case of the last and smallest invoice, containing 14 specimens, Nos. 113–126, that Mr. Wells had undertaken to be more exact in this matter. All this emphasized the importance of my visiting the region again, and under his guidance, minutely examining each of the localities. This is what was done in October, 1898. A few of the specimens found by him were not far from the locality pointed out by Mr. Getchell as that of the original specimens, but were somewhat farther up a small ravine, which has a due south course and opens into the larger ravine having a southeasterly course that passes by the ranch house. By following up this ravine still farther, we passed over a large number of additional localities and these extended entirely over the divide to the north and northeast. All of these specimens occurred out of their natural position, among loose rocks that had slipped down from the higher cliffs, and the same is true for most of the specimens from the localities farther to the northeast on comparatively low ground. They had, therefore, no geological significance and there was no possibility of measuring a section to indicate their geological position. It was of the utmost importance, however, that a section should be made, and in order to do this I was obliged to explore the high hills to the north, which are in their original position.

About 3 miles due north of Blackhawk and 4 miles southeast of Piedmont there is a peculiar conformation of the surface, consisting of what seems to be, from whatever side it is viewed, a high plateau, rising 300 feet above the valley through which the railroad passes and having a length nearly north and south of about 3 miles and a width of nearly 2 miles. But when one reaches the summit of this high hill, one finds that it consists in reality of a sort of gulf or amphitheater, not shown on the topographic map, with a depth of between 200 and 300 feet, but having an outlet on the eastern side, and also a depression in its rim on the south side; otherwise it is entirely surrounded by the high ground covered with the Cretaceous sandstones, has every appearance of a true basin, and reaches at the highest points the 3,900-foot contour line. The uppermost rocks are somewhat quartzitic and barren, usually forming precipitous ledges, but the next terrace below consists of the typical soft sandstones with which the fossil wood and cycads are usually associated and are found mingled with them on the spurs and slopes below. In this particular case, however, it has fortunately happened that a number of cycads, and among them some of the largest and most interesting, were found virtually in place at this high level on the inner slope of the rim of this basin at its southern end. Mr. Wieland had also found a specimen on the west side at the same level and another half a mile north of the basin at a little lower level. The discovery of these specimens is very important in confirming the view at which I had previously arrived, that this highest terrace below the quartzitic cap constituted the cycad horizon. In fact it demonstrates this, at least for the Blackhawk region.

I therefore determined to make a section at the precise point at which these cycads occurred. It was impossible to obtain this from the south side on account of the gradual slope and the number of slips which obscured the strata, and I was obliged to go over on the inside of the basin at its extreme southern end and measure the section from that side. Owing to the size of this inclosed valley, however, some of the same difficulties presented themselves that occur in cases where broad valleys are adjacent to the slopes, and it was impossible to measure the thickness of the Jurassic or even to find its contact with the Red Beds, if the latter occur at all. The following is the section as thus measured:

SECTION 3 MILES NORTH OF BLACKHAWK.

	Feet.
Cretaceous, 200 feet.	
5. Whitish or yellowish sandstone, greatly varying in hardness, occasionally somewhat quartzitic	46
4. Soft, yellowish sandstone and sandstone shales with occasional reddish clay seams, especially near the base; cycads found in place within 6 feet of base	50
3. Ledge of soft light sandstone	10
2. Slope mostly covered with débris of sand rock, grass, and herbage	94
Jurassic exposed, 100 feet.	
1. Jurassic, much obscured, to bottom of canyon	100
Total exposure	300



THE BLACKHAWK REGION OF BLACK HILLS SOUTH DAKOTA

SHOWING THE CYCAD AND THE ATLANTOSAURUS BEDS

BY LESTER F. WARD

1898

A. Hoen & Co. Lith. Baltimore.

The largest cycad from that region, No. 100 of the Yale collection, and the largest but one in the world, was found at a height of 110 feet above the Jurassic contact or 80 feet below the top of the highest crest on the south end of this basin on its inner slope, and several other of the most interesting specimens were found either near this or in relatively the same position somewhat farther east.

A less successful attempt was made to measure a section at the north end of the basin, where the rim was found to rise 86 feet above the top of the Jurassic, exposed below. But it is probable that the highest part of the rim here is considerably below the cycad horizon and the plain slopes away to the northward, so that no full section can be obtained. On the west side, where Mr. Wieland found a cycad at about the same horizon as those at the south end, the rim is very thin and the rocks have the appearance of dipping rapidly to the westward. This is, however, undoubtedly due to the effect of undermining and tilting them at the time that the broad valley on the west was being eroded. On the slope toward the basin the dip is in the opposite direction, doubtless from a similar cause.

The entire cycad area therefore of the Blackhawk region, as we now understand it, forms a sort of rectangle about a mile and a half wide east and west and 3 miles long north and south, with Black's ranch at its southwestern corner, and it extends in altitude from the 3,600- to the 3,750-foot contour line (see map, Pl. LV). All the specimens, however, found below the 3,750-foot contour line are of course out of place.

IV. THE HAY CREEK REGION.

After Professor Jenney and I had discovered, in 1893, that there was a large series of beds underlying the true Dakota group in the Black Hills, the idea of developing an extensive fossil flora assumed a definite shape in the minds of both of us. His prolonged investigations in all parts of the Black Hills in the capacity of a mining expert rendered it highly probable that if such a flora existed he would sometime find it when studying such outcrops as promised to yield coal. An occasion of this kind presented itself much earlier than I had expected, when, the following year, he was employed by the railroad companies to investigate the coal fields on Hay Creek, a tributary of the Belle Fourche, which rises in Crook County, Wyoming, and flows slightly north of east, joining the Belle Fourche opposite the town of that name. Valuable beds of coal were discovered on the upper tributaries of Hay Creek, and this general region is now known as the Hay Creek coal field, with Barrett post-office near its center. The map (Pl. LVI) shows in detail the nature of the Hay Creek coal field, and indicates the stratigraphy, as worked out by Professor Jenney, and all the localities from which fossil plants were obtained by him and sections made.

The history of Professor Jenney's investigations will now be given. In June, 1894, I received a letter from him dated June 10, from which I give the following extract:

I have just returned from a three weeks' camping expedition in the foothills of the eastern part of the Bear Lodge Range. I had occasion to study carefully the Hay Creek coal field, situated 40 miles northwest of Deadwood, and have measured many sections covering the Dakota group of Newton. I found much that would interest you. It is true I could not find any cycad trunks, but think we will yet find impressions of the leaves. Fossil wood is quite abundant in this formation. In one place a huge tree is sticking in the face of a cliff; the trunk is 3 feet in diameter and extends along the face of the cliff for 40 or 50 feet, forming across the rifts in the rock a kind of natural bridge. I could only take specimens of the sapwood and heartwood of this silicified trunk. It is too large to send to Washington.

I find in the Hay Creek district four distinct plant-bearing horizons that will prove very useful in separating the Dakota group into the different epochs. I could only collect a few plants from each, but have carefully recorded the localities. Several will, if worked, yield, I am satisfied, finely preserved plants. It is true I have not found in the Lower Cretaceous a great variety of plants, and that good specimens are not common.

I discovered between the Jurassic and the Dakota group of Newton evidences of unconformity, i. e., that the Jurassic formation had suffered considerable erosion prior to the deposition of the Cretaceous. Further, between the top of the Jurassic beds with characteristic marine fossils and the base of Newton's Dakota group there are about 50 feet of beds as to which I am as yet unable to determine whether they should be classed as Jurassic or as Lower Cretaceous. These beds are ash-gray clays with calcareous clay nodules, apparently without fossils. At the top of this undetermined series of beds and just beneath the sandstone shales with plant remains, the supposed base of the Cretaceous, occurs a bone-bearing bed, from which I obtained fragments of fossil rib bones 2½ inches wide, ½ to 1 inch thick. The "Atlantosaurus" beds of Professor Marsh, that Professor Carpenter states were identified by him near Piedmont, South Dakota, at once came to mind.

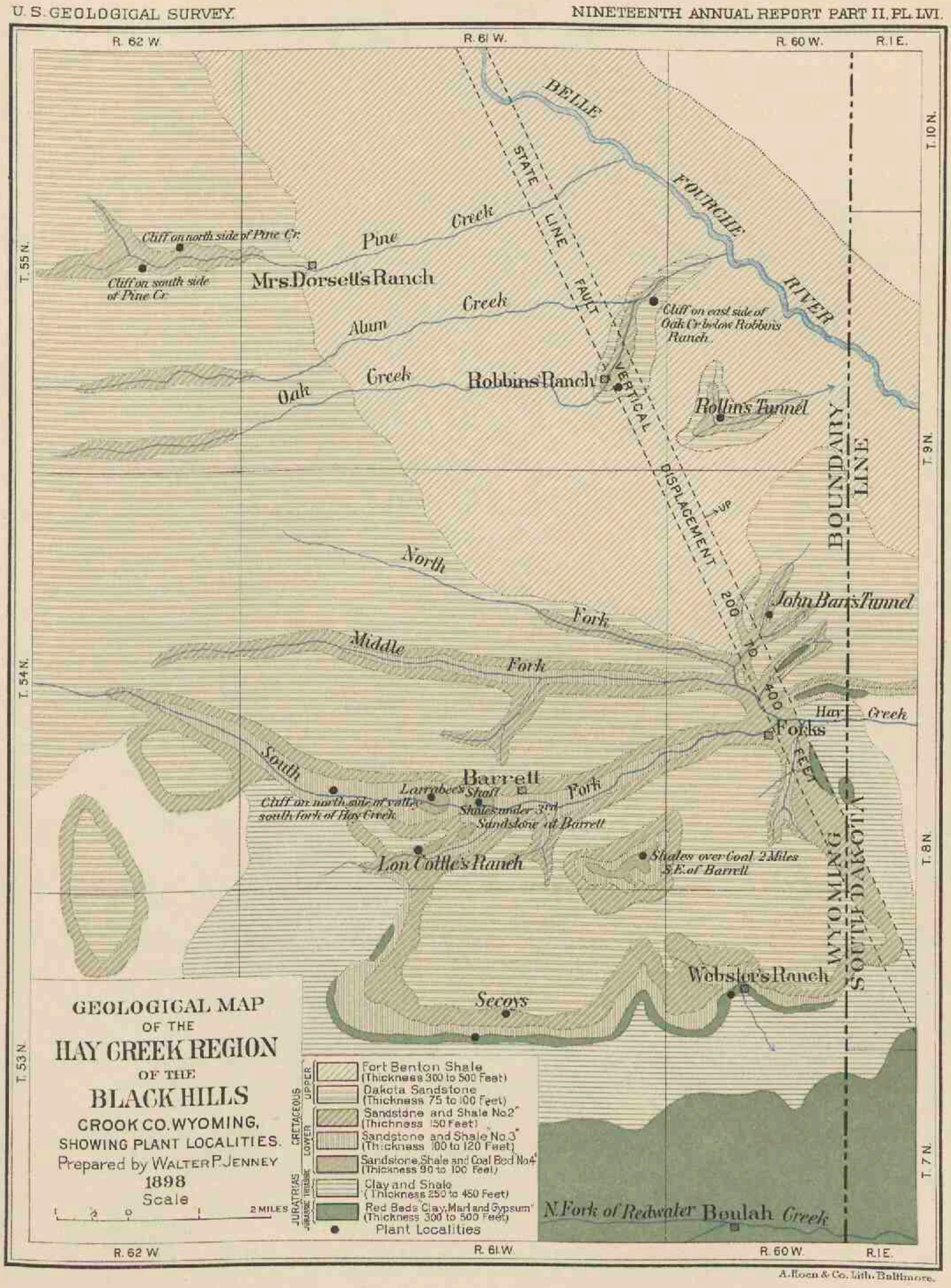
I hope to have time to search the locality and its vicinity and determine the horizon of these animal remains.

To return to the Dakota of Newton, I find it naturally separates into the following (this is of course subject to future discovery and to the determination of the plants of the several horizons):

GENERAL SECTION OF THE DAKOTA GROUP OF NEWTON.

Upper surface, probably somewhat eroded, overlain by Fort Benton Shales.

	Feet.
1. The Dakota sandstone with characteristic plant remains. The base a massive sandstone of variable character with respect to hardness, percentage of iron, etc	100
2. Clay shales, sandstone shales, and soft sandstones with, locally, beds of carbonaceous shale and plant remains, plants, ferns of modern type, and ribbon-like fucoids; at base of this member a massive cross-bedded sandstone 50 feet in thickness; contact stratum, a breccia of clay and sandstone marking unconformity	150
3. Massive sandstone 40 feet, underlain by drab clay shales and carbonaceous shales with plant remains. Plants, ferns, cycad-like in type, pine needles, plant impressions like modern Equisetum, leaves of willows, rushes, etc	100
4. Soft sandstones, clay shales and clays with one workable (3 to 5 feet thick) and several smaller local seams of coal, plant remains, peculiar ferns, cycad-like, and long flattened pine needles	100



A. Hoen & Co. Lith. Baltimore.

Page.

5. Ash-colored clays with calcareous nodules. No fossils observed; near top at contact with No. 4 occur, locally, fossil bones........................ 50

This member may be Jurassic.

6. Jurassic clays and shell limestone with marine fossils—Belemnites, Ostrea, Exogyra, etc.

Professor Jenney commenced almost immediately to send on packages of fossil plants. Three packages were sent on June 16, two on June 28, five on July 8, and one on July 12. In addition to this, he sent a box containing specimens collected in August and September. Altogether the collection is one of the finest that has ever been made from any part of the West. It came in admirable condition, with every specimen carefully and accurately labeled, indicating its locality and the particular stratum from which it was obtained. This collection was forwarded to Professor Fontaine for determination, and his report upon it is embodied in this paper (pp. 645–702, Pls. CLXII–CLXIX).

In one of Professor Jenney's letters, dated August 20, 1894, he gives the following additional facts, which are well worth recording:

I hope the collections I have sent in will insure the determination of the age of the coal and the separation of Newton's Dakota group into its several horizons. Since my last letter I have done a great deal of detailed stratigraphic work in the interval between the Red Beds and the Fort Benton shale.

I find overlying the marine beds of the Jurassic about 50 feet of light-colored clays with nodular layers of clay limestones. These beds I first supposed to be possibly Lower Cretaceous, and marked them No. 5 in the section I sent you in my letter. I have found evidences that these beds are probably Jurassic shallow-water deposits; they carry often large trunks and limbs of fossil wood, and in the layers of impure limestone a few small Ammonites near the top of these beds; just below the contact with the base of No. 4, Cretaceous, occurs a bone-bearing bed—large elongated vertebræ and fragments of leg and thigh bones, all in a poor state of preservation. These beds recall the Atlantosaurus beds of Marsh to my memory, but as I have not the original papers by Professor Marsh on those saurian remains I can not say more as to their probable place in the section.

There are evidences that the land was rising at the close of the Jurassic, for some of the No. 5 beds may be brackish or fresh water, and that before the deposition of the lowest beds of the coal series (division No. 4, Newton's Dakota) the land was above water and had suffered a quite extensive denudation, and that the workable and lowest beds of coal were deposited in basins, channels, and valleys in the eroded Jurassic. This I believe has not been noted before. I find the dynamic geology of the region far more complicated as I study it than was at first apparent. There are faults, elevations of strata, both anterior and subsequent to the formation of the coal. I have been able to send you quite a representative collection of the plants of No. 2 division of Newton's Dakota; a less extensive one of the plants of No. 3 division, and but few plants from No. 4 division, the horizon of the coal. I did not try to collect from No. 1, the Dakota sandstone proper, as the plants from that horizon are well known. I have hired three or four miners, and will open the coal in No. 4, in a new field I have discovered in an unexplored section of this region. If there are any plants I will send you collections made.

As I think I wrote you, I find evidences of unconformity between No. 3 and No. 2 and between No. 2 and No. 1. I have been unable to detect any unconformity between No. 4 and No. 3. The great unconformity of the Jurassic and No. 4 has been noted. On the higher ridges of Jurassic surface, No. 3 rests on the Jura and No. 4 is absent.

I think I can get you plants that will show No. 4 to be older and distinct from No. 3, though the stratigraphy shows apparent uninterrupted deposition.

Not content with performing these important services, Professor Jenney has taken time to prepare for me, with permission to use in this report, an extended series of notes upon the Hay Creek region and a large number of sections from the most important plant-bearing beds. It is with great pleasure that I avail myself of the data thus furnished, which I insert bodily into this memoir. The map of the Hay Creek coal field was also prepared by him; and taking this in connection with his descriptions and sections, we have a very full statement of the geology and paleontology of that region.

Professor Jenney continued to furnish these notes down almost to the time of going to press. It is my duty to add that he has performed all these services for the pure love of science, and the spirit by which he has been actuated may be gathered from the following remark in his letter of April 17, 1898, inclosing the last of his manuscript, where he says:

Use these notes when you can in writing, and all other notes, maps, and data sent. Do not worry about giving me credit. The object to be attained is the best monograph on the coal field. So use all data as your own and publish over your own signature, unless there is good reason for not doing so. You have full authority to omit, change, or publish any or all of the material sent in such manner as you shall deem best.

A copy of Professor Fontaine's manuscript describing the fossil plants of the Hay Creek coal field was sent to Professor Jenney, and his notes include a discussion of the stratigraphy from the paleontological standpoint.

FIELD OBSERVATIONS IN THE HAY CREEK COAL FIELD.

By Walter P. Jenney.

THE DAKOTA GROUP OF NEWTON.

In the report on the geology of the Black Hills based on the field work of the survey of that region made in 1875, Mr. Henry Newton, the geologist of the survey, wrote:

It has already been remarked that the concentration of attention on the main body of the Hills prevented a thorough study of the Jura. In a still greater degree it reduced our opportunities for the examination of the Cretaceous. Very few of our excursions penetrated more than the basal member, and the only examinations of the entire series were in our rapid approach to the Hills via Beaver Creek and on our return march. So far, however, as our observations extended, it was evident that the Upper Missouri section of Meek and Hayden was applicable without essential modification.[1]

Mr. Newton quotes from the Invertebrate Paleontology of Professor Meek as follows:

No. 1.—Dakota group.

Yellowish, reddish, and occasionally white sandstone, with at places alternations of various-colored clays and beds and seams of impure lignite; also silicified wood,

[1] Geology of the Black Hills, p. 175.

and great numbers of leaves of the higher types of dicotyledonous trees, with casts of *Pharella? Dakotensis, Trigonarca Siouxensis, Cyrena arenarea, Margaritana Nebrascensis*, etc.

Localities.—Hills back of the town of Dakota; also extensively developed in the surrounding country in Dakota County [Nebraska] below the mouth of the Big Sioux River, and thence extending southward into northeastern Kansas and beyond. Thickness, 400 feet.[1]

Mr. Newton, writing from his own observations on the Dakota group in the Black Hills, describes it as follows:

Prominently developed, forming the capping rock to the foothills that surround the Hills on all sides; appears with its characteristic composition—coarse yellow or red sandstones with discontinuous variegated clays. At places a considerable thickness of very soft and fine white sandstone appears at the base. Elsewhere considerable portions are of hard, dense quartzite. No animal fossils were found, but many remnants of plants—in no case more than mere coaly fragments. Thickness, 250 to 400 feet.[2]

Mr. Newton placed in the Dakota group all the sandstones and clays included between the Jurassic and the Fort Benton, following Dr. F. V. Hayden, who had studied this formation along the Missouri River, and who first identified the Dakota sandstone in the Black Hills, Dr. Hayden having accompanied as naturalist and geologist the expeditions under command of Gen. G. K. Warren in 1855 and of Capt. W. F. Raynolds in 1859, who made brief visits to the Black Hills.

Mr. Newton has in the text quoted briefly explained the imperfect and hurried character of the investigation of the later geological formations in the foothills, which was unavoidable from the necessity of concentrating the work upon the metamorphic region of the interior of the Hills, with its placer gravels and gold-bearing veins.

In the summer of 1877 Mr. Newton returned to the Black Hills for the purpose of making a more complete investigation of the geological structure and to supply many omissions in the field observations made in 1875. While there engaged he died at Deadwood from typhoid fever. The manuscript of his report on the geology of the Black Hills was left incomplete at his death and was not published until 1880.

From the early work of Dr. Hayden in this region the unity of the Dakota group was not questioned until the visit of Prof. Lester F. Ward in September, 1893, who came to the Hills with the object of determining, if possible, the horizon of the remarkable fossil trunks of cycads found near Hot Springs, South Dakota. In the search for the cycad locality and in the approximate determination of the horizon from which these fossil trunks had been derived I accompanied Professor Ward, as related elsewhere.

The following summer I was engaged in an investigation of the economic value of the coal of the Hay Creek region in the extreme northern Hills, distant 90 miles north-northwest from Hot Springs. In the progress of the field work it was found that workable beds of coal occurred in the lower part of the Dakota group. Later, as the relation

[1] Geology of the Black Hills, p. 174.

[2] Geology of the Black Hills, p. 175.

of the different beds was worked out, and as collections were made of the fossil plants, it became apparent that the Dakota group was made up of a number of distinct formations, separable stratigraphically, and that each division was characterized by a fossil flora peculiar to itself, by which it could be readily recognized. The collections of fossil plants were forwarded for determination to Professor Ward at Washington. There was also sent a general section of the strata exposed in the Hay Creek region, a description of the several divisions determined stratigraphically of the Dakota group, and a statement of the approximate position of each plant-bearing bed or horizon, referred to its proper division and measured from the Jurassic below and also from the Dakota sandstone above.

These plant collections, with the accompanying notes, were referred by Professor Ward to Prof. Wm. M. Fontaine for examination.

The divisions of the Dakota group, determined stratigraphically, were confirmed by the study of the plants by Professor Fontaine, who further determined that the divisions (Nos. 3 and 4) lying at the base of the Dakota group, and including the coal beds of economic importance corresponded most nearly in flora to the Lower Potomac. The division above (No. 2), lying immediately beneath the Dakota sandstone (No. 1), was correlated by its flora substantially with the upper portion of the Older Potomac (Aquia Creek series), and all of the Dakota group included between the Jurassic at its base and the true Dakota sandstone at the top was thus placed in the Lower Cretaceous.

In the determination of the horizon of the fossil cycads in the Hot Springs region Professor Ward had previously identified the upper 100 feet of strata of the Dakota group as constituting the Dakota sandstone proper, characterized in the southern hills by an abundance of well-preserved dicotyledonous leaves. The underlying beds included between the Jurassic and the Dakota sandstone were shown to be in all probability Lower Cretaceous, from position, from the abundance of fossil cycad trunks, and from the confirmatory evidence of a small collection of fossil plants obtained.

The field work in the Hay Creek region and the plant collections made have furnished data for the division of the Dakota group into distinct epochs, corresponding to the prominent divisions of the Cretaceous of the Atlantic coast. Further, it has made certain the determination by Professor Ward of the Lower Cretaceous age of the larger part of the strata in the Black Hills heretofore included in the Dakota group.

THE HAY CREEK COAL FIELD COMPARED WITH THE POTOMAC FORMATION.

1. *Character of the sediments.*—The beds forming the Dakota group of Newton are either pure sands, clays, or mixtures of clay and sand. Granitic sands (arkose) are absent. These sediments are consolidated into rock strata of varying hardness. The sands form sandstone in

many localities, particularly in the lower part of the Dakota sandstone, of a quality suitable for building purposes. The clays occur as clay shales, save the under and over clays of the coal beds, which are commonly soft fire clays, though with a shaly structure.

The beds show little or no disturbance after deposition. Erosion has taken place in certain beds prior to the deposition of the later strata resting upon them. The clay balls and lenses—irregular masses and sheets of clay described as occurring in the Potomac formation, the result of the destruction of preexisting clay beds—do not seem to have their counterpart in the Black Hills. So far as the writer has had the opportunity to examine the Dakota formation in other localities in the belt encircling the Black Hills, it everywhere has the above-described character.

2. *Persistence of plant horizons.*—Certain horizons carry plants throughout the Hay Creek region; notably the plant horizon of division No. 3 at the base of the cliff-forming sandstone (No. 3); also the bed of carbonaceous shales about 100 feet below the base of the Dakota sandstone in division No. 2.

3. *The Lower Cretaceous a coal-forming period in the Black Hills.*—At the opening of the Lower Cretaceous the beds of workable coal were deposited in hollows eroded in the Jurassic surface. A period of quiet must then have occurred, long enough to form coal with a thickness of from 3 to 6 feet. The coal appears to have been formed where the vegetation grew and to have been deposited in basins, channels, and small irregular swampy tracts between the Jurassic hills.

Like the coal beds of the Carboniferous, the Hay Creek coals have an under clay, filled with fragments of plant remains, and an overclay, in which occur, in favorable localities, well-preserved plants. Overlying and capping the clays with the included coal are thick beds of sandstone.

In division No. 3 thin coals occur, but are seldom found of workable thickness. In division No. 2 a bed of black carbonaceous shale occurs continuously over a considerable area. In the Dakota sandstone thin impure coal seams without economic value are found in the upper shaly strata.

4. *The Newcastle coal.*—At Newcastle, Wyoming, at the Cambria coal mines, on the southwestern border of the Black Hills, coal also occurs in the lowest beds of the Lower Cretaceous. The horizon of the Newcastle coal is about 50 feet above the top of the Jurassic. The coal is peculiar in character, having been apparently deposited in the bottom of a lake, and formed mainly from the leaves of some species of conifer. The coal is underlain by hard, massive sandstone and is directly covered by thick sandstone strata, without a trace of the underclay or overclay commonly occurring with coal beds the world over.

At the Cambria mines this coal is 7 to 9 feet in thickness. Seams of splint, or impure coal, 4 to 8 inches thick, occur in the upper part of the bed. On weathering on the slack dump the fragments of these splint layers disintegrate into bunches of long, flat, pine needles, brown colored on the surface; on breaking, of a brilliant jet-black coal within. These conifer leaves are 3 to 4 inches long, and as a result of one or two seasons' exposure to weather a fragment of splint comes to resemble a bunch of coarse brown-colored hay. These needles will burn when lighted with a match.

The Newcastle coal is heavy, dense, breaking into shaly fragments, thin at the edges, like rock spalls from a quarry. The ash is nearly pure silica, apparently made up mostly of fine sand deposited with the vegetable matter forming the coal. The percentage of ash varies widely in different parts of the coal bed, but averages about 13 to 18 per cent of the weight of the coal shipped. In coking, this coal gives off a large amount of condensable products—tar, ammonia, etc.

The Newcastle coal is used on the locomotives of the Burlington Railroad, as a fuel for steam boilers at the Homestake mines, and in the form of coke in the smelting furnaces (D. & D. Smelter) at Deadwood, South Dakota. It is not favored as domestic fuel. Microscopic examination of specimens of this peculiar coal from different parts of the bed might throw light on its origin and formation.

5. *Stratigraphical position of the Lower Cretaceous in the Black Hills.*—Most valuable of all is the precisely defined position of the Lower Cretaceous. The Dakota group of Newton embraced all the strata included between the marine Jurassic and the Fort Benton of the Upper Cretaceous. The marine Jurassic is characterized in the Black Hills by a great abundance of fossil mollusks, so that the age of the formation is well established. Resting uncomformably on the marine Jurassic, and formed from the products of its erosion, is the brackish or fresh-water formation which I have designated as later Jurassic, division No. 5 of Newton's Dakota group, the supposed equivalent of the Atlantosaurus beds of Marsh. Whether these beds should be regarded as Jurassic or as transition beds between the Jurassic and Cretaceous, or should be made the lowest division of the Lower Cretaceous is open to discussion. The marked uncomformity between the Lower Cretaceous and these later Jurassic beds, the great change in the character of the sediments in passing from the Jurassic (No. 5) to the Cretaceous (No. 4), and the resemblance of the few fossil shells found in No. 5 to Jurassic forms, have led the writer to place this formation in the Jurassic. There is little doubt that division No. 5 of the Hay Creek section is the same as the beds included between the Jurassic and the Dakota group at Piedmont, South Dakota, on the eastern border of the Black Hills, which were identified by Marsh as the representative of the Atlantosaurus beds of Wyoming and Colorado. The Piedmont locality was visited by J. B. Hatcher, who there found numerous large elongated vertebræ described by Marsh as a species of Barosaurus.[1] Similar vertebræ were found by my assistants in the upper beds of division No. 5, in the Hay

[1] Sixteenth Ann. Rept. U. S. Geol. Survey, Part I, p. 175.

Creek region. Professor Marsh gives the following general section of the geological horizon of vertebrate fossils in North America:[1]

Cretaceous	Dakota group.	
Jurassic	Atlantosaurus beds	Dinosaurs: Brontosaurus, etc.
	Baptanodon beds	Mammals: Dryolestes, etc.
	Hallopus beds	
Triassic.		

Referring to the "remains of an enormous dinosaurian"[2] found near Morrison, Colorado, in 1877, and described as *Atlantosaurus montanus*, Professor Marsh writes:

When first found these fossils were supposed to be from the Dakota group, but their Upper Jurassic age was soon after determined by the writer from evidence that placed the horizon beyond dispute.

Professor Marsh continues:

Another locality of Sauropoda, more recently explored by the writer, is in South Dakota, on the eastern slope of the Black Hills. This is the most northern limit now known of the Atlantosaurus beds, which form a distinct horizon along the eastern flanks of the Rocky Mountains, marked at many points by the bones of gigantic dinosaurs, for nearly 500 miles. The strata are mainly shales or sandstones of fresh water or estuary origin. They usually rest uncomformably upon the red Triassic series, and have above them the characteristic Dakota sandstones. On the western slope of the Rocky Mountains the Atlantosaurus beds are also well developed, especially in Wyoming, but here they have immediately below them a series of marine strata, which the writer has named the Baptanodon beds, from the largest reptile found in them. This horizon, also of Jurassic age, is shown in the section.[3]

From the above it is evident that Professor Marsh regarded the Atlantosaurus beds as later Jurassic.

The marine beds of the Fort Benton form a marked boundary to the Dakota group readily identified by the eye as far as the colors of the different formations and the peculiar topography which each impresses upon the field of view can be distinguished.

Upon examining the Dakota group of Newton in detail the Dakota sandstone is readily differentiated stratigraphically from the lower divisions by the abrupt change in the character of the sediments, the Dakota sandstone forming a prominent cliff, while the clays of the Lower Cretaceous immediately underlying it yield to erosion and are covered beneath a long grassy slope. Even more marked is the great change in the flora between the Lower Cretaceous and the Dakota sandstone, but this I need not go into further.

In the Black Hills the strata of the Lower Cretaceous are thus intercalated in a series of well-determined formations, so that the exact relative position is accurately known, both stratigraphically and paleontologically.

Fossil wood occurs in the later Jurassic of Hay Creek, and it is not improbable that fossil plants will be found in the brackish and fresh

[1] Sixteenth Ann. Rep. U. S. Geol. Surv., Part I, p. 145. [2] Ibid., p. 164. [3] Ibid., p. 165.

water deposited beds of the Jurassic when the great extent of territory covered by rocks of this age, stretching along the eastern slope of the Rocky Mountains, is carefully explored and particular search made.

6. *Resemblance of the flora of the Hay Creek coal field to that of the Lower Potomac.*—Professor Fontaine remarks:

The fact that the Hay Creek flora shows a much greater resemblance to that of the Lower Potomac than to the Kootanie floras of British America and of Great Falls, Montana, which occur much nearer to the Hay Creek region than does the Potomac, of Virginia, is another surprising feature (see infra, p. 702).

In my letter of May 26, 1896, I commented on the insular position of the Black Hills, and stated that from my own observations the modern flora is more nearly related to that of the Eastern States than it is to the flora of the Rocky Mountains.

The Black Hills may have been covered by the ocean as late as the close of the deposition of the marine Jurassic. No positive evidence has been obtained that any portion of the Hills was above water prior to that date, although the water continued shoaling from the Carboniferous to the later Jurassic. Neither has fossil wood been found in the Triassic or the marine Jurassic, and it is not until the later Jurassic is reached that it occurs.

Jurassic formations occur west of the Black Hills and along the foothills of the Big Horn Mountains, and extend north into Montana and south through Wyoming and Colorado to New Mexico. The eastern shore of the sea depositing the marine Jurassic is not known; neither is it known how far to the east the fresh and brackish waters extended in the later Jurassic. The Upper Cretaceous stretches eastward into Kansas and Iowa. Strata of Jurassic age have not been discovered east of the Black Hills. I found the marine Cretaceous in Arkansas, abutting on the Paleozoic, and searched the contact for the missing formations.

In Cretaceous time a great promontory of land, formed by the union of the Ozark and Ouachita uplifts, stretched from Missouri and Arkansas southwesterly across Indian Territory to the Pan Handle of Texas. This promontory had its origin in the elevation of the Allegheny continent at the close of the Carboniferous. The land nearest to the Black Hills on the east during the Upper Cretaceous was the northwestern shore of this upheaval, which crossed central Kansas in a line running northeastward into Iowa. In Jurassic and Lower Cretaceous time the western border of the continent may have been much nearer to the Black Hills than in the Upper Cretaceous. Is it not probable that the flora of the Hay Creek region may have been derived from the east? Further, occasional strong winds in the Black Hills come from the east and the heavy rain storms often occur with a southeast wind. With all this, with the origin of these winds in the Gulf of Mexico, with the great extension of the Gulf of Mexico to southern Illinois in the Mesozoic, may not easterly winds have been more prevalent and assisted in the migration of the plants westward?

The Cretaceous shore line lies 400 to 450 miles southeasterly from the Black Hills. The Kootanie country is situated on the head waters of the Columbia, distant 750 miles northwest from the Hay Creek coal field. Great Falls, Montana, is somewhat nearer, on the head waters of the Missouri.

Since writing the above I have found that this subject has been gone into extensively by C. A. White, J. S. Diller, and T. W. Stanton, and that Dana embodied[1] their views in a map of North America in the Cretaceous period. According to this map, the Kootanie region would lie on the northeastern shore of the "Pacific border" and naturally would belong to a different floral province. The tiny dot on the map representing the Black Hills, in the middle of the Cretaceous area, seems possibly to have derived its flora from the Alleghany continent. At the present day not only the plants, but many of the animals and birds, are of eastern species.

7. *Absence of certain forms of life in the Cretaceous formation of the Hay Creek coal field.*—Many forms of life which naturally would be expected to occur preserved in the sedimentary strata, appear to be absent. This is the more remarkable because the conditions of climate and of deposition and the known occurrence of a most varied fauna and flora in other parts of the country during Cretaceous time would seem to have been favorable not only to abundant life, but also to its preservation in the fossil state. It is true that such evidence is of a negative character, and that the collections made even in the richest plant localities are scanty, yet it is not without value in throwing some light on the conditions which subsisted in this region during the deposition of the Hay Creek beds.

a. Absence of cycads.—Careful search was made, without success, for silicified trunks or cycads, such as are found abundantly near Minnekahta station in the southern part of the Black Hills. Photographs of these cycads were shown to a number of cattlemen and settlers, but no one could recall ever having seen anything resembling them. The abundance of silicified wood shows that the conditions were favorable for their preservation.

b. Scarcity of dicotyledons in the collections made.—The collections were forwarded to Washington by mail, for which reason selected material only was preserved, but in making the selection all the material left on the ground was carefully examined for impressions of leaves of anything resembling dicotyledons. Only two or three were found, all in the beds of division No. 2. In division No. 1, Dakota sandstone, dicotyledons occur in favorable localities, but are mostly poorly preserved and difficult to identify.

c. Absence of marine beds in the Dakota group of Newton.—The calcareous clays of division No. 5, later Jurassic, appear to have been deposited in brackish waters. A small ammonite, a fragment of a shell resembling Unio, and a few other small and poorly preserved

[1] Manual of Geology, 4th ed., p. 813.

shells were found in layers of impure argillaceous limestone. These fossils bear resemblance to Jurassic forms. All the beds of the Lower Cretaceous and of the Dakota sandstones have been formed in fresh water.

d. Prevailing absence in the strata of the Lower Cretaceous and in the Dakota sandstone of all forms of life commonly occurring in bodies of fresh water.—Fossil bones of many species of the Atlantosaurus, as well as turtles, tortoises, birds, and small mammals are described by Marsh from the Atlantosaurus beds of Colorado, Wyoming, and the eastern slope of the Black Hills. Elongated vertebræ, similar to the forms figured by Marsh, were found in the beds of division No. 5 in the Hay Creek region, the supposed equivalent of the Atlantosaurus beds of Marsh.

From the base of division No. 4 to the top of No. 1, the Dakota sandstone, although many exposures were carefully examined and an area of nearly 120 square miles gone over, yet not even a fragment of a fossil bone was anywhere found, not a single specimen of a fresh water or land shell; neither are there in the beds any visible comminuted fragments of shells. Insects also seem to be wanting. What can be the reason that while the beds in divisions No. 1, No. 2, and No. 3 were formed in a body of fresh water, supposed to have stretched for hundreds of miles, fishes, turtles, reptiles, and aquatic birds have left no trace of their presence? Neither can I recall finding any fossil plants of species which would be aquatic in growth.

Fossil wood, which is very abundant in the upper beds of division No. 2, and occurs more sparingly in divisions No. 3 and No. 4, is nowhere found to have been attacked by boring mollusks. This is merely an evidence of the absence of the sea or of brackish water, all mollusks which attack wood being marine; but I have thought it best to record the fact.

Whatever may have been the character of the vast body of fresh water in which these beds were deposited, it is reasonably certain that it must have had an outlet, and during the time that the beds of divisions No. 4, No. 3, No. 2, and No. 1 were forming, it could never have been saline to such a degree that chemical precipitates would occur, such as are characteristic of salt lakes—lakes without outlet. All the beds of these divisions are either clays or sands. Chemically precipitated beds, as limestones, calcareous sediments, gypsum, and marls carrying peroxide of iron, are absent. With the exception of concretions of limonite, which occur quite abundantly in the Dakota sandstone, much of which is probably of recent formation from atmospheric waters, all the iron in these beds is in the form of peroxide.

Briefly reviewing the evidence, it may be remarked that the coal of division No. 4 and its accompanying shales were deposited in local marshes, occupying depressions eroded in the Jurassic surface. The coal was evidently formed where the vegetation grew. The beds resemble the coal formations of the Carboniferous in having underclay and overclay, the latter carrying impressions of fossil plants, and also in the character of the coal itself—dry, black, noncoking, with little ash or sulphur.

The third division opened with alternating conditions, forming thin coals interbedded with shales and soft sandstones, but closed with a considerable sinking of the region and the deposition of a persistent sandstone covering the whole Hay Creek region and dipping northerly and easterly until concealed beneath the marine beds of the Upper Cretaceous.

Division No. 2 opens with the formation of a heavy sandstone, continuous over a great area. The lower stratum of this sandstone is in many localities a conglomerate or breccia, and there are evidences that the underlying No. 3 sandstone suffered some denudation before the deposition of the No. 2 sandstone.

These sandstones show evidences, in ripple marks, in cross-bedded structure, in layers of coarse sand, and in a few beds of conglomerate, that they were deposited in shallow water by currents having frequent changes of direction. Division No. 2 closes with beds of clay and sandy shale, and locally thin, irregular seams of impure coal, deposited in quieter waters and during alternating changes of level. The evidence is seldom seen of denudation having taken place on the surface of division No. 2 before or accompanying the deposition of the Dakota sandstone, because the contact of the two divisions is in most places concealed.

The Dakota sandstone shows more than any other sandstone the effect of currents of water in its formation. The sediment varies widely in character in short distances and in different beds. Broad sheets of heavy ripple marks occur, cross-bedded structure is strongly marked, and iron in the form of limonite is abundant in certain layers. In short, from an examination of the beds there is no evidence that the conditions which existed in the Hay Creek region during the Lower Cretaceous were either unfavorable to the existence of life or to the preservation of the life record in the rocks. The land was entirely above water at certain epochs, with marshes, swamps, and shallow isolated lakes in the depressions between the hills. These conditions were permanent long enough, during the deposition of the beds of division No. 4, to form in the deeper basins solid coal 3 to 5 feet in thickness, free from partings of shale.

Later, in early Cretaceous time, there were intervals of quiet waters depositing fine sediments—clays, sandy shales, and fine sandstones. To these mud flats succeeded widespread deposits of sand, laid by swift currents, and ripple-marked by the waves. High winds occurred, which tore branches from trees and leaves from ferns and bore them to shallow sand flats, where they were buried and preserved. It was the age of reptiles and reptilian birds, yet not a bone or tooth marks their presence.

		Feet.
10.	Unexposed slope	30
9.	Yellow sandstone, weathering brown	4
8.	Gray clay shales, base covered	4
7.	Unexposed slope	28
6.	Yellow sandstone, thin bedded	8
5.	Gray sandy shales	2
4.	Clay shales with imperfectly preserved plants	2
3.	Unexposed slope	6
2.	Yellow sandstone, thin bedded	3
1.	Gray sandy shales with well-preserved plants, forming low bluff	14
	Total exposure	136
	Unexposed slope to water of Pine Creek	5

Bed 12 forms the base of the Dakota sandstone. All the rest of the section is included in division No. 2.

The section is important from the large collection of plants obtained from bed No. 1 near the roadside along the bank of Pine Creek. This horizon is 106 feet below the base of the Dakota sandstone.

About one-half mile southwest, on the opposite side of the ravine traversed by Pine Creek, the same beds appear at the top of a sandstone cliff, where the following section was measured:

Section on the south side of Pine Creek.

		Feet.
	Unexposed slope with Dakota sandstone at top not measured.	
9.	Yellow sandstone	7
8.	Gray sandy shales, partly exposed	6
7.	Light-gray sandstone	5
6.	Gray sandy shales	3
5.	Gray, drab, and black sandy shales, locally a black coal with abundant fossil plants	5
4.	Gray sandy shales	5
3.	Massive soft yellow sandstone, the upper layers somewhat shaly, with occasional plant remains	35
2.	Drab clay shale	1
1.	Conglomerate of small pebbles, base not seen	2
	Unexposed talus to creek	30
	Total exposure	99

All beds here numbered are embraced in division No. 2.

The conglomerate bed 1 resembles the stratum marking the unconformity of divisions Nos. 2 and 3 in the sections measured at the Barrett and the Larrabee and Young coal mines. Uniting these sections, the thickness of division No. 2 is 149 feet. Bed 5 of this section is the same as the plant-bearing bed 1 of the section half a mile below the north side of the creek. From this bed 5 and from the underlying sandstone a number of fossil plants were collected.

These localities on Pine Creek are rich in well-preserved plants, are accessible, and can easily be found from the data here given.

The following is a section of Cretaceous strata at Rollins tunnel, about 1½ miles southeast of Robbins Ranch, Crook County, Wyoming.

Section at Rollins tunnel.

	Feet.
Top of plateau.	
9. Soft massive reddish sandstone, forming low bluff	10
8. Unexposed slope	25
7. Massive sandstone, ocher yellow, thin bedded at base	20
6. Unexposed slope	35
5. Sandstone, ocher brown, thin bedded	6
4. Unexposed slope	20
3. Gray sandy shales	8
2. Black carbonaceous shales with finely preserved plants	3
1. Drab clay shales	5
Total exposure	132

Bed 9 forms the basal stratum of the Dakota sandstone covering the top of the plateau. All the other beds are in division No. 2. The plant horizon, bed 2, is 107 feet below the base of the Dakota sandstone and is stratigraphically the same as the bed of black shales at Robbins Ranch, Oak Creek, and at the localities 2 to 2½ miles west of Mrs. Dorset's ranch on Pine Creek. This plant locality is in a short tunnel opened at the bottom of a narrow dry ravine in the plateau extending easterly from Oak Creek to the State line.

Below is given a section of the Cretaceous strata exposed on the top of the plateau and in the bluffs along Oak Creek, near Robbins Ranch, Crook County, Wyoming.

Section on Oak Creek.

	Feet.
Top of plateau.	
17. Drab-colored clay shales, weathering in thin lamellar sandstone and sandy shales	2 to 30
16. Sandstone and sandy shales	25
15. Black carbonaceous shales with charcoal and carbonized plant remains imperfectly preserved	3
14. Sandstone, thin bedded	10
13. Massive sandstone, yellow to gray, weathering reddish and ocher brown, forming cliff	40
12. Unexposed slope with outcrops of sandstone	60
11. Soft massive sandstone, weathering thin bedded, forming top of bluff on Oak Creek	15
10. Black carbonaceous shale and clay	3
9. Light purplish sandstone	10
8. Gray clay shales	2
7. Reddish-purple sandstone and sandy shale with concretions of iron	4
6. Soft yellow sandstone	6
5. Clay shales and sandy shales with well-preserved plants	2
4. Gray shales	3
3. Carbonaceous black shale	3
2. Drab clay	3
1. Sandstone, base not exposed	5
Total exposure	224
Talus	20
Water in Oak Creek.	

Bed 17, the Fort Benton shale, rests unconformably on the denuded surface of the Dakota sandstone.

The whole formation dips northeasterly toward the Belle Fourche River, where the Fort Benton has a thickness of at least 300 feet.

The Dakota sandstone, here 78 feet in thickness, includes beds 13, 14, 15, and 16.

Bed 15 is locally a loosely coherent mass of vegetable remains, mostly leaves, too much decomposed to be determinable.

The remainder of the section lies in division No. 2.

Bed 5 yielded the collection of plants described by Professor Fontaine from the locality "Cliff on Oak Creek, near Robbins Ranch," 6 miles northeast of Barrett post-office.

Below is a section of Cretaceous strata exposed on the north side of the valley of the South Fork of Hay Creek, at the Barrett Coal Mines 1 mile west of Barrett post-office.

Section on South Fork of Hay Creek.

	Feet.
Top of hill.	
Soil, sand, and gravel resulting from weathering of the Dakota sandstone	10
19. Massive soft yellow sandstone	20
18. Unexposed slope of hill	15
17. Outcrop of stratum of yellow-brown sandstone	5
16. Unexposed slope of hill	12
15. Yellow-brown sandstone	6
14. Purple clays partly exposed	20
13. Yellow sandstone, thin bedded	15
12. Massive yellow sandstone, cross-bedded, forming cliff	45
11. Conglomerate of small pebbles of flint and quartz	3
10. Breccia of angular fragments of sandstone and shale in white clay, thickness varying	10 to 3
9. Yellow sandstone with layer near base of brown iron sand	10
8. Massive gray sandstone, weathering in thin layers, forming cliff	40
7. Drab clay shales, with plant remains	2 to 5
6. Soft sandy shales with carbonized plants	2
5. Coal	1
4. Soft yellow sandstone	4
3. Drab clay shales	12
2. Coal	3
1. Drab clay shales	15
Total exposure	246

The base of the above section is probably 30 feet above the top of the later Jurassic, which outcrops on the opposite side of the valley. Beds 1, 2, 3, and 4, a thickness of 34 feet, lie in division No. 4.

The bed of thin coal, 5, the plant-bearing shales, 6 and 7, and the cliff-forming sandstone, 8 and 9, form division No. 3, 58 feet in thickness.

Sandstones 12 and 13 unite to form the persistent sandstone stratum of division No. 2, which outcrops as a cliff along the hillsides in many localities in the area drained by the branches of Hay Creek.

In division No. 2 are the beds 10 to 18, both inclusive, aggregating 124 feet.

Bed 19, a low cliff near the crest of the hill, is the basal stratum of the Dakota sandstone. It forms a prominent landmark on the hilltops along the north and south sides of the valley of the South Fork.

In this section, estimating the thickness of the beds intervening between the lowest coal and the later Jurassic, the total exposure of Lower Cretaceous (No. 2, No. 3, and No. 4 divisions) is 246 feet.

As the section is followed westward beds 6 and 7 vary greatly in thickness, increasing locally to 30 feet, and finally thinning out to a stratum only 2 or 3 feet thick, resting unconformably on the Jurassic. These beds form a persistent plant horizon throughout the Hay Creek region. From this locality a small collection was made of fossil plants. In the shales over the lower coal fossil wood occurs quite abundantly.

The following is a section of Cretaceous strata exposed on the north side of the valley of the South Fork of Hay Creek at the coal mines of Larrabee and Young, 1½ miles west of Barrett post-office:

Section at coal mines on South Fork of Hay Creek, near Barrett.

		Feet.
	Top of hill.	
	Soil and sand resulting from the weathering of the Dakota sandstone forming the plateau	10 to 30
20.	Soft massive yellow sandstone	8
19.	Soft yellow sandstone, thin bedded, weathering in a long, grass-covered slope	15
18.	Massive soft gray sandstone	20
17.	Soft yellow sandstone, thin bedded	15
16.	Unexposed, probably clays and shales, forming a grass-covered slope	30
15.	Soft massive shaly sandstone	15
14.	Gray sandstone shales, partly exposed	10
13.	Massive yellow-brown sandstone	7
12.	Unexposed slope	40
11.	Yellow sandstone with concretions of iron oxide	12
10.	Shaly sandstone	10
9.	Yellowish-brown sandstone	3
8.	Shaly sandstone	4
7.	Soft yellow sandstone	9
6.	Breccia of fragments of decomposed clay shale in white clay	3
5.	Soft yellow sandstone	6
4.	Massive yellow sandstone, forming cliff	30
3.	Clay shales and sandy shales	3
2.	Conglomerate of pebbles and sand, with bowlders 1 inch to 2 inches diameter of hard sandstone and siliceous limestone and a few quartz pebbles	8
1.	Soft sandstone and sandy shales	20
	Top of the Larrabee shaft, which is stated to be sunk to a depth of 75 feet, passing through the following strata:	
	Shales, clays, and soft sandstone	55
	Coal	5
	Clay and shales	13
	Coal	2
	Total exposure	373

In the above section the Dakota sandstone, division No. 1, is represented by 17, 18, 19, and 20, aggregating 58 feet in thickness.

In division No. 2 lie beds 6 to 16, inclusive, with a total thickness of 143 feet.

The breccia (bed 6 of section) marks the unconformity with the underlying strata. In this locality beds 7, 8, 9, 10, and 11 of division No. 2 can be seen to unite in outcrop and form a continuous cliff along the hillsides to the east and also to the west of the section measured.

In the same manner beds 4 and 5 of division No. 3 unite to form a cliff. One mile west all these sandstones unite from the cutting out of the intervening shale beds and form a single cliff 60 to 70 feet in height, which continues westerly for 2 miles along the hills bordering the north side of the valley of the South Fork.

Beds 1 to 5, inclusive, and part of the shales in the shaft should be included in division No. 3, but the line of demarcation from the underlying coal and shales of division No. 4 is covered, so that these two horizons can not be here separated.

On the south side of the valley, at a distance of half a mile, the later Jurassic clays outcrop in a range of low hills at such relative elevation with the coal that it is not probable that more than 25 feet of beds intervene between the bottom of the Larrabee shaft and the top of the Jurassic. This gives the total thickness of the Lower Cretaceous at this exposure 302 feet.

Plant remains occur very perfectly preserved in the shales over the lowest coal in the Larrabee shaft. Only a few specimens could be obtained at the time of the examination, owing to the bad air filling the shaft.

The following is a section of Lower Cretaceous strata at John Barr's tunnel, about 4½ miles east-northeast from Barrett post-office, Crook County, Wyoming:

Section at John Barr's tunnel, near Barrett.

Top of low ridge.	Feet.
9. Gray coarse sandstone	5
8. Massive yellow sandstone, cross bedded	30
7. Massive soft yellow sandstone, thin bedded	40
6. Coal, impure and shaly	¾ to ½
5. Black carbonaceous shale with plants	2
4. Coal	1
3. Clay	2
2. Yellow sandstone	4
1. Gray clay shale	5
Total exposure	89½

In the above section beds 8 and 9 belong to division No. 2, and the underlying beds are in division No. 3.

The plant horizon, bed 5, lies approximately 150 to 175 feet below the base of the Dakota sandstone, and is the equivalent of the beds carrying plants at the Webster ranch and in shales under third sandstone at Barrett coal mines and other localities given in the third division.

This tunnel, about 60 feet long, is run on the north side of a narrow ravine, 1½ miles north-northeast from Forks post-office. Half a mile above this tunnel there are two shafts sunk in the bed of the ravine by Williams Brothers. The following section is given by Mr. Williams of the beds passed through in sinking the lower shaft:

Section of Williams shaft, near Forks.

	Feet.
Top of shaft at base of Sandstone Cliff, bed 7 of last section.	
15. Drab clay shales	20
14. Shaly coal	1
13. Sandstone	1
12. Alternating beds of shale and sandstone	12
11. Coal	½
10. Black shale	2
9. Sandstone	3
8. Coal and shale	1
7. Clay	3
6. Sandstone	2
5. Black clay shale changing to gray shale at base	12
4. Sandrock	2
3. Shale with plants	2½
2. Sandrock	6
1. White calcareous clay and blue clay	22
Total exposure	90

Bed 1 is later Jurassic, verified by inspection of the last material excavated in the bottom of the shaft and left on the dump.

Bed No. 3 and some of the associated beds may belong to division No. 4, though that formation appears to be wanting in this eastern section of the Hay Creek coal field. Nearly all, if not all, the beds in the shaft above the Jurassic clays are in division No. 3.

Below is given a section of Lower Cretaceous and Jurassic strata exposed near Webster's ranch, 4 miles southeast of Barrett post-office:

Section near Webster's ranch, southeast of Barrett.

	Feet.
Top of low hill.	
9. Yellow sandstone	14
8. Gray clay shales	12
7. Black carbonaceous shale with fossil plants	4
6. Gray shale	3
5. Unexposed	10
4. Soft sandstone, ocher yellow	10
3. Whitish gray clays	20
2. Unexposed	7
1. Calcareous sandstone with fossil shells, characteristic Jurassic species	2
Total exposure	82

In the above section beds 4 to 9, inclusive, are placed in division No. 3. The prominent sandstones of divisions Nos. 2 and 3 form cliffs one-fourth and one-half mile north of this point.

The horizon of this plant bed 7 can not be accurately determined, but is not more than 200 feet below the base of the Dakota sandstone.

Division No. 4 is wanting in this part of the Hay Creek area, and the beds of division No. 3 rest unconformably on the later Jurassic.

Beds 2 and 3 of this section are later Jurassic (division No. 5) and rest unconformably on the denuded surface of the marine Jurassic bed 1.

The plants collected at this locality were obtained from shales at the entrance to a tunnel run on the black coaly shales in search of a workable seam of coal. This tunnel is caved, so that it can not be entered. It is reported to have been 50 or 60 feet long, and that specimens of well-preserved plants were obtained by the miners working there.

This plant horizon is stratigraphically equivalent to that of the localities at the cliff on the north side of the valley of the south fork of Hay Creek, the shales under third sandstone of section near Barrett, and the beds at John Barr's tunnel, from all of which small collections of plants were made.

The following is a section of Cretaceous and Jurassic strata exposed on the hill near Lon Cottle's ranch, 1 mile southwest of Barrett postoffice, Crook County, Wyoming:

Section near Lon Cottle's ranch, southwest of Barrett.

	Feet.
Top of hill.	
Soil and gravel	5
32. Thin bedded ferruginous sandstone	15
31. Massive sandstone, yellow, and irregularly impregnated with iron oxide, weathering ocher brown	35
30. Unexposed slope of hill	20
29. Yellowish-brown sandstone	5
28. Unexposed slope	20
27. Yellowish-brown sandstone	5
26. Unexposed slope	20
25. Massive yellow sandstone, cross bedded	35
24. Yellow sandstone, weathering in thin layers	35
23. Clay shales and sandy shales	4
22. Soft yellow sandstone	2
21. Drab clay shales with plant remains	8
20. Coal	2
19. Gray clay	1
18. Soft sandstone, ocher-brown colored, thick bedded	18
17. Soft yellow sandstone	8
16. Gray sandy shales	4
15. Soft yellow sandstone	3
14. Gray clay shales	4
13. Coal, impure and shaly	2
12. Yellow sandy shales	6
11. Drab clay	3
10. Coal	1
9. Gray clay	2
8. Gray clay shales	7
7. Carbonaceous shale with thin seam of coal	1

	Feet.
6. Gray sandy shales	15
5. Carbonaceous shales with fossil plants	3
4. Soft yellow sandstone, iron stained	1
3. Light gray and white clay with calcareous concretions and some crystallized gypsum	35
2. Yellow soft sandstone and sandy shales	6
1. Drab clay shales and sandy shales	13
Unexposed	3
Total exposure	347

Water in creek, the south branch of the South Fork of Hay Creek.

In this section beds 31 and 32 represent division No. 1, the Dakota sandstone.

Beds 25 to 30, inclusive, aggregating 105 feet, form division No. 2, which is at this locality, from the union of the two massive sandstones, beds 24 and 25, into a single cliff, not separable from division No. 3.

Division No. 3 embraces beds 19, 20, 21, 22, and 23, and the cliff sandstone 24; in all, 52 feet of strata. Bed 21 is the persistent plant horizon of this division.

In division No. 4 are beds 4 to 18, inclusive, a total thickness of 78 feet; bed 4 resting on the eroded surface of the later Jurassic.

Beds 1, 2, and 3, aggregating 57 feet, are later Jurassic, and cover nearly the whole thickness of that formation; the marine Jurassic outcropping near the bed of the creek a short distance west of this section.

Adding 40 feet for the upper beds of the Dakota sandstone, removed by erosion, the thickness of the Dakota group of Newton, which included division No. 5 of the later Jurassic, is 387 feet.

At this locality the strata exposed of divisions Nos. 2, 3, and 4, representing the Lower Cretaceous, aggregate 230 feet.

From bed 5 a small collection of fossil plants was obtained.

THE GEOLOGICAL HISTORY OF THE BLACK HILLS.[1]

THE CARBONIFEROUS.

The Black Hills, in common with the whole Rocky Mountain region, were deeply submerged beneath the ocean in the early Carboniferous, the water shoaling near the close of the period. Thick limestones were first deposited, succeeded by alternating beds of brilliantly colored sandstones, with no apparent break in the regular deposition of the sediments until the purple limestone of the Triassic, lying at the base of the Red Beds in the divisions of Newton, is reached.

There are strong evidences that the Carboniferous strata extended in an unbroken sheet over the entire area of the Black Hills uplift. Cliffs of Carboniferous limestone completely encircle and inclose the

[1] The Archean, Cambrian, and Silurian are set forth in Newton's report and briefly in my late "Report on the geology and ore formation of the Black Hills in the Union Hill mine investigation" in the Black Hills Mining Review for March 21, 1898, pp. 6-17.

central metamorphic area, and attain an elevation far above the surface of the slates and schists. The great limestone divide in the northern central hills, though its surface has lost several hundred feet of Carboniferous strata by erosion, has an elevation equal to that of Harneys Peak, the highest point of granite in the Archean area. The conclusion is inevitable that these Carboniferous beds were at one time continuous over the central part of the hills and have been removed by erosion. The beds deposited later, provisionally included in the Carboniferous, are sandstones and marls, more or less colored by peroxide of iron, in every shade of color—yellowish-white, orange, light to dark red.

THE TRIASSIC.

It is as yet undetermined whether any portion of the Black Hills was dry land during the Triassic. The writer found near the head branches of Sundance Creek, in the Bear Lodge Range, evidences of faulting and unconformity between the Purple limestone and the later sedimentary formations, the Lower Cretaceous abutting on upturned Purple limestone.

The characters of the marls, Purple limestone, gypsum, and other sediments of the Red Beds indicate a deposition, mainly from the action of chemical forces, taking place in a shallow sea, probably cut off from direct communication with the ocean and subjected to recurrent periods of desiccation, all the beds apparently barren of life. The marls are colored by peroxide of iron, evidence of the absence of organic matter in the beds. Some evidences of unconformity, much obscured by the soft nature of the beds, were seen in the exposures where marine Jurassic rests on the Red Beds.

THE MARINE JURASSIC.

The Jurassic opened with a shallow mediterranean sea teeming with life. The small size of the mollusks and other forms preserved in the beds of the marine Jurassic is thought to be evidence that the water was brackish. The reddish and purple shades of color in some of the beds of fine sediment indicate that the material of which they were composed may have been derived from the erosion of the Red Beds in adjacent more elevated sections of the Hills. Fossil wood has not been found to this date in the marine Jurassic, though it is abundant in the clays of the later Jurassic, so that positive evidence is wanting of the occurrence of areas of dry land in this epoch. The increase in thickness of the Red Beds and marine Jurassic in the valley of Red Water, separating the Bear Lodge from the main range of the Beach Hills, is an indication of the proximity of land furnishing the material from which the sediments were derived. The Bear Lodge and the Black Hills are distinct upheavals, and may have been in places above water at a much earlier period than has been heretofore thought probable.

THE LATER JURASSIC.

An interval of time occurred between the elevation of the region which raised above water the marine Jurassic beds in the marginal belt of the Black Hills and the deposition of the later Jurassic (No. 5). The elevation was locally irregular; the Jurassic and underlying Red Beds were bent upward into ridges and gentle folds, still traceable in the topography of the region, and the whole surface was later subjected to erosion which wore the soft strata into hills and valleys. In the depressions in this eroded surface the soft clays and marls of the later Jurassic were laid down.

Along the crests of the Jurassic ridges in the Hay Creek coal field the later Jurassic is absent. All the evidence derived from the occurrence of the beds of division No. 5 tends to show that these low elevations were dry land in that subepoch. The old eroded Jurassic surface is in places well exposed to investigation in the Hay Creek field, notwithstanding the great relative modifications in the elevation and topography of the Black Hills due to the continental elevation of the whole Rocky Mountain region at the close of the Cretaceous and to the great volcanic disturbances which occurred in the northern part of the Hills and the Bear Lodge Range during the Tertiary.[1] The sediments of the later Jurassic were evidently formed from the denudation of the marine Jurassic beds in the vicinity. Fossil wood is quite abundant in the clays and sands of the later Jurassic (No. 5). Saurian bones, more or less waterworn and decomposed, occur locally in the upper beds.

THE LOWER CRETACEOUS.

An elevation of the region occurred at the close of the Jurassic or at the opening of the Cretaceous, shutting off the area surrounding the Black Hills from communication with the ocean. It is not improbable that this elevation of the land was continental in its extent and involved the great basin lying between the Rocky Mountains and the western shore of the Allegheny continent, stretching from the Pan Handle of Texas across Indian Territory, Kansas, Nebraska, and Iowa. Some erosion of the Jurassic surface occurred before the coal formation, division No. 4 of the Lower Cretaceous, was laid down in local swamps, basins, and irregular channels lying between the low hills and ridges of the post-Jurassic topography.

This unconformity of the Cretaceous and Jurassic is strongly marked in many places in the marginal belt and was first noted by Dr. Franklin R. Carpenter.[2]

During Lower Cretaceous time many oscillations of level occurred; the relations of dry land, swamps, and open bodies of shallow fresh

[1] Vide published report on the Geology and Ore Formation of the Black Hills, referred to above, p. 587.

[2] Preliminary Report of the Dakota School of Mines upon the Geology, Mineral Resources, and Mills of the Black Hills of Dakota, Rapid City, 1888, p. 46.

water appear never to have been constant. Only in the deposition of the coal in division No. 4 is there evidence of a period of comparative quiet sufficiently long to admit of the formation of workable beds of coal in the Hay Creek field. With respect to relative areas, the beds of division No. 4 cover or underlie the smallest area. Division No. 5 covers nearly all the marine Jurassic on which it rests. The massive sandstones of divisions Nos. 3, 2, and 1 appear to have extended over the whole Hay Creek region and to have reached nearly, if not entirely, over the Bear Lodge Range. In places on Hay Creek evidences were observed of unconformity between division No. 2 and division No. 3, a break in the uniform deposition of the beds corresponding to the marked change in the flora. Less plainly marked, owing to the soft nature of the beds, is the unconformity between the clays of No. 2 and the Dakota sandstone No. 1.

UNCONFORMITIES BETWEEN THE SEVERAL DIVISIONS OF THE DAKOTA GROUP OF NEWTON.

Between all the divisions some change of level occurred, some elevation or depression of the land, some advance or retreat of the water, with more or less denudation of the surface, before the later beds were laid down. Yet no profound disturbance of the strata or upturning of the sedimentary beds occurred. The oscillations of level were quiet and the successive deposits of clays, sands, and intercalated coals appear to be nearly conformable in position. Only by examination of extended exposures of the strata are the evidences of unconformity seen.

The unconformity between the marine Jurassic and division No. 5, or the later Jurassic, is well defined. The greatest unconformity exists between the Jurassic and the Lower Cretaceous. In all the exposures examined in the Hay Creek region division No. 4 always rests on No. 5 or the later Jurassic, but in many places the beds of division No. 4 are absent and division No. 3 rests directly upon No. 5. Along the crests of the ridges of the Post-Jurassic topography the eroded surface of the marine Jurassic is overlain directly by the shales and massive sandstone of division No. 3. No positive evidence was seen of unconformity between divisions No. 4 and No. 3 in exposures where the contact could be examined.

It should be noted that No. 4 was deposited in local basins of limited extent, covering only a relatively small part of the Hay Creek region, while No. 3 stretches broadly across the field, overlying the post-Jurassic ridges and reaching far up into the Bear Lodge Range; that No. 4 was a coal-forming epoch of comparative quiet, but that in the deposition of No. 3 there was evidently a slow sinking of the land or rising of the great body of fresh water filling the Missouri basin, the subepoch opening with quiet waters and the deposition of clays and thin coals and closing with the formation of the massive cliff-forming sandstone (sandstone No. 3), which covers a larger area than the lowest beds of the same division.

The following sketch of the ideal section across the Hay Creek coal field shows this reaching out of No. 3 beds onto the land, the waters rising, and each successive bed advancing farther and farther on to the post-Jurassic surface until all the local elevations were buried under sandstone No. 3.

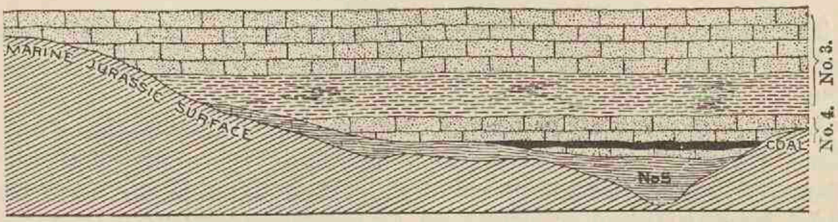


FIG. 121.—Sketch showing the extension of the No. 3 beds onto the land, the land sinking, the waters rising, and each successive bed advancing on the denuded Jura surface until all elevations were buried under sandstone No. 3; a coal-forming period in the early No. 3, a sandstone-depositing in the latter part.

While no marked break was discovered in the uniformity of the deposition of the beds between No. 4 and No. 3, the plant horizon in division No. 3, situated in the shales immediately beneath the No. 3 sandstone, can be distinguished in collecting from the plant-bearing beds of clay overlying the coal at the base of No. 4 by the greater abundance in the Hay Creek region of certain forms of plant life. In No. 3 the leaves of Cycadaceæ (Zamia-like forms), commonly in a fragmentary condition, are abundant, while in No. 4 there are more ferns, usually with delicately cut fronds, together with remains of conifers.

Unfortunately, good exposures of the plant beds in division No. 4 are rare on Hay Creek, and the collections made are very meager. Still, the plant remains found impressed the writer with the thought that there was possibly a somewhat warmer climate in the region during the deposition of No. 3 than had prevailed in the coal-forming epoch of No. 4.

Between division No. 3 and division No. 2 were found irregular beds of conglomerate composed of water-worn pebbles embedded in clay, and other evidences that some erosion of the No. 3 sandstone had taken place prior to the formation of sandstone No. 2, this unconformity marking the break in plant life.

The upper beds of division No. 2 are mostly soft clays, clay shales, and sandy shales, so that evidence of unconformity between No. 2 and the Dakota sandstone No. 1 is very difficult to obtain. Further, the contact at the base of the cliffs of the Dakota sandstone is rarely exposed for observation. There are some evidences of a denudation of the No. 2 beds before the deposition of the Dakota sandstone, and the great break in plant life makes this more probable. The Dakota sandstone covers an immense area in the Missouri basin, and from the nature of its formation should naturally be expected to be unconformable to the Lower Cretaceous, on which it here rests.

The unconformity of the Dakota sandstone and Fort Benton seems to be the result of erosion of the upper beds of No. 1 by the advancing sea depositing the Fort Benton clays, the profound sinking of the region admitting the ocean into the Missouri basin.

DYNAMIC GEOLOGY.

The relation of the coal-bearing areas to the Black Hills uplift and to local subordinate uplifts and their dependence on these will now be considered.

All the coal beds so far discovered occur in the outer border of the Black Hills, in such proximity to influences of the uplift that it is somewhat less probable that workable coal of division No. 4 will be found beneath the later formations far out from the Hills by drilling or shafting. The condition prerequisite for the formation of coal—the elevation of the land above water—seems to have obtained only in close proximity to the uplift.

In the deposition of the beds of division No. 3 the conditions were very different; there were widespread marshes forming coals, mostly of too limited duration to admit of workable beds being deposited; oscillations of level and frequent changes of conditions, both of life and of the deposition of sediments, being the rule. Thin coals have been found in No. 3 beds, in the Belle Fourche well, and in other drill holes put down through the later formations; also in this division in the areas of the Dakota group resting on the high ridges of the Jura surface in the Hay Creek region.

All coals occur in broad expansions of the belt covered by the Dakota group, which completely encircles the Black Hills uplift, and also in places where there are extensive areas of Lower Cretaceous beds nearly horizontal in dip. Where the dip (which is radial from the centers of uplift) is steep, the belt is narrow and no coal is found. For this reason the narrow outcrops of the Dakota group from Bear Buttes to Buffalo Gap, along the eastern border of the Hills, do not carry more than thin coals. This is another instance of the influence of the uplift.

All have been formed in local basins, channels, and depressions, and in some cases in the bottom of lakes, eroded in the Jura surface, so that the governing factor of the localization of the coals of division No. 4 is the post-Jurassic topography. In this localization the depressions in the Jura surface have been influenced by local uplifts and elevations of the land as well as by the folding of the Triassic and Jurassic beds, and also by certain faults, which in occurrence antedated the Cretaceous.

Incident to this deposition of the strata of division No. 4 in local basins, it is noticed that where the Dakota group is thick, particularly with the beds of divisions Nos. 3 and 4, the coal is thick; and where the formation is thin the coal beds are thin or absent. It has also been observed that the sandstone capping the coal (the No. 4 or ocher sand-

General section of the strata occurring in the Black Hills.

Position in the Black Hills.	Geologic age.	Formation.	Subdivision.	Minor divisions.	Thickness in feet.	Origin and mode of occurrence.	Water-bearing character.	Character of the strata.
Margin of the plains.	Mesozoic.	Cretaceous.	Upper.	Fort Benton.	600 to 800.	Marine formation covering a vast area surrounding the Black Hills.	A few small springs are found in this formation.	Thick beds of clays and soft-clay shales, gray, drab, and black in color, with some thin sandstones. Certain of the beds are superior brick clays.
Foothills.				Dakota.	75 to 100.	The true Dakota sandstone. Fresh-water deposition. Occurs in the outer rampart of hills along the Red Valley.	These sandstone beds form the principal water-bearing strata of the Black Hills.	Massive sandstone, with some beds of clay in the upper part. The whole formation is more or less ferruginous and the colors of the rocks vary widely, from white and yellow to iron-brown in localities but a limited distance apart. Quarried for building stone.
			Lower.	Coal, plant, and cycad beds.	250 to 350.	Formerly included in the Dakota sandstone. A fresh-water deposit.		Clays and massive sandstones, with local beds of coal near the base. The coal fields of Cambria (Newcastle) and Hay Creek are at this horizon.
		Jurassic.	Upper.	Fresh or brackish water.	35 to 50.	A brackish-water deposit occurring on the outer margin of the Red Valley.	Some small springs flow from these beds, commonly with more or less brackish water.	Soft clays, marls, and sandstones of white, olive, and reddish shades. They include local deposits of fire clay.
			Lower.	Marine.	200 to 300.	A marine formation occurring with the overlying beds.		Soft thin-bedded sandstones and shales with clays and some thin shell limestones. The beds are colored yellow, gray, olive, reddish, and purplish shades.
Marginal zone.		Triassic.	Upper.	Red beds.	300 to 350.	By erosion forms the "Red Valley" encircling the Black Hills.	A few small springs of water charged with gypsum.	Soft, disintegrating sands, marls, and clays of a brilliant Indian red from the contained iron, with local irregular deposits of gypsum mined for plaster.
			Middle.	Purple limestone.	25 to 35.	Purple limestone. Marine. Forms the inner boundary of the "Red Valley."	The source of many large springs. Water usually of good quality.	Hard, thin-bedded limestone, dark colored and bituminous, affording when burnt a remarkably pure white lime.
			Lower.	Variegated sandstone.	150 to 200.	Variegated sandstones. Marine. Bound the "Red Valley."	Not known to give rise to springs.	Soft sandstones and marls, colored all shades, from yellow, orange, and pink to light and dark red.
Central plateau and inner border region.	Paleozoic.	Carboniferous.	Upper.		350 to 500	Marine. Occurs in the inner foothills and central divide.	Seldom gives rise to springs save in the central divide of the Black Hills.	Alternating sandstones and limestones in massive strata, with some beds of shales. Prevailing colors gray and white.
			Lower.		300 to 400	Marine. Forms the great central plateau and borders the uplift.	Many streams flowing across this limestone sink in these beds. Springs occur in the central plateau.	Massive limestone, gray and white in color, often cavernous. Certain beds furnish a superior white lime.
		Silurian.	Trenton.		35 to 50	Marine. Occurs with next above.	This formation is not known to give rise to springs.	Drab and reddish colored shales. These shales have nowhere been found to carry fossils, and are provisionally included in the Trenton.
					40 to 50	Marine.		Yellow limestone in thick beds. Quarried for building purposes.
		Cambrian.			350 to 500	Marine. Borders the central metamorphic area.	Strata almost impervious to water where not fractured.	Sandstones, calcareous shales, and clay shales, mostly thin-bedded, gray, drab, and reddish-brown in color.
Outer rim of central area.			Potsdam.		25 to 35	Marine. Occurs outcropping in the zone bordering upon the metamorphic area.	A water-bearing stratum, owing to the wide joints and fissures in the beds.	Hard quartzite in thick beds, gray, brown, and iron stained, with a coarse conglomerate locally at the base in contact with the shales, on the upturned edges of which the quartzite rests unconformably.
Central nuclear area.		Algonkian.			Many thousand feet.	Metamorphic.	Carries but little water relatively.	Chloritic, talcose, and hydromica slates, hornblendic and mica schists, siliceous slates, and hard metamorphic quartzites with quartz veins.

NOTE.—On the Black Hills uplift igneous and volcanic rocks have been, in post-Cretaceous time, intruded through the Archean metamorphic slates and all the overlying sedimentary strata from the Cambrian to the Upper Cretaceous. These igneous rocks are in great variety, including porphyry, trachyte, rhyolite, and phonolite. The rhyolites and trachytes form prominent igneous peaks—Terry, Custer, Crow, and Bear Butte—in this section of the Hills.

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Foothills.	Mesozoic.	Cretaceous.	Upper.	Dakota.	75 to 100.	The true Dakota sandstone. Fresh-water deposition. Occurs in the outer rampart of hills along the Red Valley.	These sandstone beds form the principal water-bearing strata of the Black Hills.	Massive sandstone, with some beds of clay in the upper part. The whole formation is more or less ferruginous and the colors of the rocks vary widely, from white and yellow to iron-brown in localities but a limited distance apart. Quarried for building stone.
Foothills.	Mesozoic.	Cretaceous.	Lower.	Coal, plant, and cycad beds.	250 to 350.	Formerly included in the Dakota sandstone. A fresh-water deposit.		Clays and massive sandstones, with local beds of coal near the base. The coal fields of Cambria (Newcastle) and Hay Creek are at this horizon.
Foothills.	Mesozoic.	Jurassic.	Upper.	Fresh or brackish water.	35 to 50.	A brackish-water deposit occurring on the outer margin of the Red Valley.	Some small springs flow from these beds, commonly with more or less brackish water.	Soft clays, marls, and sandstones of white, olive, and reddish shades. They include local deposits of fire clay.
Foothills.	Mesozoic.	Jurassic.	Lower.	Marine.	200 to 300.	A marine formation occurring with the overlying beds.		Soft thin-bedded sandstones and shales with clays and some thin shell limestones. The beds are colored yellow, gray, olive, reddish, and purplish shades.
Marginal zone.	Mesozoic.	Triassic.	Upper.	Red beds.	300 to 350.	By erosion forms the "Red Valley" encircling the Black Hills.	A few small springs of water charged with gypsum.	Soft, disintegrating sands, marls, and clays of a brilliant Indian red from the contained iron, with local irregular deposits of gypsum mined for plaster.
Marginal zone.	Mesozoic.	Triassic.	Middle.	Purple limestone.	25 to 35.	Purple limestone. Marine. Forms the inner boundary of the "Red Valley."	The source of many large springs. Water usually of good quality.	Hard, thin-bedded limestone, dark colored and bituminous, affording when burnt a remarkably pure white lime.
Marginal zone.	Mesozoic.	Triassic.	Lower.	Variegated sandstone.	150 to 200.	Variegated sandstones. Marine. Bound the "Red Valley."	Not known to give rise to springs.	Soft sandstones and marls, colored all shades, from yellow, orange, and pink to light and dark red.
Central plateau and inner border region.	Paleozoic.	Carboniferous.	Upper.		350 to 500	Marine. Occurs in the inner foothills and central divide.	Seldom gives rise to springs save in the central divide of the Black Hills.	Alternating sandstones and limestones in massive strata, with some beds of shales. Prevailing colors gray and white.
Central plateau and inner border region.	Paleozoic.	Carboniferous.	Lower.		300 to 400	Marine. Forms the great central plateau and borders the uplift.	Many streams flowing across this limestone sink in these beds. Springs occur in the central plateau.	Massive limestone, gray and white in color, often cavernous. Certain beds furnish a superior white lime.
Central plateau and inner border region.	Paleozoic.	Silurian.	Trenton.		35 to 50	Marine. Occurs with next above.	This formation is not known to give rise to springs.	Drab and reddish colored shales. These shales have nowhere been found to carry fossils, and are provisionally included in the Trenton.
Central plateau and inner border region.	Paleozoic.	Silurian.	Trenton.		40 to 50	Marine.		Yellow limestone in thick beds. Quarried for building purposes.
Central plateau and inner border region.	Paleozoic.	Cambrian.			350 to 500	Marine. Borders the central metamorphic area.	Strata almost impervious to water where not fractured.	Sandstones, calcareous shales, and clay shales, mostly thin-bedded, gray, drab, and reddish-brown in color.
Outer rim of central area.	Paleozoic.	Cambrian.	Potsdam.		25 to 35	Marine. Occurs outcropping in the zone bordering upon the metamorphic area.	A water-bearing stratum, owing to the wide joints and fissures in the beds.	Hard quartzite in thick beds, gray, brown, and iron stained, with a coarse conglomerate locally at the base in contact with the shales, on the upturned edges of which the quartzite rests unconformably.
Central nuclear area.	Algonkian.				Many thousand feet.	Metamorphic.	Carries but little water relatively.	Chloritic, talcose, and hydromica slates, hornblendic and mica schists, siliceous slates, and hard metamorphic quartzites with quartz veins.

NOTE.—On the Black Hills uplift igneous and volcanic rocks have been, in post-Cretaceous time, intruded through the Archean metamorphic slates and all the overlying sedimentary strata from the Cambrian to the Upper Cretaceous. These igneous rocks are in great variety, including porphyry, trachyte, rhyolite, and phonolite. The rhyolites and trachytes form prominent igneous peaks—Terry, Custer, Crow, and Bear Butte—in this section of the Hills.

The fossil forests, though less important, partly because so imperfectly worked up, nevertheless possess a special historical value, as has been shown, and the one species systematically described will be placed under a special head.

The remaining material, consisting of impressions of leaves, fronds, fruits, and other organs, naturally fall under two separate heads on account of their different geological positions, those from the lower beds belonging to the Lower Cretaceous, while those from the upper ones belong to the true Dakota group. With regard to the former of these classes, in view of the small number found in the Minnekahta region, most of which also occur in the Hay Creek region, it has not been thought best to treat them separately.

Four subdivisions will therefore be made of the general subject, as follows:

1. Fossil cycadean trunks.
2. Fossil forests.
3. Other Lower Cretaceous plants.
4. Plants from the Dakota group.

1. FOSSIL CYCADEAN TRUNKS.

In the historical and geological portions of this paper it has been necessary to discuss the occurrence of cycadean trunks in the Black Hills at considerable length, and it only remains to speak somewhat more specially of the particular localities from which the important specimens were taken. The six specimens originally purchased of Mr. F. H. Cole were all reported to have been found on the spot to which Messrs. Cole and Payne guided my party in 1893, viz, on the southwest side or slope of the middle ridge of Bradleys Flat. These embrace Nos. 1–6 of the collection of the United States National Museum, and constitute the types of *Cycadeoidea dacotensis* (McBride) Ward emend., *C. Colei* n. sp., *C. pulcherrima* n. sp., *C. Paynei* n. sp., and *C. colossalis* n. sp. No. 7, which is the type of *C. minnekahtensis* n. sp., was found by me on the same spot, as were also Nos. 8–19, mostly fragments, and representing *C. McBridei* n. sp. (Nos. 8, 9, 10, 13, 14, and 16), *C. occidentalis* n. sp. (Nos. 11, 12, 17, and 18), *C. Marshiana* n. sp. (No. 15), and possibly *C. minnekahtensis* (No. 19). The small specimen obtained from Mr. Homer Moore in 1895 was thought by him to be from this locality, but as it belongs to *C. Jenneyana*, most of the specimens of which have been found in the Blackhawk region, I regard this as doubtful. The two specimens belonging to the Woman's College of Baltimore (Nos. 1501 and 2128 of the museum of that college), purchased by Mr. Arthur Bibbins at the World's Columbian Exposition at Chicago in 1893, who was informed by the person who sold them to him that they were from the Black Hills and had been cut and polished in Germany, belong also to *C. Jenneyana*, and are probably from the Blackhawk region. The two specimens obtained by Professor Jenney from Mr. McBride were doubtless correctly represented as from the last-named region, and also belong to *C. Jenneyana*. Two other specimens which Professor Jenney obtained for me from Mr. Stillwell are from the same source. One of them represents *C. Jenneyana*, and the other is the type of *C. Stillwelli* n. sp., a species which also occurs in the Minnekahta region. The precise locality from which the two original type specimens of the first of these species were obtained has already been quite fully described (supra, p. 562), and that of the only specimen known of *C. excelsa* n. sp. will be stated as accurately as the data permit under the description of that species (infra, p. 638).

The much larger number of specimens (126) represented in the great Yale collection scarcely extends the range above indicated. With the exception of No. 1 of that collection, representing *C. dacotensis*, and found 2 miles west of Sturgis, as already explained (supra, p. 548), these specimens all came from the Minnekahta and Blackhawk regions. The careful survey, however, which I made of those two fields in October, 1898, having Mr. Wells as my guide, has greatly broadened the earlier conceptions of them, and has not only shown that the area over which the cycads occur in both is quite large, but also that their geological position is everywhere practically the same. It is the geographical and probably only to a limited extent the geological position that gives specific variety to the cycadean flora of the Black Hills. The commoner species, such as *C. dacotensis*, *C. McBridei*, and *C. Stillwelli*, will probably be found at nearly all points where cycads occur, while the rarer ones will be restricted to special regions.

An important extension which these new discoveries has made in the Minnekahta region is the development of the large cycad-bearing area to the southeast of Minnekahta station eastward from Parkers Peak. Mr. Wells pointed out where he had obtained a large number of specimens in this area, but with the exception of the one that was so striking from being completely chalcedonized (No. 5 of the Yale collection), I was unable to identify any of the specimens from his verbal descriptions. This will probably be done in the future, as he can doubtless recognize most of them from the figures in this paper. As all three of the ridges constituting the cycad-bearing area of Bradleys Flat are immediately adjacent to one another, this may be regarded as a unit so far as the geographical distribution is concerned. Mr. Wells was able to show me the exact spot where each of the most striking of the large specimens occurred. Most of them were on the middle ridge, but No. 21 of the Yale collection, the large and fine specimen that constitutes the type of the new species, *C. Wellsii*, was found on the most southwesterly of the three ridges. A number of the other more striking specimens were also found there, including No. 14 of the Yale collection, doubtfully referred to *C. minnekahtensis*.

With regard to the Blackhawk region, it is equally clear that primarily there was one general area such as I have described, and that the specimens have not been laterally transported to any great distances. Those found at lower levels may be regarded as having probably been imbedded in rocks almost vertically over where they occurred. Not only are the slopes to the south and southeast of the amphitheater the result of the gradual undermining and dropping down of the higher sandstone ledges, but the amphitheater itself has its inner walls lined with these rocks, while those on the inner side of its rim dip inward toward its center on all sides, still further emphasizing the manner in which it was excavated. There is therefore no special significance in the particular parts of this general area at which different specimens were found. The two species that specially characterize this region are *C. Jenneyana* and *C. ingens* n. sp., and it may be said that the former of these species predominates at the more southern portions of the area, while the latter occurs chiefly farther north and higher up, near the rim of the basin. It was therefore not until Mr. Wells had explored these latter portions that this species was discovered, but here it was found quite as abundant as *C. Jenneyana* is below.

The general localities for all the cycads of the Yale collection are as follows:

No. 1. Two miles west of Sturgis, 1 specimen.

Nos. 2–87. Minnekahta region (impossible at present to designate their exact location except in the few cases mentioned above), 86 specimens.

Nos. 88–126. Blackhawk region (more precise location of a few specimens given above and others under the description of the species), 39 specimens.

To sum up the subject of the geographical distribution of fossil cycadean trunks in the Black Hills, it may be stated that they have thus far been chiefly found in two areas—the one on the southeast and the other on the east side of the Hills, the latter near the center from north to south. The former of these areas, if we combine, as we properly may, the Bradleys Flat and Parkers Peak localities into one, extends in an east and west direction for at least 5 miles with a width varying from half a mile to 2 miles. The other, as already stated, is from 1 to 2 miles wide east and west, by 3 to 4 miles long north and south.

In addition to these areas, however, cycads have actually been found and collected at four other widely separated points in the Cretaceous rim, one of which I have myself visited. This is 2 miles west of Sturgis, as above stated. Another is the place where the unique specimen representing the new species *C. excelsa* was found, described as fully as the data permit under that species.

A third locality is somewhere between Bellefourche and Spearfish, not yet definitely fixed, but believed to be in the breaks of Hay Creek.

This locality is well vouched for. The specimen was obtained several years ago by Mr. Stillwell from a person residing in that part of the country. Mr. Wells purchased it of Mr. Stillwell and owned it a number of years before disposing of it. He described it minutely to me, and from his description I judge that it represents a new species. He is certain of the above facts as to location and will probably learn further particulars in the future.

The fourth and last of these outlying localities is in the vicinity of Sundance, in Wyoming. Mr. Wells showed me a specimen at his house that he had himself obtained from there, and he intends to make further explorations in that region at an early day. The position of the cycads here is the same as at all other points, viz, in the soft sandstones and shales near the summit of the Cretaceous rim.

Cycads have therefore actually been found on nearly all sides of the Black Hills in the same geological position, and there is no doubt that other localities will be discovered which will close up more and more the intervals separating the areas now known.

All the fossil cycadean trunks that have been found in America thus far probably belong to one genus, the Cycadeoidea of Buckland. In 1894 I published a revision of that genus[1] and in 1897 I described the seven species then known from Maryland.[2] In the latter paper I gave a full description of the genus in the light of modern research. The classification adopted was not that of Engler in Engler and Prantl's Natürlichen Pflanzenfamilien (II. Teil, 2. Abteilung, pp. 24–26), which is modeled after Schimper's treatment in Zittel's Handbuch der Palæontologie (Abth. II, pp. 211–232), and is no longer accepted, having been materially changed by Potonié and Engler in the same work (Nachträge zu II–IV, pp. 14–17; 341, 360). According to this the Bennettitales form a class distinct from the Cycadales, or living cycads, consisting of the exclusively extinct family Bennettitaceæ, coordinate with the family Cycadaceæ, which is restricted to the forms now living. Potonié would refer the greater part of the forms that I have called Cycadeoidea to Carruthers's genus Bennettites, which Count Solms-Laubach restricts to such as have been found to contain seeds in the fruits, i. e., practically to one species, *B. Gibsoni*, and chiefly to one specimen. I have already pointed out[3] that this is simply an accident of preservation and not a good ground for the establishment of a new genus, and therefore I would adhere to Buckland's name, which has priority over all others, and call them all Cycadeoidea. In all other respects I am quite

[1] Fossil cycadean trunks of North America, with a revision of the genus Cycadeoidea Buckland: Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, pp. 75–88.

[2] Descriptions of the species of Cycadeoidea, or fossil cycadean trunks, thus far discovered in the Iron Ore belt, Potomac formation of Maryland: Proc. Biol. Soc. Washington, Vol. XI, March 13, 1897, pp. 1–17.

[3] Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, p. 79.

willing to conform to the classification of Engler and Prantl's great work. The arrangement will therefore be as follows:

Subkingdom SPERMATOPHYTA (Phanerogams).

Subdivision GYMNOSPERMAE.

Class BENNETTITALES Engler, 1897.

Famliy BENNETTITACEÆ Potonié, 1897.

Genus CYCADEOIDEA Buckland.

Pls. LVII-LXI.

1827. *Cycadeoidea* Buckland: Proc. Geol. Soc. London, Vol. I, No. 8, pp. 80–81 (session of June 6, 1827).

1828. *Cycadeoidea* Buckland: Trans. Geol. Soc. London, 2d Ser., Vol. II, pp. 375–401, Pls. xlvi–xlix (volume dated 1829, but memoir probably issued separately in 1828).

Trunks chiefly low (30 to 90 cm. in height) and more or less conical or oval in shape, but sometimes tall, reaching over a meter in height, and cylindrical, 15 to 75 cm. in diameter, usually simple, but sometimes branching, with a depression at the summit, in the middle of which, when not decayed, there is a terminal bud of conical shape; terminal bud, however, usually wanting in the fossils, leaving a cavity commonly known as the "crow's nest," by which name, for this reason, the specimens from the Portland quarries are popularly known. The armor consists of appendicular and reproductive organs surrounding and enveloping the axis, the former being the bases of the leaf stalks or petioles, which are surrounded by a dense mat of ramentum or fine hairs.

The leaf stalks are normally four-sided and four-angled, the lateral angles acute and nearly equal, the vertical angles obtuse but unequal, the lower much sharper than the upper, so as to render the cross section subrhombic. This form varies on the one hand to a true rhomb, and on the other hand to a true triangle, the most frequent intermediate type being that in which the upper angle is wanting, and the two upper sides are reduced to a simple curve or arch, so that the cross section assumes the form of a drawn bow and bowstring, the arch formed by the two upper sides representing the bow, and the two lower sides, with the reentrant angle, representing the bowstring. In size the leaf stalks vary from 15 to 35 mm. in width, measured between the lateral angles, and from 5 to 20 mm. in height measured between the vertical angles, or from the lower angle to the summit of the arch formed by the two upper sides. The line joining the former is not generally horizontal or at right angles with the axis of the trunk, but one is usually slightly lower than the other. The line joining the latter is not generally vertical or parallel to the axis of the trunk, but one is usually a little on one side of the other. The only portion of the leaf bases that is always preserved in the fossil state is the mat of ramentaceous hairs that surrounds them. In the great majority of cases the petioles themselves are decayed to a greater or less distance below the summit of these mats, which thus constitute walls surrounding and inclosing the portion that remains of the petioles, if any, and in their absence forming definite cavities having the shape of the cross section of the leaf stalks, which constitute the leaf scars. These leaf scars, with or without the lower portion of the leaf bases, penetrate to the axis of the trunk and form a varying angle with it. Normally this angle is a right angle over all the central portions of the trunk, while below the organs are slightly descending and above more and more ascending to the apex, where they become vertical. At the summit, too, they diminish in size and usually in form, and are reduced in and immediately around the terminal bud to small triangular or polygonal bracts (*perulæ* of Miquel). In some species (*C. Uhleri*) all the organs of the body of the trunk are deflexed, and in some (*C. Goucheriana*, *C. minnekahtensis*) there is a definite zone near the middle of the trunk, below which they are descending and above which they are ascending. The leaf scars are arranged in a more or less exact quincunx order, and usually in two sets of spiral rows around the trunk, in one of which they ascend from the base in the direction from left to right and in the other from right to left, crossing each other at varying angles and both rows making a certain angle with the axis of the trunk, which varies with the species and more or less with different specimens of the same species. One of the two sets of rows is usually more distinct than the other, but the more distinct rows sometimes pass upward from left to right and sometimes from right to left. The bases of the petioles when present and well preserved often show at the surface presented to view a row of pits all around parallel to the walls and at different distances from the margin representing the vascular strands. Other such pits are sometimes present near the center. The petioles are frequently disarticulated at a natural joint, which may fall near or at the summit of the scar or it may fall some distance within the scar. In some species there are two such joints separated by a node. Occasionally these joints consist of a thin membranous diaphragm stretching across the petiole, of firmer texture than the rest of its substance. Even where the petioles are wholly absent the position of the joints or diaphragms can sometimes be determined by a sharp ridge around the inside of the scar. The walls are made up of the ramentum of two adjacent petioles. In some cases these matted masses are so dense as to produce a simple homogeneous plate on all four of the sides, which, where the petioles are wanting, forms a deep, angled cavity of exactly the shape of a cross section of the petiole. Usually the portion of the wall furnished by each of the adjacent petioles can be distinguished by a junction line or commissure, visible along the outer edge of the wall. This commissure sometimes takes the form of an intermediate plate of a less dense consistency than the two outer plates. In other cases this central plate is much thicker than the two outer ones, which latter may be reduced to the appearance of thin linings of the scars. In still other cases the central portion is more or less open and cavitous. The walls vary from 1 mm., or even less, to 5 mm. or, in rare cases, 8 mm. in thickness.

The other class of organs that help to make up the armor are the reproductive organs. These are borne on all parts of the surface of the trunks, except, perhaps, in immediate connection with the terminal bud, which is exclusively an organ of growth. They are scattered about with very little order over the surface among the leaf scars. They are usually of a harder substance than that of the foliar organs, and better adapted to resist the erosive influences to which the fossil trunks are exposed. Where the trunks are worn, therefore, the reproductive axes are liable to protrude somewhat. Viewed from without, they usually present an organ with an elliptical cross section, the longer diameter being nearly horizontal, variable in size, but always larger than the leaf scars. The central portion is often wanting, and a funnel-shaped cavity less deep than the leaf scars takes its place. When the central portions are present they show markings having the form which the outer ends of the essential organs present, which is very variable and usually obscure. Surrounding the central portions are several rows of open scars arranged concentrically. These scars are sometimes triangular, quadrangular, polygonal, or nearly circular; but the most of them, especially the outer ones, are somewhat crescent-shaped, having the concave side toward the center. The inflorescence is a spadix surrounded by an involucre, consisting of the concentrically arranged bracts or scales whose scars were last described. The spadix has a receptacle at base, located near the inner surface of the armor and supplied with fibers from the axis. From the receptacle there rise two kinds of organs: first, peduncles or filaments, known in a few specimens to bear seeds, and conjectured in one specimen to bear anthers at their summits; and, second, elongated chaff-like scales more numerous than the latter and rising above them, the upper portions expanding and forming a dense mat or covering over the essential parts. In most cases all these organs are wholly included in the armor, the only seeds that have thus far been found being deeply embedded in the tissues. The organs of inflorescence are probably axillary, but owing to the proximity of the leaf scars this is not generally apparent. In regions of the surface where they occur they usually crowd the leaf scars and cause variations in their shape. This effect is most marked on the upper sides of the scars, often quite obscuring or obliterating their normal features.

The axis of the trunk inclosed in the armor when complete consists of four parts, which, enumerated from without inward, may be denominated respectively as (1) the libro-cambium, (2) the parenchymatous wood, sometimes called the cortical parenchyma, (3) the wood proper or fibrovascular zone, and (4) the medulla or pith. In many cases the libro-cambium zone can not be definitely distinguished from the cortical parenchyma, and nothing is visible but the large and numerous vascular bundles passing out from the interior into the leaves; but sometimes there occurs a definite line or thin zone of loose tissue immediately below the bases of the leaf stalks. There is usually a zone of apparently homogeneous cellular tissue, often of considerable thickness, filling the interval between the armor and the woody axis. The woody zone consists of one or more rings of exogenous tissue traversed by medullary rays. Where more than one, they are separated by thin interstices of parenchymatous tissue. The medulla is usually large and composed of coarse parenchyma.

The genus Cycadeoidea is illustrated by five plates devoted to characteristic trunks from Europe and America. Pl. LVII represents the two original species of Buckland, *C. megalophylla* and *C. microphylla*, from the Purbeck of the Isle of Portland, and also a third species, *C. portlandica*, from the same beds, described by Carruthers in 1870. All of the specimens here figured were found by Dr. Alfred Russel Wallace and myself on the occasion of our visit to Portland on August 17, 1894, and the specimen represented by fig. 3 is the one collected by us in one of the quarries.[1]

On Pl. LVIII is reproduced the figure of *Cycadeoidea Masseiana* Cap. & Solms., which appeared in the Sixteenth Annual Report of the Survey with a full history of its discovery and significance (cf. Part I, pp. 502–510, pl. ciii). It is a fair representative of the genus from the Italian beds.

On Pl. LIX is given a reproduction from a photograph sent me by Prof. H. B. Geinitz of the great *C. Reichenbachiana* (Göpp.) Cap. & Solms., now in the Dresden Museum. It was found at Lednice, near Wieliczka, in Galicia, a century and a half ago, and treated by Knorr and Walch in their great work of 1755. It was long regarded as the largest fossil cycad in the world (see infra, pp. 604, 605).[2]

Pl. LX represents a group of cycads from the iron ore beds of Maryland, all belonging to the genus Cycadeoidea. Several of these are embraced in the group represented on pl. c of Part I of the Sixteenth Annual Report of the Survey, but at that date they had not been named or described.

This was done in 1897,[3] but no references were then given to published figures. This may therefore be regarded as the first illustration of these species, and the group constitutes an excellent representation of the genus Cycadeoidea. The specimens represented in this group were all collected or obtained by Mr. Arthur Bibbins and belong to the Woman's College of Baltimore.

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[1] See Sixteenth Annual Report U. S. Geological Survey, Part I, pp. 484–486.

[2] For synonymy see Proceedings of the Biological Society of Washington, Vol. IX, 1894, p. 85.

[3] Proceedings of the Biological Society, Vol. XI, 1897, pp. 9–17.

Finally, on Pl. LXI is given a group of the leading types of the species from the Black Hills, embracing the six original trunks obtained from Mr. Cole and the large branching trunk, *C. minnekahtensis*, collected in 1893.

CYCADEOIDEA DACOTENSIS (McBride) Ward emend.

Pls. LXII-LXVI.

1893. *Bennettites dacotensis* McBride, in part: American Geologist, Vol. XII, p. 249, pl. xi, fig. 1 (non fig. 2); Bull. Lab. Nat. Hist. State Univ. of Iowa, Vol. II, No. 4, Iowa City, 1893, p. 391, pl. xii, fig. 1 (non fig. 2).

1894. *Cycadeoidea dacotensis* (McBride) Ward, in part: Proc. Biol. Soc. Washington, Vol. IX, p. 86.

Trunks large (30 to 50 cm. high, 30 to 50 cm. in diameter, 100 to 150 cm. in girth), short-cylindrical, contracted below, dome-shaped above, symmetrical, sometimes laterally compressed and elliptical in cross section, probably subsequent to entombment, bearing a number of short secondary axes or undeveloped branches in the form of rounded protuberances, or, in case of decay, of corresponding saucer shaped depressions; apex presenting a flattened surface with a central elevation, studded with polygonal bract scars and bases arranged in rows which sometimes proceed in helicoid form from the center outward; rock substance of a dark brown or reddish color, firmly silicified, hard and heavy, sometimes weighing over 100 kilograms, fine-grained; organs of the armor slightly ascending except near the base, the angle increasing toward the summit, where they become vertical; leaf scars, where not interrupted, forming two series of spiral rows which proceed in different directions and intersect one another, those from right to left nearly horizontal below and curving upward until they form an angle of 45° with the vertical axis, the opposite series less distinct, forming a small angle (5° to 10°) with the axis; scars subrhombic and nearly uniform in shape, larger below, diminishing upward, the distance between the lateral angles varying from 16 to 26 mm., and that between the vertical angles from 10 to 16 mm., empty from decay of the petioles, at least to considerable depth, sometimes to a depth of more than 5 cm.; interspaces between the scars very thick though variable, sometimes 16 mm., presenting an undulate or wrinkled surface with indications of deeper lines of separation of the walls; spadices large and somewhat elliptical in outline, the longer axis nearly horizontal, 8 to 10 cm. long, the shorter nearly vertical and 5 to 7 cm.; involucral bract scars numerous, arranged in concentric ellipses around the central organs in many somewhat distinct rows, increasing in size from the center outward, subrhombic, triangular, or polygonal in shape, 2 to 20 mm. in diameter, apparently passing insensibly into the normal leaf scars, empty like them, forming deep cavities or punctations; essential organs of the buds, flowers, or fruits sometimes wanting, their place occupied by a deep circular cavity, more frequently represented by a dark and firm substance, which in some of the smaller ones projects beyond the general surface; armor 5 to

7 cm. thick, separated from the ligneous axis by a definite line; cortical parenchyma 5 cm. thick; fibrous zone 4 cm. thick with three or more rings of wood, or sometimes presenting a number of thin concentric laminæ of alternating black and brown substance, apparently representing as many rings of wood, and inclosing the homogeneous medulla 5 to 15 cm. in diameter, conforming in cross section to the trunk.

Only one of the specimens belonging to the U. S. National Museum is referable with certainty to this species. This is the fine trunk, No. 1, of the collection of six purchased of Mr. Cole. That this is specifically identical with Professor McBride's specimen represented by fig. 1 of his plate there is no room to doubt. It is, however, difficult to reconcile it with his description in view of the fact that in that description he has included two specimens belonging to entirely different species, his fig. 2 showing none of the external characters of fig. 1, or of the specimen in hand, but clearly belonging to the same specific group as several of the fragments collected by Professor Jenney and myself from the Minnekahta locality in 1893, as will be shown below (pp. 613–614). As Professor McBride in his description includes characters that could scarcely have been exposed in the perfect trunk represented by his fig. 1, it seems clear that he derives such from the specimen fig. 2, which was probably a fragment showing these characters in the fractures. It was therefore a question whether to retain the name or not. I conclude to do so for so much of Professor McBride's description as applies to his fig. 1.

The Museum specimen is somewhat larger than the one at the University of Iowa, standing over 44 cm. high, having a girth of 122 cm., and weighing 90.27 kilograms. It is one of the most perfect and beautiful cycadean trunks that have thus far been brought to light.

Thirteen of the specimens in the Yale collection are referred to this species. These are Nos. 1, 3, 5, 6, 13, 30, 39, 43, 54, 62, 63, 95, and 106. Of these Nos. 3, 5, and 54 are nearly perfect trunks, and one of these, No. 54, is larger than the one at the U. S. National Museum.

In Pls. LXII and LXIII are given side, top, and base views of the original type specimen, No. 1, of the U. S. National Museum; in Pls. LXIV and LXV, side and top views of the equally fine and somewhat larger trunk, No. 54, of the Yale collection, and Pl. LXVI affords a view of the inner parts from one side of the Yale specimen No. 13.

This is the most common species in the Black Hills, and has been found in the Minnekahta and Blackhawk regions, and 2 miles west of Sturgis.

CYCADEOIDEA COLOSSALIS n. sp.[1]

Pls. LXVII–LXXII.

Trunks colossal, subconical, more or less laterally compressed, subcylindrical, dark colored, hard and heavy, weighing from 100 to over

[1] It was not thought necessary to alter the proofs of this memoir by quoting the Proc. U. S. Nat. Mus., Vol. XXI, pp. 197-229, as the original place of publication of the new species of fossil cycadean trunks, because the manuscript was prepared in duplicate and simultaneously submitted for publication in both places. As, however, the paper in the Proc. Nat. Mus. appeared in October, 1898, these species, with the exception of *C. Wielandi*, p. 621, are not new here in the strict sense of earliest publication.

300 kilograms, 38 to 79 cm. high, 40 to 66 cm. in major, 26 to 46 cm. in minor diameter, 100 to 180 cm. in girth, bearing numerous relatively small branches not projecting far beyond the general surface; terminal bud low, set in a circular platform of small polygonal scars filled by the bases of the leaves or bracts; organs of the armor and secondary axes horizontal at the middle portion of the trunk, somewhat descending at the lower portion and ascending at the upper portion; phyllotaxy much obscured by the intrusion of other organs, but spiral rows ascending from left to right at an angle varying from 75° below to 45° above plainly traceable; leaf scars subrhombic to nearly rhombic, very small relatively to size of trunk, 13 to 16 mm. between lateral, and 8 to 12 mm. between vertical angles, empty to a depth of 13 to 50 mm., the bottoms of the cavities apparently occupied by portions of the leaf bases; interstices between the scars very variable, but, except at the summit, generally large, sometimes 25 mm., nearly even on the surface but finally marked with mostly horizontal but variously curved or crooked ridges or wrinkles, with occasional indications of planes of separation into two, three, or even five plates; walls much thinner in the upper portion, often broken down in the specimens, displaying the striate inner surface of the scars diminishing in size below; reproductive organs abundant at all parts of the trunk, large, well developed, and conspicuous, after rising somewhat above the surface, forming gentle swellings or more abrupt protuberances, elliptical in shape, the major axis nearly horizontal, 5 to 10 cm. long, the minor axis 3 to 5 cm., usually with a solid center, sometimes with a small central cavity surrounded by firm substance, the whole inclosed within concentric elliptical rings or rows of involucral bract scars which increase in size from the center outward, are empty and have the form of the leaf scars, into which they occasionally seem to graduate; armor 5 to 10 cm. thick, attached to the woody axis by a uniform layer of bark 6 mm. thick; cortical parenchyma 4 to 6 cm. thick; fibrovascular zone also 4 to 6 cm., separated into two distinct rings of wood, each consisting of a loose, spongy substance inclosed in a firm plate or thin hard layer, the outer ring 35 mm. and the inner 25 mm. in thickness, through all of which the medullary rays pass, forming a sort of columnar structure; medulla more or less elliptical in cross section, 11 to 13 cm. by 15 to 20 cm. in diameter, decayed, leaving a cavity at the base in one specimen, and in another having a concentric structure consisting of four zones or rings of soft porous material, scarcely differing except in coloration.

The large perfect specimen, No. 6 of the Cole collection, is the largest cycadean trunk known in the world. Prior to its discovery the great *C. Reichenbachiana* (Göpp.) Cap. & Solms. (see supra, p. 601 and Pl. LIX) from Galicia, which is at the Mineralog.-Geolog. Museum at Dresden, and which I have not seen, had taken the lead. Professor H. B. Geinitz was so kind as to send me an excellent photograph of that specimen and on this I find the dimensions marked. It is 50 cm. high, 54 cm. in major and 44 cm. in minor diameter, and 157 cm. in girth. It is therefore not so tall as the American specimen by 29 cm., has a major diameter 25 cm. less, and a minor diameter 2 cm. less, showing that it is less flattened, but the circumference is 23 cm. less.[1]

Eight of the specimens in the Yale collection belong to this species, viz, Nos. 2, 7, 9, 10, 17, 37, 40, and 55, of which Nos. 2 and 10 are perfect trunks, but are both much shorter in proportion to their size than the great National Museum type. They are also less laterally compressed. They may have been somewhat vertically compressed. No. 37, though incomplete, is a fine specimen weighing nearly 150 kilograms, and has a height of 71 cm. No. 55, though it has lost considerable at the summit, still weighs 110.68 kilograms. No. 40, which represents less than half of the original trunk, is also a fine fragment. The rest are smaller and more imperfect.

In Pls. LXVII and LXVIII are shown side and base views of the great type trunk No. 6 of the U. S. National Museum. Pls. LXIX–LXXII illustrate the species as represented in the Yale collection by Nos. 2, 10, 17, and 55. They show considerable variation in the form and size of the trunks.

All the specimens of this species are from the Minnekahta region.

Cycadeoidea Wellsii n. sp.

Pls. LXXIII-LXXV.

Trunks large, ellipsoidal, subcylindrical, or somewhat barrel-shaped, more or less laterally compressed, rounded at the summit, bearing numerous small secondary axes in the form of protuberances, light reddish-brown or drab colored, fine-grained, hard and rather heavy, sometimes weighing nearly 100 kilograms, 40 to 55 cm. high, 30 to 45 cm. in diameter and more than 1 meter in girth; terminal bud not prominent; organs of the armor about horizontal except near the summit; phyllotaxy much disturbed and not traceable; leaf scars rather small, subrhombic or nearly rhombic, often trapeziform or very irregular in shape, average distance between the lateral angles 20 mm. and between the vertical ones 12 mm., none of the angles rounded, all except the small ones at the apex empty to considerable depth; ramentaceous interspaces exceptionally thick, sometimes 2 cm., presenting a smooth but gently

[1] The photograph sent me by Professor Geinitz was taken from the specimen in position as mounted on a support in the Dresden Museum. Judging from it alone I should say that the trunk is here inverted, but to be certain it would be necessary to examine it. It is clear that in the present position the leaf scars have a decided downward direction, which is rare but not unknown (e. g., *C. Uhleri*). Moreover, the scars, which are subtriangular, have now their sharp angle upward, which, if the specimen is right side up, would indicate that the keel of the petioles was on the upper side, a condition which I have met with in only two other species, *C. aspera* and *C. insolita*, described below. Göppert's figure (Jubiläums-Denkschr. d. Schles. Ges. f. vat. Cult., 1853, pl. viii, fig. 4) shows the specimen in the same position, i. e., probably inverted.

undulating surface, lowest in the middle part, rising to the scar which forms a sharp edge, producing the general effect of being molded in plastic clay; reproductive organs very large, abundant, and conspicuous, greatly distorting the arrangement of the leaf scars as well as their form, often nearly circular in cross section, 4 to 5 cm. in diameter, showing the remains of the central organs surrounded by concentric circles of large, empty, and deep involucral bract scars which are semilunar or somewhat triangular in shape, and may reach 7 mm. in length; armor about 7 cm. thick, cortical parenchyma 4 cm., fibrous zone 4 cm., showing two rings, the inner projecting at the base, concentrically laminated and inclosing the much decayed medulla about 12 cm. in diameter.

There are two specimens of this species in the Yale collection, viz, Nos. 21 and 59, the former of which is a fine, nearly perfect trunk, large and handsome, weighing 92.76 kilograms. I was at first inclined to regard them as belonging to *C. minnekahtensis* on account of the general resemblance of the external surface, but this obviously can not be done, because these trunks are unbranched and symmetrical in form. In this respect they approach *C. dacotensis* and *C. colossalis*, but here the surface differs completely. No forms intermediate in either of these respects occur in either collection, and there is no escape from regarding these two trunks as constituting a new species.

I have named the species for Mr. Henry F. Wells, who obtained these and nearly all the rest of the Yale collection, and from whom Professor Marsh purchased them. He may therefore be regarded as the collector, which, under the approved rules for naming species, requires the use of the genitive form.

Pls. LXXIII and LXXIV give side and base views of No. 21, and Pl. LXXV shows the perfect side of No. 59. Both specimens are from the Minnekahta region.

CYCADEOIDEA MINNEKAHTENSIS n. sp.

Pls. LXXVI to LXXIX.

Trunks gigantic, much branched and irregular in form, the type and only perfect specimen known weighing 219.09 kilograms, 74 cm. high, 50 cm. in diameter exclusive of branches, 79 cm. across at maximum spread of branches, 150 cm. in girth, light brown or chestnut colored, smooth on the outer surface, presenting the appearance of having been molded in plastic clay, moderately heavy; branches very large, forming conical protuberances projecting from the middle portion of the trunk, giving it a winged appearance, other branches proceeding from other parts, especially below, composite, i. e., the main branches or primary axes having lesser or secondary branches, prominent terminal buds, sometimes themselves compound, on all the branches, often very perfect with a sort of neck; organs of the armor declined over most of the surface, phyllotaxy obscure and not traceable; leaf scars subrhombic to nearly rhombic, averaging 22 mm. wide by 10 mm. high, the unusual vertical narrowness perhaps due to compression, very variable, however, in all respects, those on the lesser branches smaller, usually empty and striate within; ramentaceous interstices usually thick, 5 to 15 mm., firm and fine-grained, smooth and polished but somewhat undulating, the edges of the scars sharp, always without signs of subdivision; reproductive organs numerous, simulating the small branches, the central part preserved but heterogeneous, showing scars and markings of the essential organs, varying from 12 to 50 mm. in diameter, surrounded by small involucral bract scars; armor about 6 cm. thick, separated from the underlying tissues by a thin porous layer; cortical parenchyma about 5 cm. thick, fibro-vascular zone 8 cm. thick without visible subdivision into rings; medulla not clearly shown, and internal structure generally more or less conjectural.

The remarkably fine but weird and anomalous specimen upon which the above description is almost wholly based was found by our party lying partly buried in the ground in the same place where the other trunks had been gathered. It was overgrown with lichens in many places, and had been regarded so uncouth as not to be worth transporting to Hot Springs. I arranged with Messrs. Payne and Cole to have it shipped to Washington, and it arrived in due time in safety. It holds the fourth rank as to size and weight, but differs from all others in so many respects that a comparison with any is difficult. Specifically it approaches most closely to *C. pulcherrima*, but lacks all the symmetry and definiteness of that form. It is only in the fact that both are very branching, especially around the middle part of the trunk, that they have an external resemblance.

The specimen shows a fine terminal bud at the apex of the principal trunk, and several others on the other branches. Except near the summits of the several branches, the leaf scars and other organs of the armor are decidedly descending, but on the main branch or trunk, some distance above all the lateral branches, there is a sharp line separating the descending from the ascending scars above. This feature I have seen elsewhere only in *C. Goucheriana* from Maryland.

The only other specimen in the collection that could with any propriety be included under this specific head is the small trunk picked up at the same time and place and numbered 19. This may represent a very young state of this species with all the characters in miniature and devoid of reproductive organs. It is branched much in the same way, longitudinally compressed, lacks a little of the base and part of one side below, but for purposes of description is practically complete. The entire trunk was only 18 or 20 cm. high, 14 or 15 cm. in its longer and 7 or 8 cm. in its shorter diameter, with a maximum girth of 36 cm. Its present weight is 1.81 kilograms. The dimensions are therefore less than one-fourth and the weight is less than one-twelfth of the large trunk. It might even have been wholly subterranean, as in the living *Zamia angustifolia*.

Among the fragments in the Yale collection I found eight that belong to this species, and, as the National Museum type is nearly perfect, these add somewhat to our knowledge of the inner parts of the trunk. These specimens are numbered 14, 22, 24, 32, 41, 71–72, 83, and 86. They consist chiefly of branches torn away from large trunks, and several of them may have belonged to the same trunk. Some of them may be found to fit together, but, as they were lying about in different rooms, and even on different floors, of the Peabody Museum, it was impossible for me to correlate them. Certain ones, as No. 14, consist of a mere gnarl of branches, and most of them are proliferous or composite, the branches often having fine, sometimes compound, terminal buds.

Pl. LXXVI shows the only view that has been taken of the type specimen, No. 7, of the U. S. National Museum, and Pls. LXXVII to LXXIX represent Nos. 14, 24, 83, and 86 of the Yale collection, all of which are more or less fragmentary and aberrant.

It occurs only in the Minnekahta region.

CYCADEOIDEA PULCHERRIMA n. sp.

Pls. LXXX–LXXXII.

Trunks large (38 cm. high, 4 cm. in diameter, 130 cm. in girth in the only complete specimen known), short ellipsoidal or subspherical, of a light ash color and moderately heavy, bearing numerous large, short branches at and below the center all round, forming conical protuberances, some of which are 8 to 10 cm. long and 12 to 18 cm. in diameter at the base, rarely compound, i. e., the branches themselves bearing other smaller ones, or two or more arising side by side; branches and all other organs radiate, i. e., proceeding in the direction from the center of the trunk, those of the equatorial zone horizontal, or making a right angle with the axis, those below descending, and those above ascending; leaf scars arranged in definite rows intersecting one another, somewhat spiral, but so placed as to simulate meridians and parellels of latitude, the former series, however, rising from left to right and making an angle which varies with the curvature from 5° to 10° with the vertical axis, the other series rising from right to left, varying from horizontal to an angle of 45°; scars varying in shape from subrhombic to nearly true rhombs and in size from 10 by 19 cm. or smaller near the summit to 16 by 22 cm. measured between vertical and lateral angles, which are usually quite sharp, the sides straight and the whole very definite and symmetrical, usually empty to considerable depth, but partially filled by the remains of the leaf bases, which occasionally show punctations representing the vascular bundles; ramentum walls 2 to 5 mm. thick, wrinkled on their outer edges, often with a distinct median groove, sometimes reduced to thin lamallæ with sharp edges, striate within the scars in the direction of the petioles; reproductive organs not abundant, the more typical ones mostly in the equatorial zone among the branches, which they sometimes resemble, being large with a solid central axis surrounded by relatively large bract scars, nearly circular, with a diameter of 5 cm., other smaller ones scattered among the leaf scars, only slightly disturbing their arrangement, often abortive and reduced to collections of pits in the angles of the walls; armor 6 to 8 cm. thick, irregularly attached to the ligneous axis, which consists of a parenchymatous zone 3 cm. thick inclosing a fibrous zone 25 to 35 mm. thick and divided into two to four exogenous rings; medulla 10 cm. in diameter at the base, enlarging upward to more than twice that size, porous in structure, its outer surface marked with longitudinal ridges which are interrupted and alternating, forming the bases of the medullary rays.

The trunk upon which the above description is almost exclusively based is the one which was called No. 3 of the collection obtained from Mr. Cole, and is certainly, in my judgment, artistically the most beautiful cycadean trunk known. I say this deliberately, after having seen the greater part of all thus far discovered in all countries, and where I have not actually seen the specimens themselves I have in almost all cases seen artistic models, or at least excellent photographs or drawings. The specific name is therefore fully justified.

The characters of the internal structure and the medulla are derived from the large decayed area at the base on one side, which well exposes them, leaving the other side still perfect. The total weight of this specimen is 85.73 kilograms.

Only one imperfect specimen, viz, No. 78, of the Yale collection could be referred to this species, and this not without some doubt.

Pls. LXXX and LXXXI represent side, top, and interior views of the type specimen, No. 3, of the U. S. National Museum. In the last (Pl. LXXXI) the specimen was purposely inverted in order to let the light penetrate more thoroughly the exposed interior and bring out the structure. Pl. LXXXII is a fair view of No. 78 of the Yale collection, which was doubtfully referred to this species on account of the shape of the leaf scars on certain parts of the trunk, which, however, are not well brought out in the photograph.

Known only from the Minnekahta region.

CYCADEOIDEA CICATRICULA n. sp.

Pls. LXXXIII, LXXXIV.

Trunks small and short, subconical, more or less laterally compressed, smooth and symmetrical, unbranched, light yellowish-brown on the weathered surfaces, fine-grained and flinty within, about 20 cm. high, 18 by 22 cm. in diameter, with a girth of about 60 cm., and weighing 13 or 14 kilograms; organs of the armor nearly horizontal; leaf scars arranged in two definite series of spiral rows, those from left to right forming an angle near the base of about 70° with the axis but curving inward in their upward course so that the angle progressively diminishes to about 30° at the summit, those from right to left only slightly curving and making an angle of about 45°; scars very small, almost exactly rhombic, uniform and definite with all the angles sharp, distance between lateral angles 9 to 12 mm. and between vertical ones 6 to 8 mm.; leaf bases present filling the scars to near the top, presenting a roughened spongy tissue; ramentaceous walls very thin, varying from the thickness of tin foil to 2 mm., presenting a beautiful and regular network of whitened lines over the entire outer surface of the trunk, with a faint commissure or elongated openings between the contiguous plates of the thicker ones; reproductive organs not abundant nor well developed, the most typical 3 cm. in diameter, variable in shape and character, consisting of protuberances with a depression at the top or ridges with bract scars on the sides, others anomalous, consisting of small projections or elevations, probably abortive, none of them greatly disturbing the form or arrangement of the leaf scars; armor 3 cm. thick, separated from the wood by a definite line or crack; cortical parenchyma 2 cm.; secondary wood 3 cm., consisting of an outer ring 2 cm. thick and an inner one 1 cm., with a fissure between; medulla elliptical, 5 by 7 cm. in diameter, consisting of a homogeneous substance resembling fine yellow sandstone, clearly marked off from the inner ring of wood.

This species is one of the best defined of all, notwithstanding that it is based upon a single specimen, viz, No. 118 of the Yale collection. This is an almost perfect trunk, and is only obscured by sand and gravel cemented in the scars, so that very little can be seen of the summits of the leaf bases. It was collected by Mr. H. F. Wells three-fourths of a mile north of Black's ranch, about 3 miles north of Blackhawk, South Dakota. Its only affinities are with *C. pulcherrima*, with which it shares the rhombic scars and their definitely arranged rows.

The most perfect side is represented on Pl. LXXXIII, showing the arrangement of the scars. The base is shown on Pl. LXXXIV, Fig. 1, and the summit by Fig. 2 of the same plate.

Cycadeoidea turrita n. sp.

Pls. LXXXV-XC.

Trunks moderate sized, profusely and irregularly branched, the primary branches often bearing secondary ones, the branches symmetrical, abruptly contracted at the base into cylindrical turret-shaped projections, dome-shaped at the summit, with a terminal bud at the apex composed of small polygonal organs, usually light reddish, soft, friable, and of low specific gravity, but sometimes darker, harder, and heavier, 20 to 40 cm. high, 25 to 50 cm. in diameter, the branches 10 to 20 cm. long, 10 to 30 cm. in diameter, 30 to 90 cm. in girth; leaf bases slightly ascending; leaf scars very irregularly distributed over the surface except of the branches, here sometimes arranged in two sets of spiral rows which intersect each other at about the same angle (60°) with the axis of the branch, subrhombic, the upper and lower angles reduced to mere curves 23 mm. wide, 12 mm. high; leaf bases almost always present, usually projecting, porous; vascular bundles often distinct, set well apart in a row some distance from the margin, with a few others near the center, appearing either as small pits or black dots; ramentum walls thin, 1 to 2 mm., usually with a groove or commissure, sometimes thickening at the angles and affected with elongated pits and other openings, some of these latter passing into abortive flower buds, which constitute all that is known of the reproductive organs of the species; armor 5 cm. thick; woody axis only known in certain branches, thin, 2 to 3 cm., and not visibly divided; medulla in one specimen 9 cm. in diameter, black and homogeneous.

Twelve of the specimens of the Yale collection have been referred to this species, viz, Nos. 15, 45, 49, 51, 65, 66, 67, 70, 74, 75, 82, and 85, and still much remains uncertain as to the characters. They nearly all agree in the most striking feature—the possession of peculiar turret-like branches—but owing to the fragile nature of the rock and the sprangling habit of the species all the specimens were badly broken to pieces and nothing remains but *disjecta membra.* Some of these plants evidently consisted entirely of branches and possessed no trunk proper which could be regarded as bearing these branches, but usually there was a large shapeless mass at the base from which they proceeded in all directions. Such was the case in Nos. 45, 51, 66, and 67, some of which must be nearly complete. Nos. 45 and 75 belong to the harder and heavier sort, and possibly may not belong to this species. They might be referred to *C. minnekahtensis* or *C. Marshiana* but for differences in the leaf scars and petioles, which agree with this species. No. 74 is very anomalous and is only placed here to avoid making new species out of deficient material. The turret, if such it was, is reduced by erosion to a pointed cone without character. The specimen is worn to and into the medulla on one side, but the opposite side is well preserved. The leaf scars are typical, but there is a number of large projecting axes looking like horns, and the specimen, laid on the worn side, has the shape and semblance of a gigantic "horned toad." All the other specimens are much alike, and No. 82 is taken as the type for most of the characters.

So far as the rock substance, color, and external organs are concerned this species is very close to *C. McBridei*, but that species is always simple and consists of one large, short trunk, constituting a broad distinction which all the numerous specimens of both species do not tend in any way to obliterate. In its branching habit it approaches *C. minnekahtensis* and *C. Marshiana*, but the external characters persistently keep it separate from either. In color it somewhat resembles the former, but this is all that can be said.

Pls. LXXXV and LXXXVI show the characteristic turret-shaped branches as typified in Nos. 82 and 67. Pls. LXXXVII and LXXXVIII give side and base views of the fine specimen No. 49. Pl. LXXXIX represents the anomalous trunk No. 74, and Pl. XC reveals a little of the medulla and axis of No. 15.

All the specimens are from the Minnekahta region.

CYCADEOIDEA MCBRIDEI n. sp.

Pls. XCI–C.

1893. Bennettites dacotensis McBride, in part: American Geologist, Vol. XII, p. 249, pl. xi, fig. 2; Bull. Lab. Nat. Hist. State Univ. of Iowa, Vol. II, No. 4, pp. 391–392, pl. xii, fig. 2.

1894. Cycadeoidea dacotensis (McBride) Ward, in part: Proc. Biol. Soc. Washington, Vol. IX, p. 86.

Trunks large and very short (25 to 40 cm. high, 25 to 75 cm. in diameter, with a girth of 80 to 250 cm.), more or less laterally or longitudinally compressed, well silicified but somewhat porous or spongy and therefore only moderately heavy, reddish brown in color, occasionally bearing small secondary axes which only slightly project; organs of the armor variable but usually radial in direction; leaf scars arranged in spiral rows intersecting each other at various angles, usually forming an angle with the axis in either direction of from 40° to 55°; scars subrhombic or lozenge-shaped, the distance between the lateral angles varying from 22 to 35 mm., that between the vertical angles varying from 13 to 16 mm., nearly always filled with the well-preserved bases of the leaves which have disarticulated at natural joints leaving a smooth surface, either convex or concave, or occasionally nearly flat, presenting a spongy appearance; vascular bundles of the leaves usually distinct in the form of pits or of dots of darker color arranged in one row all round the margin a short distance from it and with a few additional ones near the center; ramentaceous interspaces thin for the size of the trunks (1 to 4 mm.), compound, i. e., consisting of two or more plates of firmer material separated by intervals of loose porous tissue, very uniform in character and little distorted, the porous tissue often worn to some distance, leaving fissures divided by thin projecting walls; reproductive organs sometimes abundant and conspicuous, but usually rather scarce and poorly defined, some quite large with a cavitous funnel-shaped or crater-shaped center, others simulating leaf scars except that they are surrounded by a loose porous tissue in which angular pits occasionally occur, still others resembling small branches, making it difficult in some cases to decide to which class to refer them, one which has been cut through the center longitudinally showing a heterogeneous mass of internal organs resting on a conical receptacle 25 mm. below its somewhat projecting summit; armor 4 to 8 cm. thick, separated from the cortical parenchyma by a layer of true bark 6 mm. in thickness, of soft texture, its inner surface (exposed in one specimen) covered with small pits or punctations and definitely marked by elliptical scars about 9 mm. long and 5 mm. wide, which are aligned horizontally around the trunk, the longer axis being in this direction, the upper side of the scars usually so indistinct as to make them appear kidney-shaped, the lower side and ends consisting of a dark raised ring or welt with a groove all round it and exterior to it, the central portion occupied by a number of punctations more or less concentrically arranged; woody axis 9 to 12 cm. thick, of which the parenchyma occupies somewhat more than half and is very porous except where traversed by the medullary rays of firmer consistency; fibrous zone divided into an outer soft and an inner harder ring, the inner wall of the latter conspicuously marked by the scars of the medullary rays; medulla in the larger specimens 15 cm. in diameter, but usually elliptical and about 8 by 11 cm., of a uniform porous consistency.

I name this species for Professor McBride because he was the first to deal with it, although he confounded it with *C. dacotensis*, and parts of his description apply to the one and parts to the other species. Still his figures are clear and leave no doubt that his fig. 2 belongs here. In his description of that figure he says that it belongs to "another individual," which, of course, would have been otherwise evident, and parts of his description show that either this or other material in his hands consisted of fragments showing the interior of the trunks, which could not have been exposed in the "large, perfect individual." Most of his description of the internal parts must have been based on such fragments, and the following words appear to apply entirely to the present species: "Leaves not known; their bases as perceived are fusiform or lozenge-shape in cross section, one-half inch by one inch in dimensions, and show the remains of numerous equally developed fibrovascular bundles."

His specimens seem to have come from exactly the same locality as those purchased from Mr. Cole, which I subsequently visited in company with Professor and Mrs. Jenney, with Messrs. Cole and Payne as our guides. There was found the large branching specimen, *C. minnekahtensis*, and there, too, I picked up 12 fragments of different sizes and shapes. These were numbered in continuation of the Black Hills collection, of which there are 7 nearly perfect trunks, and therefore included Nos. 8 to 19. Of these, 6 certainly belong to the present species, viz, Nos. 8, 9, 10, 13, 14, and 16. Two of these fragments, Nos. 10 and 14, are found on comparison to fit together, and therefore, of course, to belong to the same trunk. When placed in their proper position they constitute the greater part of it, but a large segment is missing from one side. Among these specimens, all differently broken, a much larger number of characters are exposed than could be seen in any number of perfect trunks. Wherever two or more display the same parts they are in substantial agreement, and it is therefore assumed that such features as are only visible in some one specimen would be found in the rest if the proper parts could be exposed. The beautiful markings on the inner surface of the liber zone, as above described, are to be seen only in specimen No. 16 (see Pl. XCIII). That all trunks of the species were of the short, conical shape indicated by Nos. 10 and 14 when placed in their natural position can not, of course, be demonstrated, but the other specimens do not negative this view.

Professor McBride remarks that "the present species is near *Bennettites Gibsonianus* Carr., from which it may be distinguished by greater size and by the fact that in our species the fibrovascular bundles of the leaf stems are of uniform size and distribution, and do not form a horseshoe shape in cross section, as is said to be the case in the English species." In this last one would suppose he was confounding the undivided vascular bundle as it appears in the axis, and especially in its passage through the cortical layer (cf. Carruthers's pl. lvii, fig. 3, in Trans. Linn. Soc., Vol. XXVI) before it divides, with the form assumed by the numerous strands that enter the petiole and appear as small dots on a cross section of the latter (cf. loc. cit., pl. lviii, fig. 2). Neither in the American Geologist nor in the Bulletin of the Laboratory of the State University of Iowa do these strands show clearly in fig. 2, still I think I can detect them; but in nearly all our specimens these bundles are very clearly shown, and they do agree remarkably well with those of Carruthers's figure (loc. cit., pl. lviii, fig. 2). Still I should hesitate to refer the American forms to *C. Gibsoni* on this character alone, and having myself examined the British specimen I do not think it is very close in other respects (cf. Sixteenth Ann. Rept. U. S. Geol. Surv., Pt. I, p. 487).

The absence of perfect trunks of this species in the National Museum collection is not due to its rarity in the Black Hills, as I was satisfied after examining the large number of fragments picked up by myself, but to the frailty of the species. There is in fossil cycads certainly a close connection between the mineral constitution and the original nature of the tissues, and both vary with the species much as different kinds of wood differ in their qualities of hardness, durability, tenacity, etc., in our living forests. Accordingly the substance of the rock in this species is always soft, porous, and light, easily worn by attrition, and therefore frail. Moreover, there is a tendency to early decay of the medulla and woody axis, which caused many of the trunks to become hollow before they were entombed. This made compression and general destruction easy and accounts for the difficulty in securing good specimens.

In view of these facts, I was not surprised to find a large number of specimens of this species in the Yale collection. There are no less than thirteen which I have so referred, although several of these are very abnormal and doubtful. The ones so classed are Nos. 8, 19, 23, 26, 27, 29, 38, 42, 46, 53, 73, 76, and 110. No one of these is absolutely complete, and the greater part of them are mere fragments. In the majority of cases the specific determination is clear at a glance, and this is true even of the smaller fragments. No. 19 is a typical and nearly complete trunk, weighing 51.46 kilograms, and No. 23 is by far the most perfect specimen of the species known to me. It weighs nearly

59 kilograms, but there is a vast cavity at the summit. No. 76 is also nearly complete and a fine example, weighing 23.59 kilograms. There are four dwarf specimens, Nos. 26, 29, 42, and 53, which, though nearly perfect, must be immature trunks if they belong here. They differ too much from each other to constitute a specific group, and I have been obliged to treat them as young, dwarf, or aberrant forms of this species. Nos. 26, 29, and 42 have each a good terminal bud, the only such seen in the species. No. 53 is very small, only 11 cm. high, weighing only 1.57 kilograms, short-conical, and very symmetrical. It represents the species in miniature, and is doubtless undeveloped.

Only one of the specimens of the Yale collection from the Blackhawk region belongs to this species, viz, No. 110, which consists of nearly half of a large trunk showing the much worn outer surface with deep holes, which are often united a short distance within by the decay of the walls so as to produce communicating chambers. The opposite side exposes a large hollow, or trough, consisting of the inner wall of the woody zone. It also shows the attachment of the armor and the underlying axis in an exceptional manner.

Pl. XCI shows the broad side of the trunk resulting from joining Nos. 10 and 14 of the U. S. National Museum collection, which were found to fit together and make considerably more than half of the trunk. This also shows the full height, as we have the true base and all that was left of the summit after the decay of the terminal bud. The scars are clearly shown on the surface, but less so than in fragment No. 9, a portion of the surface of which, enlarged, is shown on Pl. XCII. In Pl. XCIII we have a clear view of the inner wall of the liber zone or true bark, which is marked by scars of a different pattern from any elsewhere observed.

No. 23 of the Yale collection is perhaps the most complete trunk of this species known, and has been illustrated from the broad side, the hollow summit, and the base on Pls. XCIV–XCVI. The inner wall of the armor is exposed in No. 27, and this is shown on Pl. XCVII. Pl. XCVIII, Fig. 1, represents the small trunk, No. 29, of the Yale collection, which may be a dwarf form of this species. It will be noticed that dwarf forms are the only specimens known in which the terminal bud is preserved. This might happen in immature specimens, when in all old trunks this organ would decay too rapidly to become silicified. Fig. 2 shows the smallest specimen of the species, and, indeed, there is much doubt as to whether it belongs here, but it bears too many evidences of being a very young trunk to make it safe to call it a new species, and the characters, so far as they go, point to *C. McBridei.*

Pls. XCIX and C represent the outer (Fig. 1) and inner (Fig. 2) surfaces of the specimen No. 110 from the Blackhawk region, above described.

All the specimens except the one above mentioned have been found in the Minnekahta region.

CYCADEOIDEA MARSHIANA n. sp.

Pls. CI–CV.

Trunks very large, profusely branched, the primary branches often bearing secondary ones, the whole individual frequently consisting of branches, sometimes with a sort of common base, the branches irregular in size, form, and direction, making shapeless or grotesque objects; summits of the branches rounded, bearing small polygonal scars with depressed or cavitous centers separated by deep channels as if from the disappearance of the walls, or filled with the bases of the apical leaves often set in a circular, smooth, flattened area, and having a small conical protuberance or terminal bud at the center; rock substance hard, heavy, and dark colored; general external appearance rough and massive; forms very variable in size and difficult to measure, the largest attaining 91 cm. in its greatest dimension, the lateral generally greater than the vertical dimensions when standing on the base, the former often 50 to 60 cm., the latter 30 to 40 cm.; branches 15 to 30 cm. long, 10 to 40 cm. in diameter, and often over a meter in girth; organs of the armor ascending on all the branches; phyllotaxy usually so disturbed as not to be traceable, but consisting of at least one series of spiral rows of scars passing from right to left at an angle of about 75° with the axis of the branch; leaf scars of medium size or small for the size of the trunks, normally subrhombic, but varying from triangular, or with a mere groove to represent the upper angle, to nearly rhombic, 15 to 30 mm. wide, 7 to 15 mm. high, averaging 12 by 25 mm. for the body of the trunk and 10 by 18 mm. for the branches, usually empty to considerable depth, sometimes filled with the leaf bases, which either present a smooth concave surface or a rough projecting surface formed in part by rows of pointed elevations consisting of the exposed extremities of the vascular bundles lying on the sides of a central conical protuberance the apex of which is formed in part of the more interior strands; ramentaceous interstices usually thick, 5 to 15 mm., hard, roughened, wrinkled, or grooved, often highest next so the scars, sometimes thinner with only a median line; reproductive organs generally abundant on the body of the trunk and larger branches, large, 7 cm. long in a circumferential direction, 5 cm. high, conspicuous, either projecting or cavitous and crater-shaped from the decay of the essential organs, surrounded by concentric rows of large bract scars, sometimes more rare and smaller; armor 4 to 7 cm. thick, but difficult to observe except on the branches where it has little significance; cortical parenchyma 3 to 4 cm.; fibrous zone 2 to 4 cm. with two rings; medulla sometimes seen at the compound base, 12 cm. in diameter, often decayed so as to leave a large cavity, its surface exposed in one specimen showing the scars of the medullary rays in the form of elongated ridges increasing in thickness upward and terminating in a sharp point.

This magnificent species was first clearly made known to me in the Yale collection, where it is represented by five, and probably six, specimens. These are Nos. 4, 11, 33, 44, 47, and 79. The doubtful ones are Nos. 33 and 79. These are single branches of much larger trunks, and their characters are somewhat aberrant. Of the other five there is no doubt, as they agree in all their characters. No. 11 is taken as the type. It is larger than any of the rest, and the next largest specimen in the Yale collection, weighing 221.35 kilograms, and therefore holding the third rank in this respect among the cycads of the world. It has the form of a huge animal, has five primary branches, and when placed in the position in which it probably grew four of these, with the mass to which they are attached, constitute a sort of forepart, with head, thorax, and fore limbs, while the other represents the hinder part and is aligned in the opposite direction. Between these parts is a constriction dividing the two systems. It is very complete, so much so that it has furnished few of the internal characters.

Nos. 4 and 47 are also large trunks, weighing, respectively, 52.62 and 34.93 kilograms, and the other fragments supplement the more perfect specimens so as to make a pretty full description of the species possible.

I have named the species in honor of Professor Marsh, to whose energy and munificence this great collection is wholly due.

When engaged in examining and describing these specimens in the Yale collection I supposed that none existed in the U. S. National Museum, but on revising all my previous descriptions in the light of the new material I discovered that I was mistaken, and that specimen No. 15 belongs to this species. I had referred it with doubt to *C. colossalis*, and under that head had made the following remark: "The only other specimen in the collection of the U. S. National Museum that I can refer to this species is the fragment No. 15, collected by myself in 1893 on the same spot where the others were found. This is a very irregular block or segment broken from near the top of a great trunk. It is similar in mineral character to No. 6, and the leaf scars and other organs agree well with the upper parts of that specimen. The fractures are downward, but follow the plane of the petioles, which are here erect. In No. 15, however, two large and nearly equal branches, whose axes were nearly at right angles to each other, are represented. Viewed from the broken sides, the two axes are clearly seen in contact, having a gnarly appearance, such as is normally produced at the junction or crotch between two branches."

This branching character, as I was well aware, does not belong to the large, perfect specimen, but, having no others, I thought it possible that some of the small secondary axes might in other cases become primary branches; but after seeing so many other specimens of *C. colossalis* all agreeing in this respect, and also a large number of the present species also all agreeing and exhibiting no tendency to vary in the direction of the other species, it became obvious that the branching forms all belonged to one species and the simple ones to another. The specimen No. 15 clearly belongs to the branching species, and now it is easy to see other specific differences.

Pls. CI–CIII furnish a fairly good idea of the great type specimen, No. 11. Pl. CIV represents one of the large limbs torn from a specimen of unknown size, No. 47. Finally, Pl. CV gives us a side view of No. 33, the anomalous character of whose scars has been described. Of course, the peculiarity in the vascular bundles could not be expected to appear in a photograph.

All the specimens are from the Minnekahta region.

CYCADEOIDEA FURCATA n. sp.

Pls. CVI–CIX.

Trunks large, forking above, or sometimes with a third branch, simple below, laterally compressed, eccentric, light colored, soft and of low specific gravity, 35 to 45 cm. high, 25 to 30 by 35 to 40 cm. in diameter, 90 to 110 cm. in girth; organs of the armor mainly horizontal; leaf scars subrhombic, or somewhat triangular, the vertical angles generally rounded, the lateral acute, variable in size, averaging 15 by 25 mm., those on the branches smaller, or sometimes nearly as large, empty; ramentaceous walls variable, usually thin, 1 to 5 mm., much thicker in the angles, firm in texture, grooved or divided into two or three plates; reproductive organs few, large, elliptical, 4 to 7 by 7 to 10 cm. in diameter, either set in depressions or somewhat elevated, surrounded by bract scars, either cavitous in the center or solid, the larger ones simulating small branches; armor 4 to 7 cm. thick; cortical parenchyma 7 cm., clearly distinguishable from the darker zone of wood 6 cm. in thickness; medulla elliptical, 9 to 11 cm. in diameter.

This species is thus far represented by only two specimens, viz, Nos. 18 and 60, of the Yale collection, the latter of which is in such a complete state of preservation that little can be known of its internal structure. It is distinguished from all other trunks known to me by a true dichotomy,. consisting of a simple trunk with two nearly equal erect branches and a natural junction or crotch at their point of separation. The axis is far to one side and the trunk is flattened on that side, the entire true base being lateral and the trunk, standing on a false base, belonging to the armor, but naturally flattened in transverse direction. These peculiarities were doubtless the result of the position in which the trunk originally grew among rocks. Besides this striking characteristic, the light color and soft constitution of the rock, as well as the form and arrangement of the scars, ramentum walls, reproductive organs, etc., distinguished this from all other cycadean trunks. It is a fine specimen, and weighs 49.9 kilograms.

No. 18 consists of two nearly equal branches and one somewhat smaller, arranged in a triangular cluster. Two of them are flat on one side from growing against rocks. The trunk proper can scarcely be said to be represented. The two larger branches are each about 30 cm. in diameter and 23 cm. long, with rounded summits forming something analogous to terminal buds. Fractures about the lower portion yield elements of internal structure, but they relate to the branches only. The external surface is beautifully preserved. This specimen weighs 66.22 kilograms.

Two views of specimen No. 60 were taken, one of the rounded outer surface or back, Pl. CVI, and the other of the opposite flat side, Pl. CVII, within which the true base, set on one side, wholly falls. The indications are that the trunk grew with this side against a vertical rock and was connected with the soil beneath it.

Pl. CVIII is a view of the specimen No. 18, seen from above, and Pl. CIX shows it from the base.

Both specimens are from the Minnekahta region.

CYCADEOIDEA COLEI n. sp.

Pl. CX–CXII.

Trunks rather large, ellipsoidal, 34 to 48 cm. high, elliptical or nearly circular in cross section, 30 to 39 cm. in diameter and 90 to 118 cm. in circumference at the thickest part, simple, the apex studded with small polygonal scars and presenting a smooth disk with a central elevation; rock substance dark brown in color and moderately heavy; organs of the armor except the very lowest manifestly ascending; leaf scars arranged in two series of more or less distinct spiral rows, those passing from left to right forming an angle of 75° and those from right to left of 45° to the vertical axis; scars subrhombic, varying from almost rhombic to nearly triangular with rounded angles, large, averaging 22 mm. wide and 13 mm. high, but ratio of width to height variable, empty to a depth of 2 to 5 cm.; ramentaceous walls usually thick but very variable, doubly grooved or wrinkled, cracked or fissured, often pitted by the scars of small bristles or perulæ; fruiting axes numerous, small, most or sometimes all of their surface occupied by bract scars, central portion correspondingly small, generally cavitous from the disappearance of the essential organs, which appear to have often been immature or abortive; armor about 6 to 7 cm. thick; cortical parenchyma 3 cm. thick; fibrous zone 2 cm., consisting of two rings of wood; medulla about 9 cm. in diameter.

This is a very handsome species of which the type specimen was purchased of Mr. F. H. Cole, for whom the species is named. That specimen weighs 63 kilograms.

The Yale collection contains nine specimens that I was obliged to refer to this species. These are Nos 12, 20, 25, 28, 48, 52, 57, 68, and 80. Of these Nos. 25 and 80 are small and either dwarfed or immature, and Nos. 28 and 52 are small fragments. The rest are fairly typical and furnish good characters. No. 48, though small, weighing only 29.49 kilograms, is perhaps the most typical. No. 57, though not complete, weighs 56.24 kilograms, and was doubtless originally quite the equal of the National Museum type. No. 12 has an unusual number of fruiting axes.

Pl. CX shows a side view of the type specimen, No. 2 of the U. S. National Museum, and Pl. CXI that of the very similar trunk, No. 48 of the Yale collection. The fragment No. 12 of the Yale collection represented on Pl. CXII is somewhat anomalous if not specifically doubtful, but can not be referred to any other known species.

All the specimens are from the Minnekahta region.

Cycadeoidea Paynei n. sp.

Pl. CXIII-CXV.

Trunks medium sized, laterally compressed, usually enlarging from the base upward to near the summit but sometimes subcylindrical, 30 to 55 cm. high, 65 to 85 cm. in average girth, 20 by 25 cm. to 25 by 35 cm. in diameter, light or darkish brown in color, not specially firm or heavy, bearing few or not any secondary axes; organs of the armor horizontal; phyllotaxy rather obscure, but scars arranged in imperfect spiral rows, chiefly subrhombic, but varying to rhombic or triangular, much distorted in the specimens in hand, but where clearly shown 10 to 16 mm. high and 16 to 31 mm. wide, empty to some depth, their bottoms filled with the partially decayed remains of the petioles; ramentaceous interstices rather thin but variable, usually with a more or less distinct commissure; reproductive organs or their remains numerous and conspicuous, often projecting considerably beyond the general surface in the form of protuberances or terete spongy cylinders, often decayed, leaving large cavities more or less crater-shaped or funnel-shaped, the interior sometimes definitely grooved or marked, surrounded by numerous, sometimes large, triangular involucral bract scars; armor varying in thickness from 2 to 7 cm., attached by an irregular line or thin layer of bark to the cortical parenchyma which is 1 to 2 cm. thick and incloses a fibrous cone of about the same thickness, which is divided into two or three rings; medulla less compressed than the outer parts, 6 to 10 cm. in diameter.

The only specimens that certainly belong to this species are Nos. 4 and 5 of the collection purchased from Mr. Cole. The description of the internal parts is chiefly based on No. 5, which is the smallest of that collection and has been cut longitudinally through the axis, one of the halves cut transversely 12 cm. above the base and the surfaces polished. These sections furnish clear views of the organs of the armor and of the relations of the armor to the underlying parts. The specific identity of the two specimens is based on the external characters, which substantially agree. No. 4 weighs 33.11 kilograms and No. 5, 22.22 kilograms. I name the species for the ranchman, Mr. Payne, who originally discovered the cycads of that region and from whom Mr. Cole obtained them. He it was, moreover, who finally guided us to the locality after Mr. Cole had vainly sought to take us to it the previous day, missing the way notwithstanding that he had been at the spot.

In the Yale collection there are two specimens, Nos. 58 and 69, which I have doubtfully referred to this species, although some of the characters are different from those above described. They are vertically instead of laterally compressed. If this is due entirely to pressure of the superincumbent mass after entombment, it has no systematic value and depends upon the position occupied by the specimen; but eminent authorities have insisted that it is a condition of growth. I am inclined to think that this may be true in some cases, but that the former explanation is the chief one.

The Yale specimens are both smaller than either of the National Museum types, No. 69 weighing 20.86 kilograms, and No. 58, which is dwarf, abnormal, and perhaps immature, 5.33 kilograms.

Pls. CXIII and CXIV give side and base views of the type specimens Nos. 4 and 5 of the U. S. National Museum, and Pl. CXV represents the polished surface of the interior of No. 5, bringing out the relations of the various tissues in a very satisfactory manner.

All the specimens are from the Minnekahta region.

Cycadeoidea Wielandi n. sp.

Pl. CXVI.

1893. *Cycadeoidea Paynei* Ward, in part: Proc. U. S. Nat. Mus., Vol XXI, pp. 212–213 (quoad No. 77 of the Yale collection).

Trunks medium sized or small, cylindrical-conical, somewhat laterally compressed, dark colored, moderately hard with medium specific gravity, rough or jagged on the outer surface, unbranched, about 40 cm. high, 21 by 25 cm. in diameter at the middle portion, 70 to 80 cm. in girth; organs of the armor about horizontal, at least in the middle part; phyllotaxy not traceable; leaf scars normally subrhombic and narrow but much distorted by the fruits, often triangular, sometimes with the upper side downwardly curved, 20 to 25 mm. wide, 12 to 20 mm. high; leaf bases present but not reaching the surface, porous or spongy without visible bundle scars; ramentum walls thin, 1 mm. or less, much broken down in the specimens, with or without an obscure median line; reproductive organs abundant over all parts of the trunk, covering half of the surface and distorting all other organs, large and somewhat elliptical but sometimes nearly circular, 25 to 35 mm. in diameter, often cavitous with a very definite bowl-shaped interior, the bottom smooth and usually raised like that of a blown bottle, or with a boss or button in the center, i. e., the receptacle of the spadices rising up with a depression all round it, sometimes resembling a saucer inside the larger bowl, the central boss or button sometimes with a large, deep slit nearly transverse to the axis of the trunk or in line with the major axis of the cross section, this slit occasionally replaced by a sharp ridge or by a few pits; fruits often partly or wholly preserved, obovate, sometimes rising above the general surface and convex at the summit, either smooth or granular from the exposed extremities of the numerous densely matted seeds; spadices surrounded by involucral bracts, consisting of the receptacle above described as a central boss or button from which rise numerous seminal peduncles of varying lengths, the central ones longest and ascending to the summit, the more lateral ones proceeding outward and terminating at the periphery in such a manner as to form a cylindrical body with a rounded outer extremity, each peduncle terminating in a single seed; seeds 1.5 mm. to nearly 2 mm. in diameter, oblong in shape, 5 mm. long, surrounded by an opalized double seed-coat, their combined mass forming a somewhat irregular layer over the whole upper part of the fruit, extending downward to about the middle, each seed containing a number (6 to 12) of relatively large spherical bodies, sometimes opalized like the seed-coats, possibly representing the archegonia; armor thin, about 4 cm. thick; woody zone not visibly divided, 4 cm. thick; medulla elliptical in cross section, 4 by 6 cm. in diameter.

At the time I described No. 77 of the Yale collection in June, 1898, the specimen was almost wholly covered with an incrustation of lime and very little could be learned of its nature. Sufficient, however, was visible to indicate that it possessed an especial interest. The peculiar granular structure of some of the fruits could be seen, and from such examination as I was able to make I derived the description that I gave on page 213 of the Proceedings of the United States National Museum, Vol. XXI. I included it provisionally and doubtfully in *C. Paynei*, from the general form and appearance, although there were differences even in the external character which were there pointed out, and I was careful not to include the peculiarities observed in the reproductive organs in the description of that species, because I anticipated that these and the other differences might require it to be removed from *C. Paynei* when a fuller study of them should be made.

On my next visit to New Haven in November, 1898, to study a fresh invoice of cycads sent by Mr. Wells, I found another specimen, No. 131, which exhibited most of the external characters of No. 77 and had similar fruits, very few of which, however, contained the whole of the spadix. In a number of cases this had fallen out, leaving the bowl-shaped cavity, but with some of the seminal peduncles adhering to its sides and terminating in the little elongated sockets in which the seeds had lain. This at once revealed to me the true nature of the fruits of No. 77, and I thereupon placed that specimen in a vat of acid and removed the coating of lime. The specific identity of the two specimens was then manifest and it became clear that the small bodies described in the latter and erroneously taken for the silicified cores of the seminal peduncles were the seeds themselves.

I endeavored to impress upon Professor Marsh the great importance of this discovery and the urgent necessity of having sections made of this first case thus far discovered of seeds preserved in the trunk of an American cycad. The extreme rarity of such cases justified this exceptional interest, and I succeeded in arousing in Professor Marsh a part of the interest that I felt in the matter.

It chanced that Mr. George R. Wieland was at the time working in the Peabody Museum. He had himself collected a considerable number of cycads, had spent one day with Mr. Wells and myself in the Blackhawk region, and was greatly interested in the general subject. He had had considerable training in the technique of section cutting, and, with Professor Marsh's approval, he proceeded to make some sections of one of the best spadices of No. 77, which was easily detached from near the fractured margin of the trunk. The longitudinal section first made revealed the whole nature of the fruit and showed its essential identity with the fruits of *C. Gibsoni*, that had been the subject of such prolonged and exhaustive studies on the part of Carruthers and Solms-Laubach, in Europe. It proved also to be at least generically identical with the celebrated fruit called *Bennettites Morierei*, from the Jurassic of Calvados in France, so beautifully monographed by Professor Lignier.

A cross section was also made while I was at New Haven, and from these sections I was able to write the description of the internal structure of these fruits as given above.

I was convinced that other specimens, both in the Yale collection and in that of the United States National Museum, would show perfect fruits if properly treated, and I took that occasion to urge Professor Marsh to inaugurate a systematic study of the Yale collection from this point of view, which he did, and Mr. Wieland has continued the work so auspiciously begun. It is therefore with great pleasure that I dedicate this species to him, the first to bring to light the internal structure of the reproductive organs of the fossil cycads of America.

This species is therefore founded on the two type specimens, Nos. 77 and 131 of the Yale collection. No. 77 is smaller above than below, and is naturally oblique at both base and summit, having lost nothing. It is jagged on all sides with its unequal walls and protruding fruits. It is 32 cm. high. Its major diameter varies from 23 to 25 cm., and its minor from 16 to 21 cm. It has a girth near the base of 74 cm. and at the summit of 66 cm. Its weight is 21.09 kilograms.

No. 131 is larger than No. 77. It is long-conical, very obliquely truncated above so as to want the apex entirely, also irregularly broken across below, but the lowest part probably shows the true base, which was little if at all contracted. It is elliptical in cross section, and a number of pieces broken out of one side of the base have been saved and accompany the specimen. Its present height is 40 cm., which, owing to the obliquity of the fractures, probably represents its full length. The longer diameter near the base is 26 cm. and the shorter one 21 cm. The girth at the base is 70 cm., and at a point just below the upper fracture 66 cm. It weighs 22.22 kilograms.

Pl. CXVI shows a side view of trunk No. 77. A number of fruits are clearly brought out.

CYCADEOIDEA ASPERA n. sp.

Pl. CXVII.

Trunks small, subconical, simple, very rough on the surface, light brown varying to whitish, dark with white streaks within, moderately heavy, about 20 cm. high, nearly the same in diameter, and 70 cm. in circumference; organs of the armor somewhat declined throughout; phyllotaxy not traceable; leaf scars anomalous in having the upper angle much sharper than the lower, the reverse of the usual case and only elsewhere observed in *C. insolita*, lower angle reduced to a groove, a curve, or a straight line, lateral angles always sharp; scars small, 12 to 25 mm. wide, 10 to 15 mm. high, subrhombic; leaf bases present usually projecting 5 to 10 mm. above the walls, presenting a light brown, very spongy and porous surface, without evidence that any of the pores represent the scars of vascular strands; ramentaceous interstices thin, 1 to 5 mm., dark reddish brown, sunk to varying depths among the projecting leaf bases and other organs, scaly and laminated with crooked and twisted plates; reproductive organs as numerous as the leaf scars, projecting much beyond the petioles, sometimes 3 cm. high, solid or variously broken and jagged, occasionally somewhat cavitous, scarcely showing any involucral scales, but in addition to all the other organs described are small angular bracts, mostly broken down, presenting sharp edges and projections over the surface, intermediate in character between scales and leaves, properly to be classed as bristles or perulæ; all the different projecting organs giving the trunk a ragged and bristling appearance; armor, including projections, 6 cm. thick, the vascular strands traceable far into the woody zone and inner limit not definite; parenchymatous layer 15 mm. thick, penetrated by the whitened leaf bundles; secondary wood 2 cm. thick, consisting of two nearly equal rings, the outer white, the inner black or dark blue in the only specimen known; medulla 6 cm. in diameter, dark, fine-grained and homogeneous.

This species is based on the single specimen, No. 104 of the Yale collection, which is somewhat less than half of a trunk that divided along a vertical plane from top to bottom almost as smooth and even as if sawn through by a gang saw, exposing the interior in an admirable manner. Its only affinities are with *C. Paynei*, and the specimen, though smaller, has a remarkable resemblance to No. 5 of the U. S. National Museum (cf. Pls. CXIV and CXV), which was cut through on the same plane as this specimen. The resemblance is, however, more apparent than real, and the descending leaves and especially the inverted scars clearly exclude it from that species. Add to this that no specimens of *C. Paynei* have been found elsewhere than in the original Minnekahta locality, and the improbability of this belonging to that species is very great. It is too perfect a specimen to class as undeterminable, and there seems no course left than to treat it as constituting a new species.

Fig. 1 of Pl. CXVII represents the rough outer surface and Fig. 2 the inner face.

The specimen is from the Blackhawk region.

CYCADEOIDEA INSOLITA n. sp.

Pls. CXVIII, CXIX.

Trunks medium sized, unbranched, somewhat elliptical in cross section, subcylindrical or subconical; rock substance light colored, moderately hard and heavy; height of trunks 30 to 40 cm., diameter 30 to 35 cm., girth about 1 meter; organs of the armor nearly horizontal; leaf scars irregularly distributed over the surface, very variable in size and shape, rhombic or subrhombic, in the latter case having the more acute angle above and the more obtuse one below, i. e., the opposite of the normal condition, 15 to 25 mm. wide, 8 to 15 mm. high, sometimes empty to some depth, but in some such cases the summits of the leaf bases showing the vascular bundles in the form of little rods or pins projecting upward and forming a row all round the leaf bases close to the margin with others near the center, about 18 to each leaf; leaf bases sometimes projecting in the form of small cones, in which cases the bundles can be seen either as black dots or as little protuberances around the sides of the cones; ramentum walls thin but variable, 1 to 4 mm., firm and sharp on the edges of the scars, grooved along the middle; reproductive organs abundant, disturbing the phyllotaxy, tending to congregate and blend together, presenting a rough surface, usually projecting, rather small and with few bract scars; armor 4 to 6 cm. thick; cortical parenchyma 2 to 3 cm.; fibrous zone 15 to 30 mm., with two or three rings, the outer either preserved and showing fine-grained structure or much decayed, in either case conspicuously partitioned off by the medullary rays, the others also showing woody wedges; medulla 8 by 12 cm. in diameter at the base, enlarging upward, hard and homogeneous in structure.

This species is founded on two specimens in the Yale collection, Nos. 50 and 64, chiefly the latter, No. 50 being only a small fragment. The characters can not be forced into any other species, especially the inverted leaf scars and the peculiar habit of the vascular bundles in the petioles. In No. 33, which is a branch of a trunk of the type of No. 11, and has been referred to *C. Marshiana*, this latter peculiarity is nearly repeated, but this happens in no other specimen of that species.

No. 64 is the lower part of a trunk irregularly broken across the top and down one side to near the middle. The apex is therefore unknown. It is this specimen that has furnished all the external characters, but No. 50 shows precisely the same characters so far as it goes, and adds somewhat to the knowledge of the internal parts. No. 64 weighs 24.95 kilograms and No. 50, 3.29 kilograms.

Pl. CXVIII and Fig. 1 of Pl. CXIX illustrate the trunk, No. 64, but the views can not be said to be very satisfactory. Fig. 2 of Pl. CXIX affords a much better idea of the leaf scars as they are seen on the outer surface of the smaller fragment, No. 50. Their inverted form is here made clear, though some appear as true rhombs.

Both specimens are from the Minnekahta region.

CYCADEOIDEA OCCIDENTALIS n. sp.

Pl. CXX.

Trunks medium sized, conical or ellipsoidal, simple or with a few small secondary axes, well silicified, moderately hard and heavy, reddish brown without, dark or nearly black within; organs of the armor generally ascending; phyllotaxy not traceable in any of the specimens; leaf scars subrhombic, variable in size, 16 to 25 mm. long, 10 to 16 mm. high, usually filled by the leaf bases; bundles not visible; ramentaceous interspaces thin, less than 2 mm., roughened without, white within, contrasting strongly with the black petiolar substance in longitudinal section; reproductive organs rare, slightly protruding, usually having remains of the organs preserved, occasionally decayed so as to leave openings, obscure from without, distinct in sections longitudinal to them, penetrating to a depth of 6 cm.; the substance above the fruit light colored; fruit dark, elliptical or ovate, nearly homogeneous and showing no structure, subtended by strong involucral bracts and crowded by a mat of chaff probably consisting of the summits of the interseminal scales; seeds not detectable; armor 5 to 8 cm. thick, irregularly joined to the woody axis, the outer or parenchymatous portion of which, to a thickness of 3 cm., is more or less decayed in most of the specimens; fibrous zone divided into two rings, each about 15 mm. thick, the innermost very firm and fine-grained, its inner wall (exposed in two specimens) regularly marked by the scars of the medullary rays, the scars consisting of conspicuous elongated depressions arranged in longitudinal rows at equal distances (1 cm.) from one another; the scars nearly the same distance one above another but alternating so as to form diagonal rows crossing the vertical ones at an angle of nearly 45°; inner face of the second ring of wood (exposed over a small area in one specimen; nearly smooth but faintly striate in a horizontal direction, marked with smaller, more distant scars; medulla (represented only in one small disk-shaped specimen from near the top of a trunk, and here thoroughly crystallized) scarcely known.

Four of the fragments picked up by me belong to this species. They are Nos. 11, 12, 17, and 18. No. 11 is a large block weighing over 7 kilograms, showing considerable of the external surface, which is not very clear. Portions of it have been detached and cut in several directions to show the internal structure. Most of such characters above given are derived from this source. No. 12 is a very small piece, consisting entirely of the fibrous zone of wood, of which it shows the inner wall with the scars identical in character with those of No. 11, of which it is probably only a detached fragment. No. 17 is a crescent-shaped fragment from a small trunk, and weighs 2.27 kilograms. It appears to have come from near the top of the trunk. No. 18 is a thin horizontal zone or disk from near the top of a small trunk. The internal portion is much crystallized.

The specimens on which this species are based, though clearly distinct in their external characters from any of the rest, are still so fragmentary and imperfect that in photographing the material they were overlooked, and no views were taken of the outer surface. One of them, however, No. 11, has furnished an excellent section through the armor and wood, an enlarged view of which is shown on Pl. CXX.

All the specimens are from the Minnekahta region.

CYCADEOIDEA JENNEYANA Ward.

Pls. CXXI–CXXXII.

1894. *Cycadeoidea Jenneyana* Ward: Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, p. 87.

Trunks large and tall, attaining a height of 130 cm., cylindrical, little compressed, 30 to 40 cm. in diameter, the girth reaching over a meter and a half, firmly silicified, more or less chalcedonized or opalized within, very hard and heavy, light brown or reddish externally, white or reddish, sometimes black within; organs of the armor horizontal except near the summit; leaf scars arranged in intersecting spiral rows, those passing from left to right making an angle of about 40° and those from right to left of about 50° with the vertical axis; scars subrhombic to subtriangular with mostly rounded angles, sometimes kite shaped, large, 20 to 30 mm. wide, 12 to 25 mm. high, partially or wholly filled with the remains of the leaf stalks; vascular bundles in the petioles arranged in an imperfect row all around near the margin with other straight rows, or somewhat scattered in the interior, numerous (40 were counted in one cross section), circular, elliptical, crescent-shaped or kidney-shaped in section; ramentaceous interspaces very thick but somewhat variable (6 to 13 mm.), sometimes roughened or irregularly affected by small pits representing bract scars, a line of which may run through the center, dividing the walls, or by cracks which divide them into plates or small partitions; reproductive organs numerous, large, and well developed, often protruding, sometimes cavitous, scattered over all parts of the surface, axillary to the leaf scars, whose shape and order they distort, elliptical in outline, 25 to 40 mm. in a horizontal and 18 to 26 mm. in a vertical direction, surrounded by concentrically arranged semilunar or somewhat triangular bract scars, which are sometimes continued in a horizontal direction, converging and blending with the rows dividing the walls, the central portion, when exposed at the margin of a fracture, taking the form of an elongated cylindrical spadix or fruit, which, seen in cross section, proves to be made up of four large organs that seem to contain two axes, and seen in longitudinal section, to constitute a convex receptacle from which arise seminiferous peduncles (or filaments) and interseminal (or interstaminate) scales, the seeds (or anthers) having disappeared, leaving a region of amorphous decayed tissue occupied by the matted prolongations of the chaff; armor 8 to 9 cm. thick; liber zone very indistinct; cortical parenchyma 3 to 4 cm. thick; fibrovascular zone about 2 cm., without visible subdivision into rings; medulla slightly elliptical, the major diameter 16 to 17 cm., the minor 13 to 14 cm., black and cherty in all the specimens, showing no structure, giving off rays which may be seen traversing the woody cylinder.

The above description is based mainly on two large trunks, or parts of the same trunk, which, through the intervention of Professor Jenney, were generously loaned to the Smithsonian Institution by Dr. V. T. M'Gillycuddy, director of the State School of Mines of South Dakota at Rapid City, where they had been deposited. There are many reasons for believing that these two pieces belong together, and with a small missing intermediary piece constituted a tall, cylindrical trunk. One of the pieces, about 40 cm. long, represents the true base and the other, 58 cm. long, the true summit. The former is scarcely worn at all while the latter is deeply eroded all round as the result of having been long exposed to adverse influences, probably by having lain in the bottom of a gulch. It is therefore considerably smaller than the normal diminution upward would require. The difference applies, however, wholly to the exterior, and the medulla and woody cylinder are no smaller than would be the case in an entire trunk at different heights. After a careful examination I have arrived at the conclusion that if they are parts of one trunk it would only indicate the loss of about 30 cm., which would give a total height for the trunk of about 130 cm.

Only two other tall, cylindrical species of Cycadeoidea are known to me, viz, the *C. excelsa*, described below, and the *C. gigantea* of Seward from the Purbeck beds of Portland.[1] Specifically, of course, *C. Jenneyana* is very distinct from both of these, but in its straight, erect

[1] On Cycadeoidea gigantea, a new Cycadean stem from the Purbeck beds of Portland, by A. C. Seward: Quart. Jour. Geol. Soc. London, Vol. LIII, February, 1897, pp. 22–39, pls. i–v.

habit it somewhat resembles *C. gigantea*. It is much less compressed laterally, and if my conclusions are correct as to the amount missing between the two sections, it was taller by 11 or 12 centimeters. Mr. Seward does not state the weight of his specimen, but if the material at all resembles that of all other cycads from those quarries its specific gravity is low and the weight would be small in relation to the bulk. He states the girth of the specimen at 107 cm, while that of *C. Jenneyana* is very nearly 130 cm. More exactly, the lower piece measured at the middle is 129.54 cm, while the upper piece, both at the lower end and at the middle, measures 107 cm. The difference, as explained above, is chiefly due to erosion of the surface of the latter. The lower piece weighs 95.26 kilograms, and the upper 86.18 kilograms, a total of 181.44 kilograms. The entire trunk must therefore have weighed nearly 250 kilograms, which would give it the third rank, from this point of view, among the fossil cycads of the world.

The question whether there are any other specimens in the U. S. National Museum collection that belong to the same species is a more difficult one. In 1893, as stated above (p. 562), an expedition was made to the locality. No other fragments were found by any of our party, although we all searched diligently for several hours and collected a large amount of silicified wood. We were told at the ranch that a man named McBride (not Professor McBride, of course) had been in the region and had gathered and taken away all the specimens he could find.

Later in the summer, when I was in California, Professor Jenney learned the whereabouts of Mr. McBride, who was then in Deadwood, and purchased two fragments of cycads from him that he said came from that locality. He also purchased two other fragments from Mr. L. W. Stillwell in Deadwood, which, as he was informed, came from the same place. All these he sent to Washington, and they constitute a part of the cycad collection in my hands.

Upon careful examination of all four of these fragments I conclude that there is nothing to negative the supposition that three of them belong to the same species as the large trunks, and I have accordingly included them under *Cycadeoidea Jenneyana*. They were numbered in the collection as McBride fragments Nos. 1 and 2 and Stillwell fragment No. 1.

These fragments are irregular and not well preserved, but they evidently came from large trunks, and all the characters that they show agree substantially with those of this species. As they come from the same locality and as a portion of the great trunk is missing, I have examined them carefully to see whether they might possibly belong to that trunk, but I find no evidence of this. These fragments weigh, respectively, 12.25, 11.34, and 7.26 kilograms.

A few days after visiting the locality on Black's ranch I was in Hot Springs, and purchased a number of fragments of cycads from a dealer named Homer Moore. Two of these which fitted together, forming a block weighing a little more than 7 kilograms, evidently belonged to a very large trunk, and these show a number of characters which agree with those of *C. Jenneyana*. In fact they very closely resemble the Stillwell fragment No. 1, so that whatever is done with the one must be done also with the other. Mr. Moore thought that these specimens came from the Minnekahta region, but was uncertain as to their source. They certainly differ specifically from any of the material from that region and agree substantially with most of that from Black's ranch. I shall therefore include them under *C. Jenneyana*.

I had in hand two small slabs belonging to the Woman's College of Baltimore, purchased by Mr. Arthur Bibbins for that college at the World's Columbian Exposition in Chicago and sent over along with the Bibbins collection from Maryland. Mr. Bibbins was informed when he purchased these fragments that they came from the Black Hills in America and that they were cut and polished in Germany. I can well believe this, as, so far as they go, they are substantially identical with the material from Black's ranch, and I am obliged to refer them to the present species. They contain none of the woody cylinder but are confined to the armor, of which they show a thickness of 3 to 5 cm. The exterior is obscure and closely resembles the Stillwell fragment No. 1, and the Homer Moore fragment, but the inner face is cut in a direction transverse to the leaf bases, which are beautifully shown, and also in the opposite direction showing the organs in longitudinal section. Fruiting axes are thus exposed, and much of the above description relating to the structure of these organs is derived from a study of these sections. I have no doubt that the other specimens when similarly cut, as they will be eventually, will furnish the same characters. In fact, they can now be indistinctly seen on a number of fractured surfaces.

These specimens bear the labels of the museum of the Woman's College, Nos. 1501 and 2128. The former weighs 532 grams and the latter 489 grams. They are exactly alike in all essential respects, and may well have belonged to the same trunk.

In the Yale collection there are 24 specimens that appear to belong to this species. These are Nos. 81, 87, 88, 90, 91, 93, 96, 97, 98, 101, 102, 108, 109, 111, 112, 113, 114, 115, 116, 120, 121, 124, 125, and 126. It will be observed that all but the first two of these came with the last two invoices and are from the Blackhawk region, the same from which the original type of the State School of Mines was obtained. The two reported from the Minnekahta region, Nos. 81 and 87, also belong to this species beyond a doubt. No. 81 consists of eight small fragments which all fit together and form an irregular segment from a large trunk similar to those belonging to the State School of Mines of South Dakota. Indeed, they might have belonged to the supposed missing portion of the tall trunk which those two pieces are believed to have so nearly constituted (see Pl. CXXV). The eight fragments together weigh 9.5 kilograms.

No. 87 also consists of a number (five) of small fragments that can be built up into a segment of a trunk, and all together weigh 7.6 kilograms; but these do not so closely resemble the type specimens. Still the characters they possess are those of this species. Professor Marsh thought that these specimens came from the Blackhawk locality, but Mr. Stillwell, from whom they were purchased, states that they were obtained 3 miles southwest of Minnekahta station. This agrees closely with the original locality. I am disposed to believe that there has been some mistake, and that these particular specimens are, after all, from the Blackhawk region.

Of the other 22 from the Blackhawk region Nos. 91, 113, 120, and 124 are somewhat doubtful. No. 91 has a large terminal bud 8 cm. high, elliptical in cross section and 15 by 20 cm. in diameter, studded with polygonal bract scars 5 to 8 mm. in diameter, filled with the bases of the bracts or small leaves matted together and exposed on the sides of the terminal bud, which have suffered from erosion (see Pl. CXXXI). I have not included this bud in the description of the species on account of doubts as to the true affinities of this specimen, which, if it belongs here, is the only one in which the bud is preserved. The surface is so badly worn that all the reliable characters are obscured, except that in general shape the specimen agrees with others of this species. The scars are large and the walls thick, which further confirm this supposition. No. 113 is also badly worn and metamorphosed, but probably belongs to this species. It is a fine trunk, nearly complete, 55 cm. high, and weighs 91.17 kilograms. No. 120 is an interesting specimen, and shows a great number of large fruits, which stand out, having resisted the deep erosion of the surface (see Pl. CXXXII). No. 124 is a mass of quartz and only a fragment, but in all probability came from a trunk of *C. Jenneyana*.

The rest of the specimens, though mostly fragments and segments from large trunks, are not doubtful, as they show surface characters in all cases which are distinctive. Several, however, are fine trunks. No. 101, though in three sections perfectly fitting together, is an almost complete trunk, laterally compressed, 97 cm. high, and weighs 183.71 kilograms, which is a little more than 1 kilogram heavier than both pieces of the type specimen from the State School of Mines of South Dakota. Unfortunately the surface is badly worn and the most important characters are obscured. No. 102 is the lower part (36 cm.) of the largest trunk of the species thus far known. It is nearly circular in cross section, has a diameter of 47 cm., and a girth of 156 cm. Its surface is also in a fair state of preservation (see Pls. CXXVII–CXXIX). No. 121 is a similar but much smaller basal portion. No. 115 is anomalous in many respects and might have been included among the doubtful cases. Though in two pieces it is nearly complete and weighs 87.77 kilograms, having a height of 60 cm. and a girth of 106 cm. Some of the leaf bases are horizontal, while others are strongly declined. The latter are all on one side below the middle, and in the case of certain abnormally small but strongly projecting leaf bases there is the additional peculiarity that they are converted into impure opal or blue quartz (see Pl. CXXX). No. 116 is also a fine, nearly complete trunk 49 cm. high, 42 by 36 cm. in diameter, 120 cm. in girth, and weighs 85.73 kilograms.

Pls. CXXI–CXXV illustrate the great trunks from the State School of Mines of South Dakota. Pls. CXXI and CXXII show the external surface of both trunks on the two opposite sides. Pl. CXXIII shows the true base and true summit, the latter somewhat decayed, forming a depression or "crow's nest." Pl. CXXIV gives a view of the two ends that would have matched each other had nothing been lost. In Pl. CXXV the two segments are placed as nearly as possible in the position in which they stood when living, with an estimated interval between them for the portions lost.

Pl. CXXVI represents the polished surface of No, 1501 of the Museum of the Woman's College of Baltimore and shows the characters above described for that specimen.

Pls. CXXVII–CXXXII represent the specimens of the Yale collection, Nos. 91, 102, 115, and 120, as mentioned above and as fully explained in the descriptions of the plates.

It will be seen from the above that 32 specimens have been referred to this species. Of these, 27, including all the larger trunks, were found with certainty in the Blackhawk region. Two were reported from the Minnekahta region and probably came from there. The source of the other three is uncertain.

Cycadeoidea ingens n. sp.

Pls. CXXXIII–CXLIII.

Trunks large or colossal, ellipsoidal in form, thickest at the middle part, diminishing and more or less rounded off at both base and summit, slightly elliptical or nearly circular in cross section, unbranched or with a few small secondary axes in the form of protuberances, usually of a dark color, hard consistency, and high specific gravity, attaining a maximum height of 85 cm., girth of 170 cm., and weight of over 300 kilograms; organs of the armor slightly declined near the base, horizontal in the middle portion, ascending above, and erect at the apex, producing a large terminal bud consisting of the bases of somewhat flattened leaf-like bracts or scales; leaf scars arranged in two sets of rows passing spirally round the trunk, intersecting each other, and forming each a different angle with the axis, those passing from left to right forming an angle of about 35° to 45°, while those passing from right to left form an angle of 50° to 60°; scars large, 35 to 50 mm. wide, 20 to 35 mm. high, peculiar in shape, the lateral angles drawn out into sharp points by the incurving of the sides, the vertical consisting of mere curves, varying from this to simple gibbosity; leaf bases always present, filling the scars and often projecting, presenting either plane or slightly convex surfaces; vascular bundles in one row closely set together and very near the margin, and an irregular ring at the center inclosing an empty space; ramentaceous interspaces thin, 3 to 10 mm., scaly or laminated, sunk below the leaf bases, forming grooves on the surfaces of the trunk, often white in color, contrasting with other parts; reproductive organs abundant, especially in the upper part of the trunks, very different from the leaf bases, usually large, elliptical, 5 to 6 cm. wide by 3 to 4 cm. high, sometimes solid and projecting, but usually with an opening at the top or cavitous and crater-like, surrounded by numerous bract scars filled with the bases of the bracts, which are usually narrowly triangular or nearly flat; armor 5 to 10 cm. thick, more or less clearly marked off from the underlying tissues; cortical parenchyma 3 to 4 cm. thick; zone of secondary wood 4 cm.; medulla 10 to 20 cm. in diameter.

A perfectly well characterized species differing entirely from any of those based on specimens from the Minnekahta region. It is also very distinct from *C. Jenneyana*, which is the leading form of the Blackhawk region. Still, this species is also common there, and is represented in the collection by eight specimens, viz, Nos. 92, 94, 99, 100, 103, 117, 122, and 123. No. 100 is taken as the type and is the next largest cycadean trunk known in the world, weighing 303.91 kilograms. It slightly exceeds in height the U. S. National Museum type of *C. colossalis*, having a maximum length of 85 cm. Its diameters are respectively 62 cm. and 49 cm., and it has a girth of 170 cm. But, like all other specimens of this species, it diminishes in size toward each end and is somewhat barrel-shaped. Nos. 103 (see Pl. CXXXVI, CXXXVII) and 117 (see Pl. CXXXVIII, CXXXIX) represent the lower part of two other large trunks, and the summit is represented only in No. 100. No. 94 (see Pl. CXL, CXLI) comes next in point of interest in affording most of our knowledge of the internal structure of the species, including the markings on the medulla. No. 123 (see Pl. CXLII, CXLIII) is also instructive from this point of view. The rest are fragments, but all add to the complete conception of the species.

The form of the leaf scars is imitated very closely by two other species, one of which, *C. formosa*, is represented by only one specimen, No. 89. The other is *C. Stillwelli*, and this is made very clear by the new material added by the specimens last sent from the Blackhawk region by Mr. Wells, especially No. 105. In both these cases, however, the scars are much smaller, and this is particularly the case with *C. Stillwelli*.

The species is illustrated by Pls. CXXXIII–CXLIII, which have been commented upon in the foregoing remarks and are further fully explained in the descriptions of the plates.

All the specimens are from the Blackhawk region.

CYCADEOIDEA FORMOSA n. sp.

Pls. CXLIV-CXLVI.

Trunks of moderate size, short-conical, unbranched, dark brown, nearly black within, of average specific gravity, about 25 cm. high, nearly 30 cm. in diameter and having a girth of somewhat less than a meter; organs of the armor, even the lowest, somewhat ascending with a uniform angle; leaf scars arranged in two series of spiral rows, those of both series making an angle with the axis of about 50°; scars large for the size of the trunk, peculiar in shape, the lateral angles very sharp, the vertical ones very obtuse and rounded, the bounding sides usually curving downward and upward on the right and left, causing the scars to be drawn out laterally corresponding to wings of the petioles, lower side more pronounced than the upper in such a manner that a line joining the lateral angles divides the scar into unequal areas, varying to simply gibbous by the absence of the above-described curves; distance between lateral angles 25 to 30 mm., that between highest and lowest points 16 to 20 mm.; leaf bases always present, usually projecting somewhat, sometimes nearly 1 cm., outlines definite, conforming to shape of scars, exposed ends presenting surfaces that are exactly square or tangential to the trunk, never convex nor concave, smooth but not polished, covered by a diaphragm representing a natural plane of disarticulation, this layer, however, sometimes removed, in which case small projecting points are irregularly scattered over the surface of the leaf base; outer row of leaf bundles very close to the margin, faintly visible at the ends, more clearly as striæ on the eroded sides of projecting leaf bases; ramentum walls thin, 1 to 3 mm., thickening at the angles, sunk below the petioles and usually separated from them by a crack, dull colored, loose in structure and somewhat pitted, having the appearance of cracks filled with mud or extraneous matter; reproductive organs numerous and well marked, occurring at all points, but tending to an arrangement in vertical rows, one above another, with a trend different from that of either of the rows of leaf scars, projecting beyond the leaf bases to which they bear no resemblance, rounded or elliptical, 3 to 6 cm. in diameter, never cavitous, usually exhibiting concentrically arranged scars, the circular central portion inclosed in a tube surrounded by involucral bract scars occupied by the bases of the bracts which project in miniature imitation of the leaf bases, the central portion sometimes occupied by small cylindrical bodies or rods 1 mm. in diameter and 1 to 5 mm. long, consisting of nearly pure quartz; armor 5 cm. thick, definitely separated from the axis by a porous liber zone of appreciable thickness; cortical parenchyma 15 mm. thick; secondary wood 4 cm. thick, consisting of two distinct rings of about equal thickness separated by a peculiar scalloped line, apparently caused by the convex edges of woody wedges, 5 mm. thick, separated by thin medullary rays; medulla 9 cm. in diameter, somewhat heterogeneous or chambered in structure.

This species is represented by the single specimen No. 89 of the Yale collection. It has close affinities on the one hand with *C. ingens* and on the other with *C. Stillwelli*, while all these are related to *C. McBridei*, but it is impossible to refer it to any of these species.

Pl. CXLIV shows the side of the trunk with the peculiar shaped scars and two of the vertical rows of fruiting organs. Pl. CXLV shows the remarkable smooth base with its concentric structure. Pl. CXLVI is a view of the top where the thickness of the armor and other features appear to advantage.

The specimen is from the Blackhawk region.

Cycadeoidea Stillwelli n. sp.

Pls. CXLVII-CLII.

Trunks small, cylindrical, or more or less laterally compressed, 30 to 40 cm. high, 15 to 25 cm. in diameter, 40 to 70 cm. in girth, reddish or light colored externally, cherty, flinty, or more or less agatized within, simple, or bearing a few small branches in the form of projections or protuberances, short-conical at the summit, with a natural depression at the apex studded with small polygonal scars and a gentle swelling at the center; organs of the armor nearly horizontal; leaf scars arranged in two series of spiral rows, those from left to right making an angle of 40° to 50°, those from right to left of 30° to 50° with the axis of the trunk; leaf scars normally almost exactly rhombic or diamond-shaped, but with a tendency on the one hand to the rounding of the vertical angles and on the other to the incurving of the sides so as to exaggerate the acuteness of the lateral ones, this sometimes very marked; scars small, 20 to 25 mm. wide, 15 to 20 mm. high, occasionally almost as high as wide, the lateral diagonals about horizontal and the vertical ones perpendicular to them or vertical; leaf bases always present, filling the scars, often projecting, sometimes considerably, the petioles disarticulating at several different points by means of a diaphragm which forms a thin layer over the exposed summits, the occasional absence of which leaves a rough, spongy or porous structure; vascular bundles arranged in two rows, one near the margin and parallel to it, the other forming an elliptical ring at the center 3 by 4 mm. in diameter, both rows usually appearing in the form of denticulate ridges; ramentaceous walls very thin, 1 to 2 mm., often sharp at the surface, generally sunk below the leaf bases, forming grooves or deep channels between them, the surface therefore consisting chiefly of the latter, in the more abnormal forms of scar describing a double curvature and having somewhat the shape of a "line of beauty" in penmanship or one of the parts of a Buddhist cross or "swastika," sometimes, however, projecting so as to leave a groove around the outer edge of the convex summits of the leaf bases; reproductive organs few, more numerous on the narrower sides of the trunk, disposed somewhat in rows or chains, generally parallel to the axis but sometimes running round the trunk, more or less contiguous, consisting of protuberances, some rising above the highest leaf bases, closed, or more commonly open at the top, sometimes crater-like but generally truncated, presenting an irregular surface with numerous pits or pores at the center surrounded by bract scars which are sometimes empty, but usually occupied by the bases of narrowly triangular or flattish bracts projecting and squarely truncated with thin interspaces in miniature imitation of the leaf bases; armor much thicker on the narrower than on the broader sides of the trunk, 3 to 6 cm. thick in the former and 2 to 3 cm. in the latter case, clearly and definitely marked off from the woody axis by a cambium line; cortical parenchyma 15 to 20 mm. thick; secondary wood zone 10 to 20 mm., very fine grained and clearly marked off from the last; medulla somewhat elliptical, 5 to 8 cm. in diameter, marked on its external surface by rows of small rhombic projections of a dark color terminating small longitudinal ridges representing the origin of the medullary rays.

The small cylindrical section of a trunk acquired through Professor Jenney's intervention from Mr. L. W. Stillwell, of Deadwood, exhibited so many good characters, all different from those of any other specimen in the U. S. National Museum collection, that before I had seen the Yale collection—in fact, long before it was made—I had described it as a new species and named it for Mr. Stillwell. It was reported to have been found in the Blackhawk region, and there is every reason to believe that such was the case.

The Yale collection contains six specimens of this species, each of which adds something to our knowledge of it. These are Nos. 16, 36, 56, 105, 107, and 119. The first three of these purport to come from the Minnekahta region, while the others are certainly from the Blackhawk region. The first of these is somewhat smaller than the type and has near its summit two small branches. The leaf scars are normal and confirm my suspicion that the peculiar form which they have in the original specimen is due to lateral compression. It weighs nearly 5 kilograms. No. 36 represents the upper part of a trunk of exactly the same diameter as the Stillwell specimen, but with the outer parts all worn away. The summit, however, is perfect. The transverse fracture has supplied a number of otherwise missing or imperfect characters. This specimen weighs 8.17 kilograms. No. 56 is larger and entire from base to summit, but broken in two near the middle. It is very elliptical in cross section from lateral compression, badly worn like the others, and has a slab scaled off from one side, exposing the outer surface of the medulla and corresponding inner wall of the woody zone. This specimen is 39 cm. high, 15 by 20 cm. in diameter, and has a girth of 54 cm. Its ellipticity is, however, exaggerated by the greater erosion of the flat sides. It weighs 12.7 kilograms.

No. 105 is only a section weighing 12.8 kilograms, with base and summit wanting, also a piece from one side, part of which was saved, but the part that remains shows the outer surface in the most perfect state of preservation, and much of the above description of the phyllotaxy, leaf scars, petioles, vascular bundles, ramentum walls, etc., is derived from it. No. 107 is also an exceedingly interesting specimen, weighing 9.07 kilograms, and is especially valuable as showing the true base. It is obliquely broken through from the top to near the bottom, but one side shows the spiral rows of leaf scars. No. 119, although larger, weighing 14.29 kilograms, is not as well preserved, but also shows the base, which is slightly concave.

Upon the whole, this species may be regarded as one of the best characterized of all that have been based on cycadean trunks alone.

Pl. CXLVII shows the best side of the original Stillwell type with its peculiar scars. Pl. CXLVIII gives views of No. 36 of the Yale collection seen from its best side (Fig. 1) and from the transverse fracture (Fig. 2). In the latter the ring of exogenous tissue can be distinctly seen. Pl. CXLIX shows trunk No. 56 of the Yale collection to good advantage, including the exposed medulla. The small piece on the lower left fits into the upper part of the fracture. It is here turned round so as to exhibit the counterpart of the medulla as impressed on the inner wall of the woody zone. Pl. CL shows at Fig. 1 the most perfect side of No. 105, the regularity of whose scars is scarcely exceeded by any known cycadean trunk. Fig. 2 of the same plate shows the side opposite, on which the leaf bases project to unequal distances above the surface. Pl. CXLI gives two views of No. 107, the peculiar shape of which is described above. Fig. 1 represents the narrow portion between the oblique even base and the plane fractured surface parallel with it. It is over this area that the arrangement of the scars is most definite. Fig. 2 is a good view of the base, but also takes in the broadest side of the inclined trunk above. Pl. CLII shows a side (Fig. 1) and a base (Fig. 2) view of No. 119. The latter is perhaps the best exposure of the base that we have.

Cycadeoidea excelsa n. sp.

Pls. CLIII–CLV.

Trunks tall, compressed-cylindrical (only specimen known 91 cm. high and truncated) with an enlarged base, 112 cm. in circumference at the base, 80 to 90 cm. at all other points, light ash colored without, whitish or bluish within, soft externally, fine-grained inside and moderately hard, with the specific gravity rather low, unbranched but more or less irregular, crooked, zigzag, and inclined; organs of the armor horizontal, or at right angles to the axis; leaf scars disposed in two series of spiral intersecting rows, those from left to right making an angle of 20°, those from right to left of 50° with the axis; scars imperfectly rhombic or rectangular, the diagonals 16 to 25 mm., the lateral angles nearly alike, the vertical ones usually unlike, the upper consisting of a deep but obtuse sinus, the lower also obtuse but relatively shallow, sometimes reduced to a gentle concave curve formed by the two lower sides; leaf bases generally preserved to within 2 cm. of the surface, disarticulated at a natural joint, their surfaces even and concave but roughened and affected by many small dots of a dark color, irregularly arranged, perhaps representing gum ducts, and some large pits which may have contained leaf bundles; ramentaceous walls thin and frail, 1 to 2 mm., of a light color within, contrasting with the darker leaf bases, thickened at the angles and more or less compound, with a few small pits representing scars of bracts or perulæ; reproductive organs numerous, usually solid, harder than the remaining parts, hence often projecting from the eroded surfaces, of different sizes, the smaller ones probably abortive and occupying angular spaces among the leaves, the walls dividing and surrounding them, circular in section, with or without bract scars, the larger ones lying in interrupted rows running in the same direction as those of the scars which they crowd and distort, elliptical in section, the longer diameter being along the line of the rows, 25 by 38 mm. in diameter, usually solid except their roughened extremities, sometimes open or crater-like at the summit, a few solid and cylindrical (one of which has been detached and will be sliced for microscopic sections); armor 4 to 7 cm. thick, separated from the axis by an even line; parenchymatous zone 2 cm. thick; fibrous zone 3 cm., divided into three rings, one of which exhibits in places a somewhat open structure, crossed by thin medullary rays and inclosed between walls or sheaths of harder material; medulla 13 cm. in diameter and nearly circular, solid, fine-grained, and homogeneous in structure.

The fine specimen upon which the above description is wholly based was purchased by me from Mr. Homer Moore, at Hot Springs, South Dakota, on August 22, 1895, together with the two fragments above described belonging to *C. Jenneyana*. It consists of four pieces which belong together and form a very remarkable trunk, differing greatly from any other from the Black Hills or from any other section.

I inquired carefully into the history of these specimens and learned that some years before they had been found by a railroad employee named A. B. Noble, who was no longer in that region, some 2 miles below Hot Springs in a canyon or ravine which makes into Fall River from the northeast. No further details could be gathered, but as it is 4 miles to Evans quarry, where the true Dakota group is exposed, it is certain that the horizon must be in the Lower Cretaceous, and it is probably substantially the same as that of all the other trunks.

The four pieces or sections which have been numbered from 1 to 4, beginning with the basal one, may be briefly described as follows:

No. 1, which is considerably the largest in all respects, represents the true base and swells out below to a diameter of over 40 cm. and a girth of nearly 112 cm. It is slightly elliptical, the minor axis of a cross section being only 33 cm., but part of this difference is due to the erosion of the armor on the broader sides.

No. 2 is a shorter and smaller piece, but fits perfectly upon the upper fracture of No. 1, which is somewhat oblique. On one side a large elliptical area has decayed, forming a depression which reaches to the bottom of the leaf stalks. This depression is about equally divided between Nos. 1 and 2.

No. 3 is a much shorter piece, the upper fracture of which is very oblique, so as to make it almost wedge shaped. The upper surface of No. 2 and the lower surface of No. 3 do not form a perfect joint. A thin slice or a number of such pieces have apparently scaled off and are wanting. There is, however, abundant evidence of the general agreement of the two sections, and one decayed area extends across the break and reappears on No. 3.

No. 4, which is the uppermost section, fits perfectly upon No. 3. The fracture across the top is oblique in the opposite direction from that of the lower end, thus increasing the cuneiformity of both sections. When superposed upon each other these two upper sections form a sort of crook or bend in the trunk, so that the center of gravity falls considerably on one side and the upper piece falls off unless supported.

The trunk has evidently long lain on one side or the other as determined by the above-mentioned crook or bend and been subject to much erosion on the two exposed sides, while the other two sides have correspondingly escaped. The result is that the leaf scars are deeply worn over much of the surface, while along the protected sides they are preserved or only irregularly broken down, leaving what look like jagged projections.

The weight of the several pieces is as follows:

	Kilograms.
No. 1	50.80
No. 2	21.32
No. 3	17.02
No. 4	18.37
Total weight	107.51

Nothing at all approaching this species was found in the Yale collection.

This species is illustrated by three plates. One side of the specimen is better preserved than the other, and I have given views of both on Pl. CLIII and CLIV, the first of which shows the trunk leaning to the left and the second to the right. Pl. CLV affords a good view of the base.

CYCADEOIDEA NANA n. sp.

Pls. CLVI, CLVII.

Trunks very small, symmetrical, short-conical, laterally subcompressed, 12 cm. high, 15 by 17 cm. in diameter, 49 cm. in girth, dark colored, well silicified, of medium hardness and specific gravity, unbranched, summit not depressed, terminal bud projecting from apex;

leaf bases ascending, even the lowest ones, scars arranged in two series of spiral rows, those from left to right making an angle of 80° and those from right to left of 50° with the axis, very small, subrhombic, averaging 10 mm. wide by 6 mm. high, smaller near the summit, empty to considerable depth; ramentaceous interstices 1 to 3 mm. thick, firm in texture, usually consisting of three layers, which may be regarded as a lining to each of the adjacent scars, with a thicker membrane between; reproductive organs few, poorly defined, slightly projecting, with irregular markings on their outer surfaces, probably for the most part immature or abortive; armor 3 to 5 cm. thick; axis 8 cm. in diameter, somewhat clearly marked off from the armor but without clear boundaries between the cortical parenchyma and fibrous zone or between the latter and the medulla, so far as the single known specimen shows without cutting.

This species differs from all others in a number of characters besides its small size.

The only specimen is No. 84 of the Yale collection, a small, almost perfect trunk, weighing only 2.95 kilograms. At first glance it recalled the *C. pygmæa* of England, from the Lias of Lyme Regis, figured by Lindley and Hutton in the Fossil Flora of Great Britain, Vol. II, pl. cxliii, but on confronting the specimen with that figure the differences are obvious. Except for its small size it might be compared to *C. marylandica*, from the iron-ore clays of Maryland, and of all the specimens of that species it most resembles the fragment which Professor Fontaine designated as No. 2,[1] and which I have described as Johns Hopkins Cycads, No. 3.[2] That specimen, however, has a large secondary axis, which, with better material, might take it out of that species.

Of all the forms from the Black Hills, it most resembles in the character of the scars, etc., some of the smaller branches of *C. Marshiana*, in which these are considerably reduced in size. I have therefore had a faint suspicion, which I would not leave the subject without expressing, that it might be one of these secondary axes or knots, as it were, wrenched from the larger trunk and found in an isolated position. With this thought in my mind I have examined a great many such cases, but I can find none in which the fracture at the point of separation at all resembled the base of this specimen, they all showing the break to have been due to some extraneous cause, whereas the base of this specimen is perfectly natural, not torn nor cracked, and shows the medulla at the center. Nevertheless, there is something a little anomalous in the way the armor surrounds the axis.

The specimen is nearly uniform on all sides, as shown by the two figures of Pl. CLVI, which afford side views of two of the sides. Pl. CLVII is a view of the base, which shows no depression, but simply

[1] Potomac or Younger Mesozoic Flora. Monogr. U. S. Geol. Surv., Vol. XV, 1890, p. 192.
[2] Proc. Biol. Soc. Washington, Vol. XI, March 13, 1897, p. 11.

a convex surface with the medulla near the center, and elongated leaf scars ascending in all directions from it.

The above arrangement of the species of Cycadeoidea from the Black Hills is not wholly without method. It is true that there is no lineal arrangement that can be regarded as satisfactory, and yet there are decided affinities among the species. These affinities, however, are shown in particular characters, and the same species may have some characters almost in common with two or more other species that are otherwise very different. This is specially the case with branching species in which other characters resemble those of unbranched species. For example, *C. turrita*, except in its branching habit, is closely allied to *C. McBridei*, which never branches; *C. Marshiana*, but for its branching, would be nearly related to *C. colossalis*; and *C. Wellsii* may be almost regarded as an unbranched form of *C. minnekahtensis*.

In view of these and many other more subtle peculiarities, I have sought, since the arrangement must be lineal, to compromise in such a manner as to bring those species most akin as near together as possible, but it is clear that any arrangement would widely separate species that are similar in one respect or another.

C. dacotensis and *C. colossalis* are obviously very closely allied species. *C. Wellsii* can scarcely be said to form a transition from *C. colossalis* to *C. minnekahtensis*, but it resembles the former at least in the one fact of being simple. *C. pulcherrima* is somewhat close to *C. minnekahtensis*. *C. cicatricula* can not be said to form a transition from *C. pulcherrima* to *C. turrita*, but it has considerable affinity to the former. *C. turrita* is related to *C. minnekahtensis* and *C. pulcherrima*, and from it to *C. McBridei*, as already remarked, the distance would be very small but for the branching habit of the former.

Between *C. McBridei* and *C. Marshiana*, however, there is scarcely any bond, and it might have been as well to place the latter immediately after *C. colossalis*. We virtually begin a new series here and pass naturally through *C. furcata* to *C. Colei* and *C. Paynei*. *C. Wielandi* has so much affinity to *C. Paynei* that it was first placed in that species. *C. aspera* also closely resembles *C. Paynei* in external aspect, but the two anomalous characters noted clearly distinguish it from all others. It fits in here, however, and *C. insolita* and *C. occidentalis* belong to this same general group.

C. Jenneyana, *C. ingens*, *C. formosa*, *C. Stillwelli*, and *C. excelsa* may also be said to form a group. The first and the last two constitute the only cylindrical forms known in America. The shape of the scars in *C. ingens*, *C. formosa*, and *C. Stillwelli* unite these three from that important point of view, while those of *C. Jenneyana* and *C. ingens* tend to approach each other. *C. excelsa* has little in common with any other species, and *C. nana* almost nothing. These two are therefore properly made to close the series.

2. THE FOSSIL FORESTS.

In the historical introduction to this paper (p. 529), and again in the chapter on the Minnekahta region (p. 552), the remarkable fossil forests of that section of the Black Hills were unavoidably discussed. In the chapter on the Blackhawk region (p. 562) the occurrence of silicified wood in great abundance was noted. Professor Jenney, in his very full treatment of the Hay Creek region, lays proper stress on the great quantities of fossil wood at many of the localities and horizons where he worked. It is much to be regretted that this important department of the present section on the Flora of the Black Hills could not have received full treatment. This deficiency is not due to any lack of material for such a treatment, but almost wholly to the special difficulties attending the elaboration of this class of material. A good collection was made from the original forest, some of the specimens being broken from the great fossil log described, others picked up among the branches. A short distance northwest of this spot wood was also very abundant, and many specimens were taken. This wood usually has the outward appearance of showing the internal structure well, and two of the most promising specimens were cut and microscopic slides mounted for determination; but when these were examined by Dr. F. H. Knowlton with the compound microscope they were found to be too obscure to show any characters. It is evident that a large number of specimens will have to be examined before one is found that will yield the desired results. This there has not been time to do, and Dr. Knowlton has been too much occupied with other pressing work to undertake such a systematic study of this material as will be necessary to test its value.

A fine collection of silicified wood was made from the Blackhawk region, partly from the particular spot where Mr. Getchell told us the cycad trunks lay and partly from the general vicinity, particularly from a locality half a mile east of the ranch house. As showing how deceptive a microscopic examination of such material often is, I may add that by far the finest looking specimen found in this region, in which the grains of the wood are seen with great distinctness, was cut in all necessary directions and slides were made from it, in full confidence that they would clearly indicate the nature of the timber of that region in Lower Cretaceous time, but to our great disappointment no detailed structure was revealed.

Professor Jenney collected a considerable amount of fossil wood at a number of horizons in the Hay Creek region, but none of it looked promising, and after so many failures with much better appearing material it was not thought worth while to attempt its study, although it is quite possible that some of it may prove much better than it looks.

While our party were gathering up the fragments of cycads on the slope where so many fine trunks were found, a peculiar block attracted the attention of Mrs. Jenney, who brought it to my notice. I first thought it might be the internal portion of a cycadean trunk, but upon examination I was convinced that it was a piece of silicified wood. It was thrown into the wagon with the rest and shipped to Washington. No other fossil wood was seen by me at the cycad locality. Coming as it did from the very same spot as the cycads, its importance was greatly increased, and at my request Dr. Knowlton took it up, marked it for sectioning, and had some slides made. To our great delight it was found to be in an admirable state of preservation and perfectly determinable. It belongs to the genus Araucarioxylon—i. e., it is the ancient representative of the Araucarian pines of the Southern Hemisphere, which have long since disappeared from all our Western forests.

Dr. Knowlton furnished me a brief report upon this species for my early paper, and, although he has now described and figured it thoroughly, it will be of interest to reproduce his original and less technical account of it as follows:

The structure of this wood is very finely preserved, and a glance suffices to show that it possesses the Araucarian type and represents, with little question, an undescribed species of the genus Araucarioxylon. The wood cells are provided with two rows of alternating hexagonal pores on the radial walls, which nearly or, in some cases, quite cover the walls. The medullary rays are composed of a single layer of thin, short, cells, each of which is covered on the radial side with numerous fine dots or punctations. The rays are from 1 to about 20 cells high, the average number being perhaps 8 or 10. A large number are composed of only 1 or 2 cells. The annual rings are rather indistinct, yet can be made out.

As far as I now know, only two species of Araucarioxylon have been described from the United States, *A. arizonicum* Kn., from the Triassic or Lower Jurassic of New Mexico and Arizona, and *A. virginianum* Kn., supposed at first to belong to the Potomac formation, but now known to be from the Trias of Virginia. These species differ markedly from the one under discussion. With the *A. arizonicum* it has almost no points in common, while it differs from the *A. virginianum* in important particulars.

To this I added the following comment:

The only sections of the fossil wood that have yet been made were cut from a specimen taken from the cycad bed proper, and not from the principal fossil forest, but it often happens that only one species can be found in such a forest. It is therefore probable that the same structure would be shown by the other specimens. I confess to a little surprise at finding that this structure represents the Araucarian rather than the Sequoian type of conifers, since, in the East at least, these two types characterize the Trias and Potomac, respectively, no Araucarian specimens having been found in the Potomac and no Sequoian specimens in the Trias. And generally the Araucarian type is more ancient. This evidence therefore points to a lower instead of a higher horizon.[1]

[1] Jour. Geol., Vol. II, No. 3, April-May, 1894, pp. 260-261.

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The following is Dr. Knowlton's revised description of the species:

SUBKINGDOM SPERMATOPHYTA (Phanerogams).

Subdivision GYMNOSPERMAE.

Class CONIFERÆ.

Family PINACEÆ (ARAUCARIACEÆ) Engler.

Genus ARAUCARIOXYLON Kraus (1870).

ARAUCARIOXYLON HOPPERTONÆ Knowlton n. sp.

Pls. CLVIII, CLIX.

1894. *Araucarioxylon* sp. Kn. in Ward: The Cretaceous rim of the Black Hills; Jour. Geol., Vol. II, pp. 260–261.

Diagnosis.—Annual rings very distinct, or 4 to 8 rows of very thick-walled fall wood; spring wood of large but thick-walled cells; medullary rays in a single series of from 3 to 12 or 15 cells; these short, covering the width of some 4 to 6 or 8 wood cells, provided with a single series of small punctations; wood cells with 1 or 2 rows of hexagonal or rarely nearly round punctations.

Discussion.—Transverse section: This section shows the annual rings to have been very plainly marked. The spring wood is made up of very large although thick-walled cells, which begin very abruptly at the fall wood. The cells gradually decrease in size until the last 5 or 8 rows of cells are very thick.

Tangential section: The medullary rays as seen in this section are quite numerous, in a single series of from 3 to sometimes as many as 15 superimposed cells. The wood cells as seen in this section do not seem to have been provided with punctations or other markings (Pl. CLIX, Fig. 3).

Radial section: As the material has been very finely preserved, this section shows remarkably well. The wide cells of the spring wood are provided with usually 2 longitudinal rows of hexagonal pores, which quite cover the walls (Pl. CLVIII, Fig. 1). Occasionally in cells of unusual width the pores while in 2 series are only slightly compressed (Pl. CLIX, Fig. 4). Usually when but 1 row is present they are hexagonal and occupy the center of the cell (Pl. CLVIII, Fig. 2).

The inner pores in these punctations are relatively small and slightly elongated in a direction at right angles to the cells.

The medullary rays as seen in this section (Pl. CLVIII, Fig. 4) are short, covering the width usually of 4 or 5 wood cells, although occasionally longer and covering as many as 8 cells. They are provided with a single row of small bordered pores so arranged that one comes over each wood cell, or occasionally there may be two over a wood cell (Pl. CLIX, Fig. 1). The inner pore is minute.

This is the third species of Araucarioxylon thus far described from the United States, and it is quite unlike either of the others. From *A. arizonicum* Kn.,[1] a species found in the Triassic or Lower Jurassic, it differs in having a clearly marked annual ring, usually hexagonal pores and no markings in the tangential walls of the wood cells. From *A. virginianum* Kn.,[2] a species of the Trias of Virginia, it differs in the annual rings, in the less number of medullary ray cells, and in having the cells of the ray short punctate.

At Professor Ward's suggestion I take pleasure in naming this very distinct species in honor of Mrs. Jenney, who discovered this block of wood among the fragments of cycadean trunks.

Locality.—Cycad bed 2 miles southwest of Minnekahta Station, South Dakota. Collected by Mrs. Mary Hopperton Jenney, September 7, 1892.

3. LOWER CRETACEOUS FLORA OF THE BLACK HILLS, OTHER THAN CYCADEAN TRUNKS AND SILICIFIED WOOD.

As already shown, the principal contribution to the Lower Cretaceous flora of the Black Hills was made by Prof. Walter P. Jenney in 1895 from the Hay Creek coal field of Crook County, Wyoming. The present chapter therefore consists chiefly of Professor Fontaine's report upon this collection. The only other forms included in it are the few that were collected by Professor Jenney and myself on the western slope of Red Canyon, about 3 miles southwest of Minnekahta station, half a mile southwest of Matties Peak, and immediately over the ridge to the west of the principal fossil forest. These were also determined by Professor Fontaine and reported upon in a letter dated January 10, 1894, which report was embodied almost entire in my paper on the Cretaceous Rim of the Black Hills.[3] His remarks on the species will be introduced in their systematic place.

Professor Fontaine's report on the Jenney collection from the Hay Creek coal field is as follows:[4]

NOTES ON LOWER CRETACEOUS PLANTS FROM THE HAY CREEK COAL FIELD, CROOK COUNTY, WYOMING.

By Wm. M. Fontaine.

In the summer of 1894, Prof. W. P. Jenney collected a considerable number of fossil plants in Wyoming, and sent them to Mr. Lester F. Ward, who referred them to me for examination.

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[1] Proc. U. S. Nat. Mus., Vol. XI, p. 4, pl. i.

[2] Bull. U. S. Geol. Surv. No. 56, p. 50, pl. vii, figs. 2–5.

[3] Journal of Geology, Vol. II, No. 3, Chicago, April–May, 1894, pp. 259–260.

[4] The only modifications that it has been found necessary to make in this report relate to the purely systematic part. Mr. Seward in his Wealden Flora has made a careful revision of the principal Wealden genera and has changed many of the names, substituting modern ones for the older Carboniferous genera to which the species had been improperly referred. In most such cases I have adopted his suggestions, but have introduced full synonymy, so that no possible confusion can arise.

Professor Fontaine simply described the species and arranged them in a general way under the heads Equiseta, Ferns, Cycads, Conifers, etc. I have changed his arrangement very little, and only to make it conform as nearly as possible to the system of Engler and Prantl. The higher subdivisions have been supplied by me. I am also responsible for all the footnotes.—L. F. W.

Professor Jenney in the same summer wrote a number of letters to Mr. Ward, giving the localities and horizons of the fossils, along with other points necessary to throw light on their occurrence. In order to give an intelligible account of these fossils it will be necessary for me to quote from these letters. As Professor Jenney states that his subdivisions of the formation containing the fossils are subject to change if called for by further field study, this qualification must be borne in mind.

Professor Jenney made his collections of plant fossils in the Hay Creek coal field of Crook County, Wyoming, a region located 40 miles northwest of Deadwood, South Dakota. A number of his localities are found on Pine Creek and Oak Creek. In one of his letters he says regarding these creeks: "Pine Creek and Oak Creek are two small streams entering the Belle Fourche, draining the area between that river and Hay Creek, and are part of the Hay Creek coal field of which Barrett post-office is the center." This statement, with the data given for each locality where plants were collected, will fix their position with sufficient accuracy. Before the examination made by Professor Jenney of this region, Newton's Dakota group was supposed to extend down to and rest upon the Jurassic. Professor Jenney, as the result of his field work, and influenced by geological data alone, was led to subdivide the Dakota of Newton into several horizons. These will be given later.

Mr. Ward, on examining the plants, recognized their striking resemblance to Lower Potomac and Kootanie plants. As I had studied the former, he sent Professor Jenney's plants to me for determination. Professor Jenney, on stratigraphical and lithological grounds, was led to make the following provisional subdivisions of the Dakota group of Newton, as exhibited in the Hay Creek region of Wyoming. I quote from his letter to Mr. Ward:

THE DAKOTA GROUP OF NEWTON.

Upper surface probably somewhat eroded, overlain by Fort Benton shales.

		Feet.
1.	The Dakota sandstone, with characteristic plant remains, the base a massive sandstone of variable character with respect to hardness, per cent of iron, etc.	100
2.	Clay shales, sandstone shales, and soft sandstones, with, locally, beds of carbonaceous shale and plant remains. Plants of modern type. * * * At base of this member a massive cross-bedded sandstone 50 feet in thickness.	150
	Contact stratum, a breccia of clay and sandstone, marking unconformity.	
3.	Massive sandstone, 40 feet, underlain by drab clay shales and carbonaceous shales with plant remains (ferns, etc.)	100
4.	Soft sandstones, clay shales, and clays, with one workable seam (3 to 5 feet thick) and several smaller local seams of coal. Plant remains, peculiar forms of cycad life, etc.	100
5.	Ash colored clays with calcareous nodules, no fossils observed; near top, at contact with No. 4, occur, locally, fossil bones	50
	(This member may be Jurassic.)	
6.	Jurassic clays and shell limestone, with marine fossils, Belemnites, Ostrea, Exogyra, etc.	

Professor Jenney, in another letter, states that his later investigations led him to conclude that No. 5 of the preceding section is composed of Jurassic shallow-water deposits, and that they are not Lower Cretaceous. He says the beds carry often large trunks and limbs of fossil wood, and, in the layers of impure limestone, a few small Ammonites, but near the top of No. 5, just below the contact with the base of No. 4 Cretaceous, occurs a bone-bearing bed with large elongated vertebræ and fragments of leg and thigh bones, all in a poor state of preservation.

He goes on to say that there are evidences that the land was rising at the close of the Jurassic, that some of the beds of No. 5 may be of brackish- or fresh-water origin, and before the deposition of the lowest beds of the coal series (those of division No. 4) the land was above water and had suffered quite an extensive denudation. The evidence also indicates that the workable and lowest beds of coal were deposited in basins, channels, or valleys in the eroded Jurassic.

Professor Jenney states that he found in the Dakota group of Newton evidences of unconformity between No. 1 and No. 2, and between No. 2 and No. 3, but was unable to find any between No. 3 and No. 4, while there is great unconformity between No. 4 and the Jurassic.

These extracts from Professor Jenney's letters show that, from stratigraphical evidence, the Dakota group of Newton, which has hitherto been supposed to contain no strata older than the typical Dakota with dicotyledons, and to extend as a unit down to the Jurassic, is really divided by two marked unconformities into at least three members. The strata of division No. 1 contain the dicotyledons of the typical Dakota, while those of No. 2 and the lower divisions do not show these, but a quite different flora, whose age will be discussed in this paper.

If Professor Jenney is right, as he no doubt is, in his conclusion that the land rose after the Jurassic submersion, and then, after an interval, vegetation established itself on it finally in amounts sufficient to form coal beds, it follows that even the oldest of the plants described in this paper are decidedly younger than Jurassic. Here we have a flora that established itself after the retreat of the Jurassic sea. But in the case of plants in the Trinity group of Texas, as Professor Hill shows, we have a different condition of things, for the sea advanced upon the land, finding an established flora, whose remains it swept away and preserved in the beds then formed. The same is true of the Lower Potomac fossil plants of Virginia. In the case of these two groups of fossil plants, the *geological* conditions do not indicate positively that they are younger than Jurassic, for we may have the remains of a Jurassic flora preserved in the lowest beds of the Lower Cretaceous. Professor Jenney's discovery of fossil plants is especially fortunate in the fact that, according to the stratigraphy, they are clearly and distinctly younger than the Jurassic, for they are found in strata that rest upon Jurassic beds, and in addition an erosion interval separates the two. When we take into consideration the want of conformity of the Jurassic and these Lower Cretaceous beds, as well as the lapse of time required for a flora to establish itself on the land newly emerged from the Jurassic sea, it is surprising to find so many Jurassic types surviving in this lower division of the Lower Cretaceous.

As Professor Jenney collected his plants from several horizons, and at different localities, it will be necessary, before passing to the description of the species, to give some account of the geological horizon of the different localities from which the plants were obtained. The following statements give the localities from which plant fossils were obtained, with their position in the Lower Cretaceous group, as given by Professor Jenney on labels accompanying each package of fossils. It will be noted that he fixes their geological position by referring the horizon in some cases to the Jurassic below, and in others to the typical Dakota sandstone above, with dicotyledons as the predominant plants. This latter will be mentioned simply as the Dakota sandstone.

Professor Jenney determines the following localities as lying 60 feet below the base of the Dakota sandstone:

1. Bed of carbonaceous shales in a cliff in the east bank of Oak Creek, 2 miles below Robbin's ranch, Crook County, Wyoming. This horizon is in his division No. 2 of Newton's Dakota group, which is the uppermost of the divisions made by Professor Jenney of the strata underlying the typical Dakota. This horizon is the highest in division 2 which has yielded fossil plants. In the description of the species it will be referred to as Cliff in east bank of Oak Creek.

2. Cliffs along the north side of Red Water Valley, about 4 miles south of Larrabee's coal mine. These localities will be designated Cliff along the north side of Red Water Valley.

3. The next lower horizon at which plant fossils were found is located by Professor Jenney at 100 feet below the base of the Dakota sandstone. On this horizon, and still in division No. 2, plants were found at a cliff on north side of Pine Creek, 2 miles above (west of) Mrs. Dorsett's ranch. This will be referred to as Cliff on north side of Pine Creek.

4. Cliff on the south side of Pine Creek, 2½ miles above (west of) Mrs. Dorsett's ranch. This will be referred to as Cliff on the south side of Pine Creek.

5. Bed of carbonaceous shales in Rollin's tunnel, 1½ miles southeast of Robbin's ranch, on Oak Creek. This will be referred to as Carbonaceous shales in Rollin's tunnel.

6. Cliff on Oak Creek at Robbin's ranch, 6 miles northeast of Barrett, Wyoming. This will be designated as Cliff on Oak Creek, at Robbin's ranch.

The following localities, lying in Professor Jenney's third division of Newton's Dakota, were located by him about 150 feet above the top of the Jurassic, and about 170 feet below the base of the typical Dakota, or his division No. 1:

1. Bed of shales in cliff on the north side of the valley of the South Fork of Hay Creek, 2½ miles west of Barrett post-office, Crook County, Wyoming. This locality will be designated as Cliff on the north side of the valley of the South Fork of Hay Creek.

2. Bed of shales under the third sandstone, Barrett, Wyoming. This locality was not given so precisely as some of the others, and it will be referred to as Shales under the third sandstone, Barrett.

3. From John Barr's tunnel, 1 mile north of Forks of Hay Creek post-office, Crook County, Wyoming. This will be designated as John Barr's tunnel.

4. Locality not given. The package of fossils was marked simply as coming from the third division of Newton's Dakota group, 150 feet above the top of the Jurassic. The locality is probably the same as No. 2 of this list, and it will be referred to as Locality unknown. Horizon 150 feet above the Jurassic.

The next horizons in descending, at which fossils were found, according to Professor Jenney, occur in his division No. 4, of Newton's Dakota group, and they are probably essentially the same, but from the distances given by Professor Jenney for them above the Jurassic, there is some variation in their height above that formation. This variation, however, is not greater than might be expected from varying thickness in the beds underlying them, which are superposed immediately on the Jurassic. I give the localities and the distances determined by Professor Jenney at each, from the plant-bearing bed down to the Jurassic:

1. Shale over the lowest coal bed, Larrabee's shaft, Barrett, Crook County, Wyoming. This stands from 50 to 75 feet above the top of the Jurassic, and the locality will be referred to as Shale over the lowest coal, Larrabee's shaft.

2. Bed of shales over coal, T. 54, R. 61, sec. 36, 2 miles southeast of Barrett, Crook County, Wyoming, about 30 to 50 feet above the top of the Jurassic. This will be referred to as Shales over coal, 2 miles southeast of Barrett.

3. Bed of highly carbonaceous shale 50 feet above the top of the Jurassic, Webster's ranch, 4 miles northeast of Beulah, Crook County, Wyoming. This will be referred to as Carbonaceous shale, Webster's ranch.

4. The lowest horizon in No. 4 that promised fossil plants is a bed of shales at the contact of the Cretaceous with the Jurassic, at Lon Cottle's ranch, 1 mile southwest of Barrett, Crook County, Wyoming. This bed of shales is the lowest bed in division 4. The locality will be referred to as Bed of shales, Lon Cottle's ranch.

DESCRIPTIONS OF THE SPECIES.

Subkingdom PTERIDOPHYTA (Ferns and fern allies).

Class EQUISETALES Engler.

Family EQUISETACEÆ (Joint rushes).

Genus EQUISETUM Linnæus.

EQUISETUM VIRGINICUM Fontaine.

Pl. CLX, Fig. 1.

1889. *Equisetum virginicum* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 63, pl. i, figs. 1-6, 8; pl. ii, figs. 1-3, 6, 7, 9.

A single good specimen of a small Equisetum was obtained from the horizon 100 feet below the base of the Dakota sandstone, and another doubtful one from the horizon 150 feet above the Jurassic. It belongs to the small type of Equisetum, with many branches and narrow teeth, that is so characteristic of the Lower Cretaceous, and which contains the species of *E. Burchardti* from the Wealden of Germany, and *E. virginicum* from the Lower Potomac (Neocomian) of Virginia.

The plant is decorticated and does not show plainly the nodes and sheaths in any place. What indications may be seen point to the possession of narrow acute teeth, like those of *E. virginicum*. The size of the branches, their number, and the general facies of the plant are features which strongly indicate that this is a species which can not be separated from the Virginia plant.

The species was evidently a copiously branching one, for the best specimen, that from the horizon 100 feet below the Dakota sandstone, shows a number of small stems diverging as if from insertion on a common stem. The insertion, however, is not visible.

The plant was found in one good specimen, that figured, in the cliff on the north side of Pine Creek and in a single stem of doubtful character at the horizon 150 feet above the Jurassic, at the cliff on the north side of the Valley of the South Fork of Hay Creek.

Class FILICALES Engler.[1]

FERNS.

Genus WEICHSELIA Stiehler.[2]

WEICHSELIA RETICULATA (Stokes & Webb) Ward n. comb.

Pl. CLX, Figs. 2 to 4.

1824. *Pecopteris reticulata* Stokes and Webb: Trans. Geol. Soc. London, 2d ser., Vol. I, p. 424, pl. xlvi, fig. 5; pl. xlvii, fig. 3.
1828. *Lonchopteris Mantelli* Brongn.: Prodrome, p. 60, 199; Histoire, Vol. I, p. 369, pl. cxxxi, figs. 4, 5.
1836. *Polypodites Mantelli* (Brongn.) Göpp.: Syst. Fil. Foss., p. 341.
1838. *Lonchopteris Huttoni* Presl in Sternberg: Flora der Vorwelt, Vol. II, p. 166.
1844. *Pecopteris* sp. Auerbach: Bull. Soc. Imp. Nat. de Moscou, Vol. XVII, Pt. I, p. 148, pl. v, figs. 10, 11.
1845. *Polypodites reticulatus* (Stokes and Webb) Ung.: Synops. Pl. Foss., p. 93.
1845. *Pterophyllum Murchisonianum* Göppert in Murchison's Géologie de la Russie, Vol. II, Pt. III, Paléontologie, p. 501, pl. G, figs. 5, 6a (non fig. 3).
1845. *Pterophyllum filicinum* Göppert in Murchison's Géologie de la Russie, Vol. II, Pt. III, Paléontologie, p. 50i, pl. G, figs. 4a, 4b.
1846. *Pecopteris Murchisoniana* (Göpp.) Auerbach and Freers: Bull. Soc. Imp. Nat. de Moscou, Vol. XIX, Pt. I, p. 495, pl. ix.
1846. *Pecopteris Auerbachiana* Rouillier: Bull. Soc. Imp. Nat. de Moscou, Vol. XIX, Pt. II, p. 412.
1849. *Pecopteris Auerbachiana* Rouillier: Op. cit., Vol. XXII, p. 16, pl. J, fig. 55.
1852. *Alethopteris recentior* Ett.: Abh. d. k. k. geol. Reichsanst., Vol. I, Abth. III, No. 2, p. 16, pl. iii, figs. 17, 18.
1854. *Anomopteris* sp. Stiehler: Zeitschr. d. deutsch. geol. Gesellschaft, Vol. VI, p. 661.
1855. *Anomopteris Ludowicæ* Stiehler: Bericht d. naturwiss. Vereins d. Harzes f. 1853 and 1854, p. 14.
1857. *Weichselia Ludovicæ* Stiehler: Zeitschr. d. gesammt. Naturwiss. z. Halle, Vol. IX, p. 454.
1858. *Weichselia Ludovicæ* Stiehler: Palaeontographica, Vol. V, Lieferung 3, p. 73, pl. xii, xiii.
1865. *Pteris reticulata* (Stokes and Webb) Ett.: Die Farnkräuter der Jetztwelt, p. 117.
1869. *Alethopteris Ettingshausii* Schimp.: Traité de Pal. Vég., Vol. I, p. 569.
1869. *Lonchopteris recentior* (Ett.) Schenk: Palaeontographica, Vol. XIX, p. 4, pl. i, figs. 2–6, 6a.
1870. *Asplenites klinensis* Trautschold, in pt.: Nouv. Mém. Soc. Imp. Nat. de Moscou, Vol. XIII, p. 209 (Livraison 3, p. 21), pl. xx, figs. 1, 5–8 (non figs. 2–4).
1883. *Cladophlebis nebbensis* Geinitz-Rostock [non (Schouw) Schimp.]: Arch. Ver. Freund. Nat. Mecklenb., Jahrg. XXXVI, p. 50.
1890. *Pecopteris Geyleriana* Nathorst (in pt.): Denkschr. Wien. Akad., Vol. LVII, p. 48, pl. iv, f. 3.

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[1] In view of the imperfect state of our knowledge of fossil ferns no attempt will be made in this paper to assign the genera to the now recognized families, Osmundaceæ Hymenophyllaceæ, Schizæaceæ, Polypodiaceæ, etc., especially as Engler and Prantl's great work has not at this writing embraced this part of the vegetable kingdom.

[2] The genus Weichselia was founded in 1858 (Palaeontographica, Vol. V, p. 73) by August Wilhelm Stiehler for the species *W. Ludowicæ*, which Mr. Seward regards as identical with *Lonchopteris Mantelli* Brongn. (Histoire, Vol. I, p. 369, pl. cxxxi, figs 4, 5.) Lonchopteris is a Paleozoic genus and this form had to be called by a different name.

1891. *Weichselia erratica* Nathorst: Arch. Ver. Freund. Nat. Mecklenb., Jahrg. XLIV, p. 24.

1894. *Weichselia Mantelli* (Brongn.) Seward: Wealden Flora, Pt. I, p. 114, figs. 12, 13 on p. 120, pl. x, fig. 3.

The horizons in division No. 2 made by Professor Jenney in Newton's Dakota, lying 60 and 100 feet below the Dakota sandstone, contain in abundance a fern that is so close to Schenk's *Lonchopteris recentior*, referred by Seward to *Weichselia Mantelli*, that it can not be separated from that species.

Schenk in his work, Die fossilen Pflanzen der Wernsdorfer Schichten (Palaeontographica, Vol. XIX), p. 4, pl. i, figs. 2–6, describes and figures fragments of a fern with reticulate nervation that was obtained from the Wernsdorf beds of the northern Carpathians, which are of Urgonian age. In the size, shape, and mode of insertion of the pinnules, in the character of the nervation, and, indeed, in all important points, the agreement between the Wyoming and European plants is very close.

Schenk is no doubt correct in his supposition that this fern is bipinnate. It is a rather peculiar fact that in all the numerous specimens coming from the Hay Creek coal field and examined by me there are none that show the insertion of the ultimate pinnæ on a primary one. The specimens are all small bits of ultimate pinnæ, as were those of Schenk, and show only a few pinnules. From the imprints left on the stone, and the amount of carbonaceous matter left by the pinnules, we must conclude that they were thick and leathery in nature. Owing to this, in most of the specimens it is difficult to see the details of the nervation. Some of the pinnules approach in shape very near to *Lonchopteris Mantelli* Brongn., from the Wealden of England and France, for there is some variability in them, although for a fern this is surprisingly small. Schenk says of his form that it is with difficulty to be separated from the Wealden species, and the Wyoming forms make still more doubtful the propriety of making two species of them. I have in Pl. CLX, Figs. 2 to 4, endeavored to give average forms. Fig. 2 represents the terminal portion of an ultimate pinna with pinnules of average size. Fig. 3 gives this enlarged three diameters, to show the nervation. Fig. 4 gives a portion of an ultimate pinna lower down than the portion given in Fig. 2 and represents pinnules somewhat larger than those of Fig. 2, being the average of the larger pinnules possessed by this fern. It should be noted that in the Hay Creek pinnules their margins are often bent under and the lamina on each side of the midrib is convex in form, giving the pinnule something of the aspect of an Alethopteris, a feature mentioned by Schenk as shown in the Wernsdorf plant.

Weichselia reticulata is one of the most common plants in Jenney's second division, and forms nearly all of the material obtained at certain localities. This is the case with the collections made from cliffs along the north side of Red Water Valley, cliff on the south side of

Pine Creek, carbonaceous shales in Rollin's tunnel, and cliff on Oak Creek at Robbin's ranch. Besides these localities, numerous specimens occur at the cliff in east bank of Oak Creek.

It thus seems to be abundant on both plant-bearing horizons in division No. 2 of Jenney, that 60 feet and that 100 feet below the base of the Dakota sandstone, and it is without doubt one of the most characteristic plants of this division. No trace of it has so far been found in the divisions of the Lower Cretaceous lying under No. 2. Its great abundance in division No. 2 and its absence in the underlying divisions indicate a change in the flora which is in keeping with the differences seen in the other plants of the two portions of the Lower Cretaceous.

Both the specimens figured are from the black carbonaceous shales in Rollin's tunnel.

Genus MATONIDIUM Schenk.

MATONIDIUM ALTHAUSII (Dunker) Ward n. comb.

Pl. CLX, Figs. 5-8.

1844. *Cycadites Althausii* Dunker: Programm d. höheren Gewerbschule in Cassel, 1843-1844, p. 7.
1846. *Pecopteris Althausii* Dunker: Mon. d. Norddeutsch. Wealdenbildung, p. 5, pl. ii, fig. 2.
1846. *Pecopteris polydactyla* Göppert in Dunker: op. cit., p. 5, pl. vii, fig. 4.
1846. *Pecopteris Conybeari* Dunker: op. cit., p. 7, pl. ix, figs. 8, 8a.
1846. *Alethopteris elegans* Göppert in Dunker: op. cit., p. 8, pl. vii, figs. 7, 7a.
1849. *Pecopteris elegans* (Göpp.) Brongn.: Tableau, p. 107.
1852. *Alethopteris Gœpperti* Ett.: Abh. d. k. k. geol. Reichsanst. Wien, Vol. I, Abth. III, No. 2, p. 16, pl. v.
1869. *Laccopteris Gœpperti* (Ett.) Schimp: Traité de Pal. Vég., Vol. I, p. 582; Atlas, pl. xxxi, figs. 5-8.
1870. *Pecopteris explanata* Trautschold: Nouv. Mém. Soc. Imp. Nat. de Moscou, Vol. XIII, p. 220 (Livraison 3, p. 32), pl. xix, fig. 7.
1871. *Matonidium Gœpperti* (Ett.) Schenk: Palaeontographica, Vol. XIX, p. 220, pl. xxvii, fig 5; pl. xxviii; pl. xxx, fig. 3.
1888. *Alethopteris polydactyla* (Göpp.) Schenk: Die fossilen Pflanzenreste, p. 39.
1891. *Laccopteris polydactyla* (Göpp.) Sap.: Plantes jurassiques, Vol. IV, p. 384.

This fern, described by Schenk as abundant in the Wealden formation of northern Germany, and found by Heer in the Wealden of Portugal, is one of the most common plants at the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek. It occurs also very rarely in the carbonaceous shales in Rollin's tunnel. It has not yet been found at any other localities or on any other horizon. Schenk's specimens as described and figured in Die Foss. Flora der Norddeutsch. Wealdenformation, pp. 17, 18, pl. vi, fig. 5; pl. vii, figs. 1, 1a-c, 2, 2a (Palaeontographica, Vol. XIX, pp. 220, 221, pl. xxxvii, fig. 5; pl. xxxviii, figs. 1, 1a-c), show much more of the plant than can be seen in the fossils from the Hay Creek beds. These are always fragments of ultimate pinnæ. They are pinnæ of both the sterile and fruiting forms of the fern. In their dimensions the pinnules are in most cases larger than those figured by Schenk, and smaller than those of Heer, given on pl. xv of his Contributions à la Flore Fossile du Portugal. The agreement in all essential points of the Hay Creek fossils with those from both European regions is exact. The fructified pinnules mostly carry sori from their tips, and they are proportionally very large, so as to cover the entire lamina on each side of the midnerve. The sori show a proportionally large and distinct depression in their center. Fig. 5 gives average sterile pinnules, and Fig. 6 represents these enlarged two diameters, to show the character of the nerves. Fig. 7 represents the fertile pinnules, and Fig. 8 gives these enlarged two diameters, to show the sori.

Both the specimens figured are from the cliff on the north side of Pine Creek.

Genus PECOPTERIS Brongniart.[1]

PECOPTERIS GEYLERIANA Nathorst.

Pl. CLX, Figs. 9-13.

1890. *Pecopteris Geyleriana* Nath.: Denkschr. d. Wien. Akad. d. Wiss., Vol. LVII, p. 48, pl. iv, fig. 1; pl. vi, fig. 1.

This fern, coming from the Lower Cretaceous of Japan, was first described and figured by Nathorst in his Beiträge zur Mes. Flora Japans (Denkschr. Wien. Akad., Vol. LVII), p. 48, pl. iv, fig. 1; pl. vi, fig. 1. It was later found by M. Yokoyama at additional localities in the same country and formation, who noticed the plant in the Journal of the College of Science, Imperial University of Japan, Vol. VII, Pt. III, 1894, pp. 219-220, pl. xxi, fig. 12; pl. xxiii, fig. 1, 1a; pl. xxviii, fig. 5, giving some excellent figures. The figures of both Nathorst and Yokoyama show that the plant possesses some characteristic features that render it rather easy to identify. The Japanese forms are far more complete than those of the Hay Creek beds, but fortunately the peculiarities are found mostly in the pinnules, and these are well shown in the American fossil.

In the Hay Creek strata *Pecopteris Geyleriana* is always found in detached fragments of ultimate pinnæ and mostly associated with *Weich-*

[1] There are probably no true representatives of the genus Pecopteris in the Cretaceous, but in default of the fruiting organs a large number of forms of Mesozoic age have from time to time been referred to this genus on account of the similarity of the fronds and their nervation. In recent times there has been a strong movement in the direction of assigning such forms to more modern genera, and in due time all will probably be so referred. They are found to fall under several different genera, but the majority of them probably belong to the genus Cladophlebis, established by Brongniart himself in 1849 (Tableau, p. 25), for the reception of a number of those that he had formerly included under Pecopteris. Among other Mesozoic genera to which these forms have been referred are Weichselia of Stiehler, Matonidium of Schenk, and Scleropteris of Saporta. A number have also been placed in the living genera Pteris, Thyrsopteris, and Gleichenia. This, however, is probably going almost as far to the opposite extreme. Until the subject shall have been properly monographed we shall be obliged to follow the authorities we have.

selia reticulata. While it is much less abundant than this latter, both occur in the same condition of preservation, which shows that the fragments had been transported some distance from the place of their growth. The specimens of this Pecopteris are nowhere very abundant and the fragments of ultimate pinnæ are never very large. Still the pinnules show their character very distinctly and the number of different parts is great enough to indicate almost all the variations mentioned and illustrated by Yokoyama. The pinnules of all the Hay Creek specimens are quite small. They must have been thick and leathery, as is indicated by Yokoyama's figures. They must have been quite durable, for they leave a thick layer of carbonaceous matter that obscures the nerves. Yokoyama mentions as a peculiar feature that the lowest pinnules on the front of the rachis of the ultimate pinnæ are often falcate backward instead of forward, and he says that they are mostly blunt and that the views are in most cases indistinct. All these features are seen in the specimens from the Hay Creek beds. The midnerve is generally persistent to near the tip and it sends off on each side forking lateral nerves, which, owing to the thickness of the carbonaceous film, are not often seen. Another peculiarity seen in both the Japanese and Hay Creek specimens is the rounding off of the pinnules at their base, so as to form ears, and the posterior ear is usually larger than the anterior one. The pinnules are more or less triangular in shape.

Pl. CLX, Fig. 11, represents a fragment of an ultimate pinna with pinnules of the largest size that were seen. Fig. 12 gives those of intermediate size, while Fig. 9 gives the smallest size. The enlargement of Figs. 9 and 12 and in Figs. 10 and 13 are four diameters.

This plant has been found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek, one specimen; and a number of specimens on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek; carbonaceous shales in Rollin's tunnel, and cliff on Oak Creek at Robbin's ranch.

The specimen represented by Figs. 9 and 10 of Pl. CLX is from Rollin's tunnel; that by Fig. 11 is from the cliff on the north side of Pine Creek, and that by Figs. 12 and 13 from the east bank of Oak Creek, 2 miles below Robbin's ranch.

PECOPTERIS BOREALIS Brongniart.

Pl. CLX, Figs. 14, 15.

1828. *Pecopteris borealis* Brongn.: Histoire des Végétaux fossiles, Vol. I, p. 351, pl. cxix, figs. 1, 2.

A single specimen of a plant so much like the *Pecopteris borealis* of Brongniart that it may be identified with it was found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek. It shows a considerable portion of an ultimate pinna with a number of pinnules that are quite well preserved. These are shown in

Fig. 13. The ultimate pinnæ must have been quite long and have had closely set pinnules that were separate near their bases. The lower surface of the rachis seems to have had a corded appearance, from the existence of the rachis in the midst of a wing on each side, caused by the union of the bases of the pinnules. The pinnules have the aspect of those of Cladophlebis of the Jurassic type. They are small, broadest at their bases, inclined forward, more or less ovate and subacute toward their tips. The nerves are very distinct, as shown in Fig. 14. The general aspect of the pinnules is much like those of the pinnules of the specimen figured by Heer in Flor. Foss. Arct., Vol. I, pl. xliv, figs. 5a, 5b. The rigid wing on each side of the rachis in the Hay Creek plants makes the rachis of the ultimate pinna appear much thicker than it really is. Only two specimens were found.

Genus CLADOPHLEBIS Brongniart.

CLADOPHLEBIS WYOMINGENSIS n. sp.

Pl. CLX, Figs. 16, 17.

A single mutilated specimen of a fern was found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek, that is probably a new species. The specimen shows only a fragment of an ultimate pinna with pinnules more or less distorted by pressure. Some of them, however, show their original character pretty well. The description of the plant is as follows: Frond bipinnate, pinnules remote, obliquely attached, falcate and acute, slightly decurrent, midnerve slender and continuous to near the tip of the pinnules, where it splits up into branches. Lateral nerves going off obliquely, forking once, the forking taking place near their insertion.

Although not enough material of this plant was obtained to permit the determination of its full character and the establishment consequently of a good species, it is not near enough to any species known to me to justify its being identified with any hitherto described. Where a plant from some new region possesses only a slight resemblance to one previously described from some remote locality it appears to be better usage to regard them as different species. Still more is this true if the two belong to different geological formations. It is true that this involves a multiplication of species, but the making of species, which can be easily merged into others if necessary, involves possible errors of less importance than the unjustified assumption that the same plant existed in widely separated localities and survived through different geological periods.

The plant now in question is a good deal like *Pecopteris virginiensis*, which I have described in Monograph XV of the U. S. Geological Survey, from the Lower Potomac of Virginia; but it lacks the toothing, which is a very persistent feature on the pinnules of that plant, being shown on them even high up toward the ends of the ultimate pinnæ.

It is also like the narrower forms of the pinnules of *Cladophlebis acuta*, which is found in the Lower Potomac formation (see Mon. U. S. Geol. Survey, Vol. XV, pl. xi, fig. 7), but the pinnules of this form are closely placed and united at bases. A larger amount of material would very probably justify its identification with *Cladophlebis acuta*. Our plant has an obvious resemblance to the fern from the Kootanie formation of British America which Sir William Dawson considers as identical with Heer's *Asplenium distans* from the Jurassic of Siberia (see Dawson on the Mesozoic floras of the Rocky Mountain region of Canada: Trans. Roy. Soc. Can., Sec. IV, Vol. III, 1885, p. 5, pl. iii, fig. 7). But the Kootanie plant is a fern with larger pinnules. Whatever its specific order may be, our plant belongs to a type which is quite characteristic of the later Jurassic and basal Cretaceous.

CLADOPHLEBIS PARVA Fontaine?

Pl. CLX, Fig. 18.

1899. *Cladophlebis parva* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 73, pl. iv, figs. 7, 7a; pl. vi, figs. 1, 1a, 2, 2a, 3, 3a.

At the cliff on the north side of the valley of the South Fork of Hay Creek and on the horizon 150 feet above the Jurassic a small fragment of a fern was found that appears to be identical with *Cladophlebis parva* of the Lower Potomac. For description of this species see Mon. U. S. Geol. Survey, Vol. XV, p. 73. The amount of material is much too small to permit its true character to be made out. However, the pinnules, which are well preserved, are exactly like those of *Cladophlebis parva*. These look much like Jurassic forms of Cladophlebis, and are probably survivors from the Jurassic. Several imperfect specimens, which may also be placed doubtfully in this species, were found on the horizon 100 feet below the Dakota sandstone, at the cliff on Oak Creek, Robbin's ranch.

Genus SPHENOPTERIS Brongniart.[1]

SPHENOPTERIS PLURINERVIA Heer?

Pl. CLX, Figs. 19, 20.

1881. *Sphenopteris plurinervia* Heer: Contributions à la Flore fossile du Portugal; Section des Travaux géologiques du Portugal, 1881, p. 13, pl. xi, figs. 6, 6b; pl. xv, figs. 8, 8b, 8c.

The specimen identified doubtfully with Heer's species is a portion of an ultimate pinna of a small fern. It shows a number of minute pinnules that have lost their tips, but were evidently elliptical in form

[1] Sphenopteris is another mainly Paleozoic genus of ferns to which Cretaceous forms probably ought never to have been referred. Many of them have gone into Onychiopsis, Cladophlebis, Scleropteris, Dichopteris, Cyathea, Dicksonia, and Thyrsopteris, but a considerable number still remain and it will be impossible in this paper to assign them to their proper genera. They will therefore be left in this genus until a thorough revision can be made of the group.

and narrowing to their base in such a manner that they were attached to the rachis almost by a petiole. They resemble *Sphenopteris plurinervia* enough to justify a doubtful identification with the species. There is not enough material to permit the determination of a full specific character. Heer describes his plant in Contr. à la Flor. Foss. du Portugal, pp. 13–14, pl. xi, fig. 6; pl. xv, fig. 8, as coming from the Lower Cretaceous of Portugal. The plant in the Hay Creek series occurs on the horizon 150 feet above the top of the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek, in only two specimens.

Genus THYRSOPTERIS Kuntze.[1]

THYRSOPTERIS PINNATIFIDA Fontaine?

Pl. CLXI, Figs. 1, 2.

1889. *Thyrsopteris pinnatifida* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 136, pl. li, fig. 2; pl. liv, figs. 4, 5, 7, 7a, 7b; pl. lvii, figs. 7, 7a.

On the horizon 150 feet above the Jurassic and at the cliff on the north side of the valley of the South Fork of Hay Creek a small fragment of a fern was found, having a character unlike the others, and resembling *Thyrsopteris pinnatifida* of the Lower Potomac of Virginia. As there is not enough material to permit its full character to be made out, its identification must be doubtful. The fragment shows a piece of an ultimate pinna carrying several fragmental pinnules which have all the character of those of *Thyrsopteris pinnatifida.* They have the same size, shape, and lobing of the pinnules of that plant when they occur toward the ends of ultimate pinnæ, being quite small, elliptical in shape, and cut obliquely into minute lobes and teeth.

THYRSOPTERIS CRASSINERVIS Fontaine.

Pl. CLXI, Figs. 3, 4.

1889. *Thyrsopteris crassinervis* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 130, pl. xli, figs. 1, 1a, 1b, 2, 2a, 2b, 3, 3a, 3b.

At the same locality and on the same horizon with the doubtful specimen of *Thyrsopteris pinnatifida* another small specimen of a different fern was found. This has pretty strongly shown the features of *Thyrsopteris crassinervis* of the Lower Potomac of Virginia, but in this case also the amount of material does not justify a positive identification with that form. The specimen is very distinct in the features shown. It is a portion of a penultimate pinna from toward its tip, that contains several short ultimate pinnæ. These have broadly elliptical pinnules that are united at the base. The upper basal pinnules, as is

[1] Professor Fontaine has referred a large number of Potomac ferns to this living genus, perhaps correctly, but it would probably have been better to place them in Brongniart's extinct genus Coniopteris. For a brief account of the general subject see the Fifteenth Annual Report of the U. S. Geological Survey, p. 383.

the case with *Thyrsopteris crassinervis*, are a good deal larger than the others, but it is not lobed as is the case with the corresponding pinnules of the Potomac plant. This is probably owing to the fact that the ultimate pinnæ of the Hay Creek specimen come from a portion of the penultimate pinna nearer its end than those of the Potomac form that show lobed basal pinnules. The nerves are strong and distinct.

THYRSOPTERIS ELLIPTICA Fontaine.

Pl. CLXI, Fig. 5.

1889. *Thyrsopteris elliptica* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 133, pl. xxiv, figs. 3, 3a; pl. xlvi, figs. 1, 1a; pl. l, figs. 6, 6a, 9; pl. li, figs. 4, 6, 6a, 6b, 7; pl. liv, fig. 6; pl. lv, fig. 4; pl. lvi, figs. 6, 6a, 7; pl. lvii, figs. 6, 6a; pl. lviii, figs. 2, 2a.

This plant, which is abundant in the Lower Potomac strata of Virginia, and has been described in Monograph XV, p. 133, is rather rare in the Hay Creek beds. So far as yet found it occurs on the horizon 150 feet above the Jurassic at two localities: Cliff on the north side of the valley of the South Fork of Hay Creek, and shales under the third sandstone, Barrett, with one doubtful small fragment at the contact of the Jurassic with the Cretaceous, Lon Cottles' ranch. At all the localities only small, imperfect fragments were obtained, showing portions of ultimate pinnæ. At the first-named locality the fragments are larger, but the pinnules are not so well preserved. At the second locality the small bits of pinnæ, with often very distinct pinnules, go to help form a mat of vegetation along with small fragments of *Pinus susquaensis* and *Czekanowskia nervosa*, that covers the cleavage surfaces of the shale. The plants here seem from some cause to have been torn into small bits, which, however, are very distinct in character.

The shale under the third sandstone at Barrett deserves a careful and prolonged search. It would no doubt yield many beautifully preserved specimens of those plants already made out and some new species, for very suggestive fragments, too small to give any positive character, may sometimes be seen. The shale is well fitted to preserve plants and is full of fragments. It is very fine-grained, gray in color, with a tinge of buff. It splits into laminæ as thin as paper, and the surface of these takes a perfect imprint of a plant. Unfortunately, only a very small amount of this material was obtained. It is a noteworthy fact that this shale is physically strikingly like the carbonaceous shale at Webster's ranch, which Professor Jenney places geologically 100 feet below it. *Czekanowskia nervosa* and *Pinus susquaensis* occur in both. The only difference, as shown by the plants, is that the small Zamites, *Z. borealis*, is common on the lower horizon, while it is not found on the upper, and *Thyrsopteris elliptica* occurs on the upper and not on the lower horizon.

The specimen figured was found at the cliff on the north side of the valley of the South Fork of Hay Creek, 2½ miles west of Barrett.

THYRSOPTERIS DENTIFOLIA n. sp.

Pl. CLXI, Figs. 6-9.

Frond bipinnate; only the terminal portions of some of the ultimate pinnæ were seen. The ultimate pinnæ have their terminal portions long and narrow, with an unusually gradual reduction in the size of the lobes and teeth which they carry, and which represent the pinnules of lower portions of the pinnæ and frond. The lowest pinnules seen on the ultimate pinnæ (Fig. 6) are united at base, very obliquely inserted on the rachis, oblong in form, with margins notched as if for incipient lobes. Toward the end of the pinnæ the pinnules pass very gradually, by diminution in size and increasing union, into lobes and then into teeth. These lobes and teeth are narrowly ovate, acute, and very oblique, diverging from the rachis (Fig. 8). The lobes have each a single nerve, which sends a branch to the upper margin or tooth. In the notched lower pinnæ a midnerve sends off on each side a branch into each incipient lobe.

It is obvious that not enough material is possessed to give certainly the character of this small fern. The long drawn out tips of the ultimate pinnæ, with small dentate lobes and acute diverging teeth, appear to be a new and constant character. The tips of the pinnæ look like portions of a twig of some conifer. These terminal portions seem to have been rather easily broken off, for they form most of the imprints found. One of these bits, 18 mm. long, shows only the tooth-like lobes, the width from tip to tip of which is only 2.5 to 3 mm. The plant looks much like *Sphenopteris Mantelli* Brongn. [*Onychiopsis Mantelli* (Brongn.) Sew.], and would have been so regarded were it not for the passage in the lower portions of the pinnæ of the lobes into Thyrsopterid pinnules. At any rate it belongs to the kind of fern with narrow, rigid pinnules which appears common in the Lower Cretaceous, and of which *Onychiopsis Mantelli* may be taken as the type.

This fern occurs sparingly on the horizon 50 feet above the Jurassic, at the shales over coal 2 miles southeast of Barrett.

THYRSOPTERIS BREVIFOLIA Fontaine.

Pl. CLXI, Figs. 10-15.

1889. *Thyrsopteris brevifolia* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 121, pl. xxiv, figs. 5, 5a, 5b, 5c, 5d, 10.

This pretty little fern is one of the most common plants on the horizon 50 feet above the Jurassic at the shale over coal 2 miles southeast of Barrett, where its fragments cover thickly some of the cleavage surfaces of the shale, being mingled with fragments of *Thyrsopteris dentifolia* and *T. pecopteroides*. It never shows, in any imprint, more than detached fragments of ultimate pinnæ. These, however, are numerous enough to give a pretty full representation of various portions of these pinnæ from different parts of the frond. At the same time gradations show connecting links between the detached portions. This plant was found in the Lower Potomac of Virginia, occurring at the Dutch Gap Canal, in a ball of red clay or shale, which was embedded in the layers of bluish-gray clay and sand that form the banks of the canal. It was found nowhere else in that formation, and it is interesting to note that it occurs in the Hay Creek region, at only one locality, in a shale that resembles that containing it at the Dutch Gap. Its description was given in Mon. XV, p. 121, pl. xxiv, figs. 5, 5a–d, and 10.

The larger number of imprints occurring in the Hay Creek beds enable us to see parts not shown in the Potomac fossils. These are portions from lower down on the ultimate pinnæ and parts of ultimate pinnæ from higher up toward the summit of the frond. All the parts indicate a fern somewhat more robust than the Dutch Gap plant. The pinnules from the lowest portion of the pinnæ and frond are still more like *Sphenopteris hymenophylloides* Brongn. than any of the Potomac specimens. The ultimate pinnæ from both regions were evidently very long and slender, and the Hay Creek specimens show that they ended in long drawn out and attenuated terminations. Especially is this true of the pinnæ from the upper part of the frond, as shown in Figs. 12 and 14 of Pl. CLXI. The deeply incised pinnules, Fig. 10, graduate into elliptical lobes and teeth toward the ends of the pinnæ. These are shown in Figs. 12 and 14, Fig. 12 giving the lobed forms and Fig. 14 those with teeth. All this is clearly shown in the enlarged Figs. 11, 13, and 15.

THYRSOPTERIS PECOPTEROIDES Fontaine.

Pl. CLXI, Figs. 16–19.

1889. *Thyrsopteris pecopteroides* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 135, pl. li, figs. 1, 1a.

This small, delicately incised fern was found by the writer in the Lower Potomac of Virginia at Fredericksburg, where it occurs quite rarely. It occurs in the Hay Creek beds, on the horizon 50 feet above the Jurassic, at the shales over coal 2 miles southeast of Barrett, along with *Thyrsopteris brevifolia* and *T. dentifolia*, being almost as common as the former. The specimens show only portions of the ultimate pinnæ, but some of these appear to come from parts of the frond lower down than any seen in the Potomac fossils. Hence some of the pinnules are somewhat larger than any belonging to the Virginia specimens and show a greater tendency to lobing. These are given in Figs. 16 and 17. At the same time pinnæ from parts of the frond higher up than those seen in the Potomac specimens were obtained. These are very minute. They are shown in Figs. 18 and 19.

It is a noteworthy fact that the three ferns last described, viz, *Thyrsopteris dentifolia*, *T. brevifolia*, and *T. pecopteroides*, occur together in comparative abundance on the horizon given by Professor Jenney at 30 to 50 feet above the Jurassic, at shales over the coal 2 miles southeast of Barrett, while they are found nowhere else in the Hay Creek region. Only one small collection from this locality was placed in my hands, and it is much to be desired that additional collections should be made there. The shale preserves the plants well, it cleaves nicely, and seems to be rich in fossils. Some bits indicate that other and new forms may be found there. It is peculiar that so many parts of detached, ultimate pinnæ are found at this locality with their terminal portions perfectly preserved, while in no case were the pinnæ seen attached to a rachis. The terminal portions of pinnæ of delicate ferns like these are usually the parts most poorly preserved.

THYRSOPTERIS BREVIPENNIS Fontaine?

Pl. CLXII, Fig. 1a.[1]

1889. *Thyrsopteris brevipennis* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 124, pl. xxxiv, figs. 3, 3a; pl. xxxvi, figs. 2, 2a; pl. xxxvii, figs. 3, 9; pl. xxxviii, figs. 1, 1a, 1b; pl. xli, figs. 4, 4a.

This species was described by the writer from the Lower Potomac in Monograph XV of the U. S. Geological Survey, page 124. In the Hay Creek beds were found several small fragments of ultimate pinnæ, carrying a few pinnules, of a fern that is apparently the same species, but the amount of material is not sufficient to permit positive identification. They occur only on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek.

Genus SCLEROPTERIS Saporta.[2]

SCLEROPTERIS DISTANTIFOLIA n. sp

Pl. CLXII, Figs. 2, 3.

This is apparently a new Scleropteris that occurs at the same locality and horizon as *Thyrsopteris pinnatifida* and *T. crassinervis*, on the South Fork of Hay Creek, 170 feet below the Dakota sandstone. It occurs in only one specimen, but that is characterized well enough to justify its being provisionally made a new species.

The specimen shows a fragment of a long, slender ultimate pinna. The lobes, or rather pinnules, are remote from one another and very obliquely directed toward the ends of the pinna, so that they diverge very slightly from the rachis to which they are attached. They are very small, narrowly ellipitical in form and decurrent at base, so as to

[1] Where the material was scarce and doubtful, Professor Fontaine did not always select specimens for illustration. It seemed to me all the more important that such cases should be illustrated in order that the occurrence of the species in the Black Hills might be fully attested. I have therefore had figures made, however imperfect, to support his notes.

[2] This genus was established by the Marquis Saporta in 1872 (Plantes Jurassiques, Vol. I, p. 364) to embrace a number of forms of Mesozoic ferns previously referred to Sphenopteris, Loxopteris, Pachypteris, and Dichopteris, but without wholly absorbing these genera. The Lower Cretaceous of America contains some forms that fall distinctly within the limits of the genus.

form a comparatively wide wing. The nervation consists in each pinnule of a parent nerve that splits up into several branches which are directed very obliquely upward toward the tip of the pinnule. One or more of the branches may be forked.

The shale which yields these plants at the cliff on the north side of the valley of the South Fork of Hay Creek is a fine-grained fissile material, gray in color, with a slight brownish shade. It preserves the plants beautifully, although most of those obtained are in small bits, owing to the small fragments of the shale obtained. This is no doubt due to the fact that the specimens come from weathered shale of surfaces long exposed. From the character of this material there is little doubt that if specimens be taken from fresher rock, farther in from the surface, larger and more complete imprints of the plants would be found. Only a small amount of the rock was obtained, and no doubt prolonged and careful search would result in finding other plants. Occasionally to be seen on the specimens are small bits and fragments that indicate the existence of other plants besides those mentioned in this paper. In addition a number of the plants found here are not found elsewhere, so that it is very desirable that additional collections should be made at this spot.

SCLEROPTERIS ROTUNDIFOLIA n. sp.

Pl. CLXII, Figs. 4, 5.

Frond probably tripinnatifid. The ultimate pinnæ or pinnules are very small. Their tips are not preserved, but they were probably not more than 5 mm. in length. They are alternate and attached at an angle of about 45° with the principal rachis. They carry minute circular lobes or pinnules that are united at base by a proportionally broad wing. This latter is thick in texture and rigid, so that when the rachis is seen from above the wing seems to be a part of it. Hence the rachis appears abnormally strong. When the underside of the rachis is presented it is seen to be very slender. The pinnules or lobes become more and more united toward the tips of the ultimate pinnæ. They are not more than three-fourths of a millimeter wide. In each lobe a nerve ascends from a very oblique insertion and splits in a flabellate manner into two or more branches.

This minute Scleropteris is not near any described plant known to me. The best preserved specimens do not show enough to enable the character of the plant to be made out fully, but enough may be seen to indicate that it is a pretty well marked new species. Pl. CLXII, Fig. 4, gives the most complete imprint found.

It occurs in several specimens on the horizon 150 feet above the Jurassic at the cliff on the north side of the valley of the South Fork of Hay Creek, and has been found as yet nowhere else.

Genus ASPLENIUM Linnæus.

ASPLENIUM DICKSONIANUM Heer?

Pl. CLXII, Figs. 6-8.

1874. *Asplenium Dicksonianum* Heer: Die Kreide-Flora der arctischen Zone, K. Svensk. Vet.-Akad. Handl., Vol. XII, No. 6 (Fl. Foss. Arct., Vol. III, Pt. II), p. 31, pl. i, figs. 1 (excl. b, c), 1aa, 2, 3, 3b, 4, 5 (excl. a, b, c).

The specimens represent the summits of ultimate pinnæ of a fern which is decidedly like *Asplenium Dicksonianum* Heer, from the Kome beds of Greenland. It has also something of the character of the widely diffused Potomac plant *Thyrsopteris rarinervis*. but is, I think, nearer Heer's plant.[1]

Genus GLEICHENIA Smith.

GLEICHENIA ZIPPEI (Corda) Heer?

Pl. CLXII, Fig. 9.

1846. *Pecopteris Zippei* Corda in Reuss: Versteinerungen d. böhm. Kreideformation, Abth. II, p. 95, pl. xlix, figs 2, 3.
1868. *Gleichenia Zippei* (Corda) Heer: Fl. Foss. Arct., Vol. I, p. 79, pl. xliii, figs. 4, 4b.

Some ends of the ultimate pinnæ of a small fern with the facies of Gleichenia occur in the collection. This is nearest to Heer's *G. Zippei* from the Kome beds, but the pinnules are rather more acute than most of those of that plant, and indicate that those on this plant lower down are somewhat larger than those of *G. Zippei*. The form is also something like *Aspidium heterophyllum* of the Potomac formation, but seems to be smaller and more delicate. It may, however, be the same.[2]

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[1] The above is all that Professor Fontaine says in his letter of January 10, 1894, about the three small fragments figured on Pl. CLXII, Figs. 6-8, which were collected by Professor Jenney and myself on the slope of Red Canyon in the Minnekahta region. After examining the specimens he returned them with labels, on all of which he wrote: "Probably *Asplenium Dicksonianum*." It is a significant fact that neither this species nor the Potomac fern *Thyrsopteris rarinervis* Font., occurs in the Hay Creek collection. A comparison of these fragments with the fine specimens of *Asplenium Dicksonianum* collected by us near Evans quarry, in the true Dakota group (see infra, p. 704, Pl. CLXX, Fig. 1), will be of interest.

[2] The above description by Professor Fontaine was based chiefly on the specimen figured on Pl. LXXX, Fig. 9, but of which, at the time he examined it, scarcely more than 2 cm. were visible of the upper part of the pinna. After its return I observed that the impression passed into the rock below the exposed portion, and by a little skillful manipulation I succeeded in scaling off a piece of rock and exposing the remainder that we here see, amounting to considerably more than 5 cm. The lower lobes are somewhat more toothed than the upper ones, thus differing from Heer's figures. They are not pointed like *Aspidium heterophyllum* Font., and it seems to me probable that the impression may represent a pinnule of *Thyrsopteris pecopteroides* Font.

Subkingdom SPERMATOPHYTA (Phanerogams).

Subdivision GYMNOSPERMAE.

Class CYCADALES Engler 1897.[1]

Family CYCADACEÆ.

No unequivocal cycadaceous plants occur above the horizon lying 150 feet above the Jurassic. The only possible exceptions are the one or two small fragments of leaves that occur at higher horizons, and that look more like Zamites than any other plant. They show, however, neither basal nor terminal portions, and may be Nageiopsis. Cycads of the type of Zamites described by Heer, so characteristic of the Kome beds of Greenland, are the only certain ones found in the Hay Creek strata. On the horizon 150 feet above the Jurassic at John Barr's tunnel they are the most common plants. Elsewhere they are rare. It is a noteworthy fact that this type of cycad seems to be the most characteristic one in the Kootanie beds, as made known by Sir William Dawson, and in the strata of similar age at Great Falls, Montana. Taking all these occurrences into consideration, it seems that this type is highly characteristic of the Lower Cretaceous, at least of North America.

Genus ZAMITES Brongniart.

ZAMITES BREVIPENNIS Heer.

Pl. CLXII, Figs. 10-13.

1874. *Zamites brevipennis* Heer: K. Svensk. Vet.-Akad. Handl., Vol. XII, No. 6 (Fl. Foss. Arct., Vol. III, Pt. II), p. 67, pl. xv, figs. 8-10.

Several well-preserved specimens of a small Zamites occur on the horizon 150 feet above the Jurassic at John Barr's tunnel, and nowhere else, which are identical with *Z. brevipennis* obtained by Heer from the Kome beds of Greenland and described by him in Vol. III of Fl. Foss. Arct., Pt. II, Die Kreide-Flora des Arctischen Zone, p. 67, pl. xv, figs. 8, 9, 10. They agree so far that even Heer's largest and smallest forms of this plant can be duplicated from the Hay Creek beds. Fig. 10 agrees well with Heer's larger forms, and Fig. 12 with his smaller. The nerves could not be made out, for it appears that they are not visible in this type when the upper surface of the plant is presented uppermost. The plants must have had a coriaceous and double-leaf texture, for in the shale the leaf substance is to a large extent preserved, and may be peeled off so as to remove all trace of the plant.

[1] The class Bennettitales (see supra, p. 598) does not include the foliage, fruits, etc., of cycadean vegetation found in a fossil state, but only petrified trunks. We are, therefore, compelled to refer the former still to the class Cycadales and family Cycadaceæ. There is evidently an inconsistency in this, as it is altogether probable that the impressions from the same horizon represent the foliage, etc., of the forms whose trunks were entombed at other localities under different conditions.

The shale at John Barr's tunnel deserves careful examination, and additional collections should be made from it. Only one small bundle of specimens was placed in my hands as coming from this locality, and it contained at least one species not found elsewhere, while it gives promise of well-preserved specimens from a critical horizon in the Lower Cretaceous. Besides it is of a nature to preserve in great perfection the plants that it contains. Even in the apparently weathered fragments obtained the points were shown with a distinctness rarely found. The shale is very fine-grained and fissile, splitting into thin and smooth laminæ.

ZAMITES BOREALIS Heer.

Pl. CLXII, Fig. 14.

1874. *Zamites borealis* Heer: K. Svensk. Vet.-Akad. Handl., Vol. XII, No. 6 (Fl. Foss. Arct., Vol. III, Pt. II), p. 66, pl. xiv, figs. 13, 14; pl. xv, figs. 1, 2.

A Zamites, which is identical in all respects with Heer's *Z. borealis* from the Kome beds of Greenland, is one of the most common fossils at some of the localities yielding plants from the lower horizons of the Hay Creek beds. It occurs on the horizon 150 feet above the Jurassic, at John Barr's tunnel, where it is the most common fossil, and appears to be abundant. On the horizon 50 feet above the Jurassic, it occurs also in carbonaceous shale; Webster's ranch, where it is rather common, and from which the specimen figured on Pl. CLXII, Fig. 14, was obtained; also at the shales over lowest coal, Larrabee's shaft, where it is not so common. The nerves were not seen, as they are probably immersed in the rather thick leaf substance.

This Zamites seems to me to be identical with that coming from the Kootanie beds and described by Sir William Dawson in his paper on the Mesozoic floras of the Rocky Mountain region of Canada: Trans. Roy. Soc. Can., Sec. IV., Vol. III, p. 7, pl. i, fig. 5. This he has identified with Heer's *Z. acutipennis*, from the Lower Cretaceous of Greenland. This Zamites is evidently widely diffused in the Lower Cretaceous of North America, and is highly characteristic of it. On this account, the entire absence in the Lower Potomac of the type of Zamites to which it belongs is all the more noteworthy.

ZAMITES? sp.

Pl. CLXII, Fig. 15.

On the horizon 100 feet below the base of the Dakota sandstone, at the cliff on Oak Creek at Robbin's ranch, a small fragment of a leaf was found, which looks like a portion of a Zamites. It has pretty strong, closely placed, and numerous nerves. As it shows neither base nor termination, its character can not be determined. It may be Nageiopsis or Podozamites. If it be a Zamites it does not belong to the type of *Z. borealis* Heer, but rather to that of *Z. tenuinervis* Font., of the Lower Potomac.

The above constitute all the occurrences of possibly cycadaceous foliage in the Hay Creek strata.

Genus GLOSSOZAMITES Schimper.

GLOSSOZAMITES FONTAINEANUS Ward n. sp.

Pl. CLXII, Figs. 16-18.

1894. *Glossozamites?* sp. Font.: Journal of Geology, Vol. II, p. 260.[1]

The most common fossils are fragments of detached leaflets and one entire leaflet of a plant which is strikingly like a Neuropteris of the Coal Measures (*N. flexuosa*). I am pretty sure, however, that it is a Glossozamites, a form of cycad that has leaflets which closely resemble Neuropteris in form and nervation. This, if a Glossozamites, has leaflets proportionately broader and shorter than any known to me, and it is probably new. I wish that you would compare it with the figures of Glossozamites in your library.[2]

Genus CYCADEOSPERMUM Saporta.

CYCADEOSPERMUM ROTUNDATUM Fontaine.

Pl. CLXII, Fig. 19.

1889. *Cycadeospermum rotundatum* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 271, pl. cxxxvi, fig. 12.

A single specimen of a round, nut-like seed was found on the horizon 100 feet below the Dakota sandstone, at the cliff on Oak Creek, at Robbin's Ranch. This in all respects is exactly like the seed found in the Lower Potomac of Virginia, and described under the name *Cycadeospermum rotundatum*, in Mon. U. S. Geol. Survey, Vol. XV, p. 271. A similar seed was found in the Trinity division of the Comanche series of the Lower Cretaceous of Texas. The Hay Creek seed has the shape and size of *C. rotundatum*, with also its characteristic epidermis, which is smooth, parchment-like, and durable.

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[1] As this species is very well characterized and evidently new, I thought it deserved a specific name, and have therefore dedicated it to Professor Fontaine, who determined its generic affinities and described it.

[2] I have complied with the last suggestion in the above, which is contained in his report on the small collection made by Professor Jenney and myself from the slope of Red Canyon, west of the fossil forest containing these specimens. I have examined all the figures of Glossozamites and of the forms originally referred to other genera (Podozamites, Pterophyllum) that Schimper referred to that genus when he established it. The pinnules are generally more elongated and narrow, conforming to Schimper's character (Traité de Pal. Vég., Vol. II, p. 128) "folia linealia, obtuse acuminata, foliolis lingulatis." This, however, has not been consistently adhered to. The figure that approaches ours most nearly is that of Kurr in his Beiträge z. foss. Fl. d. Juraform. Württemburgs, 1845, pl. i, fig. 5, called by him *Pterophyllum oblongifolium*, and referred to Glossozamites by Schimper.

In their short, rounded form they approach much more closely to some species of Otozamites (cf. *O. Beanii*) (L. & H.) Brongn. in Saporta, Plantes Jurassiques, Vol. II, pl. xcv, Fig. 2), and our Fig. 17 even shows a slightly auriculate base. That genus passes in some of its species into Sphenozamites, in which the pinnules are wedge-shaped at the base, and either sessile or raised on a short stalk. Our forms may be compared with *S. latifolius* (Brongn.) Sap. (cf. op. cit., pl. cxiii, figs. 2, 3).

Genus WILLIAMSONIA Carruthers.

WILLIAMSONIA ? PHŒNICOPSOIDES Ward n. sp.[1]

Pl. CLXII, Fig. 20.

An imperfectly preserved imprint of a portion of a plant was found on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek. This, owing to its strong resemblance to Williamsonia, is placed doubtfully in that genus. It consists of the summit of what seems to have been a thick, fleshy stem, from which radiate flabellately the basal portions of what were probably thick, fleshy bracts, having the character of those of Williamsonia. The nature of these can not be made out, as only their bases are preserved, and these seem to be distorted from compression by crowding. This gives them less width than is shown in the bracts of most Williamsonias. The fossil looks something like a palm leaf, which preserves only the portion immediately around the summit of the petiole. It resembles, also, some of the forms of Jurassic Phœnicopsis, which Heer has described in his Fl. Foss. Arct., Vol. IV, Pt. II (Beiträge zur Juraflora, Ostsib.), p. 112, pls. xxix, xxx, and it is not impossible that it may belong to this genus. If it is a Williamsonia, it is probably a new species.

Class CONIFERÆ (Conifers).[2]

Conifers form the most abundant plants in the Hay Creek strata. They surpass in species any other great group, and far exceed in the number of individuals of some species any other plants. They are, as a rule, the best preserved specimens that are found at the several localities. While they are the most abundant forms in the higher strata, there is a noteworthy scarcity of them in the lower.

[1] Whatever may be the objections to giving names to defective objects, it is found in practice that to designate them merely "sp." after assigning them even doubtfully to a genus leads to great confusion and involves much more labor on the part of all who may subsequently have anything to do with them than to give them specific names. Such a designation is a name. It has to be credited to the namer, and the awkward combination thus produced becomes a permanent part of the synonomy. But it involves the possibility that several different objects may have the same combination throughout. Some papers are so burdened with these names, falsely supposed to obviate the objection of *nomina nuda* or of undue definiteness, that it becomes necessary to number them and refer to them as Nos. 1, 2, 3, etc., or even to count the lines on the page where the particular one in question is mentioned and refer to them in this way. If they are not described they are *nomina nuda*, and if described they are names, and must be identified in some way. The evils of this practice have become so great that it might almost be given as a rule that if a form is worth mentioning at all it is worth a specific name.

In view of the above I have given names to most such objects treated in this paper, and the name here employed is justified by Professor Fontaine's comparison of it with Heer's genus Phœnicopsis.

[2] I have not attempted in this paper to classify the Coniferæ according to the latest systems, but have left the arrangement substantially as Professor Fontaine drew it up. The forms enumerated, however, embrace not only the families Taxaceæ and Pinaceæ but also the class Ginkgoales.

Genus ARAUCARITES Presl.

ARAUCARITES WYOMINGENSIS n. sp.

Pl. CLXIII, Figs. 1–9.

A number of cone scales and seeds were found in the lower strata of the Hay Creek Lower Cretaceous series which seem to belong to a new species of conifer closely resembling Araucaria. The fossils occur as cone scales and seeds on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek. A cone scale (Pl. CLXIII, Fig. 7) was discovered with traces of a seed on it at the contact of the Cretaceous with the Jurassic, at the bed of shales, Lon Cottles's ranch; also a number of detached seeds (Pl. CLXIII, Figs. 1–6, 8, 9). Some seeds attached to scales and some scales without seeds were found. These fossils form pretty much all that were obtained from this locality. Some of the seeds and scales are remarkably well preserved, and show very well the relation of the seeds to the scales, as well as the form of the latter. The scales, like those of the true Araucaria, were evidently very deciduous, for no indication was found of their attachment to an axis. Both the seeds and the scales vary a little in shape, which is no doubt due to distortion from pressure. The seeds are hard and bony or nut-like in structure, and have an ovate-cuneate to nearly cuneate form. They are 4 to 5 mm. long, and have a width of 3 to 3.5 mm. in their widest portion. The forms of these seeds, differing somewhat in shape, are given on Pl. CLXIII, Figs. 1–9. Fig. 1 (enlarged 2 diameters in Fig. 2) gives the most common and normal form. This seed shows on its margin a remnant of the cone scale to which it was once attached. Fig. 3 (enlarged 2 diameters in Fig. 4) shows a seed somewhat larger and narrower than that given in Fig. 1. Fig. 5 (enlarged 2 diameters in Fig. 6) gives a shape that is more ovate than the normal, more enlongated, and narrower proportionally than common. This shape nears that of *Carpolithus fœnarius*, described below, and suggests the idea that this latter may be an abnormal form of the Araucarites now being described. These variations are most probably due to distortion from pressure.

The cone scales are strikingly like those of Araucaria. They are broadly cuneate in outline, and leaving out their terminal part, are not unlike the seeds borne on them. In their widest portion they are about 9 mm. wide. Including their beak-like tips, they have a length of about 12 mm. Their free ends or summits are thickened and carry a beak-like projection, as in Araucaria. They show, as might be expected, more distortion from pressure than do the seeds. They were apparently leathery, firm in texture, and very durable. Fig. 7 shows a cone scale that has indications of the thickening at its summit. Fig. 8 (enlarged 2 diameters in Fig. 9) gives the most complete and undistorted scale found. It has a seed partly embedded in its surface, and this embed ding of the seed in the inner surface of the scale appears to have been the normal mode of attachment of the seed to the cone scale. Judging from this specimen the seeds were borne singly under each scale, embedded in its inner surface. They were flattened, and in shape resembled the scale to which they were attached. These features remind one strongly of the cones of *Araucaria Cunninghamii* Aiton, the Moreton Bay pine, which contains similar seeds in the same way in its cone scales.

ARAUCARITES CUNEATUS Ward n. sp.[1]

Pl. CLXIII, Fig. 10.

This is a single cone scale found at John Barr's tunnel, on the horizon 150 feet above the top of the Jurassic. It is too poorly preserved and there is too little material to enable one to fix the character. It is, however, a cone scale of some Araucarites, and it is clearly a different species from *Araucarites wyomingensis*, for it is much longer than any of the cone scales of that plant, and it tapers more gradually. It is spatulate-cuneate in form, rounded at the free end, and widest here, having the width of 9 mm. in this portion. It is 2 cm. long and tapers very gradually to the end by which it was attached, where it shows a width of 2 mm. It shows no trace of a beak at the free end, and none of a seed, as it has evidently suffered from maceration.

Genus PINUS Linnæus.

PINUS SUSQUAENSIS Dawson.

Pl. CLXIII, Figs. 11a, 12, 13.

1883. *Pinus susquaensis* Dn.: Trans. Roy. Soc. Can., Sec. IV, Vol. I, p. 23, pl. iii, fig. 36.

Sir William Dawson, in his paper on the Cretaceous and Tertiary Floras of British Columbia and the Northwest Territory (1883) and on the Mesozoic Floras of the Rocky Mountain Regions of Canada (1885), p. 9, pl. ii, figs. 6, 6a, has described very narrow and long Pinus leaves, which he has named *P. susquaensis*. Fragments of precisely similar leaves occur mostly in the lower strata of the Hay Creek Lower Cretaceous. This gives another connecting link with the Kootanie flora. The specimens found in the Hay Creek beds are much more imperfect than those described by Sir William Dawson. They are never found entire or grouped, but are fragments sufficient to show that they must have been quite long. Their fragmentary and scattered condition indicate that they must have drifted some distance. It is not always easy to distinguish leaves like these from those of *Leptostrobus longifolius*, which they much resemble, especially when no nerves are visible. The possession of a midnerve, when this is visible, is decisive. Otherwise the decidedly greater thickness and rigidity of the Pinus leaves points

[1] Professor Fontaine did not give this a specific name, and I have supplied it on the principle stated in the last footnote. It is perhaps better than to reject it altogether.

to their presence. The Hay Creek leaves are one-nerved, about 1 mm. wide, quite thick and rigid. They occur on the horizon 100 feet below the Dakota sandstone, in small bits, which are rather rare and of doubtful character. They may be leaves of Leptostrobus, which by wrinkling from pressure, appear to have a midnerve. The locality showing these doubtful forms is the cliff on the north side of Pine Creek, where a multitude of Leptostrobus leaves occur with them.

On the horizon 150 feet above the Jurassic, at the shales under the third sandstone, Barrett, it is more certainly shown; still, however, in rather rare and small fragments. These are thick in texture, one-nerved, and rigid. On the horizon 50 feet above the Jurassic, at the carbonaceous shales, Webster's ranch, it is quite common in pretty large, well characterized fragments.

The specimen figured in Pl. CLXIII, Fig. 11a is from the cliff on the east bank of Oak Creek; that in Fig. 12 is from the shales under the third sandstone above the coal at Barrett, and the large leaves shown in Fig. 13 are from the cliff on the east bank of Oak Creek, 2 miles below Robbin's ranch.

Genus ABIETITES Hisinger.

Abietites angusticarpus Fontaine.

Pl. CLXIII, Fig. 14.

1889. *Abietites angusticarpus* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 263, pl. cxxxiii, fig. 1.

A specimen of a narrow cone was found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek. This is apparently identical in species with the cone of a similar character found in the Lower Potomac of Virginia and described as *Abietites angusticarpus* in Mon. U. S. Geol. Survey, Vol. XV, p. 263, pl. cxxxiii, fig. 1. It has the same form with the Potomac plant and the same kind of cone scales, which, in their lower portions at least, are thin and at the same time are closely imbricated.

Genus LEPTOSTROBUS Heer.

Leptostrobus longifolius Fontaine.

Pl. CLXIII, fig. 15; Pl. CLXV, Fig. 3.

1889. Leptostrobus longifolius Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 228, pl. ci, figs. 2, 3; pl. cii, figs. 1–4; pl. ciii, figs. 6, 6a–e, 7, 7a, 8, 8a, 9, 10, 10a, 11, 12; pl. civ, fig. 6.

This species, described by the writer from the Lower Potomac of Virginia in Mon. U. S. Geol. Survey, Vol. XV, pp. 228–230, is one of the most common plants in Professor Jenney's division No. 2, of the Hay Creek beds. Hardly a specimen at some localities is found without imprints of fragments of the leaves, and on some fragments of rocks they are piled upon one another. It is not found at all below the horizon 100 feet beneath the Dakota sandstone. With only one probable exception the leaves are found unattached to a stem. They occur mostly as scattered fragments and show neither base nor summit. In cases where the specimens are very numerous and lie one upon another there is no means of determining the original length of the leaves. They must, however, have been very long, for some of the fragments are 8 cm. long. The texture was thin, a good deal thinner than that of the leaves of Pinus. This thinness of texture and the absence of a midnerve are the most obvious differences between this plant and Pinus.

This plant occurs on the horizon 100 feet below the Dakota sandstone at the cliff on the north side of Pine Creek, which furnished the specimens figured on Pl. CLXIII, Fig. 15, and Pl. CLXV, Fig. 3. Here it is the most common plant, scattered leaves occuring on nearly all the specimens, while on some they are piled up or matted together. They occur more rarely on the same horizon, at the cliff on Oak Creek, at Robbin's ranch. On the horizon 60 feet below the Dakota, at the cliff on the east bank of Oak Creek, they are found also, but not very abundantly. The leaves are mostly 1 mm. wide, rarely attaining the width of 1.5 mm. Most of the best preserved imprints show, with the help of a good lens, a varying number of fine parallel nerves, looking like striæ, up to the number of 6, which is probably the true number. Some, however, of the exceptionally well preserved imprints with the same help disclose two comparatively strong parallel nerves, one near each margin with a flat space between, in which fine nerves like those shown on most of the leaves are visible up to about 4 in number. Heer in Fl. Foss. Arct., Vol. VI, Abth. I, Pt. I (Nachträge zur Juraflora Sibiriens) p. 25, has given these last-named characters for some of the leaves of his *Leptostrobus rigida*. The character given by Heer was not seen in any of the leaves of the Lower Potomac of Virginia, no doubt because none of these were as well preserved as are some of the Hay Creek specimens. The fact that some only of the Hay Creek leaves show the two stronger nerves seems to indicate that these are visible as such—that is, as prominent veins—only on the under side of the leaves, whereas on the upper side, if seen at all, they appear as fine nerves. On some of the best preserved imprints, with the help of a lens, these stronger nerves appear to be formed by the close approximation or consolidation of several fine nerves.

One of the specimens from the cliff on the north side of Pine Creek shows a great number of leaf fragments, and among them a number converging so as to appear to form or be attached to a short twig. This is a feature seen in some of the Lower Potomac specimens. From the great number of leaf fragments in some cases, and from the almost total absence of attachments of these, they must have been quite deciduous. From the additional facts found in the Hay Creek specimens we may amend the description of the species given in Mon. U. S. Geol. Survey, Vol. XV, as follows: Leaves thin in texture, showing on the upper surface, with the help of a lens, fine parallel nerves up to 6 in number; on the under surface 2 stronger parallel veins and between them fine nerves up to 4 in number.

It seems to the writer that some Lower Cretaceous plants described under other names should be identified with this species. Heer has described as *Pinus Peterseni* in Fl. Foss. Arct., Vol. I, Kreideflora, p. 84, pl. xliv, fig. 19, a, b, leaves which he gives as being thin in texture, about 1 mm. in width, although in fragments showing considerable length and having several nerves—in a word, as having most, if not all, of the characteristic features of *Leptostrobus longifolius*. This plant, coming from the Kome beds of Greenland, is most probably *Leptostrobus longifolius*. Heer gives as *Czekanowskia dichotoma*, also from the Kome beds, leaves which he describes in Fl. Foss. Arct., Vol. VI, Abth. II, Flora der Komeschichten, p. 14, pl. ii, fig. 12b, pl. iii, fig. 1, and which he identifies with his *Sclerophyllina dichotoma*. It, however, in its leaves appears a more delicate plant than *S. dichotoma*, and with narrower forms. The leaves do not appear to fork at all, the apparent forking, as given by Heer, being due to the fact that the ends of some of the apparent branches, really independent leaves, are hidden by the other superposed leaves. The leaves of this specimen are exactly like those of *Leptostrobus longifolius* in their general character and their arrangement on the stem, as shown in Heer's pl. iii, fig. 1, and much like some of the forms of this species shown in the Potomac specimens, for example, those in pl. cii, figs. 1, 2, of the Potomac flora.

LEPTOSTROBUS? ALATUS Ward n. sp.[1]

Pl. CLXIII, Figs. 16, 17.

A small winged seed was found on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek. It reminds one of the winged seed obtained from the Brown Jura and assigned by Heer to Leptostrobus (see Fl. Foss. Arct., Vol. VI, Abth. I, Pt. I, Nachträge zur Juraflora Sibiriens, p. 23). The seed now in question is about 4 mm. long and less than 2 mm. in width. It is elliptical in shape and appears to retain only a portion of the wing, showing on the left-hand upper portion a part of it in the form of an elliptical projection like a beak. The seed is entire, but the appendage is too poorly preserved to give any reliable indication of its true character. Its true position is quite doubtful, but it may provisionally, and for the sake of a name, be placed with Leptostrobus. *Leptostrobus longifolius* is the most common fossil at this locality.

[1] No specific name was given by Professor Fontaine to this seed. I have therefore employed the leading character in assigning it a name.

Genus ATHROTAXOPSIS Fontaine.

ATHROTAXOPSIS TENUICAULIS Fontaine.

Pl. CLXIV.

1889. *Athrotaxopsis tenuicaulis* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 241, pl. cxiv, figs. 4, 4a, 5; pl. cxv, figs. 4, 4a; pl. cxvi, fig. 6; pl. cxvii, figs. 2, 2a.

In Professor Jenney's division No. 2 of the Hay Creek beds are found some specimens of a conifer that agree well with *Athrotaxopsis tenuicaulis* as described by the writer, from the Lower Potomac of Virginia, in Mon. U. S. Geol. Survey, Vol. XV, p. 241. The fossils are in the form of fragments of alternate twigs of varying length, as shown on Pl. CLXIV, Figs. 1–3. The thickness of these will, on an average, somewhat surpass the average of the Potomac *Athrotaxopsis tenuicaulis* and will lie between it and that of *A. grandis*. This, however, does not seem to indicate a new species, but rather a more vigorous habit of growth for the Hay Creek plants, a feature shown also in the *Sequoia Reichenbachi*, from these strata. In the Hay Creek beds *Athrotaxopsis tenuicaulis* occurs on the horizon 100 feet below the Dakota sandstone rather commonly, but in small fragments at the cliff on the north side of Pine Creek. On the horizon 60 feet below the Dakota sandstone it occurs not very commonly, but in well-preserved large twigs at the cliff in the east bank of Oak Creek, from which all the specimens here figured were obtained. One of the specimens bears a cone, represented by Fig. 4 of the same plate.

Genus SEQUOIA Endlicher.

SEQUOIA REICHENBACHI (Geinitz) Heer.

Pl. CLXV, Figs. 1, 2; Pl. CLXVI, Fig. 1.

1842. *Araucarites Reichenbachi* Gein.: Characteristik d. Schichten u. Petrefacten d. sachs.-böhm. Kreidegebirges, Heft III, p. 98, pl. xxiv, fig. 4.

1849. *Araucaria Reichenbachi* (Gein.) Debey: Entwurf. z. einer geogn.-geogenet. Darstellung d. Gegend v. Aachen, pp. 63, 64 (Nachträge).

1868. *Sequoia Reichenbachi* (Gein.) Heer: Fl. Foss. Arct., Vol. I, p. 83, pl. xliii, figs. 1d, 2b, 5a, 5d, 5dd, 8, 8b.[1]

Fine leafy branches of a Sequoia, having all the characters of *S. Reichenbachi*, occur at the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek, along with the cones that probably belong to the same species.

At the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek, several cones of a similar kind are found. These latter are poorly preserved, but they retain character enough to justify identifying them with cones of *S. Reichenbachi*.

[1] The synonomy here given is only partial, as a complete one would involve the decision of a number of knotty questions, for which this is obviously not the place. The only omission that concerns us here is that of *Geinitzia cretacea* Endl., which will be considered a little later.

The fine, leafy twigs distinguished by Professor Jenney as specimens A and B are the most complete of the leafy branches. The largest of these, specimen A, shows a portion of an ultimate twig that is 15 cm. long and 3 mm. wide. It has a number of the characteristic curving leaves of *S. Reichenbachi*, which are widest at base and narrow at their ends to an acute tip. The longest of these were 16 cm. in length. The leaves that are retained are attached laterally. The upper face of the twigs show occasional elongate elliptical scars left by the bases of the leaves that have fallen off.

The slab marked B by Professor Jenney has been photographed and forms Pl. CLXV. Fig. 1, on the left, shows the leafy branch above mentioned, while Fig. 2, on the lower right, is the imprint of a small cone which may have belonged to the same branch or individual. All across the slab lie the long two-nerved leaves of *Leptostrobus longifolius* Font. (Fig. 3). This specimen is from the cliff on the north side of Pine Creek, 100 feet below the Dakota sandstone in division No. 2 of Professor Jenney.

The fine cone given in Pl. CLXVI, Fig. 1, comes from the same horizon and locality. It is almost certainly the cone of *S. Reichenbachi*, for it has attached to it a portion of the twig on whose summit the cone was borne, and this has elliptical scars like those seen on the upper surface of leafy branches of *S. Reichenbachi*. Besides, it agrees very well with the cones griven by Heer for this species in Fl. Foss. Arct., Vol. III, Pt. II (Die Kreide-Flora des Arctischen Zone) pl. xx, figs. 1a, 2, 3. The cone scales are, however, longer than those of Heer, probably on account of differences in the mode of preservation. Those of Heer seem to be compressed vertically, while in the Hay Creek specimens they may be elongated by pressure.

These cones are comparatively large for those of a Cretaceous Sequoia. With the scales closed, this one was probably broadly elliptical in shape, having a length of 30–35 mm. and a maximum thickness of 20–25 mm.

SEQUOIA GRACILIS Heer.

Pl. CLXVI, Fig. 2.

1874. *Sequoia gracilis* Heer: Die Kreide-Flora des Arctischen Zone, K. Svensk. vet.-Akad., Handl., Vol. XII, No. 6 (Fl. Foss. Arct., Vol. III, Pt. II), p. 80, pl. xviii, fig. 1c; pl. xxii, figs. 1a, 1b, 1c, 2-4, 5a-e, 7, 8, 8b, 9, 10, 10b, 10c.

Small, round cones of a Sequoia occur sparingly on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek and at the cliff on the south side of Pine Creek. The specimens here figured were obtained at the latter locality. These cones are evidently of a different species from those that occur with them, and which I have identified with *Sequoia Reichenbachi*. They are much smaller, and are round in shape. One of them is depicted in Fig. 2, Pl. CLXVI. They have not been found attached to any leafy branches, hence the character of the leaves with which they belong can not be determined. In size, shape, indeed in all features, they agree well with the cones that Heer determines as those of *S. gracilis*, and which he depicts in Fl. Foss. Arct., Vol. III, Pt. II, pl. xxii, figs. 5a, 5b, 5d.

Leafy branches of *Sequoia gracilis* have not been identified by the writer from the Hay Creek strata, but the plant identified with *Sphenolepidium parceramosum* is not uncommon in the strata containing the cones now in question. The leaves and twigs of this are so much like those of *S. gracilis* that I would not hesitate to identify these Hay Creek fossils with it were it not that the leaves contain a midrib, whereas Heer says those of *S. gracilis* are without it.

SEQUOIA sp. Fontaine (immature cone).

Pl. CLXVI, Figs. 3, 4.

An immature cone of some Sequoia was obtained on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek. It is 8 mm. long, 6 mm. wide, and nearly globular in form. On its surface it shows, rather vaguely, rhombic imprints of the character of those made by the terminations of Sequoia cone scales. There is nothing to show with what leafy branches it belongs. It is shown natural size on Pl. CLXVI, Fig. 3, and enlarged two diameters in Fig. 4.

Genus GEINITZIA Endlicher.[1]

GEINITZIA JENNEYI n. sp.

Pl. CLXVI, Figs. 5–11; Pl. CLXVII.

Certain remarkable imprints of the stems of a conifer, which seems to be a new species of the genus Geinitzia, are found in Professor Jenney's division No. 2 of the Hay Creek beds. They occur in smaller specimens on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek (Pl. CLXVI, Figs. 5–11), and on the horizon 60 feet below the Dakota, at the cliff in the east bank of Oak Creek, in larger ones (Pl. CLXVII). The stems leaving the imprints were fragments of much larger parts, for they are broken at both ends and show no appreciable change in thickness from one end to the other. In no case was any of the vegetable matter of the stem or leaf preserved, but all the fossils are in the form of flattened molds of the stem. The molds on their inner surface bear imprints in the

[1] This genus was founded by Endlicher in his Synopsis Coniferarum, 1847, p. 280, to include certain forms referred by Geinitz to Sedites and Araucarites and by Corda to Cryptomeria. Among the former was the *Araucarites Reichenbachi* of Geinitz, which Heer in 1868 identified with the living genus Sequoia, of which Endlicher was also the author. Since the latter date this well-known fossil plant has been almost uniformly called *Sequoia Reichenbachi*, and many place Endlicher's *Geinitzia cretacea* under it as a synonym. Others retain the older forms under Geinitzia, and this has been done by Professor Fontaine, while still recognizing *Sequoia Reichenbachi*. It will be allowed to stand thus, although it seems to me that the retention of the genus Geinitzia logically carries the *S. Reichenbachi* with it into that genus as the type, while, on the other hand, the recognition of *S. Reichenbachi* logically abolishes the genus Geinitzia.

inclosing shale, which are the reverse of the markings shown on the surface of the stem. The molds are so flattened by pressure that they are almost completely collapsed. In splitting the shale the cleavage took place along these collapsed molds, so that the imprint on the specimen shows the inner surface of more or less than one-half of the mold. In some of the imprints both margins of the half mold are more or less preserved, so that the original width may be detected, and in some places a narrow portion of the other half, next to the margin, is obtained, so that one can get an idea of the thickness of the stem after its flattening. When we take into consideration the considerable thickness of some of the stems, as indicated by the width, the amount of compression is surprising. Molds having a width of 15 mm. show a hollow only 2 to 3 mm. thick. This indicates that comparatively old branches were still soft and succulent. On one of these flattened molds may be seen imprints of short portions of the basal parts of a number of leaves. These leaves were a portion of those attached to the stem on the parts that, in the crushing, formed the margins of the collapsed molds, and hence were in the most favorable position to be preserved.

The stems.—In describing the stems I will give first the character of the imprints in the shale, and then from these deduce the nature of the markings on the stem that made them.

The smallest imprint seen of what seems to be a series of stems of the same plant, and the one here named *Geinitzia Jenneyi*, is that depicted in Fig. 5 of Pl. CLXVI enlarged two diameters in Fig. 6. It is 35 mm. long and 4 mm. wide, being made by a fragment of what was originally a much longer stem. If it belongs to the same plant with that making the impressions to be described further on, then it is the youngest of the series. The imprints of the leaf scars have considerable interspaces, but still are pretty thickly set on the imprint of the stem. They are rhombic in form, with the greater dimensions in the direction of the axis of the stem. Their lateral angles are more or less rounded off. The superior angle is acute and the inferior one similar in form, but this latter is generally not defined well enough to be seen. Toward the upper part of the imprint there is a vague indication, on the best preserved imprints, of a furrow running in the direction of the axis of the stem, with a pit, as if made by the entrance of the vascular bundle of the leaf. If these imprints were stretched at right angles to the axis of the stem, which would occur in the case that they are made by permanent leaf scars on stems that increase in thickness, they would graduate in shape into the forms represented on Pl. CLXVII, Figs. 1, 2.

Pl. CLXVII, Fig. 1, depicts the largest and most complete imprint found. It was evidently made by a stem that was much larger and longer than that making the imprint given in Fig. 5 of Pl. CLXVI, and apparently was correspondingly older. That it is a fragment of a much longer stem is shown by the fact that it is broken short off at both ends, and, although 16 cm. long, shows, from one end to the other, no appreciable deviation from a width of 15 mm. This is the imprint that shows traces of leaves along the margins. This imprint is thickly set with depressions made by leaf scars. These imprints of leaf scars are more closely placed and much larger and more distinct than those of Pl. CLXVI, Fig. 5. With the increased thickness of the stem, the leaf scars seem to have had their dimensions at right angles with the stem increased more than those in the direction of the axis.

The imprints of the leaf scars shown on this specimen are deep and very distinct. In contour they are approximately rhombic, with the transverse dimensions slightly greater than those in the direction of the length of the stem. The upper margin, however, is a curve, and the lower one shows a more or less obtuse angle. The right and left ends, or lateral angles, are acute and more or less drawn out into points that are directed downward, as shown in Fig. 2 of Pl. CLXVII, which represents an enlarged and restored imprint. Within the depressed area forming the imprint of the leaf scar there is a boss or proturberance, more or less elliptical in shape, with its major axis at right angles with the axis of the stem. This boss is often distorted by pressure, and varies then somewhat in shape, being sometimes even round. The boss is bounded by a depressed line or furrow that is slightly deeper than the rest of the imprint. From the right and left ends of the furrow a similar furrow, one on each side, in perfectly formed imprints, runs toward the lateral angles of the imprint of the leaf scars. But these are rarely seen. The boss is placed, not centrally, but somewhat nearer the angle of the lower margin of the imprint of the leaf scar. As indicated in the best preserved imprints, the original and normal shape of the boss and of the furrow which bounds it and determines its form was approximately that of the entire imprint—that is, rhombic—but with the difference that the lower angle, instead of the upper, is rounded out more or less into a curve. However, as stated, distortion usually destroys this form. There are sometimes indications that the central portion of the boss was raised into a sort of mamma or teat.

The imprint given in Fig. 8 of Pl. CLXVI seems to have been made by a stem older and larger than that depicted on Pl. CLXVII. Its width is about 15 mm., but one margin is not preserved, so that the imprint does not show the true size of the stem. The imprints of the leaf scars here are larger and more crowded than in the form represented on Pl. CLXVII, Fig. 1. Owing to their crowding, their upper margin no longer shows the curvature seen in that figure, but tends to become angular, giving the contour more truly a rhombic shape. The lateral angles are more rounded off, and the lower angle is prolonged to form a kind of tail, as represented in Fig. 9 of Pl. CLXVI. Between these imprints of scars there are no interspaces, as were still to be seen on the specimen figured on Pl. CLXVII, but they crowd one another. The stem, whose imprint is depicted in Fig. 8 of Pl. CLXVI, must have been larger than that figured on Pl. CLXVII, for it shows a width of 15 mm., with only one margin preserved. The amount of woody matter in the stems making the imprints must have been small, for in the specimens enough of the mold is shown to indicate that it was flattened to a thickness of only 2 or 3 mm. This leads us to infer that these imprints could not have been made by cones, and that if by stems they must have remained succulent a long time.

The imprint depicted in Fig. 10 of Pl. CLXVI, if not larger than that represented by Fig. 8, seems to have been older. As one margin of the imprint is not shown, we can not determine the true size of the stem. The imprint of the stem in this case is rather more than 15 mm. wide. The imprints of the leaf scars are larger, more crowded, and more distinct than those of any of the previously described specimens. In their shape they show still further modification. The upper margin is more decidedly angular, the tail from the lower angle is nearly or quite obliterated and the imprints are more elongated transversely. The scar imprints have here more of the true rhombic form than any of those described in the preceding pages. The imprints are deep and very distinct. The central protuberance is more distinct than any of the others, and the furrows running from its right and left ends to the lateral angles of the imprint of the leaf scar are deeper and more sharply defined than in any others.

The imprints described in the preceding account are seen in the rock material that surrounded and entombed the original stems. They are markings imprinted on the inner surfaces of the collapsed molds, and of course in character they are the reverse markings on the stems which imprinted them. Convexities on the surface of the stems form concavities in the surrounding sediment, and, vice versa, concavities correspond to convexities. It may be concluded, then, that the stems forming these fossils had on their surface prominences or cushions approximately of rhombic form, but varying in the manner described with the age and thickness of the stem. These had within their margins a rim or ridge, also approximately rhombic in form, and this inclosed a depressed, transversely elongated area which contained a circular, still deeper depression, which was caused by the entrance of the vascular bundle from the leaf into the stem. From the lateral angles of the central ridge inclosing the depression there passed, one on each side, a raised line or ridge to the lateral angles of the leaf scar. These cushions seem to have been permanent, and they were probably left by the disarticulation of the leaf bases from the stems, like the scars of Lepidodendron, which they resemble in form. They seem to have grown in size with the increasing thickness of the stem which bore them and to have become more crowded and pronounced in character. A comparison of the imprints depicted in the figures given in the preceding seems to show that they were made by stems belonging to the same species, and that the differences in their forms are caused by the fact that the scars in enlarging with age increased more in their dimensions at right angles to the axis of the stems than in the direction of that axis. At the same time they became more crowded.

The leaves.—Unfortunately, no imprints of entire leaves were seen attached to the fossils. On the margins of the imprints given on Pl. CLXVII there may be seen imprints of small portions of the lowest parts of a number of leaves. These imprints indicate that the leaves that made them are narrow, curved upward, keeled, pretty thick at their bases, and very rigid. In fact the imprints are such as would be made by leaves similar to those which Velenovský gives as those of *Geinitzia cretacea*, and which he has figured and described in Die Gymnospermen der böhm. Kreideformation, p. 15, pl. viii, figs. 11, 12; pl. ix, figs. 1, 2. The leaves referred to are given in pl. ix, fig. 1.

At first sight the imprints of the leaf scars look, in their general form, like Brachyphyllum, but the leaves of that genus have a boss in their center instead of a pit. The other markings also are too regular for those of Brachyphyllum, and are not of the same pattern. The imprints are strikingly like those made by the terminal surfaces of the cone scales of some Pinus, but to make them the scales must have stood at right angles with the axis of the cones. This is true of the cones of Geinitzia, which are also long and cylindrical. But the markings on the terminal surfaces of the cone scales of Geinitzia are totally different. Besides it would seem impossible to compress any cone into the thinness indicated by the molds, especially cones with scales at right angles to the axis. The forms represented in Fig. 5 of Pl. CLXVI and on Pl. CLXVII are obviously impossible for cones. Those given in Figs. 8 and 10 of Pl. CLXVI might more probably pass for imprints of cones, but they are clearly made by portions of long cylindrical bodies, too long for cones. Then, too, the impressions on these are clearly essentially the same in character as those on Pl. CLXVII. The impressions made by the leaf scars in these stems are so strikingly like those shown on fig. 1, pl. ix, of Velenovský, referred to above, that we can not resist the belief that if not of the same genus they must be closely allied to it. The resemblance between Velenovský's fig. 1 and Fig. 1 of Pl. CLXVII is essentially strong, extending not only to the shape of the imprints of the leaf scars, but also to the depression within it. The same gradation in shape is also indicated. The younger branches of *Geinitzia cretacea*, as given in pl. ix, fig. 2, of Velenovský's work, have the rhombic imprints with the greater dimensions in the direction of the axis of the stem, as in Fig. 5 of Pl. CLXVI. Another fact that indicates that our plant is nearly allied to that of Velenovský is the number, persistence, and distinctness of the imprints of the leaf scars. I know of no conifer except Geinitzia that shows these features. Heer's *Geinitzia formosa* shows crowded, persistent rhombic leaf scars.

Lesquereux, in his Tertiary Flora, pl. lxi, figs. 28, 29, represents stems with crowded, persistent scars of what he calls *Sequoia longifolia*. On pl. lxii, figs. 15–18, he gives representations of stems with similar scars, which he calls *Sequoia biformis*. These scars closely resemble those on our Pl. CLXVI, Fig. 5. On pl. vii, in fig. 19, he gives a similarly marked stem for *Abietites dubius*. All of these plants Schenk states he regards as Geinitzia. See Zittel's Handbuch der Palæontologie, Abth. II, pp. 299–300. On pl. vii, of the above-cited work of Lesquereux, in fig. 31, there is a representation of a stem of what he regards as *Pinus palæostrobus* (Ett.) Heer. The scars on this are strikingly like those on the older stems of the Hay Creek plant.

The resemblance between the Hay Creek forms and Geinitzia is so strong that we are justified in placing them in that genus, at least provisionally. As Geinitzia is hitherto known from no strata older than the Younger Cretaceous, it may be found that our plant is an ancestral form of the true Geinitzia. In that case it would be fittingly named *Geinitzites Jenneyi*.

Genus SPHENOLEPIDIUM Heer.

SPHENOLEPIDIUM KURRIANUM (Dunker) Heer.

Pl. CLXVI, Figs. 12, 13.

1846. *Thuites* (*Cupressites?*) *Kurrianus* Dunk.: Monographie d. norddeutsch. Wealdenbildung, p. 20, pl. vii, fig. 8.
1846. *Lycopodites?* sp. Dunk.: Op. cit., pp. 20, 85, pl. viii, fig. 8.
1847. *Widdringtonites Kurrianus* (Dunk.) Endl.: Synopsis Coniferarum, p. 272.
1849. *Brachyphyllum? Kurrianum* (Dunk.) Brongn.: Tableau, p. 107.
1852. *Widdringtonites Haidingeri* Ett.: Beitrag z. Flora d. Wealdenperiode, Abh. d. k. k. geol. Reichsanst., Vol. I, Abth. 3, No. 2, p. 26, pl. ii, fig. 1.
1852. *Araucarites Dunkeri* Ett., in pt.: Op. cit., p. 27, pl. ii, fig. 10 (non figs. 2–9).
1870. ? *Araucarites hamatus* Trautsch.: Der Klin'sche Sandstein, Nouv. Mém. Soc. Imp. de Moscou, Vol. XIII, p. 225 (Livraison 3, p. 37), pl. xxi, figs. 3, 3a, 3b, 3c.
1871. *Sphenolepis Kurriana* (Dunk.) Schenk: Foss. Fl. d. nordwestdeutsch. Wealdenformation, Palaeontographica, Vol. XIX, p. 243, pl. xxxvii, figs. 5-8, 8a; pl. xxxviii, fig. 1 (non fig. 2).
1881. *Sphenolepidium Kurrianum* (Dunk.) Heer: Contr. à la Fl. Foss. du Portugal, Section des Travaux géologiques du Portugal, p. 19, pl. xii, fig. 1b; pl. xiii, figs. 1b, 8b; pl. xvi, fig. 5c; pl. xviii, figs. 1–8 (excl. figs. 5b, 5c).
1881. ? *Thuites Choffati* Heer, in pt.: Op. cit., p. 11, pl. x, figs. 7, 8.

Specimens were obtained of a conifer that can not be distinguished from the widely diffused Lower Cretaceous plant *Sphenolepidium Kurrianum*. They occur on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Çreek, rather commonly, and sometimes in well preserved branching specimens. On the same horizon, at the cliff on the south side of Pine Creek, and the cliff of Oak Creek, at Robbin's ranch, the fossils are rarer and not so well preserved.. The best specimens are found on the horizon 60 feet below the Dakota, at the cliff in the east bank of Oak Creek. Here some very fine, freely branching specimens were obtained. The scale-like leaves of this plant in the Hay Creek beds are a little broader than those found in the Potomac, probably indicating a more luxuriant growth, which feature is seen in a number of the other Hay Creek plants.

The specimen represented by Fig. 12 of Pl. CLXVI is from the cliff on the north side of Pine Creek, and that by Fig. 13 from the shales on the south side of Pine Creek.

SPHENOLEPIDIUM PARCERAMOSUM Fontaine.

Pl. CLXIII, Fig. 11b; Pl. CLXVIII, Figs. 1-3.

1889. *Sphenolepidium parceramosum* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 257, pl. cxxix, figs. 7, 7a, 7b; pl. cxxx, figs. 8, 8a; pl. cxxxi, fig. 2.

This plant, also first found in the Lower Potomac of Virginia, occurs in the Hay Creek beds. It is confined, like *Sphenolepidium Kurrianum*, to the upper member, Jenney's No. 2 of the Hay Creek Lower Cretaceous, and occurs mostly with that plant and *Sequoia Reichenbachi*.

It is found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek (Pl. CLXIII, Fig. 11b), rather commonly, and sometimes in fine specimens. On the horizon 100 feet below the Dakota, it is found at two localities: Cliff on the north side of Pine Creek, from which were obtained the specimens figured on Pl. CLXVIII, Figs. 1-3, and cliff on the south side of Pine Creek, being rather common at the first-named locality on Pine Creek.

This plant was described by the writer in Mon. U. S. Geol. Survey, Vol. XV, pp. 257-258. It is well characterized by its long, sparingly branched, slender twigs, thickly clothed with leaves, of which the laterally attached ones have an ovate or elongate elliptical shape and rather long acute tips. They also have a midnerve. The leaves of this plant are in shape much like those that Heer has depicted for *Sequoia gracilis*, but are generally more slender. Were it not for the midnerve I would conclude that it is that Sequoia, showing only a varietal difference. Heer, however, states that *Sequoia gracilis* has no midnerve in its leaves. I would be all the more inclined to identify it with this Sequoia, because small, round Sequoia cones, exactly like those of *S. gracilis*, occur with it. This plant is highly characteristic of the upper portion of the Lower Potomac strata, such as is found near Brooke Station, Virginia, which group is called by Mr. Ward the Aquia Creek series. It forms another of the plants that indicate a similar geological age for the Brooke strata and Jenney's division No. 2 of the Hay Creek beds.

Genus GLYPTOSTROBUS Endlicher.

GLYPTOSTROBUS BROOKENSIS (Fontaine) Ward.

Pl. CLXV, Fig. 4; Pl. CLXVIII, Fig. 4.

1889. *Taxodium (Glyptostrobus) brookense* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 254, pl. cxxii, figs. 1, 1a, 1b; pl. cxxiv, figs. 3, 3a, 4, 4a, 5, 6, 7, 7a, 8, 9; pl. cxxxi, figs. 5, 5a; pl. clxv, figs. 1-3; pl. clxvi, figs. 4, 4a, 7; pl. clxvii, fig. 3.

1895. *Glyptostrobus brookensis* (Font.) Ward: Fifteenth Annual Report U. S. Geol. Survey, pp. 359, 377, 380.

Several good specimens of this plant, first described by the writer from the Lower Potomac of Virginia in Mon. U. S. Geol. Survey, Vol. XV, p. 254, occur on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek (from which the specimen here figured on Pl. CLXVIII, Fig. 4, was obtained), along with *Athrotaxopsis tenuicaulis* and *Sphenolepidium parceramosum*. It occurs also, but rarely, on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek, as seen in faint impressions on the large slab, Pl. CLXV, Fig. 4. In the Lower Potomac of Virginia this form is highly characteristic of the upper or Brooke group. Like many of the Hay Creek fossils, the twigs of this conifer are a little stouter than those of the same species found in the Lower Potomac. The leaves also diverge rather more from the stem than do most of those from the Potomac. This, however, is probably due to differences in the modes of preservation.

Genus NAGEIOPSIS Fontaine.

NAGEIOPSIS LONGIFOLIA Fontaine?

Pl. CLXVIII, Figs. 5, 6.

1889. *Nageiopsis longifolia* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 195, pl. lxxv, figs. 1, 1a, 1b; pl. lxxvi, figs. 2–6; pl. lxxvii, figs. 1, 2; pl. lxxviii, figs. 1–5; pl. lxxix, fig. 7; pl. lxxxv, figs. 1, 2, 8, 9.

In the Hay Creek series detached fragments of leaves occur that are so much like *Nageiopsis longifolia* that they may, with little hesitation, be identified with that species. *N. longifolia* occurs in the Lower Potomac of Virginia, in some fine specimens. It was described by the writer in Mon. U. S. Geol. Survey, Vol. XV, p. 195. The distinctive characters of Nageiopsis as compared with Podozamites are found in the basal and terminal portions of their leaves; that is, the characters that may be seen in the detached leaf. As the Hay Creek specimens nowhere show these portions of the leaves, we can not be certain that these fragments are Nageiopsis; but the texture, shape, size, and other features of the fragments, as well as the nervation, agree so well with *N. longifolia* that the identification is justified.

Sir William Dawson, in his paper on the "Mesozoic floras of the Rocky Mountain region of Canada" (Trans. Roy. Soc. Can., Sec. IV, Vol. III), p. 6, pl. i, fig. 3, describes a plant from the Kootanie series of Canada which he identifies with *Podozamites lanceolatus*. This is in most respects much like *Nageiopsis longifolia*, being the termination of a leaf. It is hardly possible that this Podozamites has ranged all over the Northern Hemisphere in its geographical distribution, and from the Triassic into the Lower Cretaceous in its geological age. Schenk's *Zamites Göpperti*, also from the Urgonian of the Wernsdorf beds, seems to be *Nageiopsis longifolia*. The form he gives in Die foss. Pflanzen der Wernsdorfer Schichten (Palaeontographica, Vol. XIX), pl. iii, fig. 6 is just what would be seen in *N. longifolia* if the lower surface of a large leaf be presented uppermost, so that the stem partially hides the insertions of the leaflets.

N. longifolia occurs, so far as yet seen, only at the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek, and also at shales under the third sandstone, Barrett. It is quite common at the former locality and rather rare at the latter.

Both the specimens figured are from the bed of shales under the third sandstone, 50 to 100 feet above the coal at Barrett.

Nageiopsis angustifolia Fontaine?

Pl. CLXVIII, Fig. 7.

1889. *Nageiopsis angustifolia* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 202, pl. lxxxvi, figs. 8, 9; pl. lxxxvii, figs. 2, 2a, 3, 4, 5, 5a, 6, 6a; pl. lxxxviii, figs. 1, 3, 4, 6–8; pl. lxxxix, figs. 2, 2a.

A single leaflet of a plant that appears to be identical with *Nageiopsis angustifolia* occurs on the horizon 150 feet above the Jurassic, at the shales under the third sandstone, Barrett. This species was described by the writer in Mon. U. S. Geol. Survey, Vol. XV, p. 202. It is one of the most widely diffused species of the Virginia Potomac formation. Although the leaflet is well characterized, and can hardly be anything but this Nageiopsis, I do not make the identification positive, as the amount of material is so small.

Genus BAIEROPSIS Fontaine.

Baieropsis adiantifolia Fontaine.

Pl. CLXVIII, Fig. 8.

1889. *Baieropsis adiantifolia* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 211, pl. xcii, figs. 8, 8a, 9; pl. xciii, figs. 1, 1a, 2, 3; pl. xciv, figs. 2, 3.

Fragments of detached leaves of a plant which seems to be identical with *Baieropsis adiantifolia* occur not very abundantly in the Hay Creek beds, and only at the horizon 150 feet above the Jurassic. This plant was found by the writer in the Lower Potomac of Virginia, and was described in Mon. U. S. Geol. Survey, Vol. XV, p. 211. The Potomac specimens yield some forms that are much more complete than any found in the Hay Creek beds. Still, as the leaves are of peculiar shape and have a lobing not found in any others, and as these points are clearly indicated in the specimens drawn, there does not seem to be much room for doubt that the Hay Creek forms are really *B. adiantifolia*. Most of the Hay Creek specimens do not show the margins of the leaves, or, indeed, their shape. On one of these, however, the characteristic nervation of *B. adiantifolia* was visible. This nervation is marked by fine but sharply defined and closely placed nerves that fork so as to spread in a fan-shaped manner. In the specimen figured we have a more complete fragment of a leaf. It shows enough to indicate that the shape of the leaf was the characteristic one of the species now in question, and it has in addition preserved, in the right-hand lower corner of the leaf, two of the characteristic lobes and teeth of *B. adiantifolia*. The teeth are not preserved well enough to show the spike-like tips in which they terminate. These, however, are hardly ever visible, even in the best preserved Potomac specimens.

In the Hay Creek beds this plant occurs in a considerable number of fragments, at the cliff on the north side of the valley of the South Fork of Hay Creek, and in one specimen (that here figured) at the shales under the third sandstone, Barrett.

BAIEROPSIS PLURIPARTITA Fontaine?

Pl. CLXVIII, Figs. 9-12.

1889. *Baieropsis pluripartita* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 208, pl. lxxxix, fig. 4; pl. xc, figs. 2, 2a, 3, 4, 4a, 5; pl. xci, figs. 1, 3, 3a, 4, 7.

Two specimens of a plant that is much like *Baieropsis pluripartita* were found on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek. *B. pluripartita* was found by the writer in the Lower Potomac of Virginia in fine specimens, and was described in Mon. U. S. Geol. Survey, Vol. XV, p. 208. While the Hay Creek specimens are quite fragmentary, they show enough to strongly indicate their identity with the Potomac species. We may rely more fully on conclusions drawn from a small amount of material in the case of such leaves as this than where leaves are concerned that belong to a type common to many different plants. Still, as we have only two imperfect specimens, I make the identification doubtful.

Genus CZEKANOWSKIA Heer.

CZEKANOWSKIA NERVOSA Heer.

Pl. CLXIX, Figs. 1, 2.

1881. *Czekanowskia nervosa* Heer: Contr. à la Fl. Foss. du Portugal, Sect. des Trav. Géol. du Portugal, p. 18, pl. xvii, figs. 5, 5b, 6, 7a, 8, 10, 10b, 11, 11b.

A fossil not to be distinguished from Heer's *Czekanowskia nervosa*, first found in the Wealden of Portugal, occurs in the lower members of the Hay Creek series, Lower Cretaceous. It is found not rarely. A good many fragments are found on the horizon 150 feet above the Jurassic, in shales under the third sandstone, Barrett. On the horizon, 50 feet above the Jurassic, in carbonaceous shales, Webster's Ranch, it is common, occurring there in better preserved and more complete forms than at the higher horizons. The two specimens figured were found at this locality. The leaf of this plant is of the Baiera type, and I think it, as well as Heer's plant, is a true Baiera. Heer describes his forms in Contr. à. la Flore Foss. du Portugal, p. 18. The description that Heer gives applies to the Hay Creek plant, viz, the leaves are divided into laciniæ in a dichotomous manner. The laciniæ are from 1 to 2 mm. wide and have several nerves. The figures of Heer represent that the leaf had at base a single narrow lacinia, and this, by repeated dichotomous subdivision, gave origin to the leaf. The basal lamina, as in the Hay Creek plants, probably passed downward into a petiole. Heer's figures represent the laciniæ more crowded together and looking as if the leaf had been stretched by pressure in the direction of its length. In the Hay Creek specimens the pressure seems to have operated to spread out the lobes. Heer's fig. 11 of pl. xvii represents the specimen of his plant that is nearest to our forms. He says of the nerves of his plant that they are distinct, but in the Hay Creek specimens they are seen with difficulty. Probably this distinction is caused by differences in the mode of preservation. The ultimate laciniæ of the Hay Creek plants are only 1 mm. in width, and it is possible that the subdivision was carried further than was seen.

The shale of the two localities furnishing this plant, although given by Professor Jenney as separated by 100 feet of strata and as occurring at different places, is strikingly alike, being very fine grained and fissile, the substance of the plant peeling off from the stone like paper. It preserves the plants well, and additional collections should be made from it.

Genus CEPHALOTAXOPSIS Fontaine.

CEPHALOTAXOPSIS MAGNIFOLIA Fontaine.

Pl. CLXII, Fig. 1b; Pl. CLXIX, Figs. 3, 4.

1889. *Cephalotaxopsis magnifolia* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 236, pl. civ, figs. 4, 5; pl. cv, figs. 1, 1a, 1b, 2, 4; pl. cvi, figs. 1, 1a, 3; pl. cvii, figs. 1, 2, 4, 4a; pl. cviii, figs. 1, 3, 4.

Leaves that are identical with those of *Cephalotaxopsis magnifolia*, as described in Mon. U. S. Geol. Surv., Vol. XV, p. 236, from the Lower Potomac of Virginia, are found sparingly on the horizon 150 feet above the Jurassic, at the cliff on the north side of the Valley of the South Fork of Hay Creek, and in shales under the third sandstone, Barrett. They are found also on the horizon 100 feet under the Dakota, at the cliff on the north side of Pine Creek. At these localities they are by no means common. With the larger leaves, corresponding to those of *C. magnifolia*, are others that agree better with those of *C. ramosa*. As, however, none of the leaves are attached to stems, the data are not sufficient to justify their separation into two distinct species. The probabilities, however, are that two species are present. The leaves of Cephalotaxopsis seem to have been drifted some distance. As the nut-like fruit *Carpolithus montium-nigrorum* occurs at the same locality with these leaves, and as this is much like *C. fasciculatus*, which is found in the Potomac strata with many fine specimens of Cephalotaxopsis, and as also Cephalotaxus has similar fruit, it is probable that this Carpolithus is the fruit of some Cephalotaxopsis.

The specimens represented on Pl. CLXII, Fig. 1b, and Pl. CLXIX, Fig. 4, are from the north side of the valley of the South Fork of Hay Creek, 2½ miles west of Barrett. The other specimen (Pl. CLXIX, Fig. 3) is from the shales under the third sandstone above the coal at Barrett.

Male Ament of a Conifer.

Pl. CLXIX, Fig. 5.

A small ament was found on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek, which is probably the male ament of some conifer. It is quite well preserved, and shows a length of 1 cm., with a width of 4 mm., including the deflected bracts. The form is cylindrical, with both ends obtuse. The bracts on the upper face are mostly removed, being taken off in the splitting of the shale along the plane of the ament. Hence the axis is exposed for most of its length. It is comparatively stout. The lateral bracts are preserved, and show comparatively long and slender tips, which are strongly deflected.

Subdivision ANGIOSPERMAE.

Class DICOTYLEDONEÆ (Dicotyledons).

In the Lower Cretaceous series of the Hay Creek region dicotyledons occur only in the highest portion in Professor Jenney's division No. 2. In the strict confinement of this type of vegetation to the upper portion, the Hay Creek Lower Cretaceous differs from the Lower Potomac, as shown in Virginia. This latter formation shows in its older portion a few dicotyledons of peculiar archaic type, unlike anything found in the Hay Creek Lower Cretaceous, or in that of any region. There is, however, a marked resemblance between the Hay Creek dicotyledons and those of the upper Brooke beds of the Virginia Potomac. In both cases the type of dicotyledons is more modern in facies than the element found in the older beds of the Lower Potomac. At present it is impossible to say whether or not there is really a difference in the occurrence of dicotyledons in these two widely separated terranes of Lower Cretaceous. The collections made thus far in the Hay Creek region are very scanty, and it may be true that more persistent search will disclose dicotyledons of ancient type in the lower Hay Creek beds. It is from these beds that the collections are most scanty. Conclusions, based on the failure to find certain forms, are at best uncertain, and they are especially so when the collections can not be taken as fairly representing the flora.

In the case of the Hay Creek Lower Cretaceous flora we may fairly conclude that dicotyledons were relatively not very abundant on any horizon, and, granting that they existed in the time of the deposition of the lower beds, they formed proportionally a much smaller element of the vegetation than during the era of the formation of the upper strata. The collections show that even in division No. 2 the ferns and conifers far surpassed the dicotyledons. The case is very different when we pass above No. 2 into the true Dakota formation. Here conifers, cycads, and ferns become insignificant in numbers, and dicotyledons attain an overwhelming predominance. The facts that are indicated by the Hay Creek dicotyledons, so far as the evidence now attained goes to show, are similar to those made out from the study of the Lower Potomac beds. Dicotyledons of modern aspect appear in some force in the upper strata of the Hay Creek Lower Cretaceous, but they do not form the dominant element in the flora.

Family FAGACEÆ (Beech and Oak family).

Genus QUERCOPHYLLUM Fontaine.

QUERCOPHYLLUM WYOMINGENSE n. sp.

P. CLXIX, Fig. 6.

A fragment of a small dicotyledonous leaf was found on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek. The fragment shows intact the left side of the base, a lobe, and the sinus between this and the next higher lobe, which is only partially preserved. The indications are that this latter is similar in character to the lowest lobe, which is fully preserved. The basal portion of the leaf is rounded off and passes into the lowest lobe with a considerable convexity in the margin of the leaf. The lobe that is preserved is oblong, with an elliptical-shaped tip that is turned slightly outward away from the midrib. One of the primary veins of the leaf passes into this lobe to its tips. The sinus between this and the next lobe forms a narrow, acute, inverted triangle. A similar primary nerve passes into the second partially preserved lobe. The upper portion of this latter lobe and of the leaf, as well as nearly all of the right-hand half of the leaf, are wanting. Not enough of the leaf is preserved to fix its true position. It may belong to any one of several genera. As, however, it seems to be nearer some of the forms of Quercus than to any other genus, I place it provisionally in the allied genus Quercophyllum. It should be noted that it has the facies of a recent type of leaf. Its importance as a fossil lies in the fact that it is distinctly a dycotyledon that is different from the others found in the Hay Creek Lower Cretaceous, and that the archaic features are not shown in it.

Family ULMACEÆ (Elm family).

Genus ULMIPHYLLUM Fontaine.

ULMIPHYLLUM DENSINERVE n. sp.

Pl. CLXIX, Fig. 7.

A fragment of a small leaf quite different from the other Hay Creek dicotyledons was found on the horizon 100 feet below the Dakota sandstone, in the Carbonaceous shales at Rollin's tunnel. It is 2 cm. long and 11 mm. wide, with but little variation in the width from end to end. The entire leaf was probably oblong in shape, or lanceolate. The leaf texture seems to have been firm and durable, and the nerves are but faintly shown. The midrib is slender. The secondary or lateral veins go off from the midrib almost at right angles. They are parallel, placed at equal distances, and slightly arched in the middle, with their ends directed toward the end of the leaf. They are all of equal strength and are placed about 1.5 mm. apart. No nervation other than the midrib and lateral veins was seen.

The general aspect of this leaf is much like that of a fern of the Angiopteridium type, and it resembles some of the pinnules of *Angiopteridium strictinerve*, as, for example, that given in Mon. U. S. Geol. Survey, Vol. XV, pl. xxix, fig. 8; but this leaf has a much slenderer midrib, and the lateral nerves do not fork. Besides, these nerves have the appearance of the nerves of a dicotyledon rather than of a fern.

Not enough of the plant has been found to determine positively its true position. It may belong to any one of several genera of dicotyledons. The nerves are closer than is usual in dicotyledons of this type. It is perhaps nearest to Ulmus, and I place it provisionally in the allied genus Ulmiphyllum.

Family MORACEÆ (Mulberry and Fig family).

Genus FICOPHYLLUM Fontaine.

FICOPHYLLUM SERRATUM Fontaine.

Pl. CLXIX, Fig. 8.

1889. *Ficophyllum serratum* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 294, pl. cxlv, fig. 2; pl. cxlix, fig. 9.

Ficophyllum serratum was found in the Lower Potomac of Virginia and described by the writer in Mon. U. S. Geol. Survey, Vol. XV, p. 294, pl. cxlv, fig. 2; pl. cxlix, fig. 9. A fragment of a dicotyledonous leaf was obtained in division No. 2 of the Hay Creek beds that so strongly resembles this that it may safely be identified with it. The fossil now in question occurs on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek. Only one specimen was found. It shows a portion of the lower part of the midrib and a large part of the right-hand half of the leaf. The fossil indicates a leaf of the same size and character as that shown on pl. cxlix in fig. 9 of Mon. U. S. Geol. Survey, Vol. XV. The tendency to form double teeth seen in the leaf depicted in fig. 9 does not appear here. That, however, is not a persistent feature in the Potomac plant.

Family SAPINDACEÆ (Soapberry family).

Genus SAPINDOPSIS Fontaine.

SAPINDOPSIS VARIABILIS Fontaine.

Pl. CLXIX, Fig. 9.

1889. *Sapindopsis variabilis* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 298, pl. cli, figs. 1, 1a; pl. clii, figs. 1, 4, 4a; pl. cliii, fig. 3; pl. cliv, figs. 2–4, 4a; pl. clv, figs. 2–5.

Sapindopsis variabilis was first found by the writer in numerous well-preserved specimens in the upper or Brooke group of beds belonging to the Lower Potomac. It is described in Mon. U. S. Geol. Survey, Vol. XV, pp. 298–300. It is highly characteristic of the upper portion of the Lower Potomac in Virginia, and great numbers of its fossils are found at some localities. It is by far the most common dicotyledon at the localities where it occurs.

Precisely similar leaves occur in division No. 2 of the Hay Creek beds. They are found on the horizon 60 feet below the Dakota sandstone, at the cliff in the east bank of Oak Creek, where it is the most abundant dicotyledon, and is quite common, and where the specimen here figured was obtained. It is, in fact, the only abundant dicotyledon in the Hay Creek Lower Cretaceous. It occurs also on the horizon 100 feet below the Dakota sandstone at the cliff on Oak Creek, at Robbin's ranch. Here it is found sparingly, but in well-preserved forms. This plant is a valuable one for the determination of the age of the beds in which it occurs, for it has a number of features that render it easy to identify, and which cause it obviously to differ from others. The leaves have a thick, very durable texture, that causes them to be much better preserved than most dicotyledons. The odd-pinnate leaves, owing to the persistence of the leaflets at their summits, frequently show them attached, and sometimes even the terminal leaflets. The nervation is strongly marked and characteristic. Indeed, these leaves can hardly be mistaken for others. It is significant to find that this plant, which is the most abundant in the Brooke group of the Virginia Lower Potomac, is the most common dicotyledon in the upper member of the Hay Creek Lower Cretaceous. As indicating similarity of age, such a plant is much more important than any single species, which is vaguely characteristic and represented by few individuals. This Sapindopsis is "at home" and well established in the upper portion of the Lower Cretaceous of both the Hay Creek region and of Virginia.

MALE AMENT OF A DICOTYLEDON?

Pl. CLXIX, Fig. 10.

A male ament or catkin of what was probably some dicotyledon was obtained on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek. This differs from the compactly built, chaffy aments ascribed to conifers. It has a length of about 1 cm. and a width of about 3 mm. The axis is slender and shows remotely placed bracts scattered along it. The bracts are slender and have long slender tips. For the greater portion of their length they are coiled up like a watch spring. Its true place is doubtful.

These few species are all the possible dicotyledons found thus far in the Hay Creek Lower Cretaceous.

INCERTÆ SEDIS.

FRUITS.

The following fruits have not been found connected with any foliage in a way to indicate where they belong in the various groups established from stems and leaves. It is quite possible that some of them should be placed in species described in the preceding pages.

Genus CARPOLITHUS Artis.

CARPOLITHUS FASCICULATUS Fontaine.

Pl. CLXIX, Figs. 11, 12.

1889. *Carpolithus fasciculatus* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 265, pl. cxxxiv, fig. 1.

On the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek, a single imprint, as from a nut-like fruit, was obtained. This in shape and size is identical with one of the fruits of *Carpolithus fasciculatus* from the Lower Potomac of Virginia. This species was described by the writer in Mon. U. S. Geol. Survey, Vol. XV, p. 265, pl. cxxxiv, fig. 1. *Carpolithus fasciculatus*, as found in the Potomac of Virginia, shows a group of nut-like fruits borne on a common stem. The fruit now in question agrees well with the single nuts of the Virginia plant. As Cephalotaxus has a plum-like fruit, two or three in a head, and as *Cephalotaxopsis magnifolia* occurs at this locality, this fruit may belong to the latter. *Nageiopsis longifolia* also occurs at this locality, and the fruit now described may belong to it.

The genus Nageiopsis, which is abundant in the Lower Potomac of Virginia, and highly characteristic of it, was established by the writer for certain leaves and leafy branches that agreed closely with the living genus Nageia Gaertner, generally regarded as a subgenus of

Podocarpus Endlicher, now surviving in the East Indies and Japan. When the description of the genus was written I had not seen either the foliage or fruit of Nageia. Since that time, however, through the kindness of a friend in Japan, specimens of both have been obtained. My conclusion as to the close resemblance of the foliage of Nageia and and Nageiopsis has been strongly confirmed by an inspection of these. The fruits of the living Nageia are so much like some of those of the Lower Potomac of Virginia, which I described as belonging to the groups Carpolithus and Cycadeospermum, especially the latter, that I think it quite probable that some of the Carpolithus forms and perhaps all of Cycadeospermum are fruits of Nageiopsis. It is true that most of the Nageias have single nut-like fruits, but *Nageia Blumei* Endl. (*Podocarpus Blumei* Endl.) is described as having its fruit, after the fall of the floral leaves, grouped in bunches at the ends of the branchlets. Hence it may be that even branched nutlets, like those of *Carpolithus fasciculatus* may belong to Nageiopsis.

Fig. 11 of Pl. CLXIX shows this nut natural size, and Fig. 12 is enlarged 2 diameters.

CARPOLITHUS MONTIUM-NIGRORUM Ward n. sp.[1]

Pl. CLXIX, Fig. 13.

A nut-like fruit, which is probably a new species of Carpolithus, was obtained on the horizon 150 feet above the Jurassic, at the cliff on the north side of the valley of the South Fork of Hay Creek. It is ovate in shape, 15 mm. long, and, including the rind or margin, 10 mm. wide at the widest part, which is close to its base. It has a distinct wing-like margin, which is flat, while the body of the seed is strongly convex, indicating that the margin was thinner than the seed proper. In shape and size it resembles *Cycadeospermum spatulatum* Font., of the Lower Potomac of Virginia. This latter was figured in Mon. U. S. Geol. Survey, Vol. XV, pl. cxxxv, figs. 11, 21. The Potomac fruit, however, has no wing, and is a thinner seed with a less firm texture. This seed may be the fruit of *Cephalotaxopsis magnifolia* Font., for this plant occurs at this locality, and the fruit of Cephalotaxus is fleshy, with a hard woody seed within.

The figure shows the specimen natural size.

CARPOLITHUS BARRENSIS Ward n. sp.[2]

1. CLXIX, Figs. 14, 15.

The fossil here named *Carpolithus barrensis* was obtained on the horizon 150 feet above the Jurassic, at John Barr's tunnel. It has an ovate shape and is 9 mm. long, with a maximum width at its lower portion of about 4 mm. As it leaves a pretty deep imprint in the shale,

[1] Professor Fontaine in his manuscript designates this form by a name that had been twice used before and therefore it was necessary to change it.

[2] The name that Professor Fontaine gave this form in his manuscript has already been given to three different objects by different authors. As it was found at Barr's tunnel it may be called *C. barrensis*.

it was probably quite thick and firm in texture. It is a good deal like *Carpolithus virginiensis* Font., but it is more elliptic in form than that and proportionally narrower, and had apparently a less woody texture. It may prove identical with the seed of *Araucarites wyomingensis*, but the differences seem to justify its doubtful separation as a new species.

Fig. 15 is enlarged 2 diameters.

CARPOLITHUS VIRGINIENSIS Fontaine.

Pl. CLXIX, Fig. 16.

1889. *Carpolithus virginiensis* Font.: Potomac Flora, Mon. U. S. Geol. Survey, Vol. XV, p. 266, pl. cxxxiv, figs. 11, 11a, 12, 13, 14, 14a; pl. cxxxv, figs. 1, 5; pl. clxviii, figs. 7, 7a.

Several detached nut-like seeds were found on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek. They are not attached to a stem, as were some of the forms of *Carpolithus virginiensis*, which were found in some abundance in the Lower Potomac of Virginia, and described in Mon. U. S. Geol. Survey, Vol. XV, p. 266, but they resemble strikingly the detached seed of this plant. The resemblance is strong enough to justify the identification of the Hay Creek seed with those of the Potomac. Like the Potomac seeds, those of Hay Creek seem to have had a firm woody texture. One of the seeds has a short pedicel, indicating that it was attached to a stem after the manner of the Potomac specimens.

The figure shows one of these seeds natural size.

CARPOLITHUS FŒNARIUS Ward n. sp.[1]

Pl. CLXIX, Figs. 17, 18.

This is a narrowly elliptical or fusiform seed, occurring in the strata at the junction of the Jurassic with the Cretaceous at Lon Cottle's ranch. It is 5 mm. long, with a maximum width of 1.5 mm. It has attached to it what looks like a portion of a wing. Possibly this is an abnormal seed of *Araucarites wyomingensis*, but more probably it is the seed of a different species of Araucarites, as it is proportionally too narrow for *A. wyomingensis.*

Fig. 17 of Pl. CLXIX represents it natural size, and Fig. 18 enlarged 2 diameters.

Genus FEISTMANTELIA Ward n. gen.

FEISTMANTELIA OBLONGA Ward n. sp.

Pl. CLXIX, Fig. 19.

Fusiform or cigar-shaped markings.—Certain peculiar oblong and fusiform markings are found not rarely on the horizon 100 feet below the Dakota sandstone, at the cliff on the north side of Pine Creek.

[1] The name given to this form by Professor Fontaine in his manuscript was preoccupied. The one I have chosen is derived from the Latin word for hay, in vague allusion to the Hay Creek coal field.

They appear on the surface of the rock as convex forms that are casts of concave shapes that existed apparently on woody stems of considerable size in the cambium layer under the bark. They are not arranged in a strictly definite manner or with unvarying pattern. They have their longer dimensions in the direction of the length of the stem on which they occur, and are arranged mostly in interrupted rows, with the individual markings more or less en échelon, with their ends sometimes overlapping. Sometimes they are close together and touch for most of their length. Some are curved, but most of them are straight. These markings have a sufficiently constant and definite character to enable one to recognize them at a glance. They occur only at certain horizons. Hence we must infer that they are not the results of mere accident. Another fact that gives them significance is their occurrence in the same way and with the same shapes in the Lower Potomac of Virginia. In this they are found on the same horizon at Fredericksburg and at Cockpit Point. I can offer no satisfactory explanation of them, but they are worthy of description, for they clearly belong to the wood of a particular kind of tree occurring only in the Lower Cretaceous on a definite horizon.

NOTE.—The above was Professor Fontaine's description of these objects, and Fig. 19 of Pl. CLXIX is a fairly good illustration of their appearance. I was with him when the specimens of this plant referred to by him from Cockpit Point, on the Potomac River, in Virginia, were found on the occasion of our visit to that locality on July 27, 1893, and the specimens we then collected now lie before me, as do also those from the Hay Creek coal field. Professor Fontaine states that others were obtained from Fredericksburg, but these I have not seen. The Fredericksburg horizon is the same as that of Cockpit Point, viz., his Fredericksburg or my Rappahannock series of the Potomac formation.

In addition to these three localities, I last summer found the same plant in the Cheyenne sandstone of Kansas. It is quite abundant in what Professor Cragin has called the Lamphier shales, and also occurs in the more carbonaceous portions of his Stokes sandstone. Referring to my notes, I find first the mention of broad stems resembling bamboo and subsequently of these peculiar "cigar-shaped markings identical with those from the Black Hills and Cockpit Point," so associated with the broad bamboo-like stems "that it was easy to be sure that they belong to the stems and occur in the interior as a part of the internal structure." These specimens are now in temporary storage and I can not confront them with the others, but I was too familiar with them to have been mistaken, as the Cockpit Point specimens had greatly interested me and led me to make a prolonged search for similar objects previously figured by other authors. I will now give the result of that investigation supplemented by some later discoveries.

Of all the figures thus far found that which Feistmantel gives in his Flora of Kach (Foss. Fl. Gondw. Syst., Vol. II, Pt. I, 1876, pl. x, fig. 2) comes the nearest to the American forms. In fact, it is substantially identical and must represent the same genus. It is for this reason that I dedicate this new genus to the late Dr. Ottokar Feistmantel, for whom, notwithstanding his numerous and important contributions to paleobotany, no genus of fossil plants has been named, and very few species.

Of this plant Feistmantel, on page 61 of the work quoted, says:

"Portion of a stem of a coniferous plant.—The specimen which I have figured here seems to me to be undoubtedly a fragment of the stem of a coniferous plant. The scars, it is true, remind one very much of a lycopodiaceous plant, but no Lycopodiaceæ have been found anywhere in Mesozoic strata. The scars are spirally disposed, oblong, with the broader portion above, where, I believe, leaves were inserted. The lower portion is narrower and elongate, but no other structure is to be seen. If we compare these specimens, however, with stems of living coniferous plants, we shall find that the structure of the young branches is similar. But to describe and determine them more exactly is, I believe, not possible, because it is always very difficult to recognize a plant only from a fragment of the stem. We can only say that the stems belong, perhaps, to one of the coniferous plants found in the same locality, and two especially may be suggested, the Pachyphyllum, or the plant to which the scales I shall next describe belonged. I believe this stem can not be referred to Echinostrobus Schimp., as the leaves are quite different." In the description of the plate of fig. 2 he simply says: "Stem of a coniferous plant, with leaf scars.—From Kukurbit."

Next to this in point of similarity to our forms I place three figures of Stokes and Webb in their report on Mantell's collection from the Tilgate Forest in Sussex (Wealden), contributed to the Geological Society of London and published in its Transactions in 1824 (Trans. Geol. Soc. London, 2d Ser., Vol. I, pp. 421–424, pl. xlv–xlvii). These are the figs. 8 of pl. xlvi and figs. 4b and 4c of pl. xlvii, all of which are regarded as parts of their *Clathraria anomala*, and the first of them is still included by Seward (Wealden Flora, Pt. II, p. 123) in *Bucklandia anomala*, which is the modern name of that same plant. It is generally admitted that these are the piths of cycadean trunks, and for this class of objects Saporta proposed the name Cycadeomyelon (Plantes Jurassiques, Vol. II, p. 331).

Saporta did not, however, deal with the English Wealden forms, and only included under his new genus so much of the plant described by Schimper (Traité de Pal. Vég., Vol. II, p. 183) under the designation *Clathraria liasina* as related to certain pith casts found at Hettanges near Metz. Schimper thought that these objects represented the woody cylinder of cycadean trunks (he does not say the medulla), and he suggested that they might belong to *Otozamites major*. He did not figure any of the specimens, and the only figure I have seen of this plant, which Saporta called *Cycadeomyelon hettangense*, is that of the Plantes Jurassiques, Vol. II, Atlas, pl. cxix, fig. 5. This also presents a remarkable similarity to the American Lower Cretaceous forms under consideration, and I was at first tempted to refer these to Cycadeomyelon and class them with the Cycadales; but certain weighty considerations deter me from this course.

The only other figures that I have thought it worth while to compare are those of Germar's *Omphalomela scabra* (Palaeontographica, Vol. I, pl. iii), which are without much doubt pith casts of cycads, and were referred by Schimper to Clathraria and called *Clathraria ? Germari* (Traité, Vol. III, p. 554). The markings here are quite different from those heretofore considered and approach more closely to those seen on the medulla of other cycadean trunks of which we have knowledge, some of which are described in this paper (cf. *Cycadeoidea Stillwelli*, supra, pp. 636, 637, Pl. CXLIX), and others elsewhere (see Proc. Biol. Soc. Washington, Vol. XI, p. 13).

The principal objection to regarding the American forms as distinct from Cycadeomyelon and for seriously doubting that they really represent the medulla of cycadean trunks is that the markings appear in all cases to be on the inner wall of the hollow cylinder of some vegetable trunk, and not on the outer surface of the medullary axis, i. e., in precisely the reverse position from those of Cycadeomyelon. In the case of the Indian plant, although Feistmantel supposed that the markings were leaf scars on the surface of coniferous stems, there is nothing in his figures to negative the idea that they might be internal. He speaks as if he had considerable material, and this question could perhaps be settled by an examination of it. In many of our specimens it would be difficult to decide whether the scars occupied an outer or an inner surface. and Professor Fontaine, in his description given above, does not clearly indicate what his view of the matter is by saying that "they appear on the surface of the rock as convex forms that are casts of concave shapes that existed apparently on woody stems of considerable size in the cambium layer under the bark." This, it seems to me, might admit of either interpretation. As I now examine the specimen figured by him I think I see evidence that the projections were inward, and other material that he did not figure confirms this impression. The specimens from Cockpit Point present the same difficulty, but one of these pretty clearly indicates that it forms the thin edge of a flattened hollow due to pressure, and represents itself the investing layer of whatever may have once occupied this hollow space. Put with this my observations in Kansas, which left no doubt in my mind that the bamboo-like stems on parts of which these markings occur were the interior parts of large hollow trunks, and the evidence becomes strong that our plant is not a Cycadeomyelon or any other "myelon" or pith, but part of a hollow mold with the elevations directed toward the center of the trunk.

The species of Feistmantelia will depend chiefly on the shape of the elevations. Those of Feistmantel's figure are decidedly fusiform, with the upper end of the spindle much larger. That form may therefore be called *Feistmantelia fusiformis.* His statement that they are "spirally disposed" is scarcely justified by the figure, but here, as in all other cases observed by me, they are alternately disposed, i. e., lying side by side, but each one beginning and ending at a different point from its neighbor, which is a characteristic feature of Cycadeomyelon, and strongly suggests a connection with the medullary rays. The Cockpit Point specimens have some of the half-reliefs somewhat fusiform, but often simply oblong, i. e., half cylinders abruptly rounded at the ends. This latter is almost the only form preserved by the Hay Creek specimens, and on this account I have preferred the specific name *oblonga.*

This plant affords a good example of the geological value of certain kinds of objects which appear to have very little value for biology. Many paleobotanists look with contempt upon anything whose systematic position is in doubt and declare that it does more harm than good to list forms which can not be referred with practical certainty to some definite family or genus. They argue, correctly enough, that the attempt to draw conclusions from such material as to the history of plants is wholly misleading and vitiates all reasoning from fossil plants. They forget, or never seem to have thought, that a form may have a geological value quite independent of all such conclusions. Such reasoning is really biological after all, i. e., it is an attempt to work out the genealogy of certain groups of vegetation. The forms, such as this one, are worthless for this purpose and any attempt to employ them in this manner can not be too strongly condemned. The value they have is what is called *geognostic.* If, as in the present case, the objects are clear and definite, so as to be readily recognizable whenever found, and especially if, as also in this case, they are confined to certain geological horizons, they become useful indices and characteristic marks of geological formations, and, wisely employed, become valuable aids to geology. If these peculiar markings had only been seen once, they might be regarded as mere *lusus naturæ* and neglected; but when we find them under practically the same conditions at about the same horizon and all exactly alike in widely different parts of the country, we begin to see that they represent similar beds and add important testimony to the similarity in age.

All the American forms have occurred in the Lower Cretaceous, and their range, so far as now known, is from near the base of the Cretaceous to near the top of the beds that lie below the Dakota group or Cenomanian of Europe, i. e., from the Neocomian to the Gault or Albian of Old World nomenclature. If the specimens from India are the same as ours, this carries the genus down to the Lias, provided the beds of Kach have been correctly correlated. When the Jurassic of America is better known we may expect to find representatives of this plant in them, but there is reason to believe that the species will differ in the same way that they do in other better-understood genera. It will be further observed that this range is about the same as that of the fossil cycads in general, which may or may not be taken as an argument for the cycadaceous nature of Feistmantelia.—L. F. W.

LOCALITIES AT WHICH COLLECTIONS SHOULD BE MADE.

The preceding descriptions include all the fossil plants obtained thus far from the Lower Cretaceous strata of the Hay Creek region that are sufficiently well characterized to be worthy of mention. Incidentally, in the descriptions of the plants, attention has been called to some of the localities which seem worthy of having additional collections made from them. There are some other localities equally worthy of further attention, which may be noticed here.

The shale in the cliff on the north side of the valley of the South Fork of Hay Creek, lying 150 feet above the Jurassic, is one that should have additional collections made from it. It has yielded a large number of good fossils from a small amount of material, but there are indications that a careful and prolonged examination would discover many more, probably new ones. The shale is fine-grained and fissile, having a light brown color. It preserves the plants beautifully and they are easily worked out of it. It has fragments of plants which with the material in hand are not capable of determination, but which hint at the existence of forms different from those described. A number of plants found here have not been discovered elsewhere. They occur on an important horizon and seem to be very rich in fossils.

Material occurring at the cliff in the east bank of Oak Creek, 2 miles below Robbin's Ranch, is found in a fine-grained, thinly laminated argillaceous sandstone that is interstratified with thin layers of a very fine-grained shale. These shale partings preserve plants finely and have yielded some very distinct and large imprints. Only a small amount of material has been obtained from this place. It well deserves further examination. It occurs on a critical horizon and the plants found here do not seem to have suffered so much from drifting as they have at most of the other localities.

The bed of shales at the contact of the Jurassic with the Cretaceous, at Lon Cottle's Ranch, is another critical horizon, and eminently deserves further and careful examination. This shale is light chocolate in color, very fine grained and fissile, enabling one to work out the plants easily. It preserves them finely. It is full of fragments of plants, and as the amount of material obtained from it is very small, there is little doubt that careful search would disclose many new species. This shale contains among others the seeds and cone scales of *Araucarites wyomingensis*, and the fossils found here do not occur elsewhere.

THE FOSSILS OF THE DIFFERENT HORIZONS.

Before going into the consideration of the age of the Hay Creek beds that lie beneath the typical Dakota sandstone it will be useful to present lists of the plants that occur on the several horizons. I will begin with the lowest.

Plants occurring at the contact of the Cretaceous with the Jurassic, Division No. 4.

1. Thyrsopteris elliptica Font.?
2. Araucarites wyomingensis n. sp.
3. Carpolithus fœnarius Ward n. sp.

Plants occurring from 50 to 75 feet above the Jurassic, Division No. 4.

1. Thyrsopteris dentifolia n. sp.
2. Thyrsopteris brevifolia Font.
3. Thyrsopteris pecopteroides Font.
4. Zamites borealis Heer.
5. Pinus susquaensis Dn.
6. Czekanowskia nervosa Heer.

Plants occurring on the horizon 150 feet above the Jurassic, Division No. 3.

1. Equisetum virginicum Font.?
2. Cladophlebis parva Font.?
3. Sphenopteris plurinervia Heer?
4. Thyrsopteris pinnatifida Font.?
5. Thyrsopteris crassinervis Font.?
6. Thyrsopteris elliptica Font.
7. Thyrsopteris brevipennis Font.?
8. Scleropteris distantifolia n. sp.
9. Scleropteris rotundifolia n. sp.
10. Zamites brevipennis Heer.
11. Zamites borealis Heer.
12. Williamsonia? phœnicopsoides Ward n. sp.
13. Araucarites wyomingensis n. sp
14. Araucarites? cuneatus Ward n. sp.
15. Pinus susquaensis Dn.
16. Sequoia sp. Font. Immature cone.
17. Nageiopsis longifolia Font.
18. Nageiopsis angustifolia Font.
19. Baieropsis adiantifolia Font.
20. Czekanowskia nervosa Heer.
21. Cephalotaxopsis magnifolia Font.
22. Male ament of a conifer.
23. Male ament of a dicotyledon?
24. Carpolithus fasciculatus Font.
25. Carpolithus montium-nigrorum Ward n. sp.
26. Carpolithus barrensis Ward n. sp.

Plants occurring on the horizon 100 feet below the Dakota sandstone, Division No. 2.

1. Equisetum virginicum Font.
2. Weichselia reticulata (Stokes and Webb) Ward.
3. Matonidium Althausii (Dunk.) Ward.
4. Pecopteris Geyleriana Nath.
5. Zamites species?
6. Cycadeospermum rotundatum Font.
7. Pinus susquaensis Dn.?
8. Leptostrobus longifolius Font.
9. Leptostrobus? alatus Ward n. sp.
10. Athrotaxopsis tenuicaulis Font.
11. Sequoia Reichenbachi (Gein.) Heer.
12. Sequoia gracilis Heer.
13. Geinitzia Jenneyi n. sp.
14. Sphenolepidium Kurrianum (Dunk.) Heer.
15. Sphenolepidium parceramosum Font.
16. Glyptostrobus brookensis (Font.) Ward.
17. Baieropsis pluripartita Font.?
18. Cephalotaxopsis magnifolia Font.
19. Quercophyllum wyomingense n. sp.
20. Ulmiphyllum densinerve n. sp.
21. Sapindopsis variabilis Font.
22. Carpolithus virginiensis Font.
23. Feistmantelia oblonga Ward n. sp.

Plants occurring on the horizon 50 to 60 feet below the Dakota sandstone, Division No. 2.

1. Weichselia reticulata (Stokes and Webb) Ward.
2. Pecopteris Geyleriana Nath.
3. Pecopteris borealis Brongn.
4. Cladophlebis wyomingensis n sp.
5. Pinus susquaensis Dn.
6. Abietites angusticarpus Font.
7. Leptostrobus longifolius Font.
8. Athrotaxopsis tenuicaulis Font.
9. Sequoia Reichenbachi (Gein.) Heer.
10. Geinitzia Jenneyi n. sp.
11. Sphenolepidium Kurrianum (Dunk.) Heer.
12. Sphenolepidium parceramosum Font.
13. Glyptostrobus brookensis (Font.) Ward.
14. Ficophyllum serratum Font.
15. Sapindopsis variabilis Font.

CONCLUSIONS AS TO THE DISTRIBUTION OF THE PLANTS.

From these lists it will be seen that the flora of the horizon 100 feet below the Dakota sandstone and that of the horizon 60 feet below it are essentially the same. The resemblance is not fully disclosed by the lists alone. The same plants that are abundant on the one horizon are also abundant on the other, and they show very much the same state of preservation. It is noteworthy that on both of these horizons, from some cause, the plants are more distinctly characterized than they are on the lower horizons. They also occur in larger and more complete specimens, and the leaves are more often attached to stems. The plants indicate that there is no break between the two horizons named, both of which occur in Professor Jenney's division No. 2. The horizon 60 feet below the Dakota sandstone is shown by the plants to be somewhat higher than that 100 feet below it, in the disappearance of some of the survivors from lower horizons, which had struggled on to the latter. *Thyrsopteris elliptica* Font. comes up into the horizon 100 feet below the Dakota sandstone, showing one or two doubtful specimens. It does not appear at all on the higher horizon. *Cephalotaxopsis magnifolia* Font., surviving feebly on the lower horizon in division No. 2, does not pass up into the higher. *Pinus susquaensis* Dn. is the only plant belonging to the lower horizons that is found on the highest horizon of division No. 2. It should be stated, however, that the specimens supposed to be this Pinus, that are found on the two horizons of division No. 2, are few and not well characterized, so that the identification of them with *P. susquaensis* is not entirely free from doubt.

If we compare the list of plants found on the lowest horizon in division No. 2, or that 100 feet below the Dakota sandstone, with that yielded by the horizon 150 feet above the Jurassic and occurring in division No. 3, we find a decided change. No dicotyledons occur below division No. 2. The plants that are most abundant on the lower horizon in division No. 2, and most characteristic of it, do not occur at all below it. Those that come up to it from lower horizons appear as survivors and not as well-established plants. They occur in some cases as doubtful forms, and in all cases are rare. Many of the most characteristic plants of the lower horizons, such as *Czekanowskia nervosa* Heer, *Zamites borealis* Heer, *Zamites brevipennis* Heer, do not pass up into the horizon 100 feet below the Dakota sandstone. These and other evidences derived from a study of the plants indicate a time-break between Jenney's divisions No. 3 and No. 2. On the other hand, no change in the flora of the strata from the junction of the Jurassic with the Cretaceous up to the base of division No. 2 indicates a want of conformity in them. Divisions No. 3 and No. 4, so far as the evidence of the plants goes, make one group. It is true that there are changes in the species occurring on the lower horizons varying from the contact of the Jurassic with the Cretaceous up to and including the horizon

150 feet above the Jurassic, but the general character of the flora as a whole is the same. It is much more Jurassic in type than that of the beds higher up. Thyrsopteris, Zamites (of the type of *Z. borealis* Heer), conifers with flabellate leaves like Czekanowskia and Baieropsis, Araucarites and Scleropterids with small pinnules are the most characteristic plants. It must not be forgotten, however, that the collections of plants from these lower beds, especially those of division No. 4, are very scanty, and far inferior in the number of specimens to those obtained from division No. 2. A more thorough search of these strata may furnish numerous plants that would materially modify the conclusions drawn from the material now in hand.

GEOLOGICAL AGE OF THE HAY CREEK STRATA LYING BETWEEN THE TYPICAL DAKOTA SANDSTONE AND THE JURASSIC.

As stated in the beginning of this paper, the strata yielding the plants described in it were assumed by Newton to be of the same age as the true Dakota, a system of beds in which dicotyledons form nearly all the plants, they being of comparatively modern type. The plants found even on the highest horizon of division No. 2 differ totally from those of the true Dakota beds, and indicate a distinctly older series. The plants from the two horizons in division No. 2 are essentially the same and indicate that there is no unconformity in this division. We may leave out of consideration the fusiform markings (*Feistmantelia oblonga* Ward n. sp.), the questionable species of Zamites, *Baieropsis pluripartita* Font., and the possible seeds of Leptostrobus, that occur on the horizon 100 feet below the Dakota sandstone, for they are too poorly characterized to help in determining age. We have then 24 species from the two horizons of division No. 2. Of these, 4 are new, and for that reason can not be used in fixing the geological age. Of the 20 species remaining no fewer than 14 occur in the Lower Potomac of Virginia. The dicotyledons found in this division are of a more modern type than those which occur in the Lower Potomac beneath the Brooke or upper portion of that group of beds, and *Sapindopsis variabilis* Font., the most abundant dicotyledon in the Brooke strata, is by far the most abundant one in division No. 2. Besides, such plants as *Sphenolepidium Kurrianum* (Dunk.) Heer, *Sphenolepidium parceramosum* Font., *Glyptostrobus brookensis* (Font.) Ward, and *Leptostrobus longifolius* Font., that are common on the Brooke horizon, are common here also.

Of the 20 significant species occurring in division No. 2, and not found in the Lower Potomac, 6 have been previously described as coming from other formations. *Pinus susquaensis* Dn., according to Sir William Dawson, occurs in the Kootanie formation; *Sequoia gracilis* Heer, according to Heer, is found in the Kome beds of Greenland; *Matonidium Althausii* (Dunk.) Ward, according to Schenk and Heer, occurs in the Wealden of Europe; *Pecopteris Geyleriana* Nath., as stated by M. Yokoyama, is found in the Neocomian of Japan; *Weichselia reticulata* (Stokes and Webb) Ward, Schenk gives as occurring in the Urgonian Wernsdorf beds of Europe; Heer gives *Pecopteris borealis* Brongn. as found in the Kome beds of Greenland, which he regards as Urgonian in age. The Lower Potomac is, according to the plants, Neocomian in age. The Wealden being equivalent in age to Lower Neocomian, and the Urgonian being a formation of the Upper Neocomian, and the Kootanie being also Neocomian in age, it follows that all the fossil plants found in division No. 2 that are sufficiently well characterized to throw light on its age are Neocomian species. Of the new species, we may omit *Ulmiphyllum densinerve* and *Quercophyllum wyomingensis* as being too undetermined to be significant. The two remaining ones, *Geinitzia Jenneyi* and *Cladophlebis wyomingensis*, are closely allied to Neocomian fossils.

We may then conclude without hesitation that Jenney's division No. 2 is certainly older than the typical Dakota group with predominant dicotyledons, and that its age is Neocomian. We may also hold that of the various more or less local groups of beds of Neocomian age, it is nearest to the Lower Potomac, as exposed in Virginia. We may go further and determine with great probability that the age of division No. 2 corresponds with that of the Brooke group, an upper member of the Lower Potomac.

Coming now to divisions No. 3 and No. 4, we will not be able to make so satisfactory an analysis, for the fossils are not nearly so well preserved and the specimens are not so large as those of the upper division. In addition the collections from these members of the Hay Creek series are much more scanty, so that conclusions based on the absence of types are more risky than they are in division No. 2.

In the two lower divisions 32 different species of plants have been found whose characters have been more or less fully determined. Fourteen of these are new species, 5 have been found from formations other than Potomac, whose age is known, and 13 are Potomac species.

Most of the new species are so regarded because their character has been very imperfectly determined, and not enough is known of them to permit their identification with known species. In a number of cases there is nothing shown that would prevent more complete specimens from exhibiting features that would identify them with plants previously described. Indeed it is quite probable that such forms as *Carpolithus fœnarius* Ward, *Carpolithus barrensis* Ward, *Zamites?* species, *Williamsonia? phœnicopsoides* Ward, the aments supposed to belong to some conifer and some dicotyledons, and the immature cone of Sequoia, are not really new species. The apparently large proportion of new species has then no significance. The new species that have been determined with some definiteness, such as *Araucarites wyomingensis*, *Scleropteris rotundifolia*, and *Scleropteris distantifolia*, so far as their generic character goes, indicate survivors from the

Jurassic. Thirteen species have been determined, many of them doubtfully, as identical with Lower Potomac forms. They indicate that the beds containing them correspond in age with the lower portion of the Lower Potomac. A number of them are Jurassic in type, being probably survivors of a flora of that age. The large proportion of Potomac species confirms the conclusion deduced from the plants of division No. 2, viz, that the flora of the Hay Creek beds is, among the local Lower Cretaceous floras, nearest to that of the Lower Potomac. Five of the 32 species found in the beds now in question have been previously described as coming from Lower Cretaceous groups other than Lower Potomac. *Zamites borealis* Heer, and *Zamites brevipennis* Heer, were described by Heer from the Kome beds of Greenland, and *Sphenopteris plurinervia* Heer from the Wealden of Portugal. From the latter formation Heer also describes *Czekanowskia nervosa* Heer. *Pinus susquaensis* Dn., before mentioned, seems more at home in these beds, but survives into division No. 2. Eighteen out of the 32 species are then more or less certainly Neocomian species, and they include all the plants from these lower strata that are identical with forms previously described.

We find from this review of the plants that all the species of the third and fourth divisions of the Hay Creek beds that lie under the Dakota sandstone which can be identified with previously described plants are Neocomian in age, and this is a remarkably close agreement between the flora of the strata now in question and that of the Neocomian. The fact that the Hay Creek flora shows a much greater resemblance to that of the Lower Potomac than to the Kootanie floras of British America and of Great Falls, Montana, which occur much nearer to the Hay Creek region than does the Potomac of Virginia, is another surprising feature.[1]

4. FLORA OF THE DAKOTA GROUP PROPER.

It remains only to consider the forms of plant life that have been obtained from the highest member of the Dakota group of Newton, which, there is no reason to doubt, represents some horizon of the true Dakota No. 1 of Meek and Hayden, although, in the imperfect state of our knowledge of that formation, it is impossible to fix its position with exactness. The rock or matrix in which the plants are embedded is wholly different from that of the plains of Kansas where the greater part of the plants have been found. No signs of the dark-brown ferruginous sandstones and clay ironstones so characteristic of the latter were seen by me, and Professor Jenney describes none in the Hay Creek region. But it is known that the Dakota group is not wholly made up of these, and quite recently heavy beds of different material have been found in southern Kansas underlying the typical plant-bearing Dakota

[1] This and a number of similar questions are discussed by Professor Jenney in his notes (see supra, pp. 568-593).

and overlying equally typical Kiowa shales belonging to the Comanche series.[1]

Although there is believed to be unconformity between the true Dakota sandstone of the Black Hills and the Lower Cretaceous beds beneath them, still it is not probable that the time interval was very great, and therefore it is reasonable to suppose that the Dakota sandstones here represented lie near the base of that formation and correspond rather to some of the "transition beds" of Kansas than to the plant-bearing horizons of the plains; and it seems a fair presumption that the latter are wanting in this region. We should not, therefore, expect that the flora of these beds would be precisely the same as that which is now so well known as the flora of the Dakota group—that is, we should expect it to contain some of the elements of that flora along with some of those of the underlying older floras. This, in fact, is just what the small collection made by Professor Jenney and myself, in the vicinity of Evans quarry in September, 1893, reveals, and this constitutes all that we thus far know of the plants of the Dakota group in the Black Hills, Professor Jenney not having included any of these in his collection from the Hay Creek region for reasons that he gives. We may therefore proceed at once to the examination of these plants.

The study that was made of this collection after my return, by Dr. Knowlton and myself, although characterized as "careful,"[2] was not as thorough as it might have been, and I am obliged to admit several mistakes in the determinations. No figures had been prepared at that time, and it was only in the cases where the nervation was clear that we could be certain of its nature. In very obscure and indistinct specimens there is always the liability to mistake meaningless markings on the rock for nerves. However it may be with other fossil remains, in the case of plants, and especially of dicotyledonous leaves with obscure nervation, but upon which almost everything depends, it is wholly unsafe to attempt to determine a collection without drawings, or at least pencil sketches, made with the aid of special appliances for finding the nerves and following them out to the margins of the leaves. Such drawings have now been made, and with their aid a reexamination of the specimens has resulted in the following determinations, which are probably as correct as they can be made from the material in hand.

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[1] The results of the observations made by me in company with Mr. C. N. Gould were presented in brief to the Geological Society of Washington on November 10, 1897, and an abstract prepared by myself was published in Science, N. S. Vol. VI, No. 152, for November 26, 1897, pp. 814–815. A more extended paper by Mr. Gould, entitled "On a series of transition beds from the Comanche to the Dakota Cretaceous in southwest Kansas," by Charles Newton Gould, in the American Journal of Science, 4th series, Vol. V, March, 1898, pp. 169–175, sums up more fully our joint observations.

[2] Jour. Geol., Vol. II, No. 3, April-May, 1894, p. 261.

DESCRIPTION OF THE SPECIES.

Subkingdom PTERIDOPHYTA.

Class FILICALES (Ferns).

Genus ASPLENIUM Linnæus.

ASPLENIUM DICKSONIANUM Heer.

Pl. CLXX, Fig. 1.

1874. *Asplenium Dicksonianum* Heer: Die Kreide-Flora der arctischen Zone, K. Svensk. Vet.-Akad. Handl., Vol. XII, No. 6 (Fl. Foss. Arct., Vol. III, Abth. II), p. 31, pl. i, figs. 1 (excl. b. c.), 1aa, 2, 3, 3b, 4, 5 (excl. a, b).

Several fine specimens of this fern, of which the one figured is a fair sample, were obtained from the carbonaceous shales overlying the hard sandstone at the falls of the Minnekahta Creek or Fall River on the right bank.

This plant was first described by Heer from the Kome beds of Greenland (Gault or Urgonian), but it also occurs in the Atane beds, which are correlated with the Cenomanian, and have been supposed to be nearly equivalent to the Dakota group. It has been found in the Kootanie deposits of British America, in a supposed Neocomian deposit at Cape Lisburn, Alaska, and in the Amboy Clays at Woodbridge, New Jersey. It is also one of the few ferns that have been found in the Dakota group, where, however, it is rare. Its evidence, therefore, considered by itself, would be to put even this uppermost deposit in the Lower Cretaceous, but this is overcome by that of the remaining forms. The specimens are the best in the collection, good and characteristic, leaving no doubt on the score of identity. They present a strong contrast with the few very small and doubtful forms found by us on the slope of Red Cañon and figured on Pl. CLXII, Figs. 6, 7, 8 (see supra, p. 664).

Subkingdom SPERMATOPHYTA (Phanerogams).

Subdivision ANGIOSPERMAE.

Class DICOTYLEDONEÆ.

Family FAGACEÆ (Beech and Oak family).

Genus QUERCUS Linnæus.

QUERCUS WARDIANA Lesquereux?

Pl. CLXX, Figs. 2, 3.

1892. *Quercus Wardiana* Lx.: Flora of the Dakota Group, Mon. U. S. Geol. Survey, Vol. XVII, p. 53, pl. vii, fig. 1.

These two specimens were collected from the coarse sandstone of bed No. 7 of my section, on page 258 of the Journal of Geology for April–

May, 1894, Vol. II, No. 3, reproduced in this paper (supra, p. 560). The one represented by Fig. 2 of Pl. CLXX was found in place over Evans quarry, and the one by Fig. 3 in the loose material thrown down in uncovering the workable stone, but from the character of the rock it undoubtedly came from the same stratum. The rock is too coarse to show the finer nervation, and neither specimen shows base, summit, or margin. The determination, therefore, as stated on page 262 of that memoir, must remain uncertain. Still, the midrib and secondary nerves are very distinct, and agree well with both description and figure as given by Lesquereux, while nothing else can be found into which they will fit. The general aspect is that of an oak of the type of *Q. Prinus* L.

Family LAURACEÆ (Laurel and Sassafras family).

Genus SASSAFRAS Nees and Eberm.

SASSAFRAS MUDGII Lesquereux.

Pl. CLXX, Figs. 4, 5; Pl. CLXXI, Fig. 1.

1868. *Sassafras Mudgii* Lx.: Am. Jour. Sci., 2d ser., Vol. XLVI, p. 99.

1874. *Sassafras Mudgei* Lx.: Cretaceous Flora, Contr. Foss. Fl. West. Terr. (Hayden), Vol. VI, p. 78, pl. xiv, figs. 3, 4; pl. xxx, fig. 7.

The specimens are all without doubt from bed No. 7 over the quarry sandstone at Evans quarry, but those represented by Fig. 4 of Pl. CLXX and Fig. 1 of Pl. CLXXI were found in the débris thrown down in uncovering the quarry. These are in coarse, thinly laminated sandstone shale, while the other specimen, represented by Fig. 5 of Pl. CLXX, came from a clay shale bed in place, which is much finer and shows the impression very clearly. The agreement with Lesquereux's figures is very close, and I have compared it with the original specimens. Our Fig. 4 of Pl. CLXX may be compared with Lesquereux's fig. 7 of pl. xxx, and our Fig. 5 comes nearest to his fig. 4 of pl. xiv. Both of the original specimens unfortunately bear the same number (649) of the U. S. National Museum collection, but they also bear Professor Lesquereux's original numbers, and the former is his No. 1349, while the latter is No. 682. They were collected by Mr. Charles Sternberg at Salina, Kansas, in typical Dakota sandstone.

When I studied these specimens for my paper on the Cretaceous Rim of the Black Hills (Jour. Geol., Vol. II, p. 262), I did not make out the nervation on the coarse sandstone of the two specimens now shown in Fig. 4 of Pl. CLXX and Fig. 1 of Pl. CLXXI, and from the general form I identified them with *Lindera venusta* of Lesquereux. This is now seen to have been an error. I also wrongly supposed that the specimen Fig. 5 of Pl. CLXX was the same as the others that I had referred to *Aralia Towneri* Lx., and so placed it. On careful comparison of the figures and specimens it is obvious that none of them represent that species, and that they differ generically from one another.

Family PLATANACEÆ (Plane-tree family).

Genus PLATANUS Linnæus.

PLATANUS CISSOIDES Lesquereux?

Pl. CLXXI, Fig. 2.

1892. *Platanus cissoides* Lx.: Flora of the Dakota Group, Mon. U. S. Geol. Survey, Vol. XVII, p. 75, pl. lxi, fig. 3.

This is only a fragment, but so far as it goes it agrees with the specimen figured by Lesquereux. It is in a fine-grained clay shale, which shows the nervation clearly. I referred it doubtfully to this species in my early paper, and now, after a drawing has been made and the matter has been subjected to a reexamination, I find myself unable to suggest another reference. It is a question of letting it stand or rejecting it entirely, and as it is clearly different from anything else obtained, I incline to the former course. It was found in place over the quarry sandstone at Evans quarry.

Family CELASTRACEÆ (Staff-tree family).

Genus CELASTROPHYLLUM Göppert.

CELASTROPHYLLUM PULCHRUM n. sp.

Pl. CLXXI, Figs. 3, 4.

Leaves elliptical in outline, 4 to 6 cm. long, about 3 cm. wide, crenate-dentate with rounded teeth to near the base, petioled, oblique at base, the lamina extending lower on one side, rounded at the summit; midrib strong, more or less curved; secondary nerves about 6 on a side, rather distant, irregularly placed, leaving the midrib at an angle of about 45°, curving upward, the lower more than the upper, so as to converge in crossing the blade, slightly undulating or irregular in their course, giving off a few tertiary nerves or nervilles from both sides, which sometimes join some distance from the margin and form an angular arch or loop, from the outer part of which small nerves proceed into the teeth, sometimes forking or dividing, the branches entering the teeth.

Fig. 3 of Pl. CLXXI represents a specimen from the clay shales above Evans quarry, consisting of the lower part of two leaves lying side by side, with petioles complete. Considerably more than half of one of them is preserved and one side of the other, showing the nervation clearly. In searching for the equivalent of this form I have been unable to find it in the Dakota group, and, indeed, I have thus far failed to find anything similar in any published illustrations. That it represents a Celastrophyllum is clear both from the characteristic nervation and from the general facies, and a large number of species of that genus have been described from different formations ranging from the older Potomac to the Miocene. In the Potomac formation, as I have previously shown,[1] it constitutes one of the most complete series that we have, rising with slight modifications from one horizon to another, from the lowest to the highest beds. Many of these forms have been described and figured, but others remain unpublished. I have studied them all more or less, and I remembered one species in particular obtained by me from the Aquia Creek series at Fort Foote, Maryland, in a bluff on the bank of the Potomac, to which I had given special attention, and of which pencil sketches had been made to enable me to make out the exact nervation. This I knew must be close to the form in question, and when I compared it I found them substantially identical. I had gone so far as to name the Potomac form *Celastrophyllum pulchrum* on the labels without having as yet written the description. The agreement is so close that there seems no course left but to consider the Black Hills plant as the same as the Maryland one, and I here introduce one of the figures already prepared (Fig 4, of Pl. CLXXI) for comparison. The difference in the horizon points, along with other facts, to a low position in the Dakota series for the beds in question.

Family VITACEÆ (Vine family).

Genus CISSITES Heer.

CISSITES SALISBURIÆFOLIUS Lesquereux.

Pl. CLXXI, Fig. 5.

1868. *Populites salisburiæfolia* Lx.: Am. Jour. Sci., 2d ser., Vol. XLVI, p. 94.
1872. *Sassafras obtusus* Lx.: Fifth Ann. Rept. U. S. Geol. Surv. Terr. (Hayden) for 1871, p. 303.
1873. *Sassafras obtusus* Lx.: Sixth Ann. Rept. U. S. Geol. Surv. Terr. (Hayden) for 1872, p. 424.
1874. *Sassafras obtusum* Lx.: Cretaceous Flora, Contr. Foss. Fl. West. Terr., Pt. I, Rept. U. S. Geol. Surv. Terr. (Hayden), Vol. VI, p. 81, pl. xiii, figs. 2–4.
1876. *Cissites obtusum* Lx.: Eighth Ann. Rept. U. S. Geol. Surv. Terr. (Hayden) for 1874, p. 354.
1883. *Cissites salisburiæfolius* Lx.: Cretaceous and Tertiary Flora, Contr. Foss. Fl. West. Terr., Pt. III, Rept. U. S. Geol. Surv. Terr. (Hayden), Vol. VIII, p. 66.

This fine specimen was found at the falls on the right bank of Minnekahta Creek or Fall River, below Evans quarry, in the shales overlying the hard sandstone, associated with *Asplenium Dicksonianum* Heer, already recorded. The shales were so thin that they broke into a number of pieces, which were carefully preserved, so that on examining the material it was possible to find an almost complete leaf, and for a large part of this both surfaces (counterparts) are present. It proves

[1] Fifteenth Ann. Rept. U. S. Geol. Survey, p. 367.

to be one of the most beautiful specimens that have thus far been found of this species.

In studying the broken pieces before they had been put together and a complete figure made, I was led to compare it with *Aralia Towneri* of Lesquereux, to which it bears some resemblance, but upon a reinvestigation I am satisfied that it is not that plant, which does not occur in the collection.

Our form has the very rounded lobes of those represented in the Cretaceous Flora, pl. xiii, and though considerably larger, most closely approaches figs. 2 and 3 of that plate. There is the same tendency of one of the lateral primaries to curve outward more than the other that is seen in fig. 3, only this is still more marked.

The general question as to whether plants of this type from the American Cretaceous are really the ancestors of the exclusively American genus Sassafras, or should be referred to the vine or the plane trees, need not be discussed here. It will suffice to refer to two of my early papers on the subject published in 1888 and 1890, respectively.[1]

CISSITES INGENS Lesquereux.

Pl. CLXXII, Figs. 1, 2.

1892. *Cissites ingens* Lx.: Flora of the Dakota Group, Mon. U. S. Geol. Survey, Vol. XVII, p. 159, pl. xix, figs. 2, 2a.

The specimen represented by Fig. 1 of Pl. CLXXII was collected at the falls on the right bank of Minnekahta Creek or Fall River in thin shale, which was rather coarse and had very uneven partings, rendering the collection of specimens unsatisfactory. The nervation is obscure. The other specimen, Fig. 2, is one that was picked up in the débris at the foot of the cliff below Evans quarry and must have come from bed No. 7. It is somewhat more clear in its nervation, but the upper part of the leaf is wanting and none of the lobes or sinuses remain. I had labeled it *Aralia Towneri*, and it is possible that it may represent *Sassafras Mudgii*, but I seem to see a difference in its general aspect from the other specimens so referred. Both these specimens, so far as they go, agree almost perfectly with *Cissites ingens* Lx., as shown by the perfect specimen figured on pl. xix, fig. 2, of the flora of the Dakota group. This conformity extends in both cases so far as to include the rather unusual feature seen in the opposite secondary nerves of the midrib or middle primary. I think there is good reason to believe that both these leaves belong to the same species as those figured by Lesquereux from the Dakota group of Ellsworth County, Kansas, but whether they are ancestors of the vine or of the plane tree is a much more difficult question.

[1] Proc. U. S. Nat. Mus., Vol. XI, pp. 39-42, pl. xvii-xxii, 1888; American Naturalist, Vol. XXIV, September, 1890, pp. 797-810, pl. xxviii.

Family CAPRIFOLIACEÆ (Honeysuckle and Arrow-wood family).

Genus VIBURNITES Lesquereux.

VIBURNITES EVANSANUS Ward.

Pl. CLXXII, Figs. 3, 4.

1894. *Viburnites Evansanus* Ward: Jour. Geol., Vol. II, p. 261, 262.

Leaves coriaceous, oblong, rounded at the summit, subcordate or truncate at the base, entire or slightly denticulate, pinnately nerved; midrib strong, straight or slightly curved; secondaries thick, rather near together, approximately parallel, straight or slightly curving upward, somewhat irregular in their course, closer on one side of the midrib than on the other and making a different angle with it, this angle varying from 30° near the summit, where they curve in toward the apex, to 60° near the base, some of them forking and others simple, the dichotomy sometimes taking place near the margin and sometimes near the middle of the nerve; nervilles distinct and numerous, many of them percurrent, but others joining and anastomosing to form triangular or rectangular meshes.

In my early paper I did not give the full character of this species, but only pointed out its relation to the only other two species of the genus. Professor Lesquereux, as appears from Dr. Knowlton's foot-note to page 124 of the Flora of the Dakota Group, recognized the resemblance of the forms for which the genus was established to Protophyllum, and had he not made the genus Viburnites I should have been obliged to refer these forms to Protophyllum. The difference is perhaps not generic, and it is an interesting question whether it points to a real relationship between the fossil Viburnums and Protophyllum. There is scarcely a doubt as to the correctness of the reference of many of our fossil leaves to Viburnum, and I have found seeds of Viburnum associated with such leaves.[1] The similar nervation of many species of Protophyllum, and especially the strong dichotomy of the secondary nerves, has always suggested to me an affinity between these genera. As the systematic position of Protophyllum has always been a matter of speculation, this possible connecting link in Viburnites has a special interest for the botanist.

Both the specimens were found in place in the shales above Evans quarry, bed No. 7 of my section.

I take pleasure in repeating the statement formerly made, that the specific name chosen for this plant was meant to give some slight expression of my appreciation of the favors extended to me and my party by Mr. Fred. Evans, of Hot Springs, the leading citizen of the town, proprietor of Evans's quarry, and a public spirited and generous man.

[1] Types of the Laramie Flora, Bull. U. S. Geol Survey, No. 37, 1887, p. 109, pl. li, figs. 4–8.

5. DISTRIBUTION OF THE FLORA.

Under the four preceding heads there have been described 87 distinct forms of plant life from the Cretaceous deposits of the Black Hills, viz. 22 in the condition of silicified cycadean trunks without foliage, 1 in the condition of silicified wood belonging to the Coniferæ, 57 in the condition of impressions upon the sandstones and shales of Lower Cretaceous rocks of stems, leaves, and fruits, and 8 in the same condition as the last occurring in rocks of the Dakota group proper, or Upper Cretaceous. One of these latter, *Asplenium Dicksonianum* Heer, occurs in both these beds, which accounts for the otherwise apparent increase in the number to 88 instead of 87.

Professor Fontaine has given, at the close of his treatment of the Hay Creek flora (supra, pp. 699–702), a fairly complete summary of the general results of a study of these plants, and as this constitutes the great bulk of the entire flora, there is little to add by way of correlation.

Professor Jenney has also discussed certain questions arising out of the geological and geographical distribution of the plant remains, having been furnished with a copy of Professor Fontaine's report in manuscript. It occurred to me, however, that a table showing the distribution of all the plants, not only within the Black Hills, but throughout the American beds, and also in other countries wherever species previously known have been identified in the Black Hills, would afford any who might be disposed to do so an opportunity to make general comparisons and to better understand the full meaning of the data presented.

It will be observed that the above table is divided into two principal parts, viz: First, that containing the distribution within the Black Hills; and, secondly, the outside distribution of the species that are not new. So far as the Hay Creek species are concerned, Professor Fontaine has sufficiently dwelt upon the remarkable features of the distribution, especially the great number that are common to those beds and the Potomac formation. He has also discussed the value from a paleontological point of view of Professor Jenney's stratigraphical subdivisions. I will only say on this last head that after a careful comparison of his sections with those that were made by us conjointly in 1893, I have decided that the plant bed which we discovered on the eastern slope of Red Canyon, a short distance west of the principal fossil forest, some 3 miles southwest of Minnekahta station, 50 to 75 feet above the Jurassic, and constituting No. 9 of our first section (Jour. Geol., Vol. II, p. 255), must come within his division No. 4, while the principal cycad bed, No. 12 of that section, which lies 175 to 200 feet above the Jurassic and about 60 to 100 feet below the base of the Dakota sandstone, which is eroded away in that region, probably comes within his division No. 2, and is so treated in the table. The position of the cycad bed in the Blackhawk region has also been carefully studied, and is found to occupy the same relation to the underlying and overlying strata as that of Minnekahta. I have therefore assumed that all the cycads come from No. 2, a conclusion which is subject to future correction.

Other forms of cycadaceous vegetation are very scarce, only three undoubted species of that type occurring in the collection. Two of these, *Zamites brevipennis* Heer and *Z. borealis* Heer, are from the Hay Creek region, and, as Professor Jenney in one of his letters remarks, these were found in divisions No. 3 and No. 4. The *Glossozamites Fontaineanus* found by us in Red Canyon is also referable to No. 4. If these are the leaves of the plants whose trunks occur in such great abundance the two ought to be found at about the same horizon. Still, so meager is the present known flora that no conclusions drawn from its absence in certain beds can be considered valid. The further fact, also pointed out by Professor Jenney, that the principal cycad bed is nearly 100 miles south of the Hay Creek region may possess some significance for the vertical distribution.

A glance at the first part of the table serves chiefly to impress the mind with the defectiveness of the record, and the somewhat orderless grouping of the marks in certain parts of the pages can scarcely be said to furnish a basis for discussing the range of the species. As it stands, however, it may be said in general that while most of the ferns occur in divisions No. 3 and No. 4, most of the true conifers are found in division No. 2, and well up in that. The Taxaceæ and Ginkgoales occupy a somewhat intermediate position in No. 3.

The number of forms common to the Black Hills Lower Cretaceous and the Potomac formation greatly exceeds those common to it and the Kootanie; but it must be remembered that the present known Potomac flora is many times greater than the Kootanie flora as now known, and it is probable that this difference would be equalized were we in possession of all the data for comparison. A few species occur in the Amboy Clays, Tuscaloosa formation, and Island series, i. e., in the Newer Potomac, but these are not sufficient to warrant us in assuming that any of the plant-bearing beds of the Black Hills thus far found are the equivalent of these upper beds. On the other hand, as I have already pointed out (supra, p. 703), the small flora known from the Dakota sandstone above Evans quarry and at Minnekahta Falls indicates a very low place for these beds in the true Dakota group, and would not be wholly inconsistent with their reference to the horizon of the Cheyenne sandstone or lower Albirupean.

The distribution outside of America is principally confined to the Lower Cretaceous, especially the Wealden and Neocomian, which are probably for the most part parallel series, the name being dependent upon the character of the deposits, the Wealden being the estuarine or lacustrine equivalent of the marine Neocomian of various countries. It is further significant that all the species of wide lateral and vertical range, *Weichselia reticulata*, *Matonidium Althausii*, *Sequoia Reichenbachi*, and *Spehnolepidium Kurrianum*, which make up the bulk of the foreign distribution, are primarily Wealden or Neocomian species, and their range above and below is merely the result of the great abundance, exuberance, and persistence of these forms, or in part, perhaps, of errors in determination.

I have frequently alluded to these facts and have given the distribution of the same and other similar forms occurring in the Lower Cretaceous of America,[1] and my only excuse for repeating them here, in so far as they concern this paper, is that I desire to make the evidence as complete as possible, and omit nothing that in any important degree bears upon the age of the beds yielding the flora here recorded. To any one competent to weigh this evidence there should no longer remain a doubt on the general subject, and alike the original claim that all the sandstones of the Cretaceous rim of the Black Hills belong to the Dakota group proper, or No. 1 of Meek and Hayden, and the recent contention that the cycad and other plant-bearing beds form a part of the Jurassic may be regarded as definitively overthrown.

[1] See Am. Jour. Sci., 3d series, Vol. XXXVI, August, 1888, p. 127; Fifteenth Ann. Rept. U. S. Geol. Survey, pp. 388-392; Sixteenth Ann. Rept. U. S. Geol. Survey, Part I, pp. 482-483.

Table of distribution of the fossil plants of the Cretaceous formation of the Black Hills.

Distribution within the Black Hills.

Systematic number.	Names of the species.	Division No. 4. Jurassic contact. Lon Cottle's ranch.	Division No. 4. 50 feet above the Jurassic. Webster's ranch.	Division No. 4. 50 feet above the Jurassic. Shales over coal 2 miles southeast of Barrett.	Division No. 4. 50-75 feet above the Jurassic. Larrabee's shaft.	Division No. 4. 50-75 feet above the Jurassic. Slope on left bank of Red Canyon, 3 miles southwest of Minnekahta station.	Division No. 4. Shales under third sandstone at Barrett.	Division No. 3. 150 feet above the Jurassic. John Barr's tunnel.	Division No. 3. Cliff on north side of valley of south fork of Hay Creek.	Division No. 2. 175-200 feet above the Jurassic. Cycad beds. Three miles southwest of Minnekahta station.	Division No. 2. Two miles southeast of Minnekahta station.	Division No. 2. Three or 4 miles southwest of Hot Springs.	Division No. 2. Black's ranch, 2 miles north of Blackhawk.	Division No. 2. Two and one-half or 3 miles west of Sturgis.	Division No. 2. 100 feet below the Dakota sandstone. Cliff on the north side of Pine Creek.	Division No. 2. Cliff on the south side of Pine Creek.	Division No. 2. Cliff on Oak Creek at Robbin's ranch.	Division No. 2. Rollin's tunnel.	Division No. 2. 60 feet below the Dakota sandstone. Cliff on east bank of Oak Creek, 2 miles below Robbin's ranch.	Division No. 2. Cliff on north side of Red Water Valley.	Division No. 1. Dakota group proper. Shales over hard sandstone at Minnekahta Falls.	Division No. 1. Shales over Evans quarry.
1	Equisetum virginicum Font								×						×	×	×	×	×	×		
2	Weichselia reticulata (Stokes and Webb) Ward																	×				
3	Matonidium Althausii (Dunk.) Ward														×		×	×	×			
4	Pecopteris Geyleriana Nath														×				×			
5	borealis Brongn																		×			
6	Cladophlebis wyomingensis n. sp								×													
7	parva Font								×													
8	Sphenopteris plurinervia Heer (?)								×													
9	Thyrsopteris pinnatifida Font (?)								×													
10	crassinervis Font	×					×		×													
11	elliptica Font			×																		
12	dentifolia n. sp			×																		
13	brevifolia Font			×																		
14	pecopteroides Font								×													
15	brevipennis Font								×													
16	Scleropteris distantifolia n. sp								×													
17	rotundifolia n. sp					×																
18	Asplenium Dicksonianum Heer					×							×	×							×	
19	Gleichenia Zippei Heer (?)									×	×											
20	Cycadeoidea dacotensis (McBride) Ward emend									×												
21	colossalis n. sp									×												
22	Wellsii n. sp									×												
23	minnekahtensis n. sp									×			×									
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26	turrita n. sp									×												
27	McBridei n. sp									×												
28	Marshiana n. sp									×												
29	furcata n. sp									×												
30	Colei n. sp									×			×									
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35	Jenneyana Ward												×									
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38	Stillwelli n. sp																					
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41	Zamites brevipennis Heer		×		×			×									×					
42	borealis Heer																					
43	(?) sp. Font					×																
44	Glossozamites Fontaineanus Ward n. sp																					
45	Cycadeospermum rotundatum Font								×													
46	Williamsonia (?) phœnicopsoides Ward n. sp									×					×				×			
47	Araucarioxylon Hoppertonæ Kn. n. sp								×										×			
48	Araucarites wyomingensis n. sp	×						×							×		×		×			
49	(?) cuneatus Ward n. sp		×				×								×							
50	Pinus susquaensis Dn														×				×			
51	Abietites angusticarpus Font														×				×			
52	Leptostrobus longifolius Font														×	×						
53	alatus Ward n. sp																					
54	Athrotaxopsis tenuicaulis Font														×				×			
55	Sequoia Reichenbachi (Gein.) Heer														×	×	×		×			
56	gracilis Heer								×						×				×			
57	sp. Font. (immature cone)														×				×			
58	Geinitzia Jenneyi n. sp																					
59	Sphenolepidium Kurrianum (Dunk.) Heer																					
60	parceramosum Font																					
61	Glyptostrobus brookensis (Font.) Ward						×		×						×							
62	Nageiopsis longifolia Font						×															
63	angustifolia Font. (?)						×		×						×							
64	Baieropsis adiantifolia Font						×															
65	pluripartita Font (?)		×				×								×							
66	Czekanowskia nervosa Heer						×		×													
67	Cephalotaxopsis magnifolia Font								×									×				
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69	Quercophyllum wyomingense n. sp																					×
70	Quercus Wardiana Lx. (?)																					
71	Ulmiphyllum densinerve n. sp																					
72	Ficophyllum serratum Font																×		×			×
73	Sassafras Mudgii Lx																					×
74	Platanus cissoides Lx. (?)																					×
75	Celastrophyllum pulchrum Ward n. sp																					
76	Sapindopsis variabilis Font																				×	
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81	Carpolithus fasciculatus Font								×													
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85	fœnarius Ward n. sp																					
86	Feistmantelia oblonga Ward n. gen. n. sp																					

American distribution outside of the Black Hills.

Systematic number.	Lower Cretaceous. Trinity of Texas.	Kootanie of Great Falls, Montana.	Kootanie of British America.	Cape Lisburn, Alaska.	Shasta group, California.	James River, Virginia.	Rappahannock series, Virginia.	Mount Vernon series, Virginia.	Aquia Creek series, Virginia and Maryland.	Tuscaloosa formation, Alabama.	Amboy clays, New Jersey.	Cheyenne sandstone, Kansas.	Island series.	Upper Cretaceous. Cliffwood, New Jersey, Matawan formation.	Morrison, Colorado.	Dakota group of Kansas and Nebraska.	Kanab Valley, Utah.	Vancouver Island.	Peace and Pine rivers, British America.	Belly River, British America.	Rock Creek, Wyoming.	Livingston, Montana.	Spring Canyon, Montana.
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Foreign distribution.

Systematic number.	Jurassic. Bavaria (Rhetic).	Italy (Lias).	Kach, India (Lias).	Yorkshire (Oolite).	Cracow (Oolite).	Portugal (Jurassic).	Purbeck beds (England).	Wealden. England.	France.	Germany.	Neocomian. Belgium.	Portugal.	Westphalia.	Russia.	Spitzbergen.	Japan.	Urgonian. Austrian Silesia.	Portugal.	Greenland (Kome beds).	Aptian. Portugal.	Gault. Portugal.	Switzerland.	Westphalia.	Cenomanian. Greenland (Atane beds).	Portugal.	Saxony.	Bohemia.	Moravia.	Turonian. Saxony.	Senonian. France.	Westphalia.	Aachen.	Silesia.	Quedlinburg.	Bohemia (Gosau).	Greenland (Patoot beds).
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Table of distribution of the fossil plants of the Cretaceous formation of the Black Hills.

Distribution within the Black Hills.

Systematic number	Names of the species	Division No. 4. Jurassic contact. Lon Cottle's ranch	Division No. 4. 50 feet above the Jurassic. Webster's ranch	Division No. 4. 50 feet above the Jurassic. Shales over coal 2 miles southeast of Barrett	Division No. 4. 50–75 feet above the Jurassic. Larrabee's shaft	Division No. 4. 50–75 feet above the Jurassic. Slope on left bank of Red Canyon, 3 miles southwest of Minnekahta station	Division No. 3. 150 feet above the Jurassic. Shales under third sandstone at Barrett	Division No. 3. 150 feet above the Jurassic. John Barr's tunnel	Division No. 3. 150 feet above the Jurassic. Cliff on north side of valley of south fork of Hay Creek	Division No. 2. 175–200 feet above the Jurassic: Cycad beds. Three miles southwest of Minnekahta station	Division No. 2. Cycad beds. Two miles southeast of Minnekahta station	Division No. 2. Cycad beds. Three or 4 miles southwest of Hot Springs	Division No. 2. Cycad beds. Black's ranch, 2 miles north of Blackhawk	Division No. 2. Cycad beds. Two and one-half or 3 miles west of Sturgis	Division No. 2. 100 feet below the Dakota sandstone. Cliff on the north side of Pine Creek	Division No. 2. 100 feet below the Dakota sandstone. Cliff on the south side of Pine Creek	Division No. 2. 100 feet below the Dakota sandstone. Cliff on Oak Creek at Robbin's ranch	Division No. 2. 100 feet below the Dakota sandstone. Rollin's tunnel	Division No. 2. 60 feet below the Dakota sandstone. Cliff on east bank of Oak Creek, 2 miles below Robbin's ranch	Division No. 2. 60 feet below the Dakota sandstone. Cliff on north side of Red Water Valley	Division No. 1. Dakota group proper. Shales over hard sandstone at Minnekahta Falls	Division No. 1. Dakota group proper. Shales over Evans quarry
1	Equisetum virginicum Font								×						×							
2	Weichselia reticulata (Stokes and Webb) Ward															×	×	×	×	×		
3	Matonidium Althausii (Dunk.) Ward														×			×				
4	Pecopteris Geyleriana Nath														×		×	×	×			
5	borealis Brongn																		×			
6	Cladophlebis wyomingensis n. sp																		×			
7	parva Font								×													
8	Sphenopteris plurinervia Heer (?)								×													
9	Thyrsopteris pinnatifida Font (?)								×													
10	crassinervis Font								×													
11	elliptica Font	×					×		×													
12	dentifolia n. sp			×																		
13	brevifolia Font			×																		
14	pecopteroides Font			×																		
15	brevipennis Font								×													
16	Scleropteris distantifolia n. sp								×													
17	rotundifolia n. sp								×													
18	Asplenium Dicksonianum Heer					×															×	
19	Gleichenia Zippei Heer (?)					×																
20	Cycadeoidea dacotensis (McBride) Ward emend									×	×		×	×								
21	colossalis n. sp									×												
22	Wellsii n. sp									×												
23	minnekahtensis n. sp									×												
24	pulcherrima n. sp									×												
25	cicatricula n. sp												×									
26	turrita n. sp									×												
27	McBridei n. sp									×			×									
28	Marshiana n. sp									×												
29	furcata n. sp									×												
30	Colei n. sp									×												
31	Paynei n. sp									×												
32	aspera n. sp												×									
33	insolita n. sp									×												
34	occidentalis n. sp									×												
35	Jenneyana Ward									×			×									
36	ingens n. sp												×									
37	formosa n. sp												×									
38	Stillwelli n. sp									×			×									
39	excelsa n. sp											×										
40	nana n. sp									×												
41	Zamites brevipennis Heer							×														
42	borealis Heer		×		×			×									×					
43	(?) sp. Font																					
44	Glossozamites Fontaineanus Ward n. sp					×											×					
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46	Williamsonia (?) phœnicopsoides Ward n. sp								×													
47	Araucarioxylon Hoppertonæ Kn. n. sp									×												
48	Araucarites wyomingensis n. sp	×							×													
49	(?) cuneatus Ward n. sp							×							×				×			
50	Pinus susquaensis Dn		×				×												×			
51	Abietites angusticarpus Font														×		×		×			
52	Leptostrobus longifolius Font														×							
53	alatus Ward n. sp														×				×			
54	Athrotaxopsis tenuicaulis Font														×				×			
55	Sequoia Reichenbachi (Gein.) Heer														×	×						
56	gracilis Heer																					
57	sp. Font. (immature cone)								×						×				×			
58	Geinitzia Jenneyi n. sp														×	×	×		×			
59	Sphenolepidium Kurrianum (Dunk.) Heer														×				×			
60	parceramosum Font														×				×			
61	Glyptostrobus brookensis (Font.) Ward																					
62	Nageiopsis longifolia Font						×		×													
63	angustifolia Font. (?)						×															
64	Baieropsis adiantifolia Font						×		×						×							
65	pluripartita Font (?)						×															
66	Czekanowskia nervosa Heer		×				×								×							
67	Cephalotaxopsis magnifolia Font						×		×													
68	Malo ament of a conifer								×						×							
69	Quercophyllum wyomingense n. sp																					
70	Quercus Wardiana Lx. (?)																					×
71	Ulmiphyllum densinerve n. sp																		×			
72	Ficophyllum serratum Font																					
73	Sassafras Mudgii Lx																					×
74	Platanus cissoides Lx. (?)																					×
75	Celastrophyllum pulchrum Ward n. sp																		×			×
76	Sapindopsis variabilis Font																				×	
77	Cissites salisburiæfolius Lx																				×	
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79	Viburnites Evansanus Ward																					×
80	Male ament of a dicotyledon								×													
81	Carpolithus fasciculatus Font								×													
82	montium-nigrorum Ward n. sp								×													
83	barrensis Ward n. sp							×							×							
84	virginiensis Font																					
85	fœnarius Ward n. sp	×													×							
86	Feistmantelia oblonga Ward n. gen. n. sp																					

American distribution outside of the Black Hills.

Systematic number	Names of the species	Lower Cretaceous. Trinity of Texas	Lower Cretaceous. Kootanie of Great Falls, Montana	Lower Cretaceous. Kootanie of British America	Lower Cretaceous. Cape Lisburn, Alaska	Lower Cretaceous. Shasta group, California	Lower Cretaceous. James River, Virginia	Lower Cretaceous. Rappahannock series, Virginia	Lower Cretaceous. Mount Vernon series, Virginia	Lower Cretaceous. Aquia Creek series, Virginia and Maryland	Lower Cretaceous. Tuscaloosa formation, Alabama	Lower Cretaceous. Amboy clays, New Jersey	Lower Cretaceous. Cheyenne sandstone, Kansas	Lower Cretaceous. Island series	Upper Cretaceous. Cliffwood, New Jersey, Matawan formation	Upper Cretaceous. Morrison, Colorado	Upper Cretaceous. Dakota group of Kansas and Nebraska	Upper Cretaceous. Kanab Valley, Utah	Upper Cretaceous. Vancouver Island	Upper Cretaceous. Peace and Pine rivers, British America	Upper Cretaceous. Belly River, British America	Upper Cretaceous. Rock Creek, Wyoming	Upper Cretaceous. Livingston, Montana	Upper Cretaceous. Spring Canyon, Montana
1	Equisetum virginicum Font						×	(?)																
2	Weichselia reticulata (Stokes and Webb) Ward																							
3	Matonidium Althausii (Dunk.) Ward																							
4	Pecopteris Geyleriana Nath																							
5	borealis Brongn																							
6	Cladophlebis wyomingensis n. sp																							
7	parva Font		×					×			×													
8	Sphenopteris plurinervia Heer (?)																							
9	Thyrsopteris pinnatifida Font (?)							×																
10	crassinervis Font							×																
11	elliptica Font						×	×																
12	dentifolia n. sp																							
13	brevifolia Font		×				×		×															
14	pecopteroides Font							×																
15	brevipennis Font		×				×			×														
16	Scleropteris distantifolia n. sp																							
17	rotundifolia n. sp																							
18	Asplenium Dicksonianum Heer			×	×							×		×			×							
19	Gleichenia Zippei Heer (?)											×												
20	Cycadeoidea dacotensis (McBride) Ward emend																							
21	colossalis n. sp																							
22	Wellsii n. sp																							
23	minnekahtensis n. sp																							
24	pulcherrima n. sp																							
25	cicatricula n. sp																							
26	turrita n. sp																							
27	McBridei n. sp																							
28	Marshiana n. sp																							
29	furcata n. sp																							
30	Colei n. sp																							
31	Paynei n. sp																							
32	aspera n. sp																							
33	insolita n. sp																							
34	occidentalis n. sp																							
35	Jenneyana Ward																							
36	ingens n. sp																							
37	formosa n. sp																							
38	Stillwelli n. sp																							
39	excelsa n. sp																							
40	nana n. sp																							
41	Zamites brevipennis Heer																							
42	borealis Heer		×																					
43	(?) sp. Font																							
44	Glossozamites Fontaineanus Ward n. sp																							
45	Cycadeospermum rotundatum Font	×	(?)																					
46	Williamsonia (?) phœnicopsoides Ward n. sp																							
47	Araucarioxylon Hoppertonæ Kn. n. sp																							
48	Araucarites wyomingensis n. sp																							
49	(?) cuneatus Ward n. sp																							
50	Pinus susquaensis Dn			×																				
51	Abietites angusticarpus Font					×		×		×														
52	Leptostrobus longifolius Font			×			×	×		×														
53	alatus Ward n. sp																							
54	Athrotaxopsis tenuicaulis Font						×	×		×														
55	Sequoia Reichenbachi (Gein.) Heer		×				×	×		×	×	×		×		×	×	×	×	×	×	×	×	×
56	gracilis Heer		×							×														
57	sp. Font. (immature cone)																							
58	Geinitzia Jenneyi n. sp																							
59	Sphenolepidium Kurrianum (Dunk.) Heer						×	×		×														
60	parceramosum Font							×		×														
61	Glyptostrobus brookensis (Font.) Ward						(?)		×	×														
62	Nageiopsis longifolia Font					×	×	×	×	×														
63	angustifolia Font. (?)						×	×	(?)	×														
64	Baieropsis adiantifolia Font						×																	
65	pluripartita Font (?)						×																	
66	Czekanowskia nervosa Heer																							
67	Cephalotaxopsis magnifolia Font					(?)	×	×																
68	Malo ament of a conifer																							
69	Quercophyllum wyomingense n. sp																							
70	Quercus Wardiana Lx. (?)															×								
71	Ulmiphyllum densinerve n. sp																							
72	Ficophyllum serratum Font							×		×														
73	Sassafras Mudgii Lx												×				×							
74	Platanus cissoides Lx. (?)																×							
75	Celastrophyllum pulchrum Ward n. sp									×														
76	Sapindopsis variabilis Font									×														
77	Cissites salisburiæfolius Lx												×				×							
78	ingens Lx																×							
79	Viburnites Evansanus Ward																							
80	Male ament of a dicotyledon																							
81	Carpolithus fasciculatus Font							×																
82	montium-nigrorum Ward n. sp																							
83	barrensis Ward n. sp																							
84	virginiensis Font		×				×																	
85	fœnarius Ward n. sp																							
86	Feistmantelia oblonga Ward n. gen. n. sp							×					(?)											

Foreign distribution.

Systematic number	Names of the species	Jurassic. Bavaria (Rhætic)	Jurassic. Italy (Lias)	Jurassic. Kach, India (Lias)	Jurassic. Yorkshire (Oolite)	Jurassic. Cracow (Oolite)	Jurassic. Portugal (Jurassic)	Jurassic. Purbeck beds (England)	Wealden. England	Wealden. France	Wealden. Germany	Neocomian. Belgium	Neocomian. Portugal	Neocomian. Westphalia	Neocomian. Russia	Neocomian. Spitzbergen	Neocomian. Japan	Urgonian. Austrian Silesia	Urgonian. Portugal	Urgonian. Greenland (Kome beds)	Aptian. Portugal	Gault. Portugal	Gault. Switzerland	Gault. Westphalia	Cenomanian. Greenland (Atane beds)	Cenomanian. Portugal	Cenomanian. Saxony	Cenomanian. Bohemia	Cenomanian. Moravia	Turonian. Saxony	Senonian. France	Senonian. Westphalia	Senonian. Aachen	Senonian. Silesia	Senonian. Quedlinburg	Senonian. Bohemia (Gosau)	Senonian. Greenland (Patoot beds)	Systematic number
1	Equisetum virginicum Font																																					1
2	Weichselia reticulata (Stokes and Webb) Ward							×	×	×	×	×		×	×		×	×			×			×											×			2
3	Matonidium Althausii (Dunk.) Ward	×			×	×		×			×	×	×		×																				×			3
4	Pecopteris Geyleriana Nath																×																					4
5	borealis Brongn																			×					×													5
6	Cladophlebis wyomingensis n. sp																																					6
7	parva Font																																					7
8	Sphenopteris plurinervia Heer (?)												×						×		×																	8
9	Thyrsopteris pinnatifida Font (?)																																					9
10	crassinervis Font																																					10
11	elliptica Font																																					11
12	dentifolia n. sp																																					12
13	brevifolia Font																																					13
14	pecopteroides Font																																					14
15	brevipennis Font																																					15
16	Scleropteris distantifolia n. sp																																					16
17	rotundifolia n. sp																																					17
18	Asplenium Dicksonianum Heer																			×					×													18
19	Gleichenia Zippei Heer (?)															×				×					×			×							×	×	×	19
20	Cycadeoidea dacotensis (McBride) Ward emend																																					20
21	colossalis n. sp																																					21
22	Wellsii n. sp																																					22
23	minnekahtensis n. sp																																					23
24	pulcherrima n. sp																																					24
25	cicatricula n. sp																																					25
26	turrita n. sp																																					26
27	McBridei n. sp																																					27
28	Marshiana n. sp																																					28
29	furcata n. sp																																					29
30	Colei n. sp																																					30
31	Paynei n. sp																																					31
32	aspera n. sp																																					32
33	insolita n. sp																																					33
34	occidentalis n. sp																																					34
35	Jenneyana Ward																																					35
36	ingens n. sp																																					36
37	formosa n. sp																																					37
38	Stillwelli n. sp																																					38
39	excelsa n. sp																																					39
40	nana n. sp																																					40
41	Zamites brevipennis Heer																			×																		41
42	borealis Heer																			×																		42
43	(?) sp. Font																																					43
44	Glossozamites Fontaineanus Ward n. sp																																					44
45	Cycadeospermum rotundatum Font																																					45
46	Williamsonia (?) phœnicopsoides Ward n. sp																																					46
47	Araucarioxylon Hoppertonæ Kn. n. sp																																					47
48	Araucarites wyomingensis n. sp																																					48
49	(?) cuneatus Ward n. sp																																					49
50	Pinus susquaensis Dn																																					50
51	Abietites angusticarpus Font																																					51
52	Leptostrobus longifolius Font																																					52
53	alatus Ward n. sp																																					53
54	Athrotaxopsis tenuicaulis Font																																					54
55	Sequoia Reichenbachi (Gein.) Heer						×					×				×		×		×			×		×		×		×	×	×	×	×		×			55
56	gracilis Heer																			×																		56
57	sp. Font. (immature cone)																																					57
58	Geinitzia Jenneyi n. sp																																					58
59	Sphenolepidium Kurrianum (Dunk.) Heer								×		×		×	×	×				×							×	×											59
60	parceramosum Font																																					60
61	Glyptostrobus brookensis (Font.) Ward																																					61
62	Nageiopsis longifolia Font																																					62
63	angustifolia Font. (?)																																					63
64	Baieropsis adiantifolia Font																																					64
65	pluripartita Font (?)																																					65
66	Czekanowskia nervosa Heer																				×	×				×												66
67	Cephalotaxopsis magnifolia Font																																					67
68	Malo ament of a conifer																																					68
69	Quercophyllum wyomingense n. sp																																					69
70	Quercus Wardiana Lx. (?)																																					70
71	Ulmiphyllum densinerve n. sp																																					71
72	Ficophyllum serratum Font																																					72
73	Sassafras Mudgii Lx																																					73
74	Platanus cissoides Lx. (?)																																					74
75	Celastrophyllum pulchrum Ward n. sp																																					75
76	Sapindopsis variabilis Font																																					76
77	Cissites salisburiæfolius Lx																																					77
78	ingens Lx																																					78
79	Viburnites Evansanus Ward																																					79
80	Male ament of a dicotyledon																																					80
81	Carpolithus fasciculatus Font																																					81
82	montium-nigrorum Ward n. sp																																					82
83	barrensis Ward n. sp																																					83
84	virginiensis Font																																					84
85	fœnarius Ward n. sp																																					85
86	Feistmantelia oblonga Ward n. gen. n. sp			(?)																																		86

PLATES.

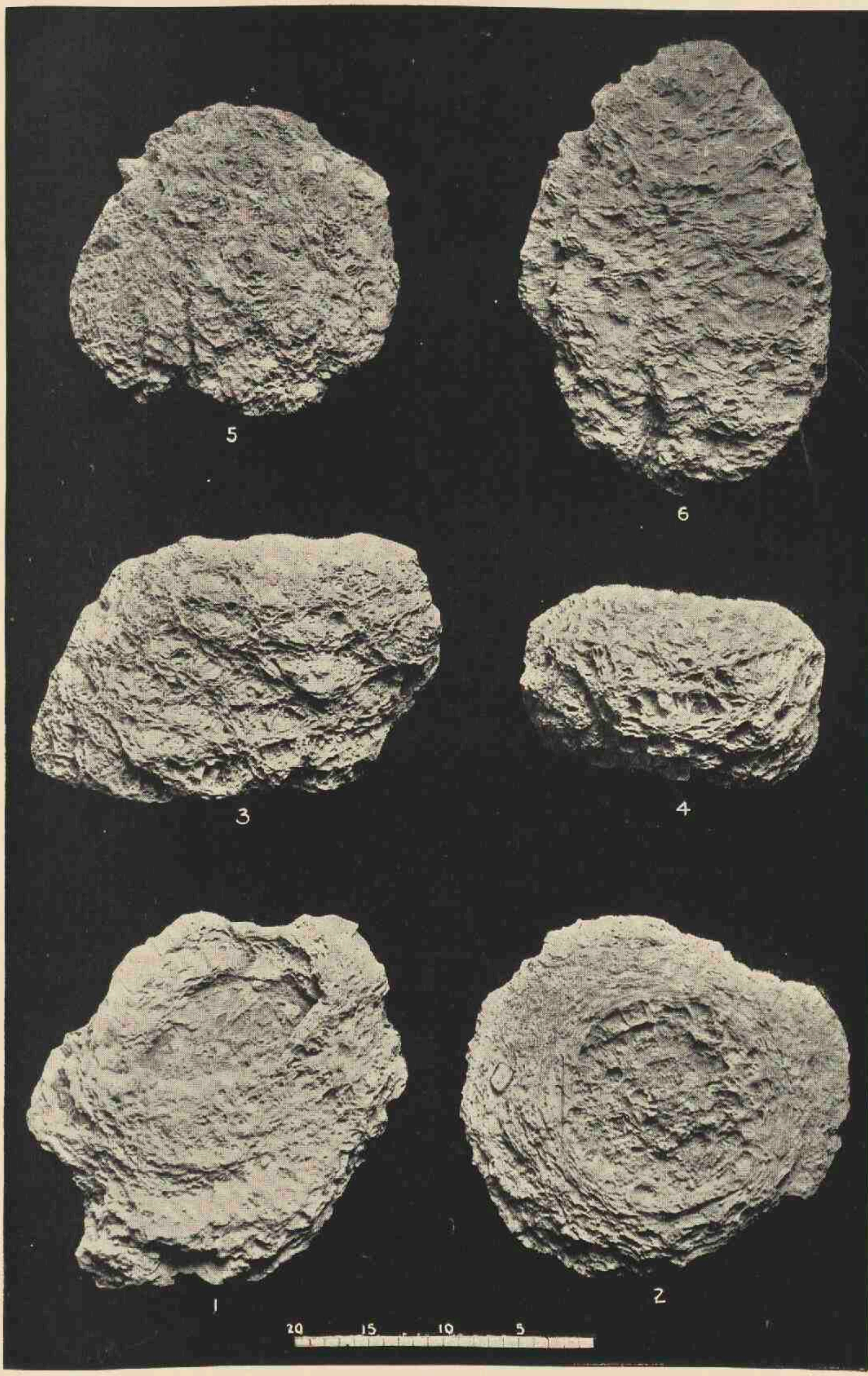
PLATE LVII.

PLATE LVII.

CYCADEAN TRUNKS FROM THE PURBECK BEDS OF THE ISLE OF PORTLAND, ENGLAND, BELONGING TO THE U. S. NATIONAL MUSEUM COLLECTION.

	Page.
FIGS. 1, 2. CYCADEOIDEA MEGALOPHYLLA Buckl	601
FIGS. 3, 4. CYCADEOIDEA MICROPHYLLA Buckl	601
FIGS. 5, 6. CYCADEOIDEA PORTLANDICA Carr	601

Scale, 20 cm.

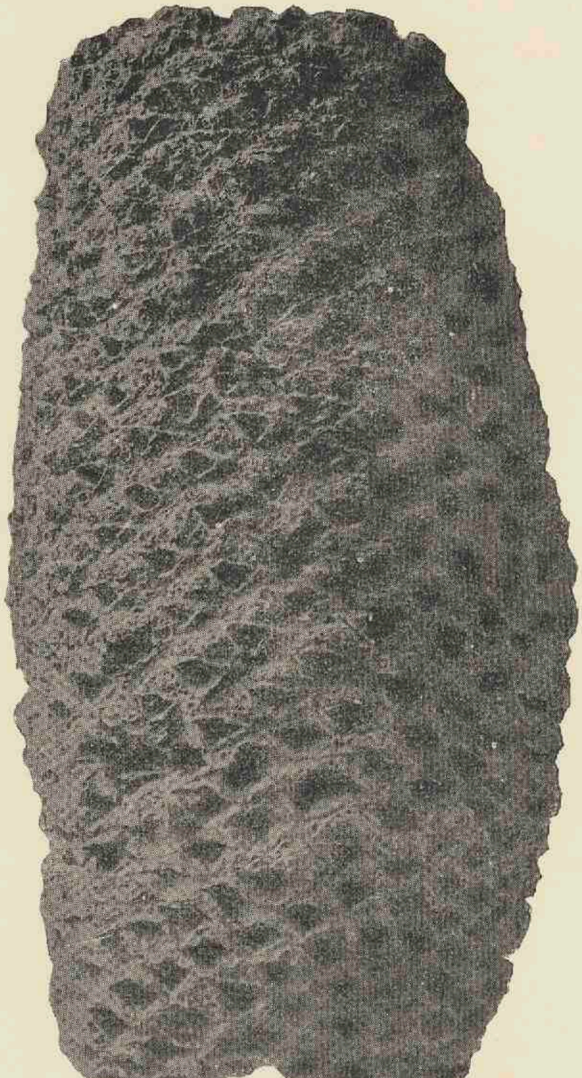


GROUP OF CYCADEAN TRUNKS FROM THE PURBECK BEDS OF THE ISLE OF PORTLAND, ENGLAND.

PLATE LVIII.

PLATE LVIII.

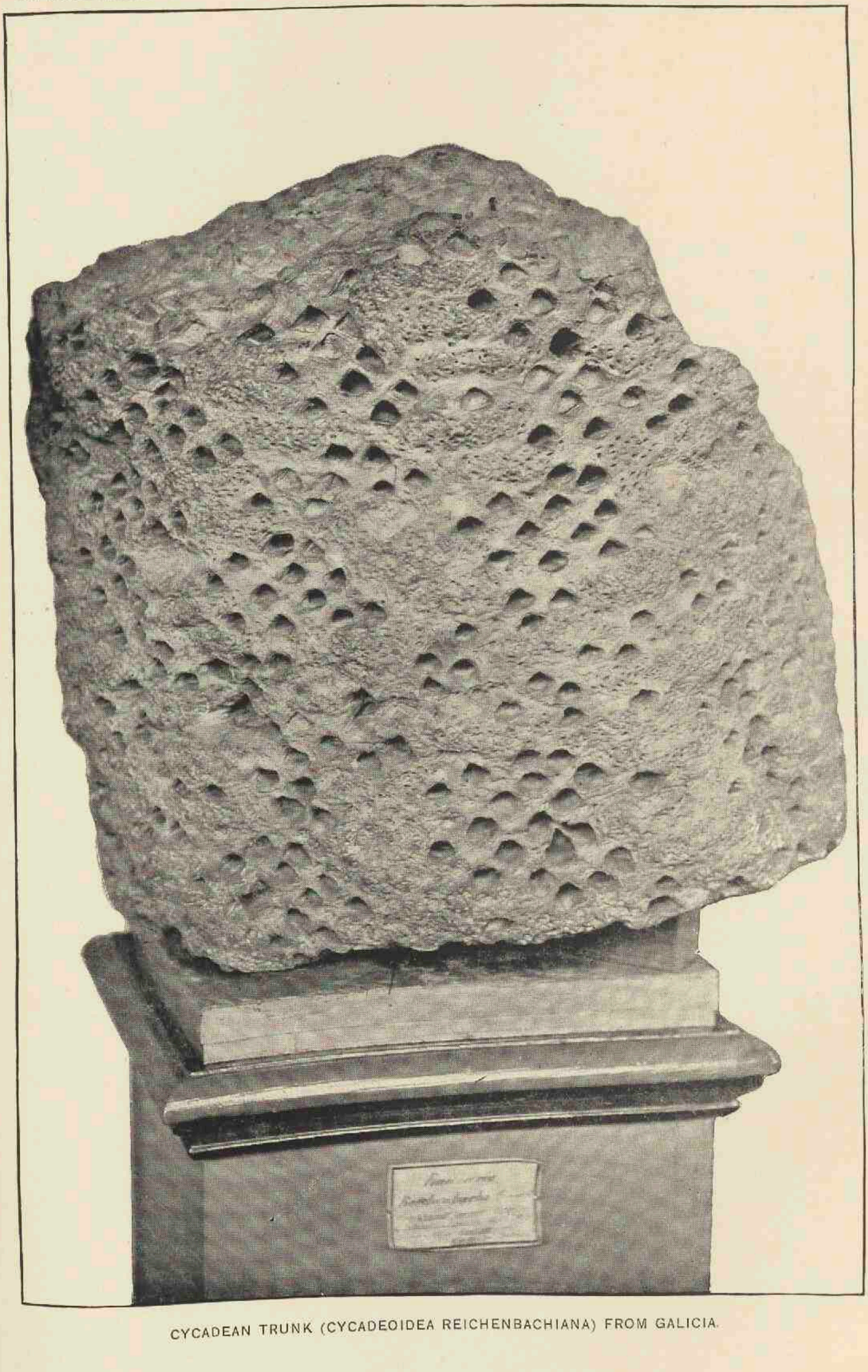
Scale, 10 cm.



CYCADEAN TRUNK (CYCADEOIDEA MASSEIANA) FROM THE SCALY CLAYS OF ITALY.

PLATE LIX.

PLATE LIX.



CYCADEAN TRUNK (CYCADEOIDEA REICHENBACHIANA) FROM GALICIA.

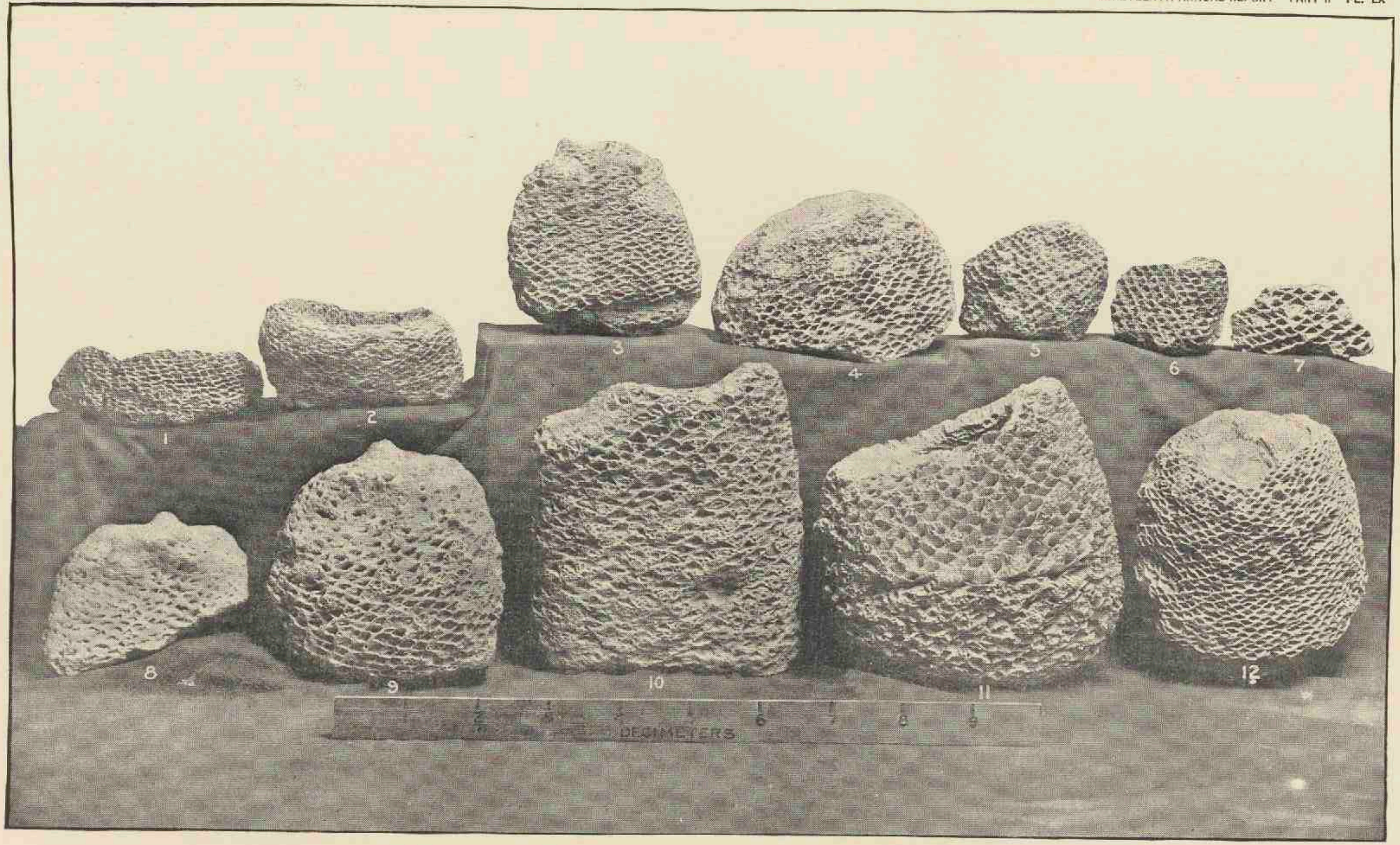
PLATE LX.

PLATE LX.

GROUP OF FOSSIL CYCADEAN TRUNKS FROM THE POTOMAC FORMATION OF MARYLAND, BELONGING TO THE WOMAN'S COLLEGE OF BALTIMORE, COLLECTED BY MR. ARTHUR BIBBINS.

Scale, 1 meter.

In photographing the trunk represented by Fig. 10 it was accidentally inverted



GROUP OF CYCADEAN TRUNKS FROM THE POTOMAC FORMATION OF MARYLAND.

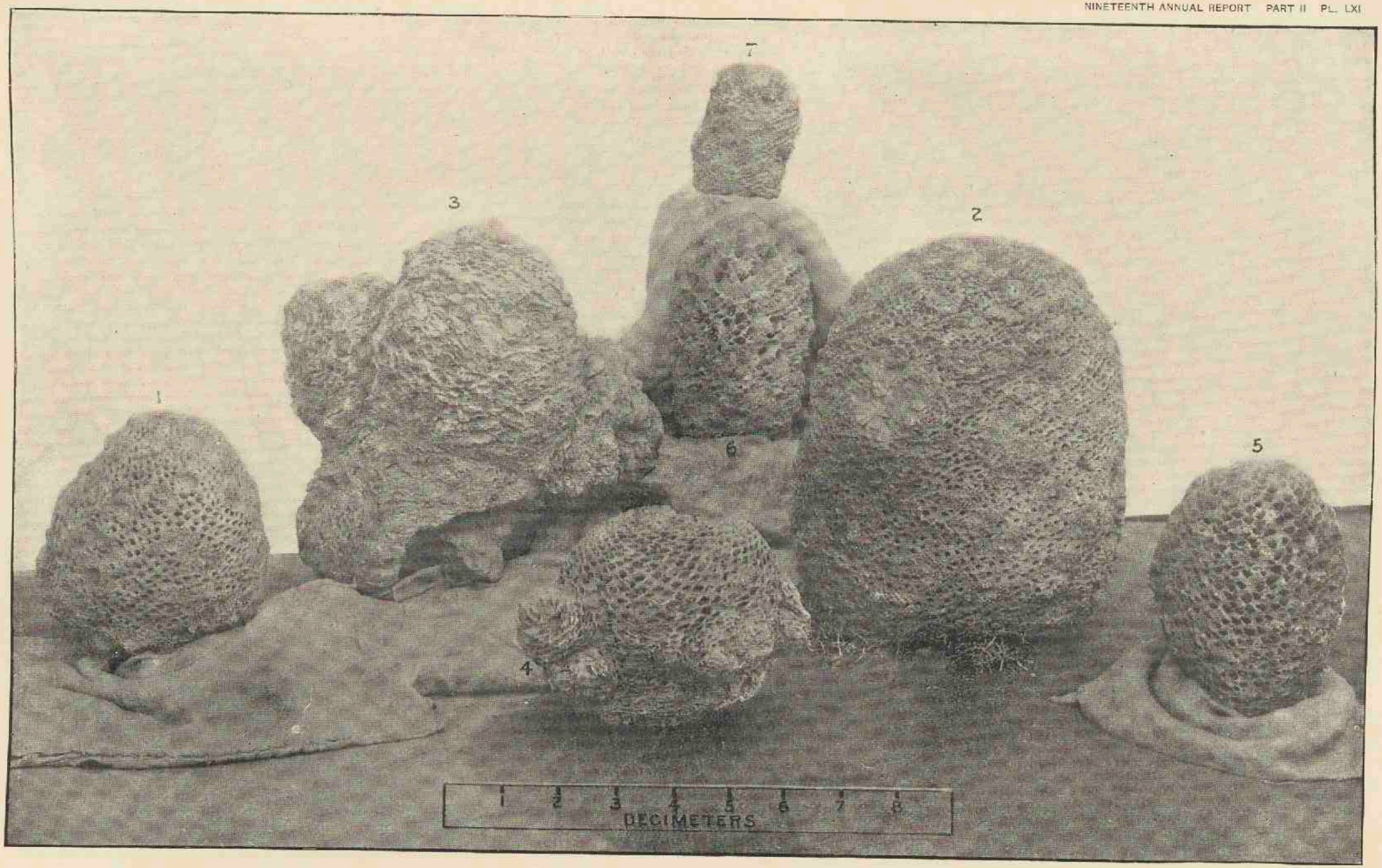
PLATE LXI.

PLATE LXI.

GROUP OF FOSSIL CYCADEAN TRUNKS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

		Page.
FIG. 1.	CYCADEOIDEA DACOTENSIS (McBride) Ward emend	602
FIG. 2.	CYCADEOIDEA COLOSSALIS n. sp	602
FIG. 3.	CYCADEOIDEA MINNEKAHTENSIS n. sp	602
FIG. 4.	CYCADEOIDEA PULCHERRIMA n. sp	602
FIG. 5.	CYCADEOIDEA COLEI n. sp	602
FIG. 6, 7.	CYCADEOIDEA PAYNEI n. sp	602

Scale, 1 meter.



GROUP OF CYCADEAN TRUNKS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE LXII.

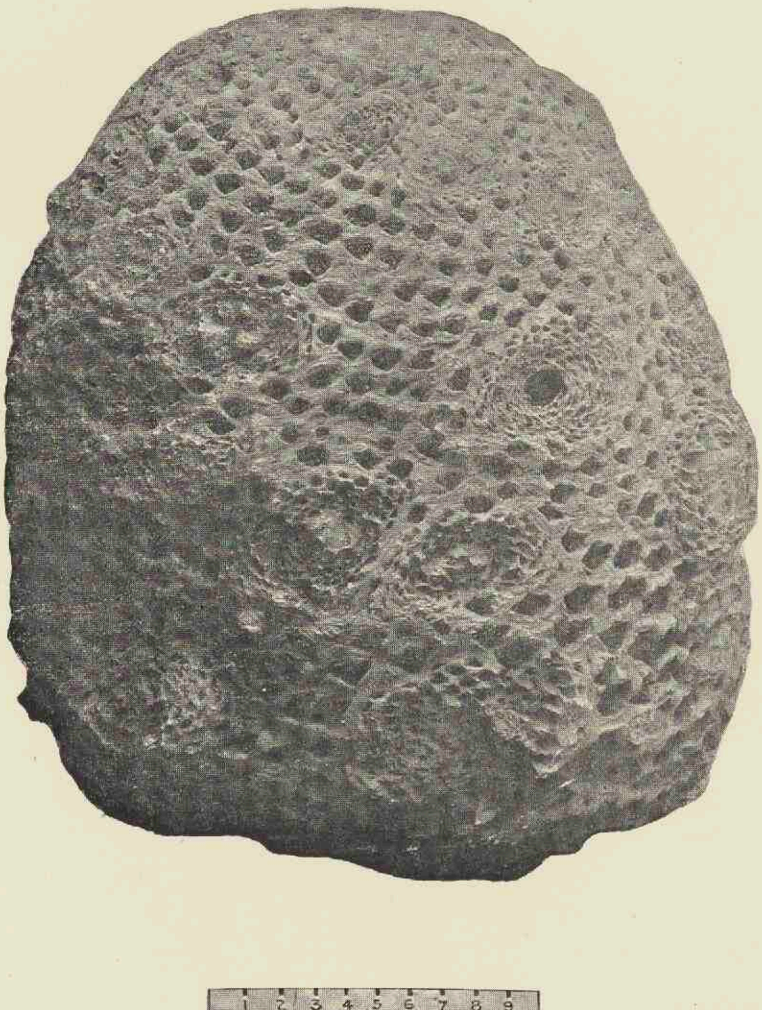
PLATE LXII.

Page

CYCADEOIDEA DACOTENSIS (McBride) Ward emend 602

Side view of trunk No. 1, U. S. National Museum collection.

Scale, 10 cm.



CYCADEOIDEA DACOTENSIS.

PLATE LXIII.

PLATE LXIII.

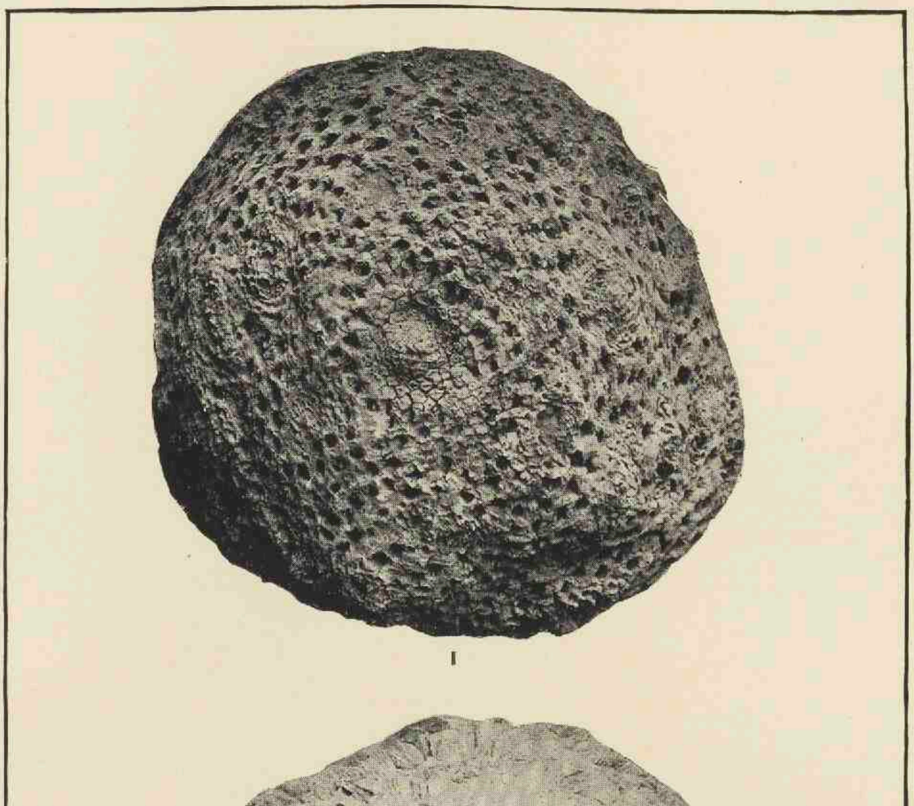
Page.

Cycadeoidea dacotensis (McBride) Ward emend., No. 1, U. S. National Museum collection 602

Fig. 1. View of the apex, showing arrangement of scars in the terminal bud.

Fig. 2. View of the base.

Scale, 10 cm.



CYCADEOIDEA DACOTENSIS.

PLATE LXIV.

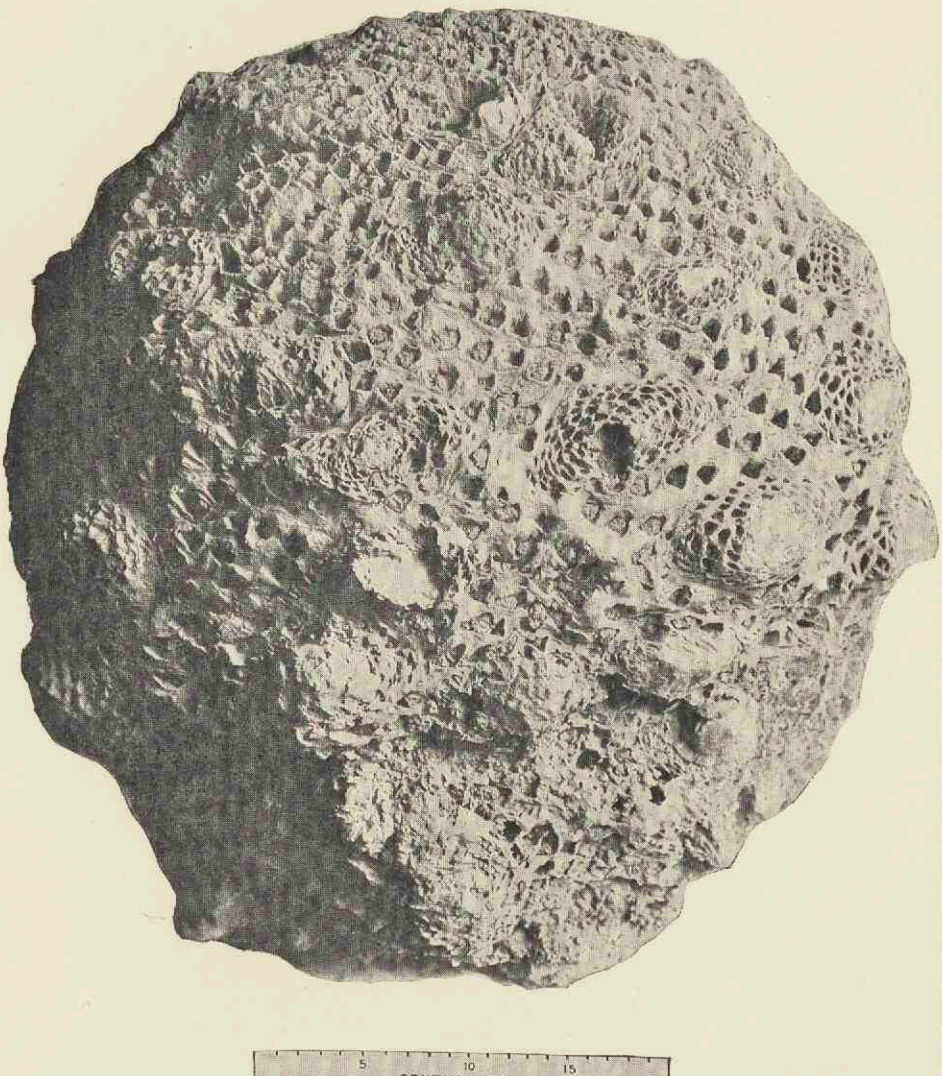
PLATE LXIV.

Page.

CYCADEOIDEA DACOTENSIS (McBride) Ward emend 602

Side view of trunk No. 54 of the Yale collection.

Scale, 20 cm.



CYCADEOIDEA DACOTENSIS.

PLATE LXV.

PLATE LXV.

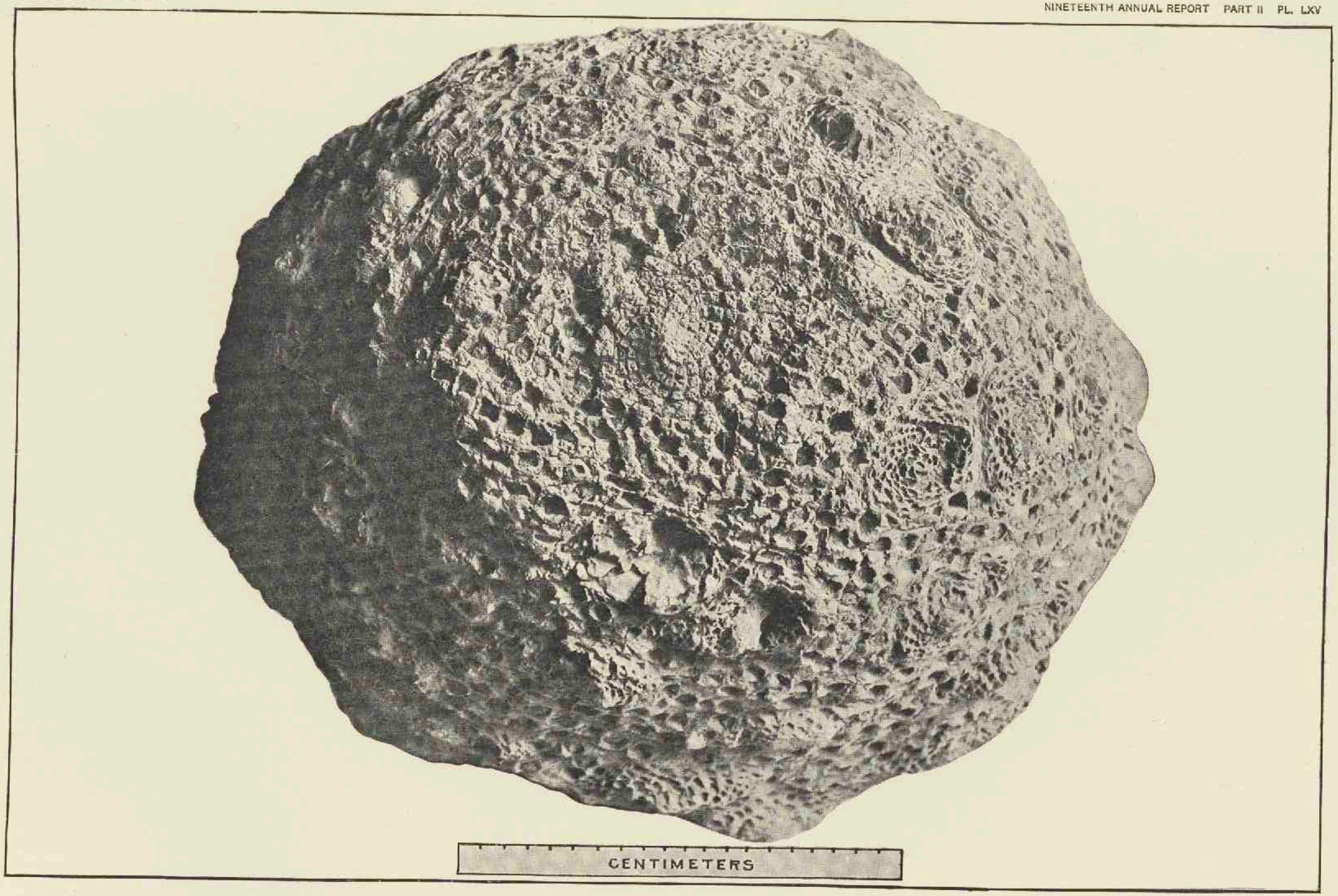
Page.

CYCADEOIDEA DACOTENSIS (McBride) Ward emend 602

View of the apex of trunk No. 54 of the Yale collection, showing helicoid arrangement of scars in the terminal bud.

Scale, 20 cm.

732



CYCADEOIDEA DACOTENSIS.

PLATE LXVI.

PLATE LXVI.

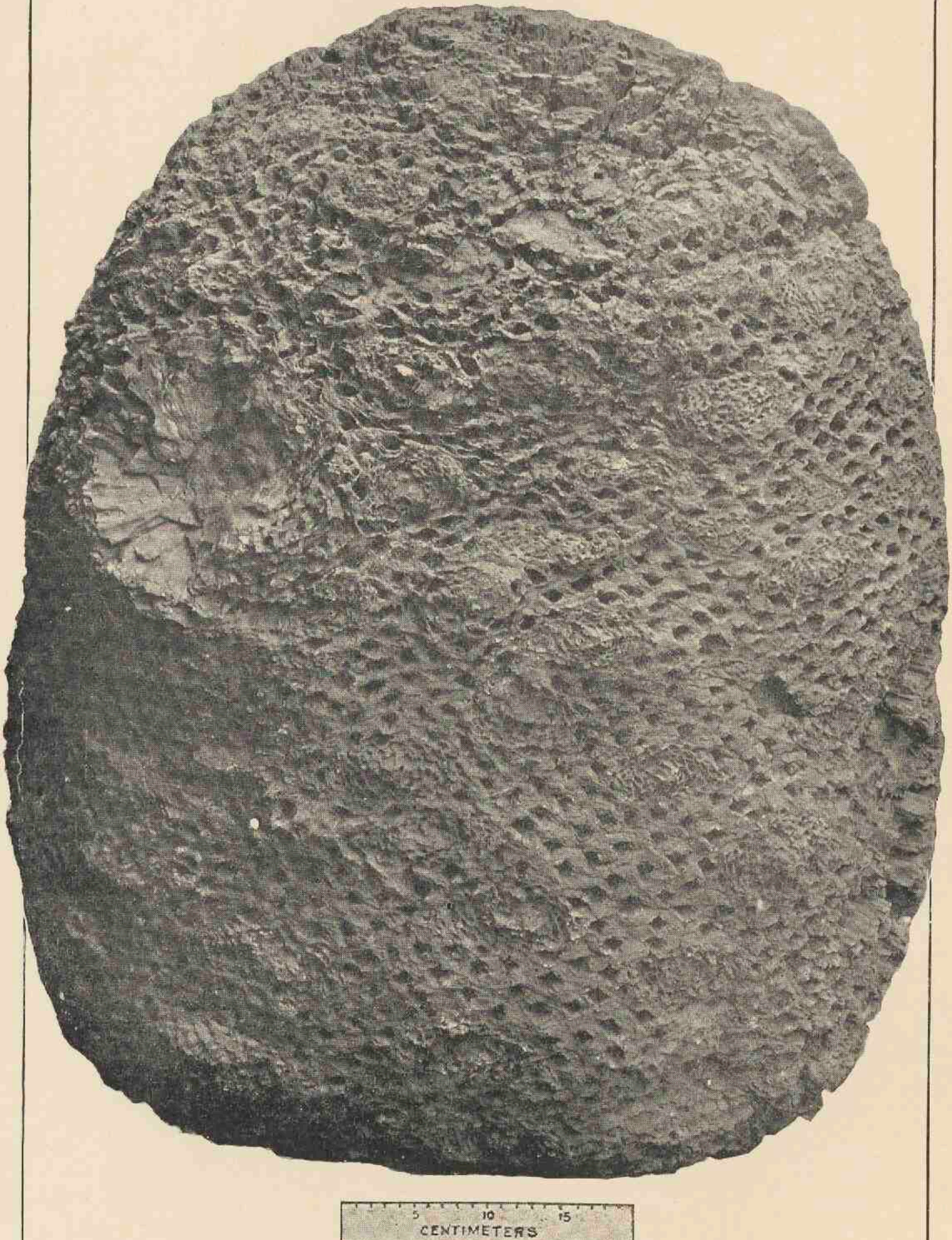
View of the fractured side of trunk No. 13 of the Yale collection, showing internal structure, terminal bud, etc.

Scale, 20 cm.

CYCADEOIDEA DACOTENSIS.

PLATE LXVII.

PLATE LXVII.



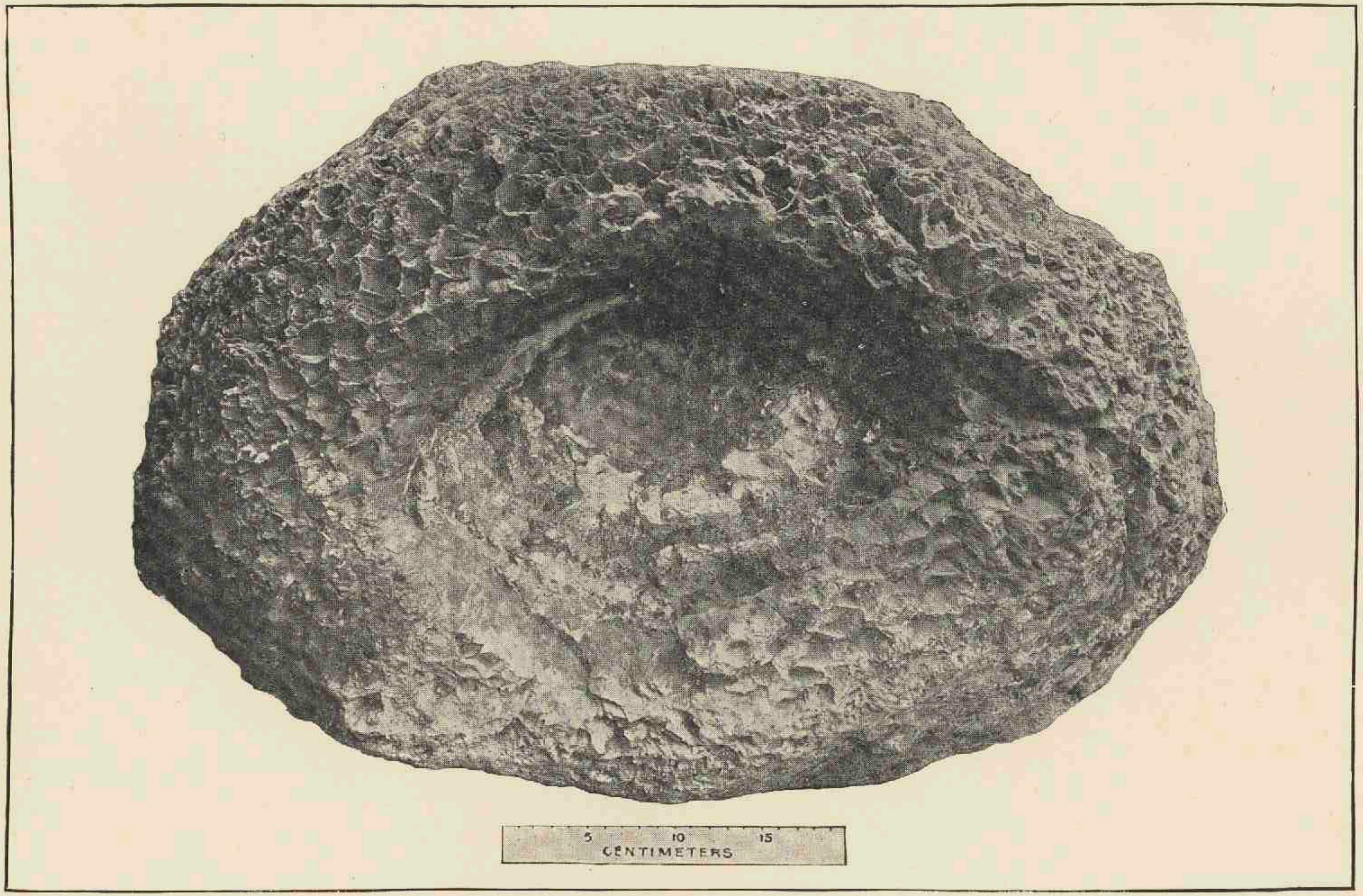
CYCADEOIDEA COLOSSALIS.

PLATE LXVIII.

PLATE LXVIII.

	Page.
CYCADEOIDEA COLOSSALIS n. sp	603

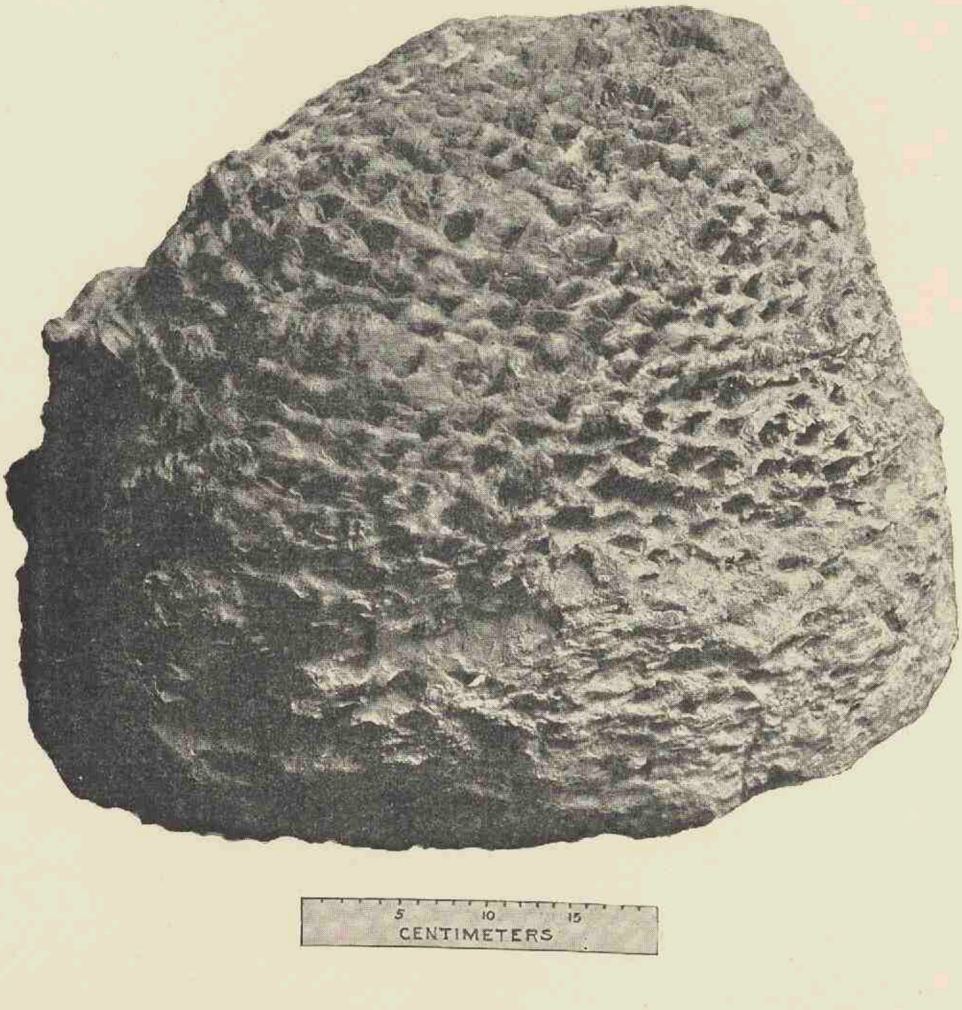
View of the base of trunk No. 6 of the U. S. National Museum collection.
Scale, 20 cm.



CYCADEOIDEA COLOSSALIS.

PLATE LXIX.

PLATE LXIX.



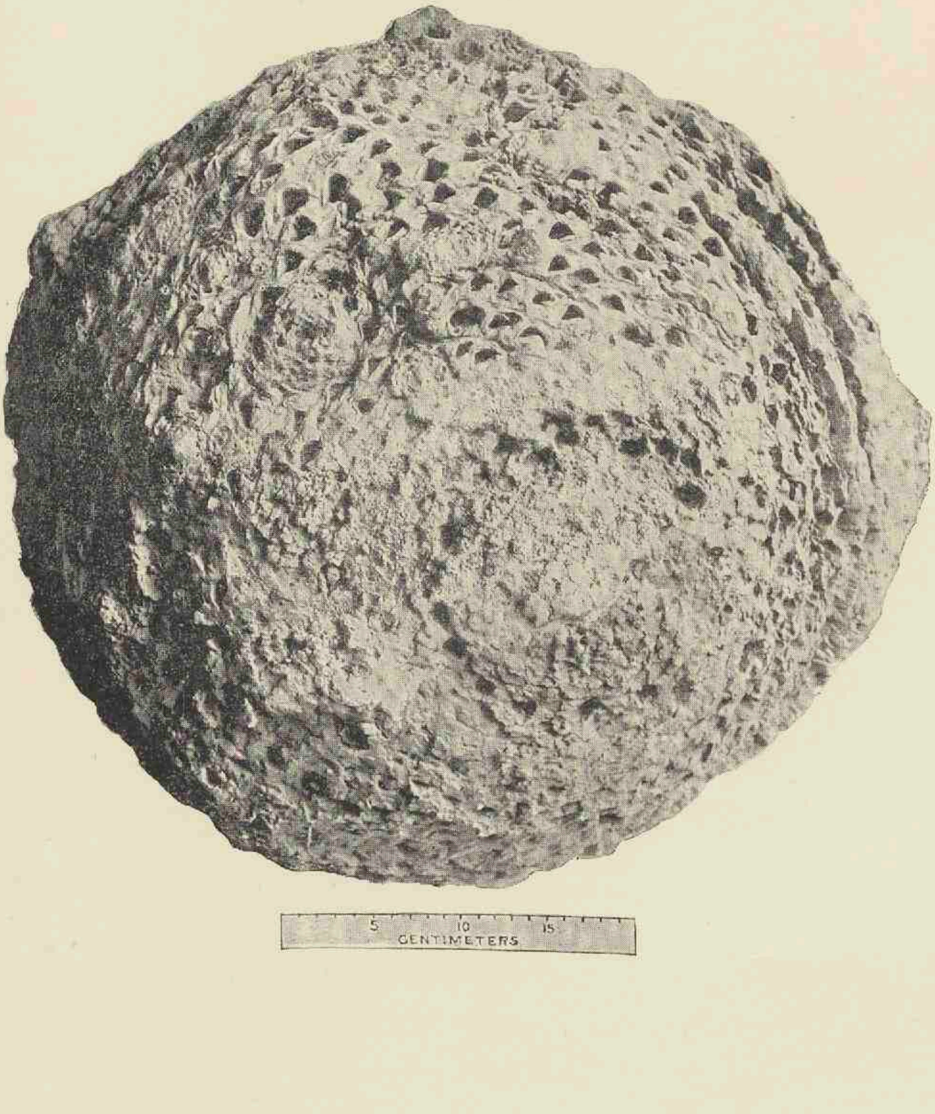
CYCADEOIDEA COLOSSALIS.

PLATE LXX.

PLATE LXX.

View of the apex of trunk No. 2 of the Yale collection.

Scale, 20 cm.

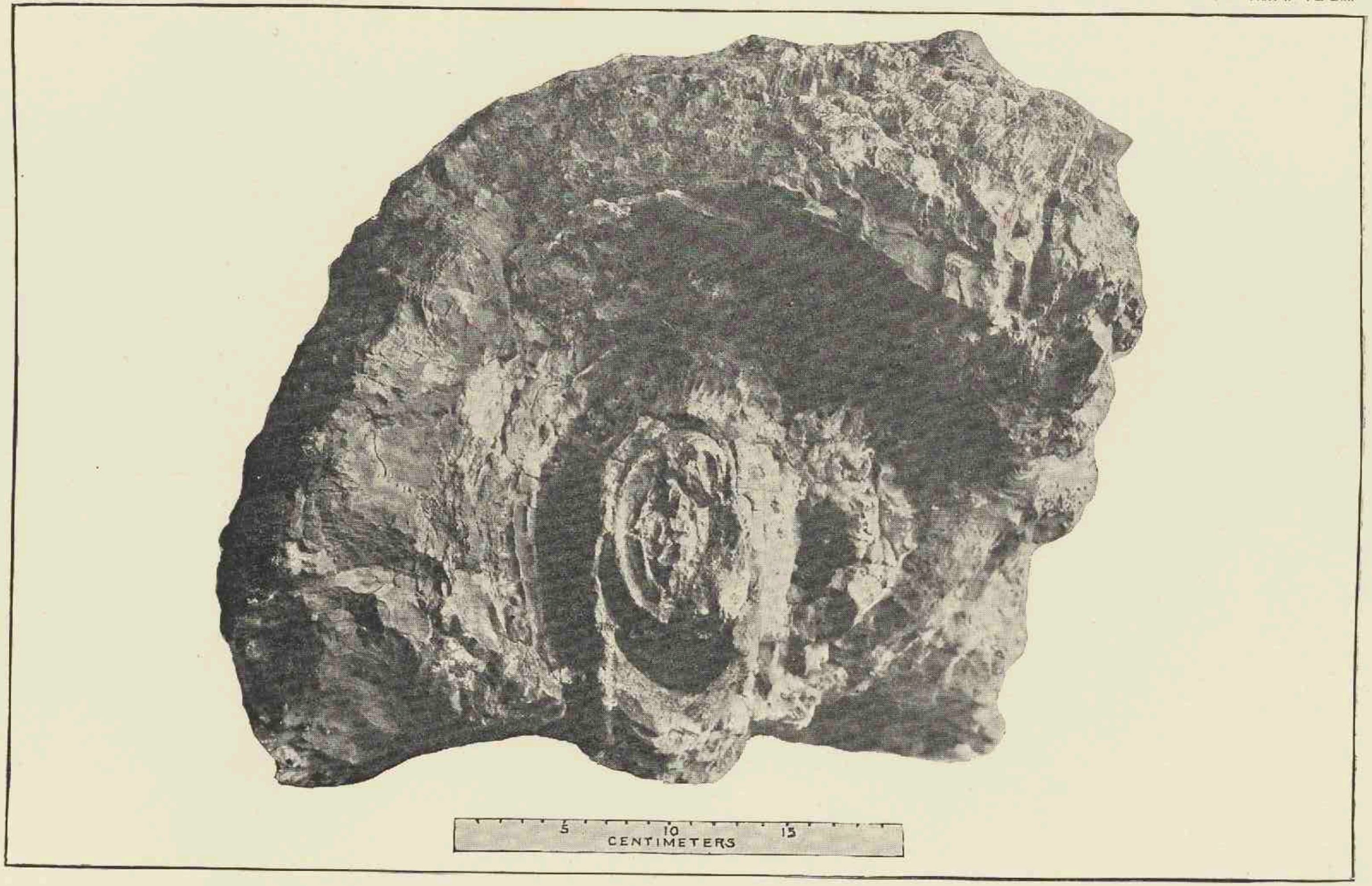


CYCADEOIDEA COLOSSALIS.

PLATE LXXI.

	Page.
CYCADEOIDEA COLOSSALIS n. sp.	603

View of the base and interior of trunk No. 17 of the Yale collection.
Scale, 20 cm.

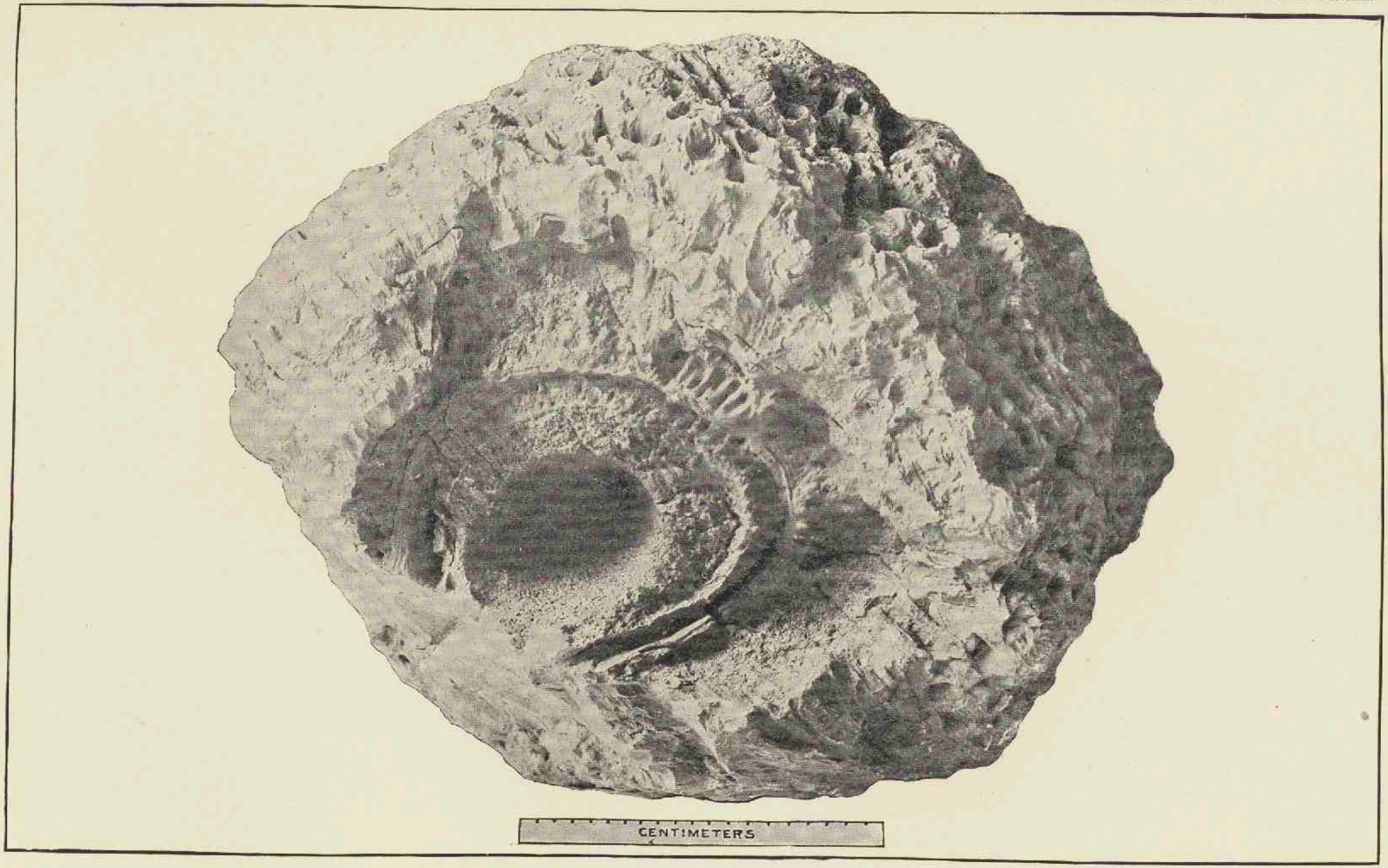


CYCADEOIDEA COLOSSALIS.

PLATE LXXII.

PLATE LXXII.

View of the base of trunk No. 55 of the Yale collection.
Scale, 20 cm.



CYCADEOIDEA COLOSSALIS.

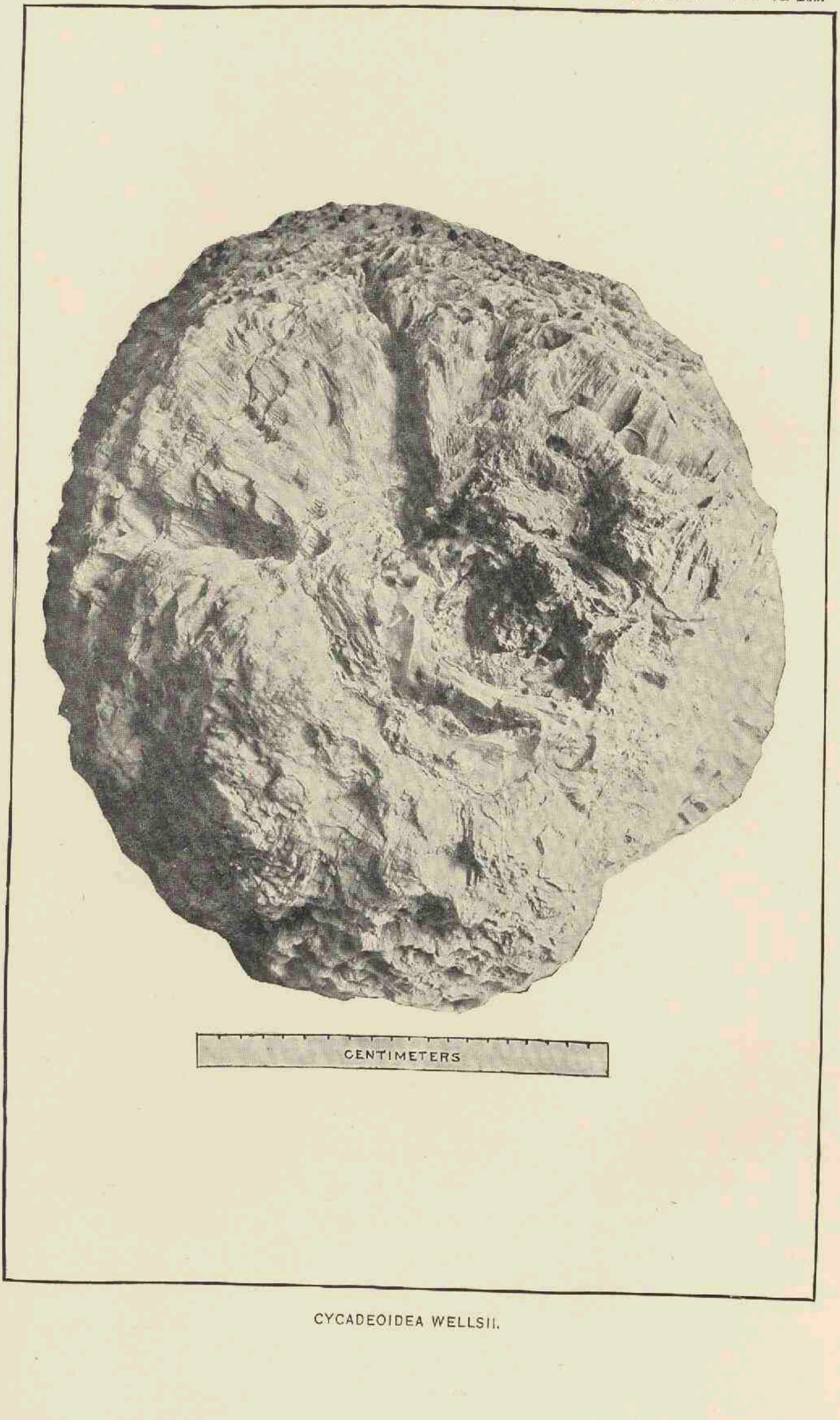
PLATE LXXIII.

PLATE LXXIII.

CYCADEOIDEA WELLSII.

PLATE LXXIV.

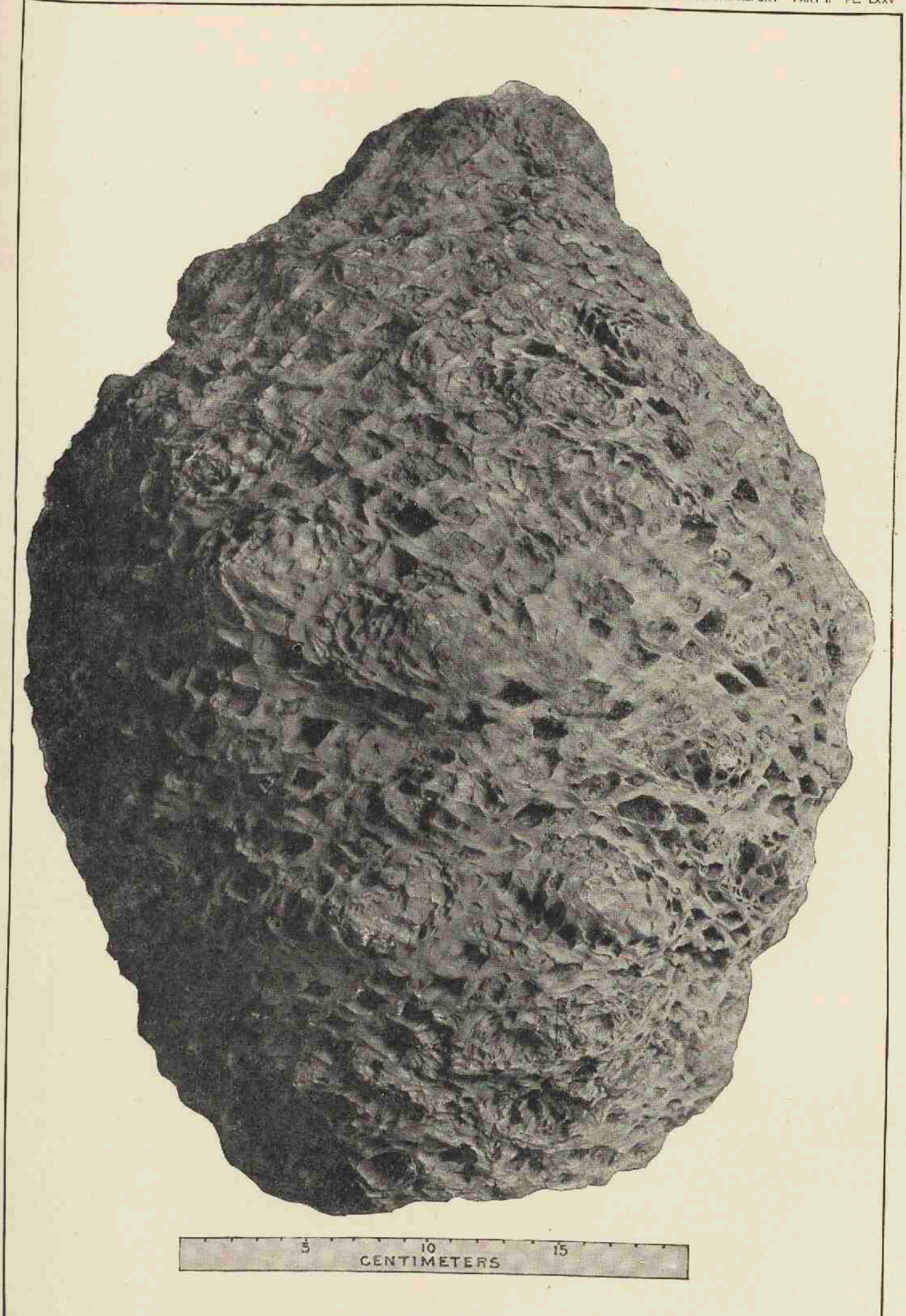
PLATE LXXIV.



CYCADEOIDEA WELLSII.

PLATE LXXV.

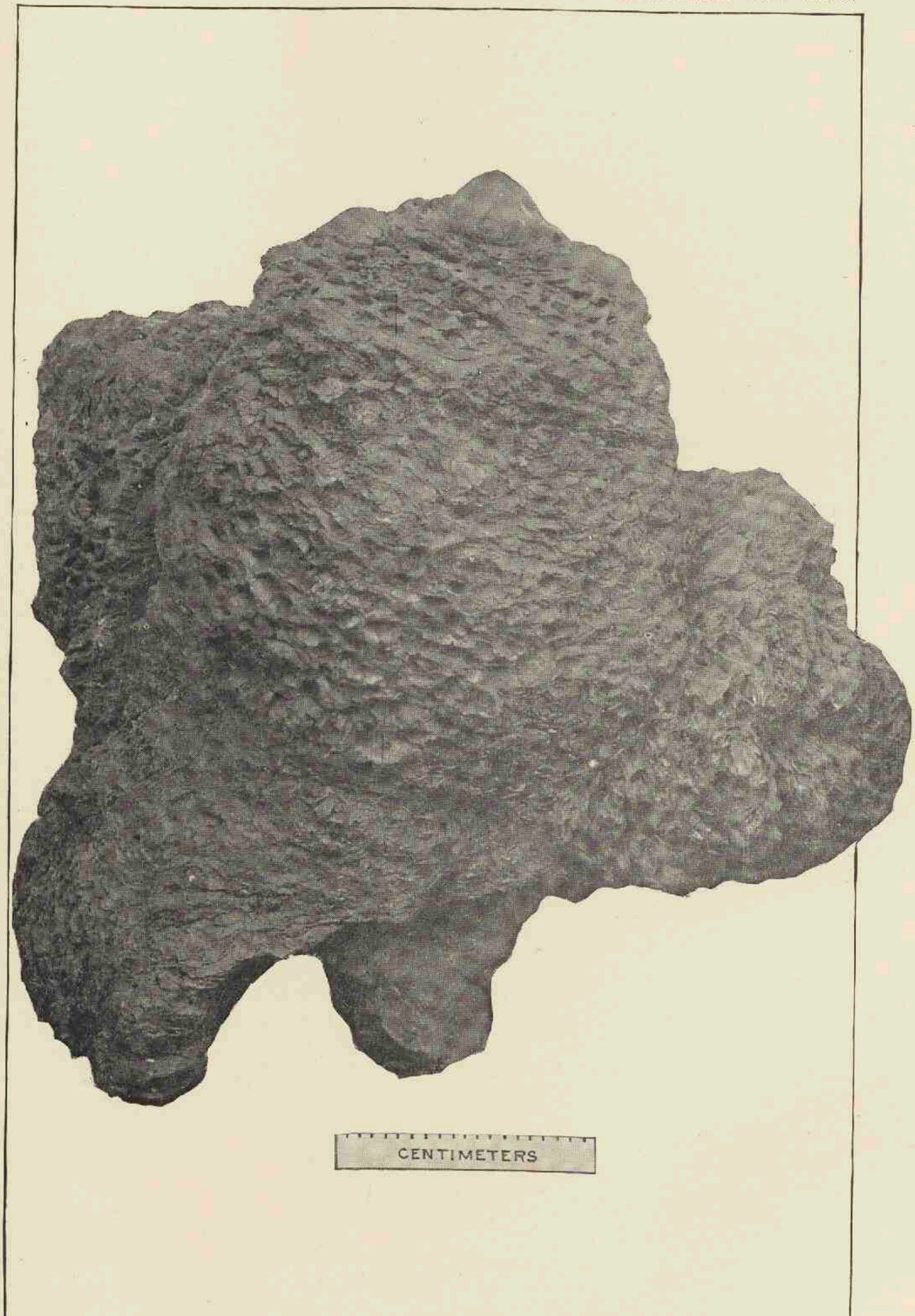
PLATE LXXV.



CYCADEOIDEA WELLSII.

PLATE LXXVI.

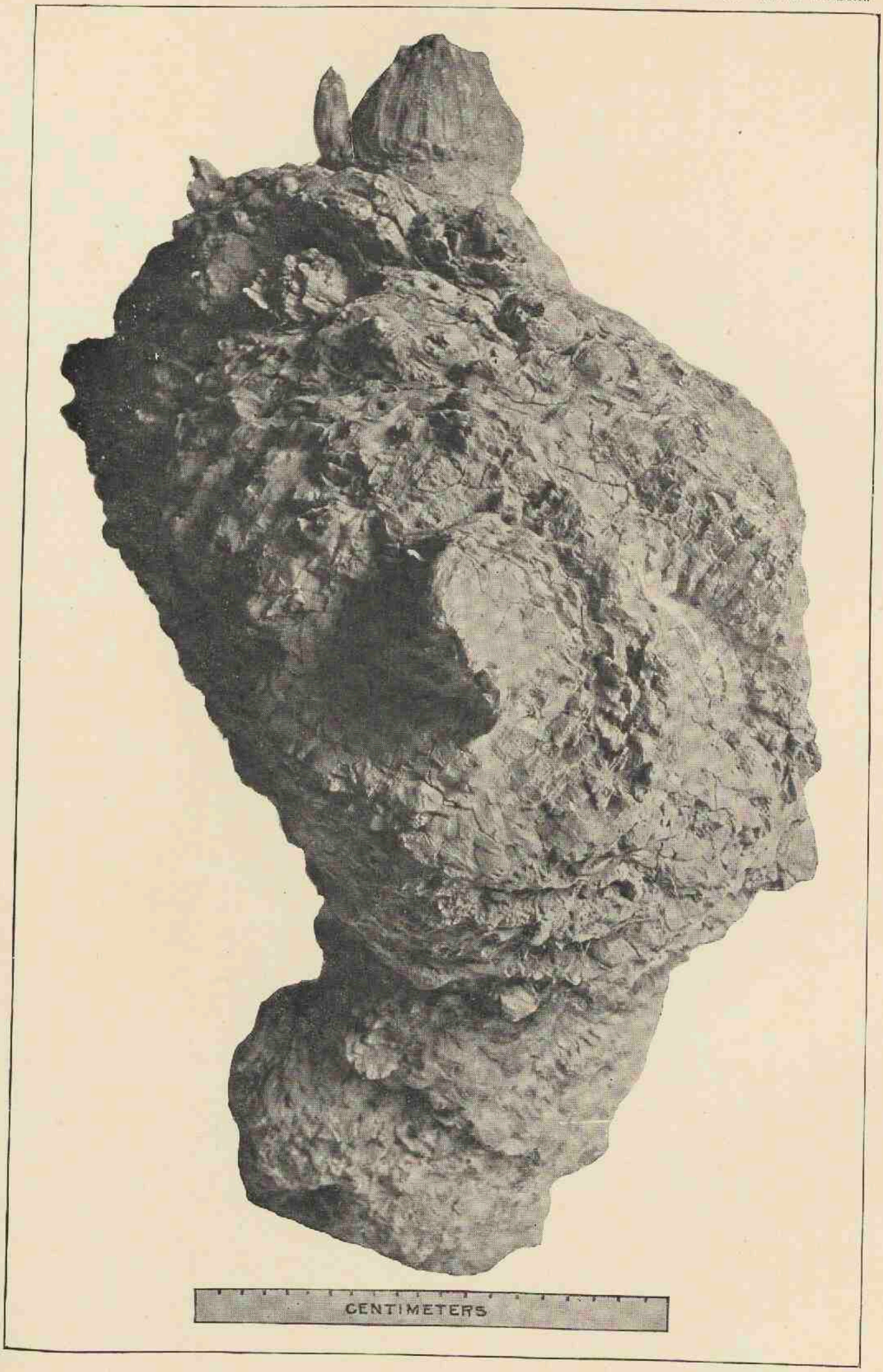
PLATE LXXVI.



CYCADEOIDEA MINNEKAHTENSIS.

PLATE LXXVII.

PLATE LXXVII.



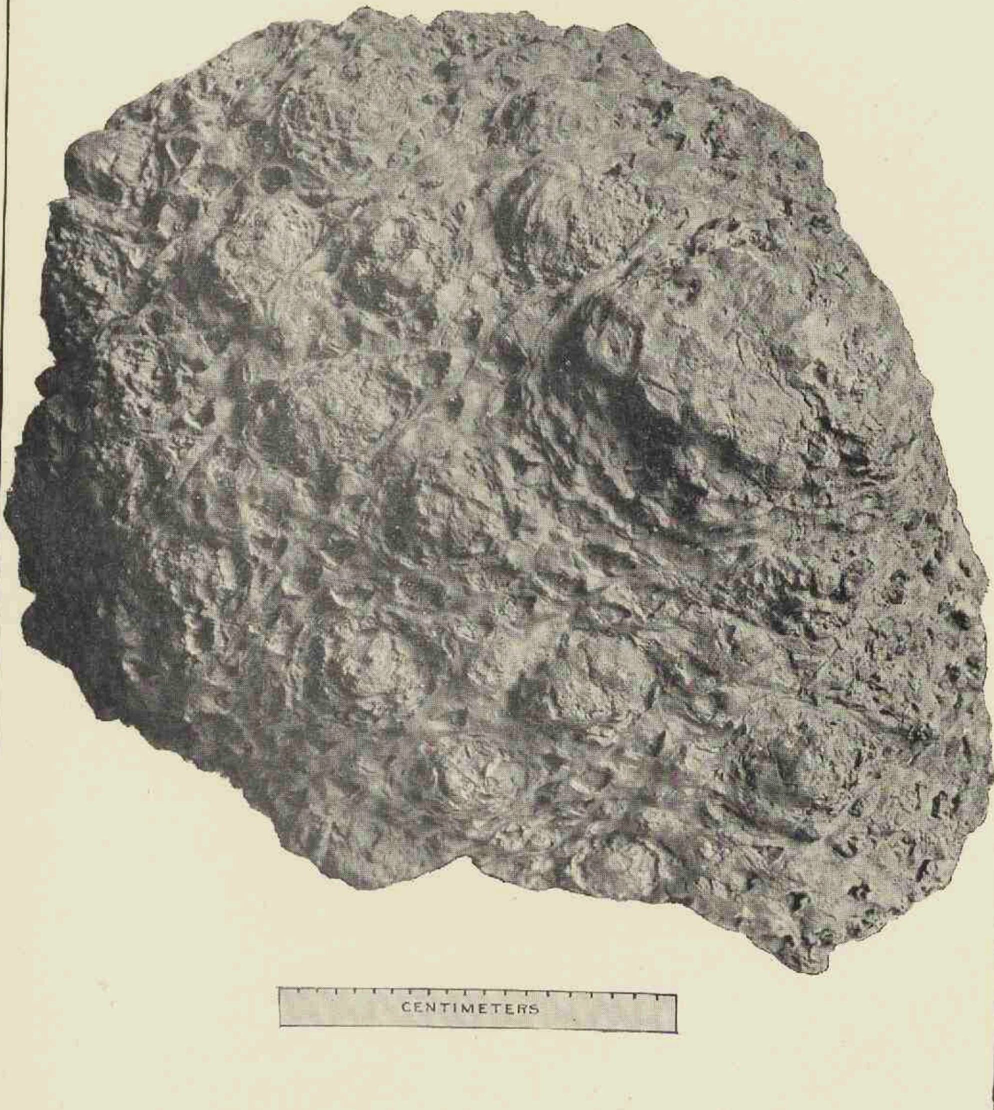
CYCADEOIDEA MINNEKAHTENSIS.

PLATE LXXVIII.

PLATE LXXVIII.

	Page.
CYCADEOIDEA MINNEKAHTENSIS n. sp.	606

View of the external surface of the slab, No. 24 of the Yale collection.
Scale, 20 cm.



CYCADEOIDEA MINNEKAHTENSIS.

PLATE LXXIX.

PLATE LXXIX.

Page.

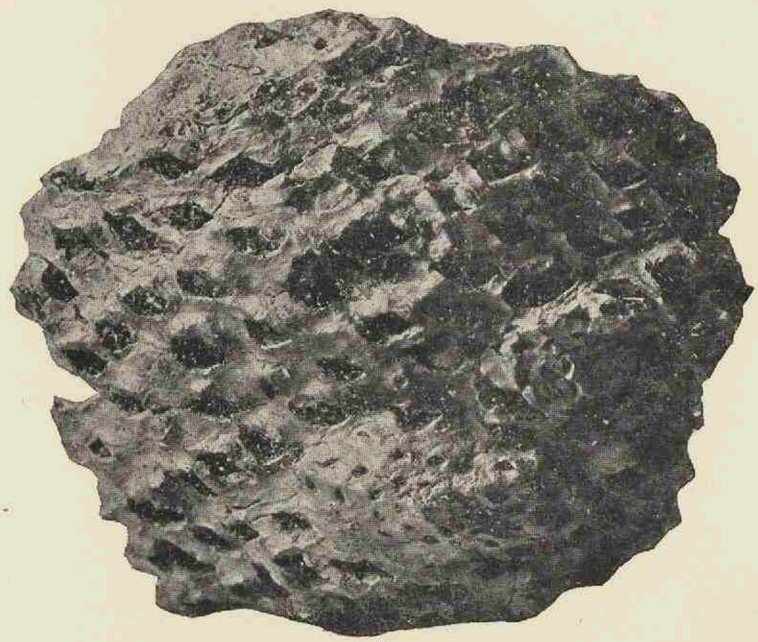
CYCADEOIDEA MINNEKAHTENSIS n. sp. 606

FIG. 1. View of the exterior of one of the fragments of No. 83 of the Yale collection.

FIG. 2. View of the fractured surface of fragment No. 86 of the Yale collection, showing also the terminal bud.

Scale, 10 cm.

2



1

CYCADEOIDEA MINNEKAHTENSIS.

PLATE LXXX.

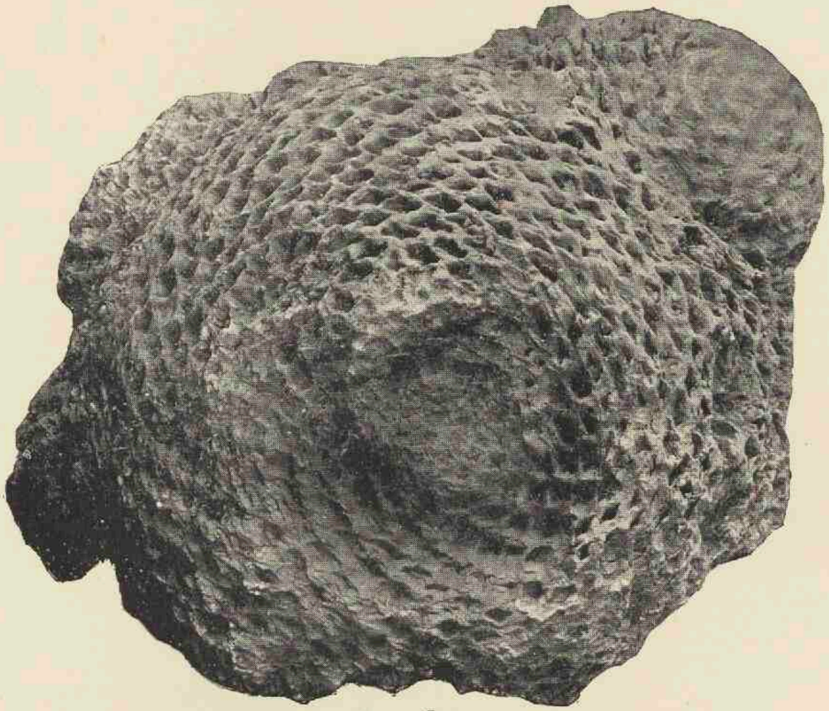
PLATE LXXX.

	Page
CYCADEOIDEA PULCHERRIMA n. sp	608

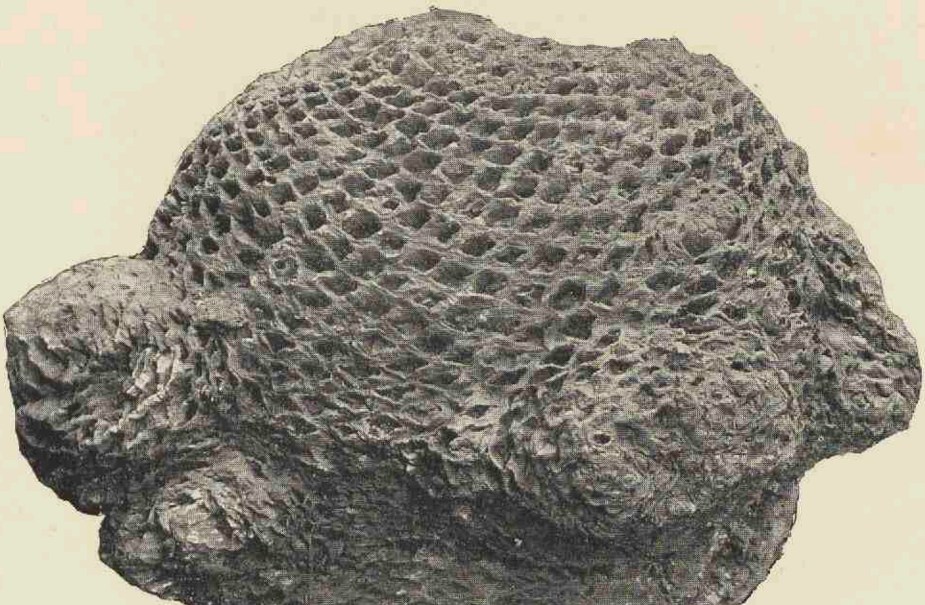
FIG. 1. View of the perfect side of trunk No. 3 of the U. S. National Museum collection.

FIG. 2. View of the apex of the same.

Scale, 20 cm.



2



1

CENTIMETERS

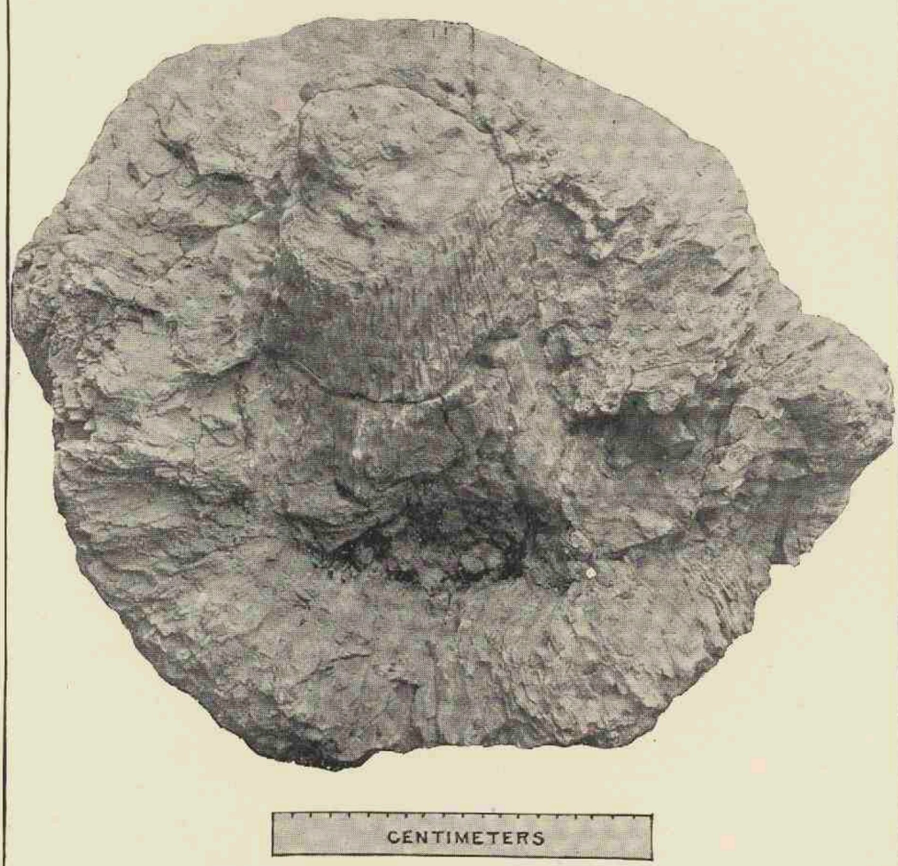
CYCADEOIDEA PULCHERRIMA.

PLATE LXXXI.

PLATE LXXXI.

	Page.
Cycadeoidea pulcherrima n. sp.	
View of the decayed side of trunk No. 3 of the U. S. National Museum collection, intentionally inverted better to show the exposed internal structure.	608
Scale, 20 cm	

764



CYCADEOIDEA PULCHERRIMA.

PLATE LXXXII.

PLATE LXXXII.

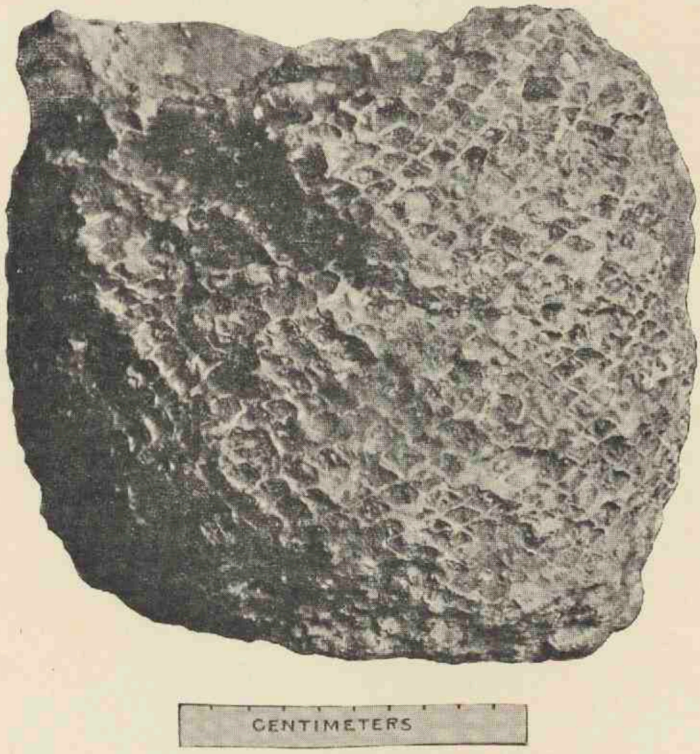
	Page.
CYCADEOIDEA PULCHERRIMA n. sp.	608

Fragment No. 78 of the Yale collection, doubtfully referred to this species. Scale, 20 cm.

CYCADEOIDEA PULCHERRIMA.

PLATE LXXXIII.

PLATE LXXXIII.



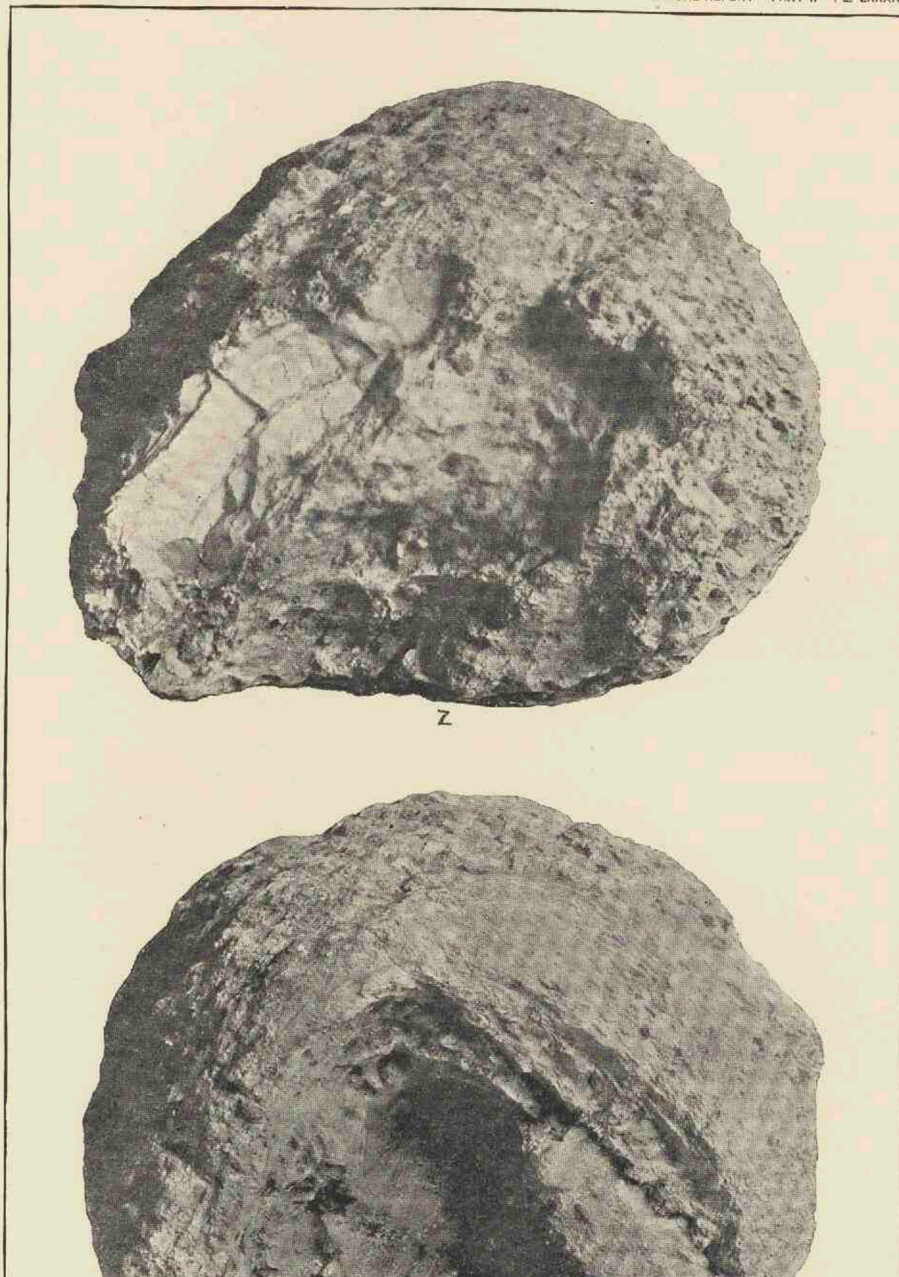
CYCADEOIDEA CICATRICULA.

PLATE LXXXIV.

PLATE LXXXIV.

	Page.
CYCADEOIDEA CICATRICULA n. sp.	609

Trunk No. 118 of the Yale collection.
FIG. 1. View of the base.
FIG. 2. View of the apex.
Scale, 10 cm.



CYCADEOIDEA CICATRICULA.

PLATE LXXXV.

PLATE LXXXV.

CYCADEOIDEA TURRITA.

PLATE LXXXVI.

PLATE LXXXVI.

	Page.
CYCADEOIDEA TURRITA n. sp	610

No. 67 of the Yale collection.
Scale, 10 cm.

CYCADEOIDEA TURRITA.

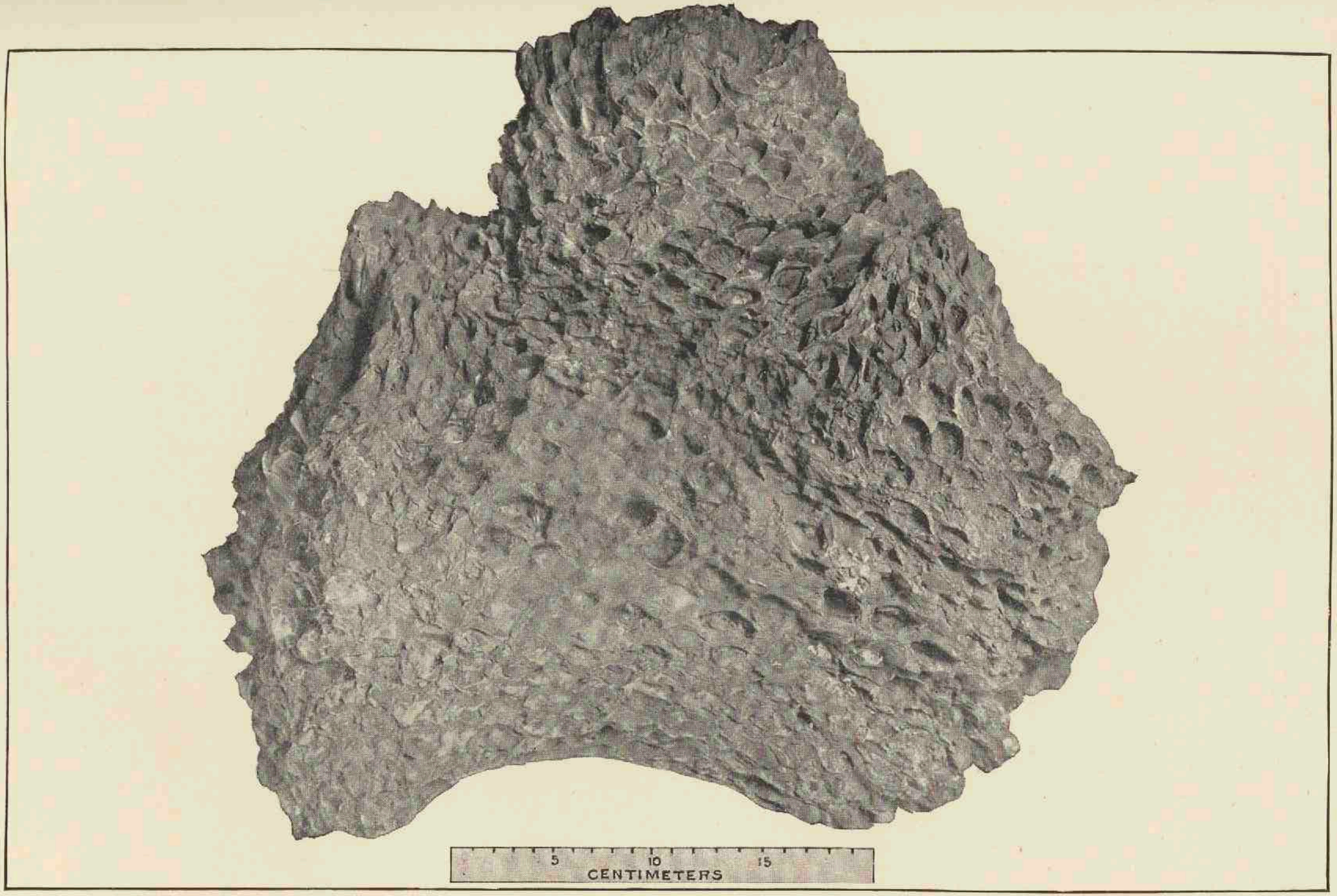
PLATE LXXXVII.

PLATE LXXXVII.

	Page.
CYCADEOIDEA TURRITA n. sp	610

Side view of No. 49 of the Yale collection.

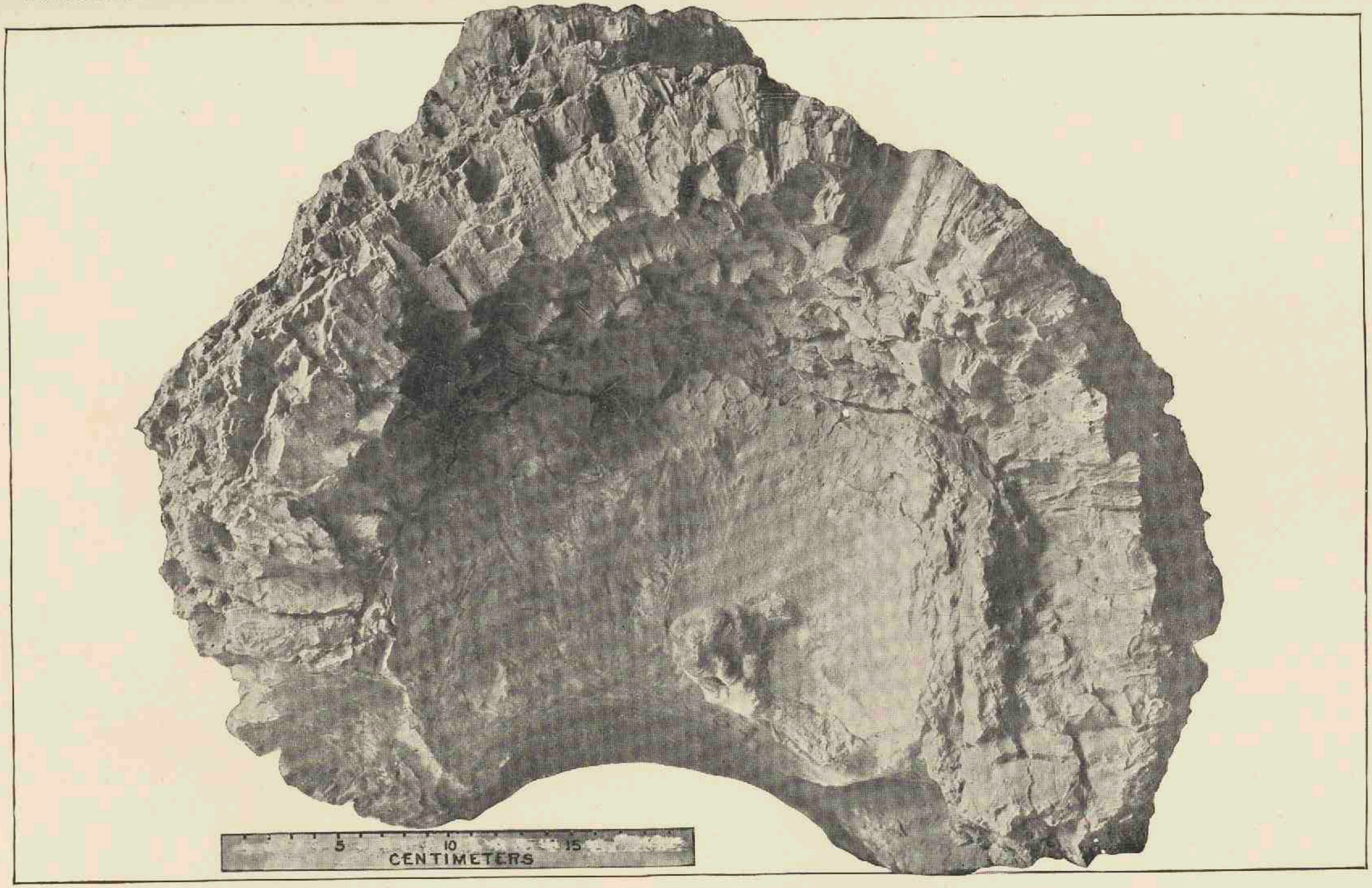
Scale, 20 cm.



CYCADEOIDEA TURRITA.

PLATE LXXXVIII.

PLATE LXXXVIII.



CYCADEOIDEA TURRITA.

PLATE LXXXIX.

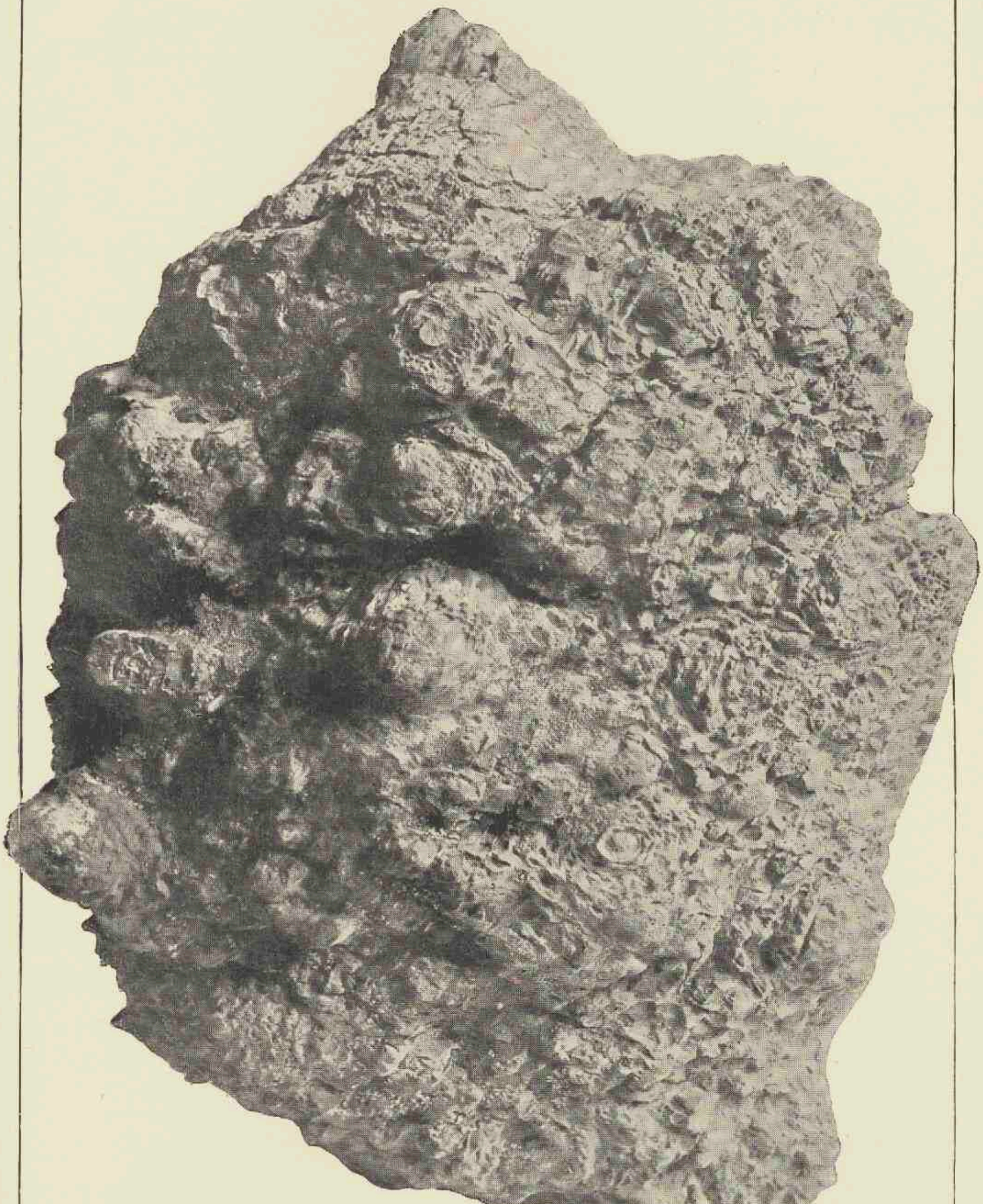
PLATE LXXXIX.

Page.

CYCADEOIDEA TURRITA n. sp 610

No. 74 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA TURRITA.

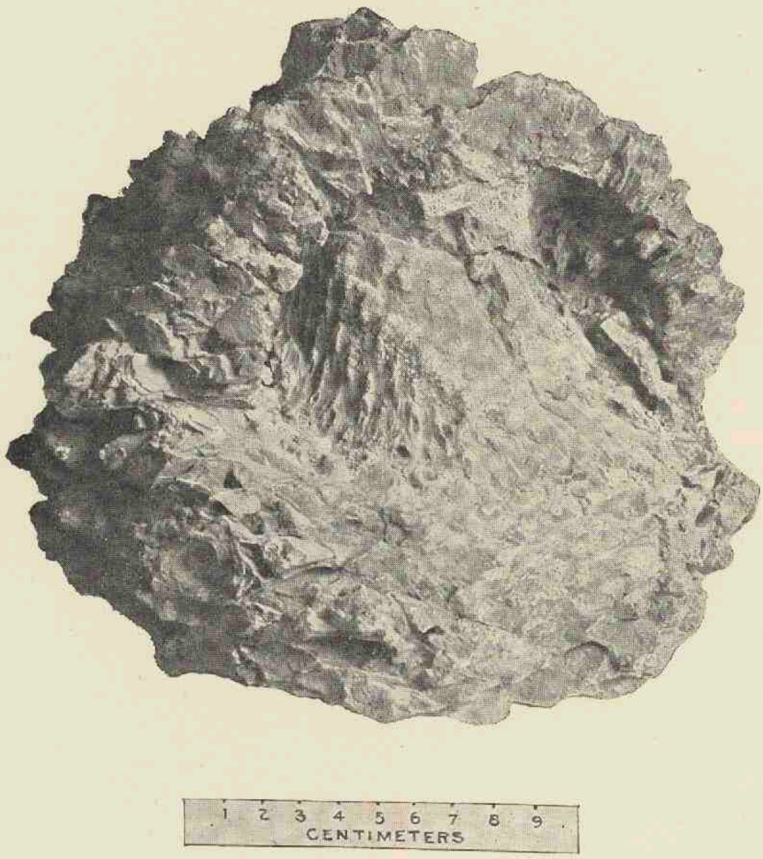
PLATE XC.

PLATE XC.

	Page.
CYCADEOIDEA TURRITA n. sp.	610

View of the fractured side of fragment No. 15 of the Yale collection, showing internal structure.

Scale, 10 cm.



CYCADEOIDEA TURRITA.

PLATE XCI.

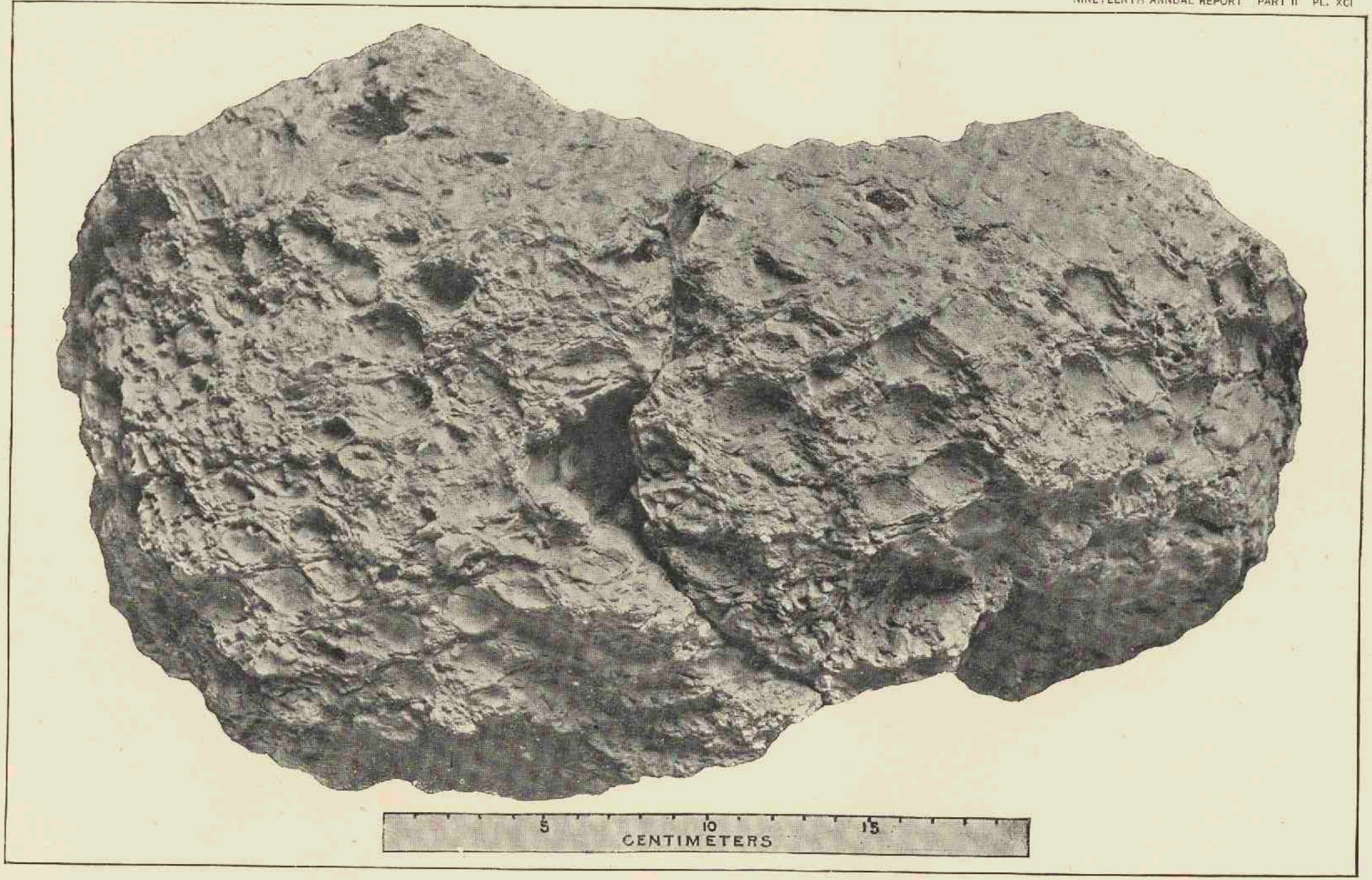
PLATE XCI.

Page

CYCADEOIDEA MCBRIDEI n. sp 612

Side view of the nearly perfect trunk, consisting of fragments Nos. 10 and 14 of the U. S. National Museum collection.

Scale, 20 cm.



CYCADEOIDEA McBRIDEI.

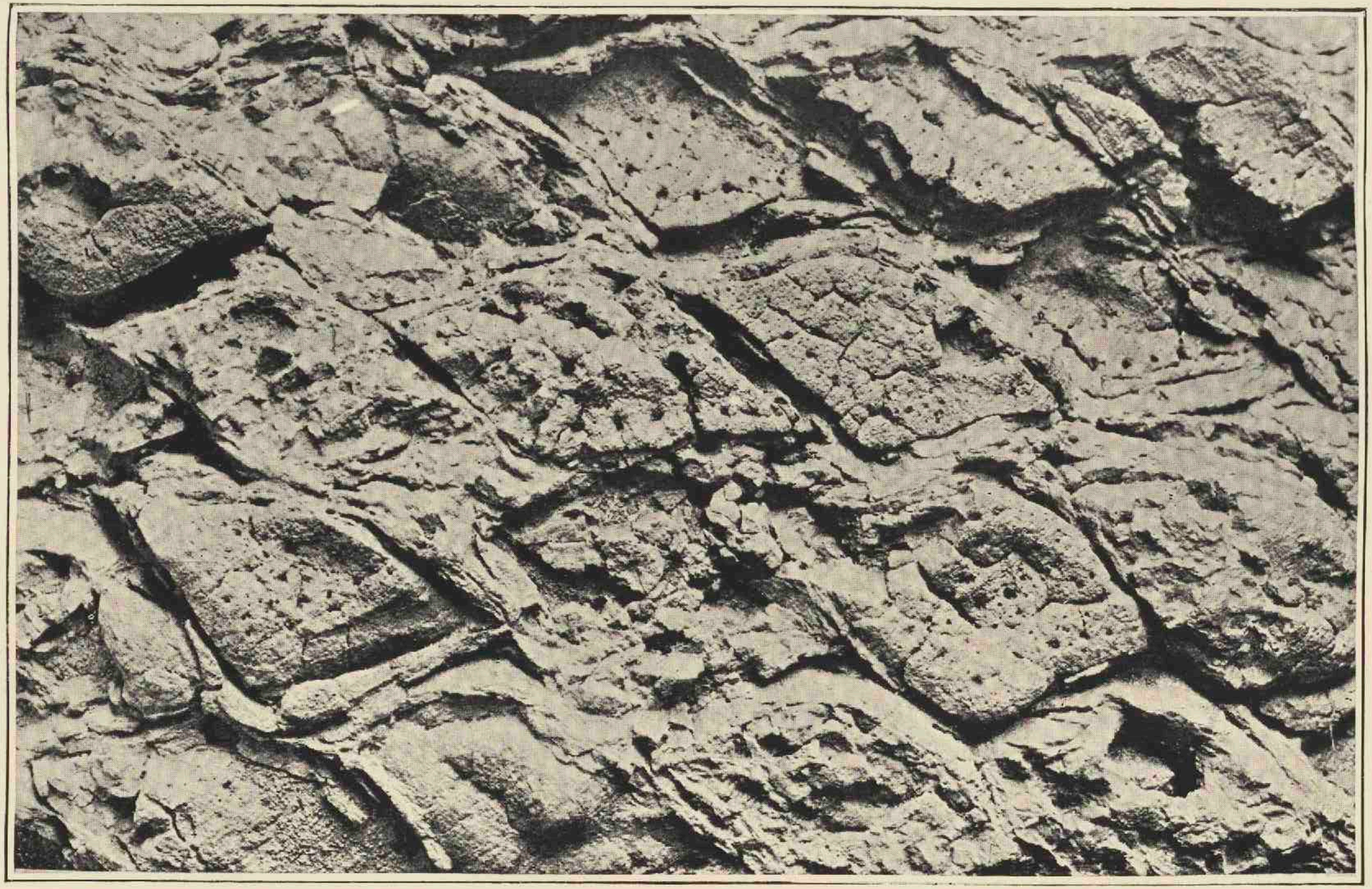
PLATE XCII.

PLATE XCII.

Page.

CYCADEOIDEA MCBRIDEI n. sp 612

View of part of the surface of fragment No. 9 of the U. S. National Museum collection, to show the leaf scars, enlarged nearly 2 diameters.



CYCADEOIDEA McBRIDEI.

PLATE XCIII.

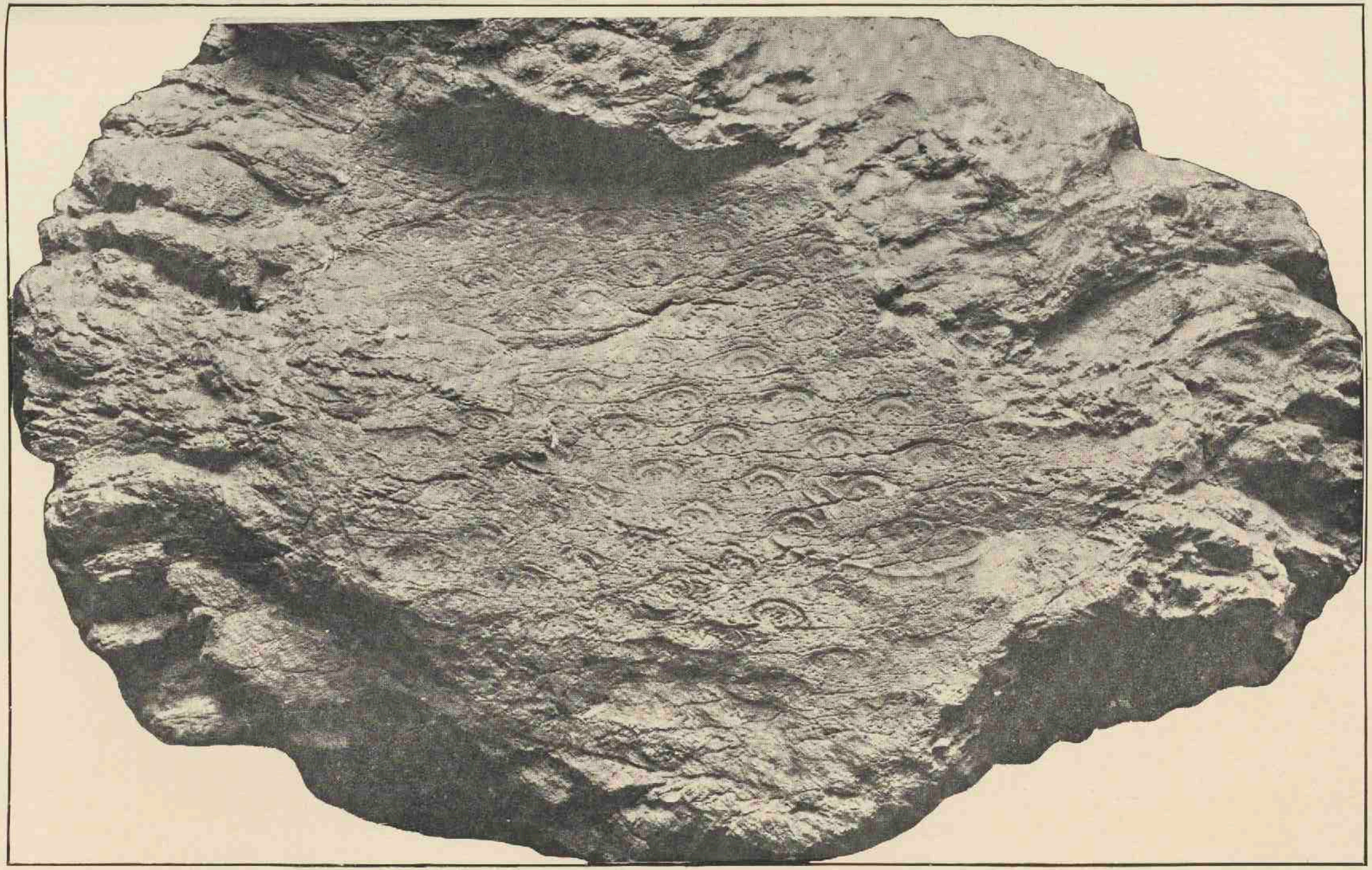
PLATE XCIII.

Page.

CYCADEOIDEA MCBRIDEI n. sp. 612

View of the exposed inner wall of the libro-cambium layer of fragment No. 16 of the U. S. National Museum collection, showing scars of the vascular bundles.

Natural size.



CYCADEOIDEA McBRIDEI.

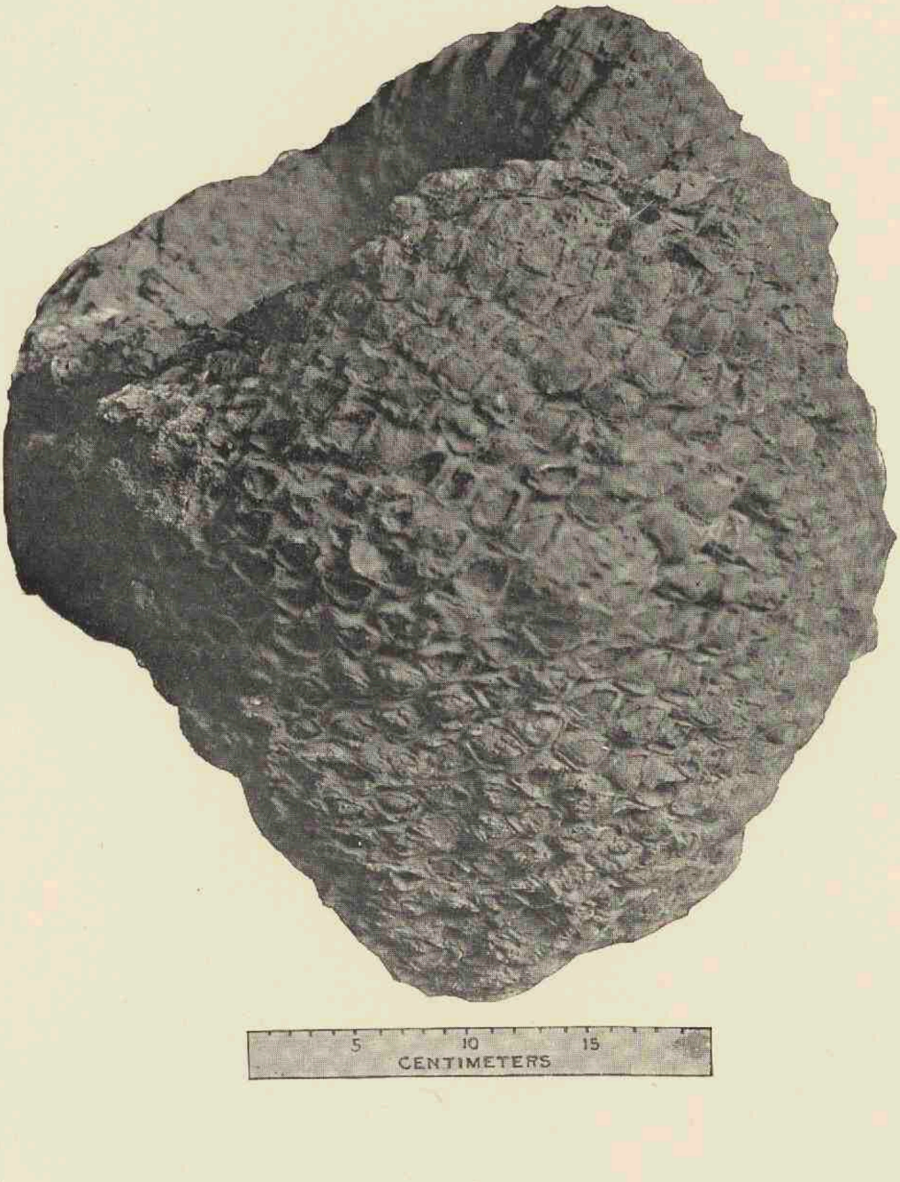
PLATE XCIV.

PLATE XCIV.

	Page.
CYCADEOIDEA MCBRIDEI n. sp	612

Side view of trunk No. 23 of the Yale collection.

Scale, 20 cm.



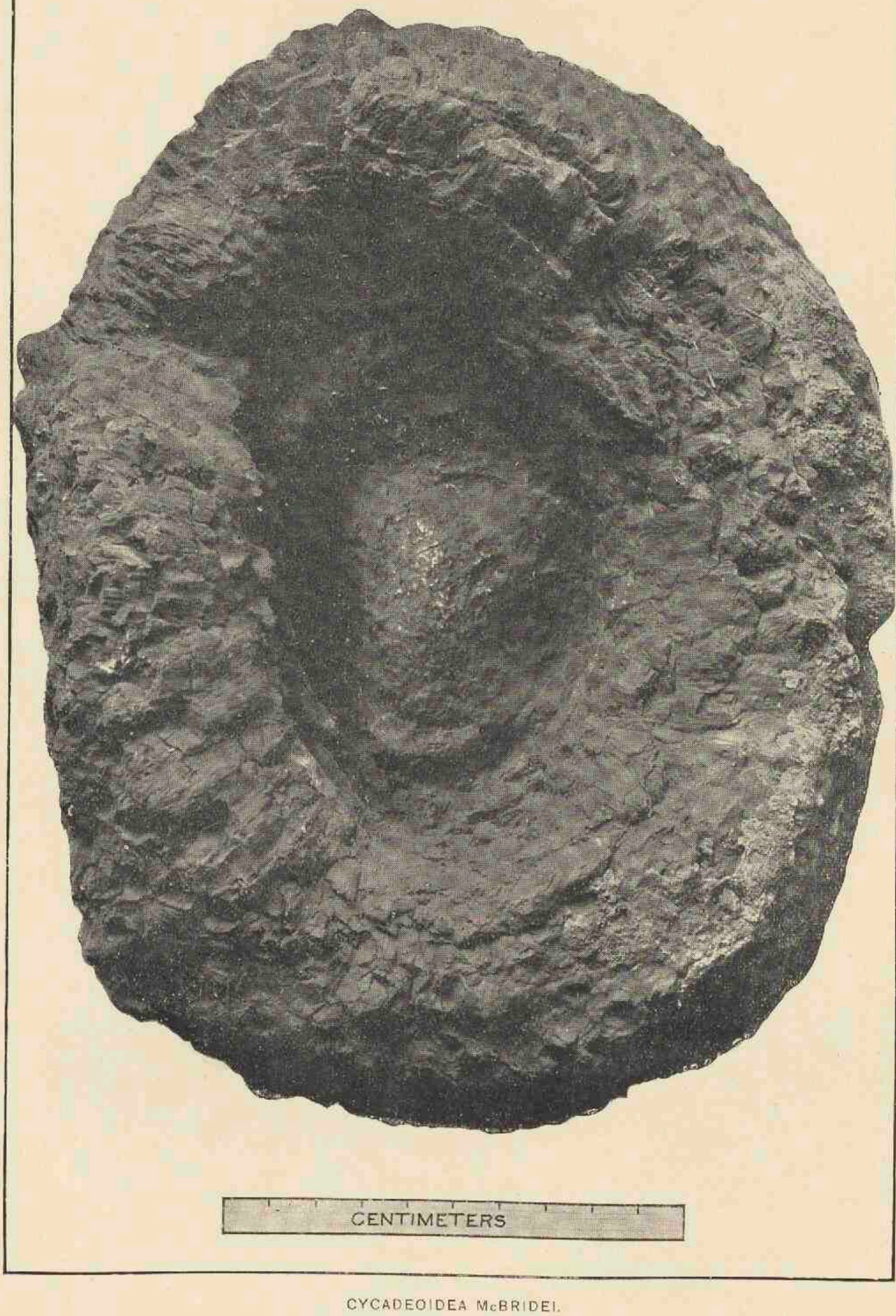
CYCADEOIDEA McBRIDEI.

PLATE XCV.

PLATE XCV.

	Page.
CYCADEOIDEA MCBRIDEI n. sp	612

View of the decayed upper end of trunk No. 23 of the Yale collection. Scale, 20 cm.



CYCADEOIDEA McBRIDEI.

PLATE XCVI.

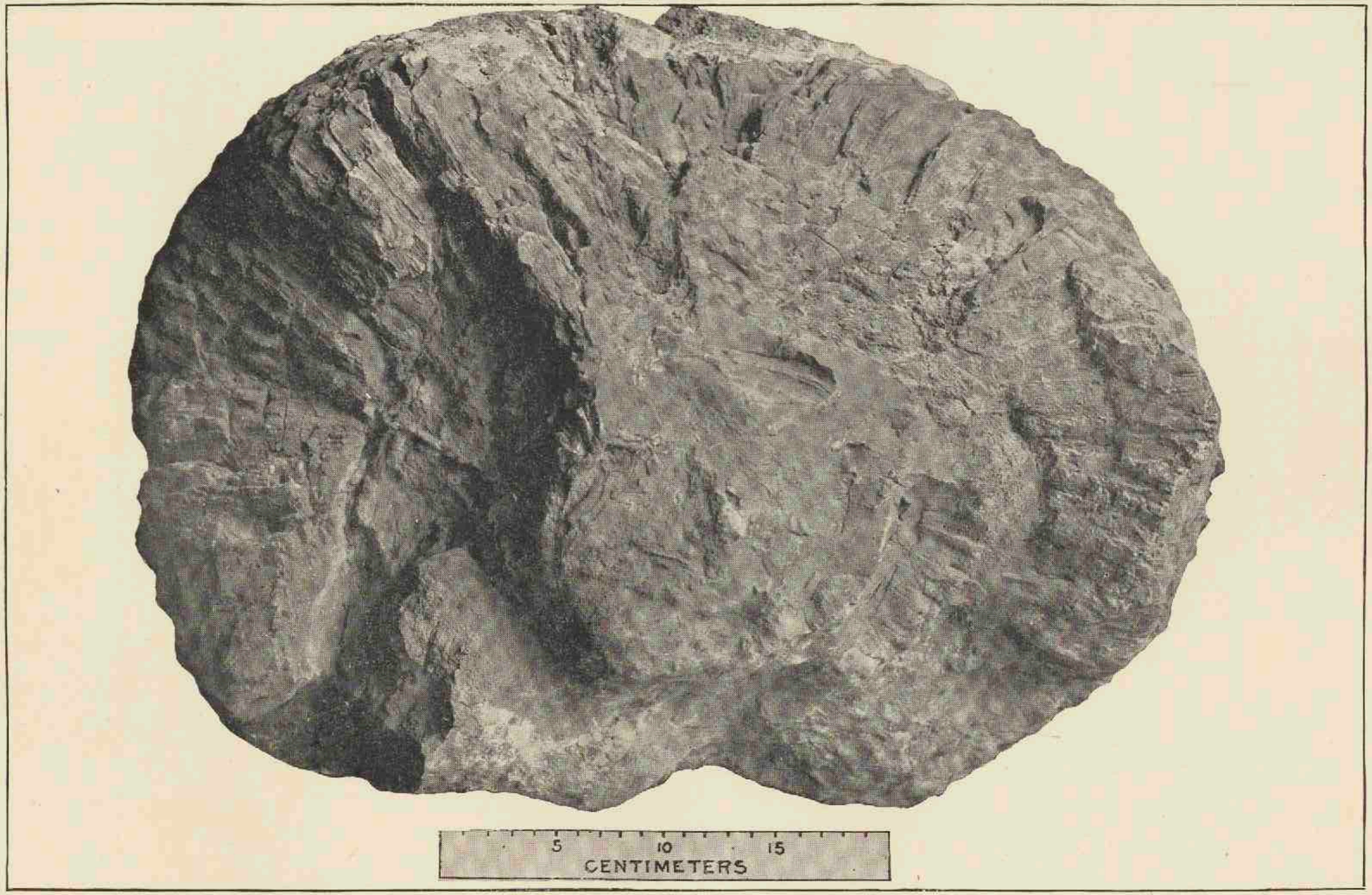
PLATE XCVI.

Page.

CYCADEOIDEA MCBRIDEI n. sp. 612

View of the base of trunk No. 23 of the Yale collection.

Scale, 20 cm.



CYCADEOIDEA McBRIDEI

PLATE XCVII.

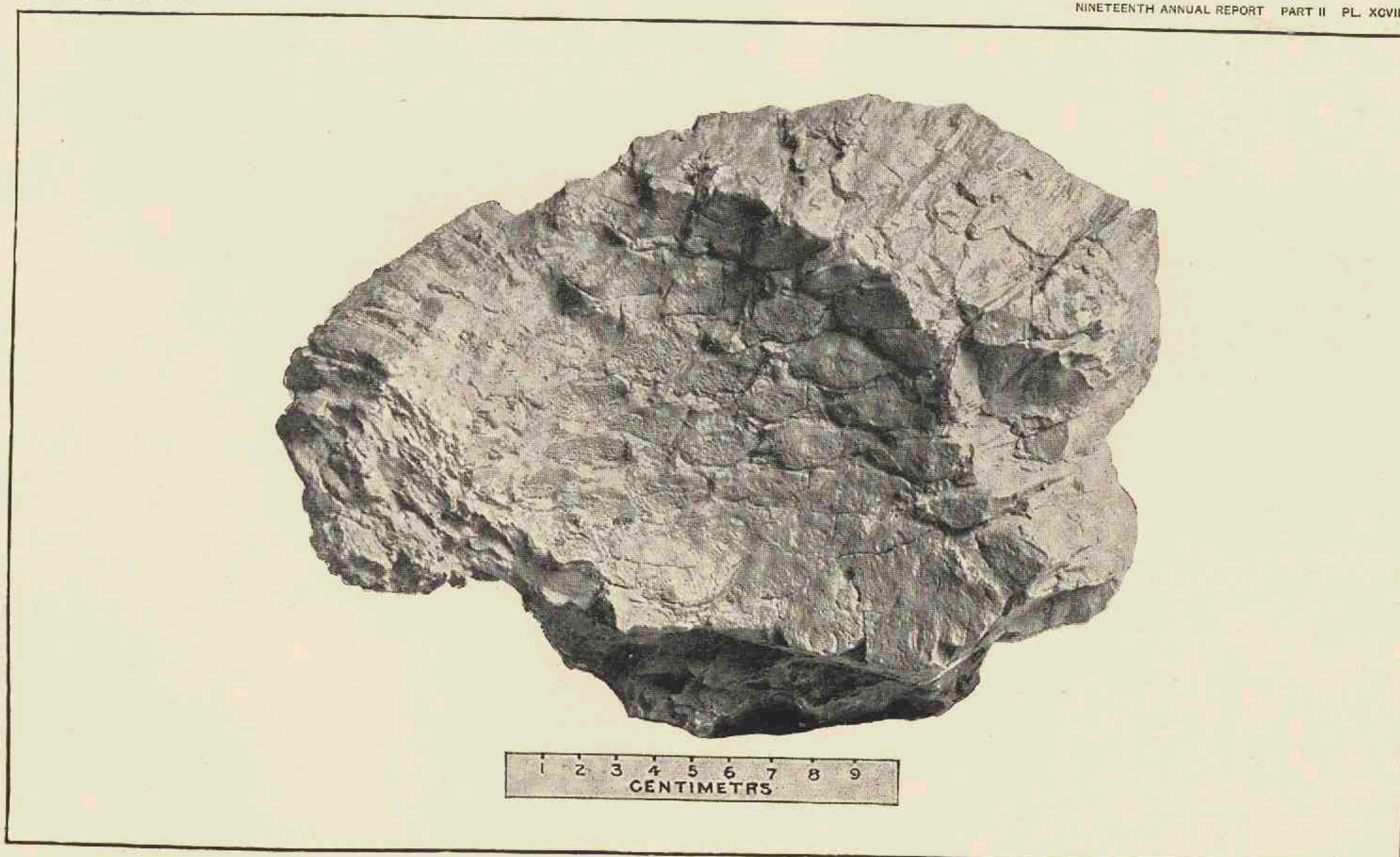
PLATE XCVII.

	Page.
CYCADEOIDEA McBRIDEI n. sp	612

View of the inner surface of the armor as exposed in the fragment No. 27 of the Yale collection.

Scale, 10 cm.

796



CYCADEOIDEA McBRIDEI.

PLATE XCVIII.

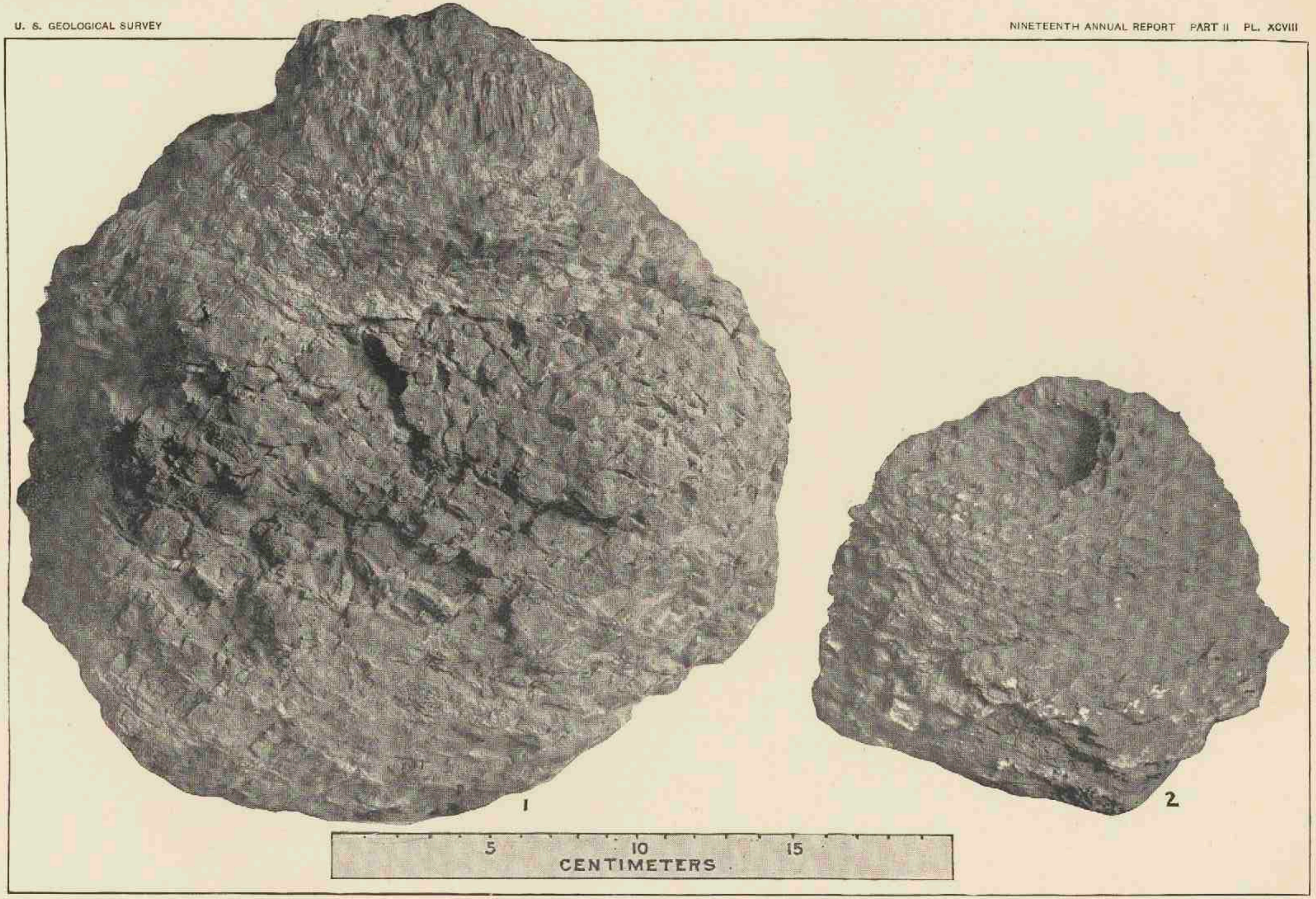
PLATE XCVIII.

	Page.
CYCADEOIDEA MCBRIDEI n. sp	612

FIG. 1. Trunk No. 29 of the Yale collection, supposed to represent a dwarf form of this species.

FIG. 2. Trunk No. 53 of the Yale collection, supposed to represent a young form of this species.

Scale, 20 cm.



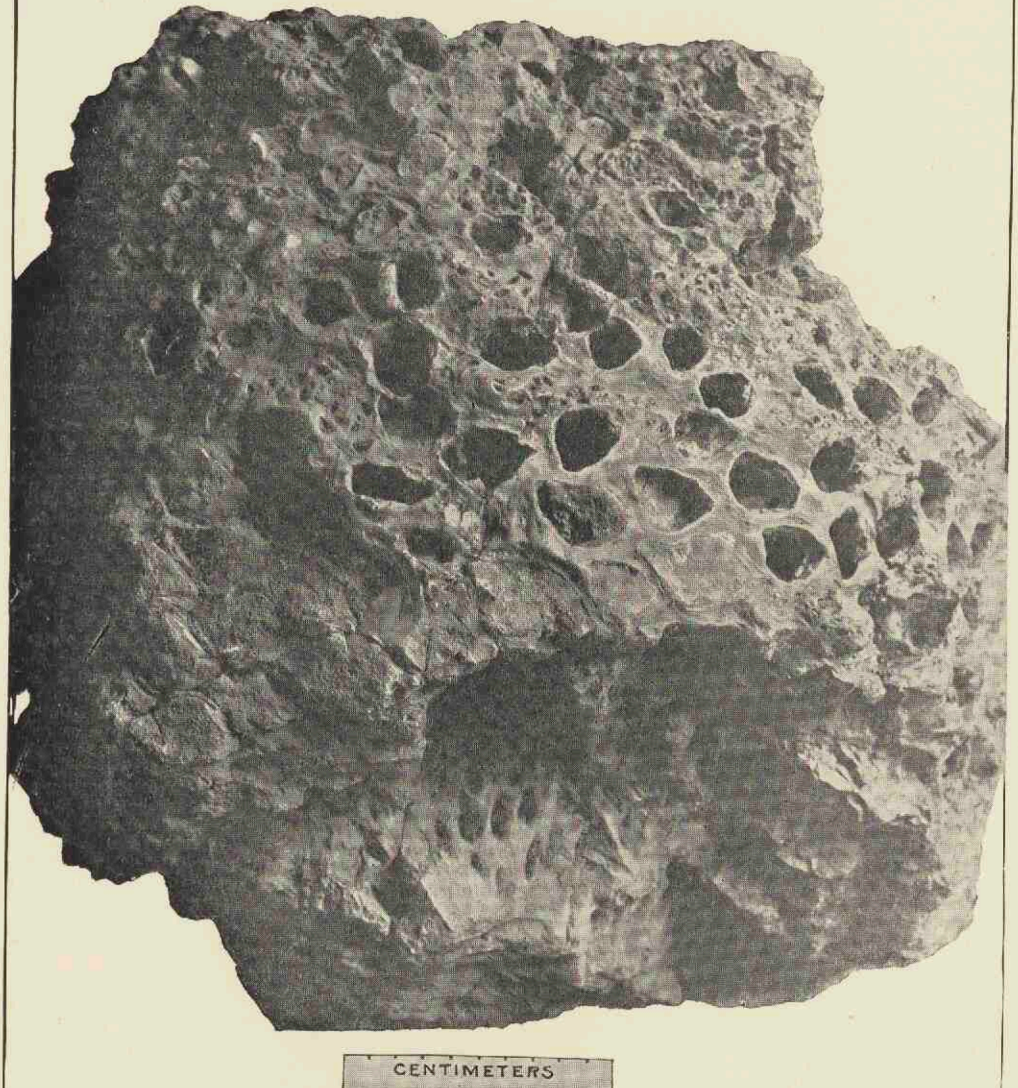
CYCADEOIDEA McBRIDEI.

PLATE XCIX.

PLATE XCIX.

	Page.
CYCADEOIDEA MCBRIDEI n. sp	612

View of the external surface of No. 110 of the Yale collection.
Scale, 10 cm.



CYCADEOIDEA McBRIDEI.

PLATE C.

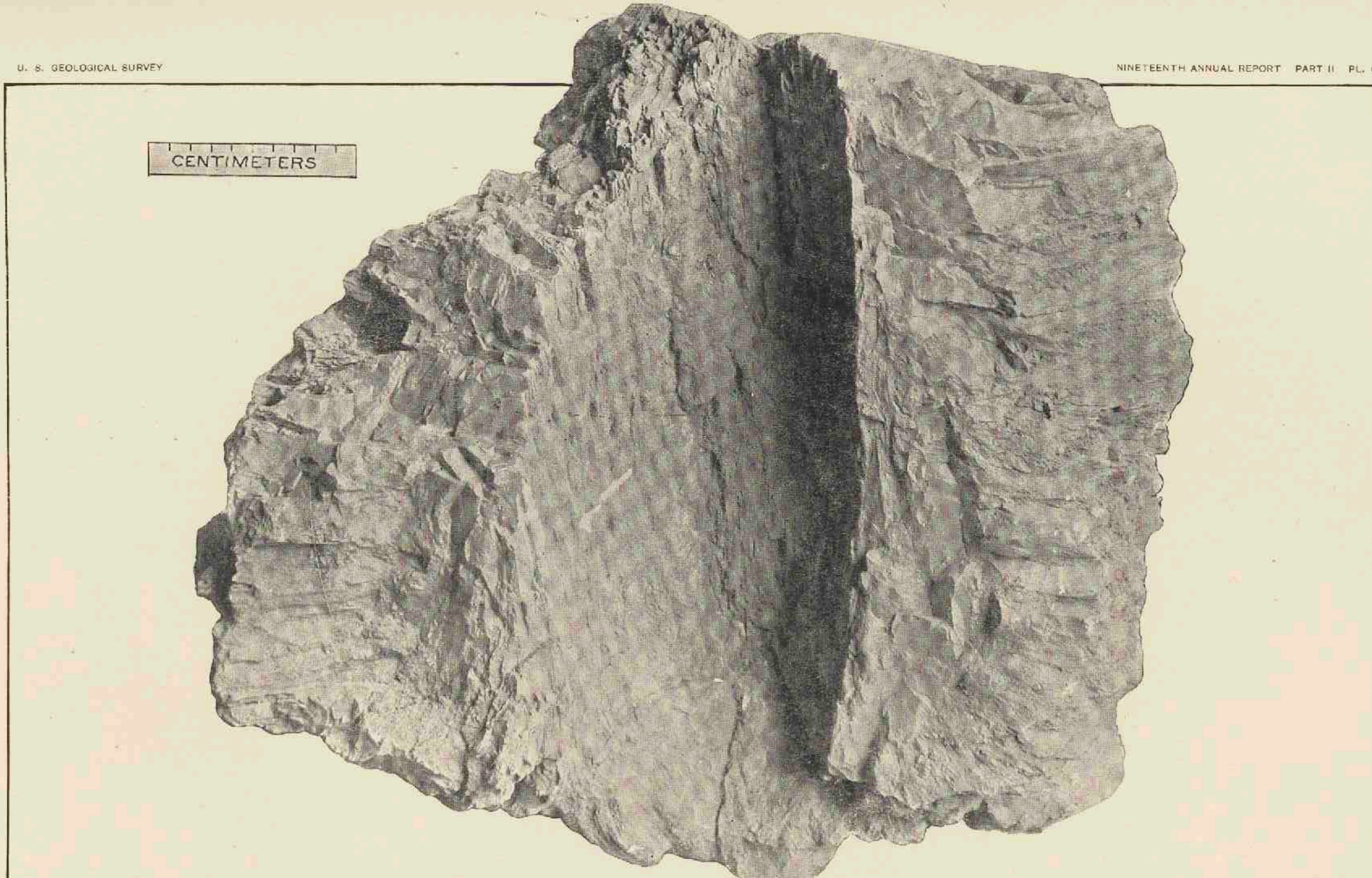
PLATE C.

Page.

CYCADEOIDEA MCBRIDEI n. sp. 612

View of the exposed inner wall of the woody zone and sections of the armor and axis of No. 110 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA McBRIDEI.

PLATE CI.

PLATE CI.

CYCADEOIDEA MARSHIANA.

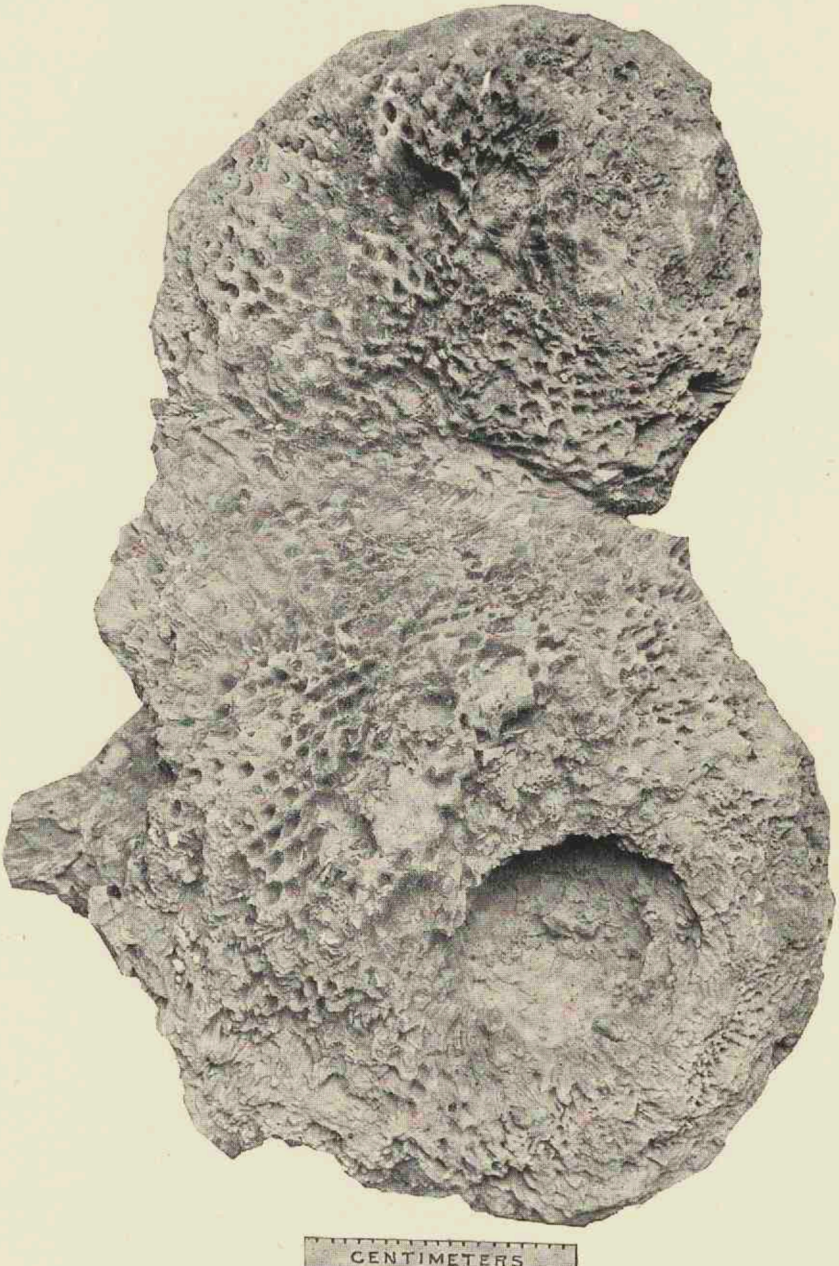
PLATE CII.

PLATE CII.

View of the under surface of Trunk No. 11 of the Yale collection.

Scale, 20 cm.

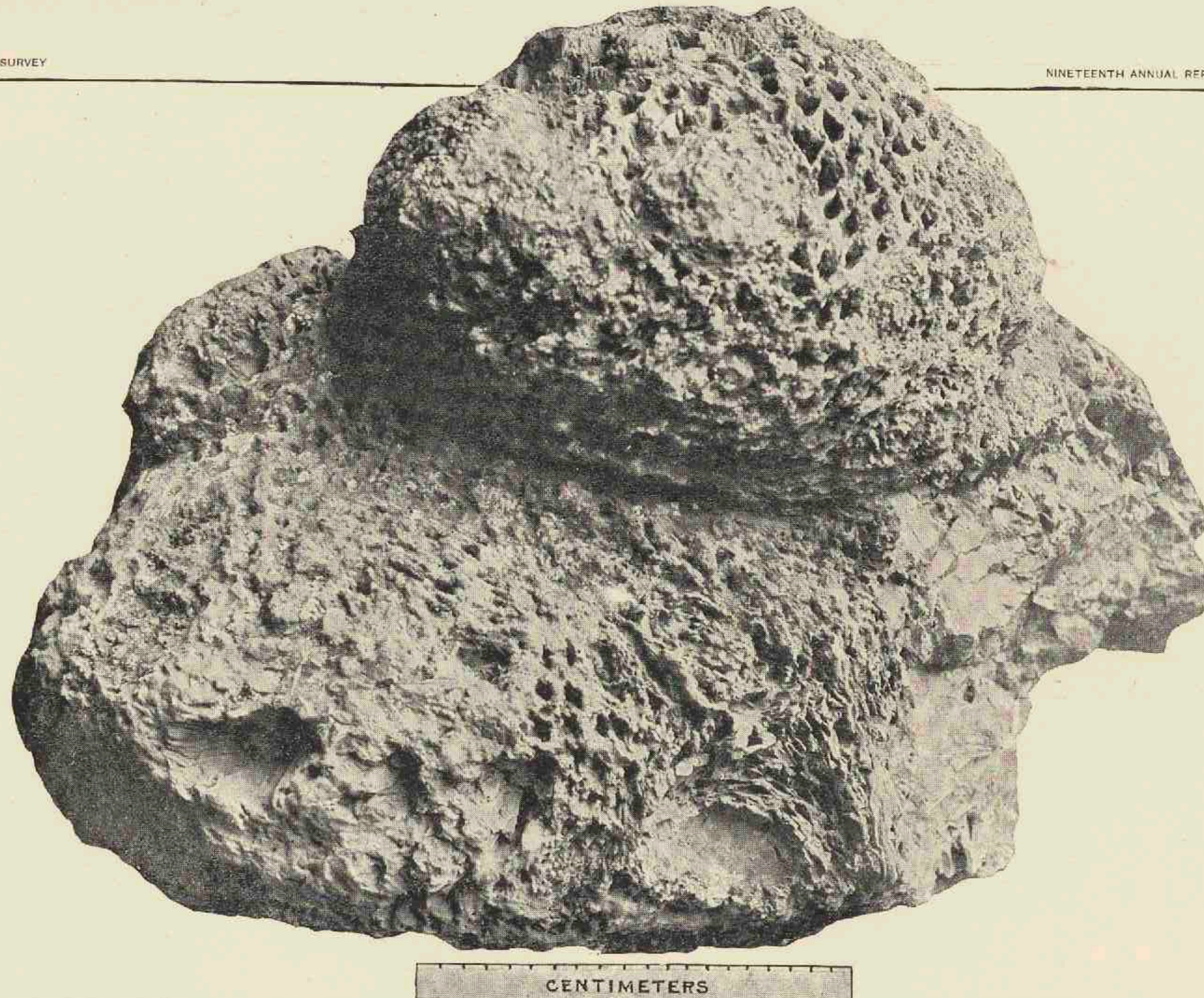
806



CYCADEOIDEA MARSHIANA.

PLATE CIII.

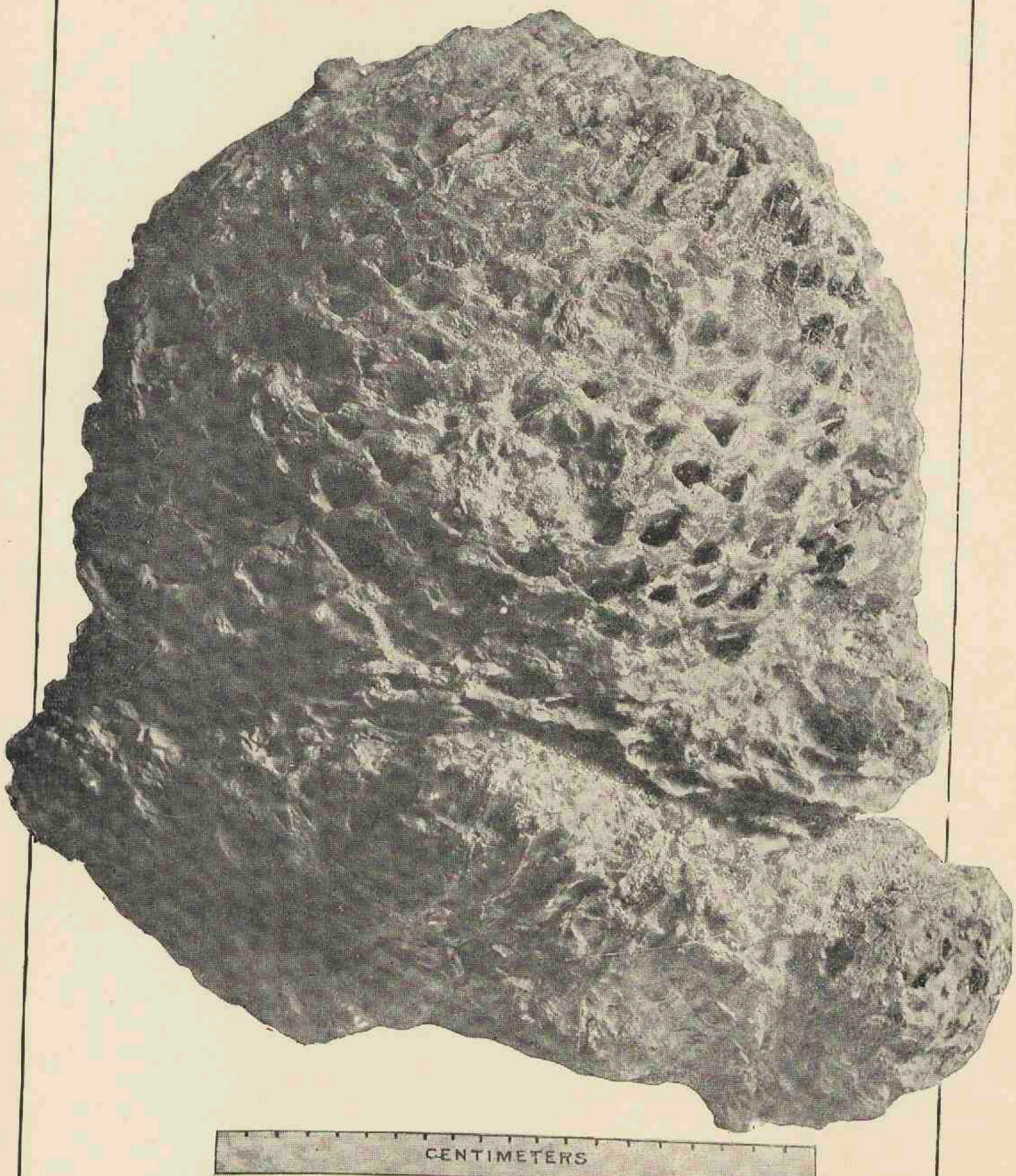
PLATE CIII.



CYCADEOIDEA MARSHIANA.

PLATE CIV.

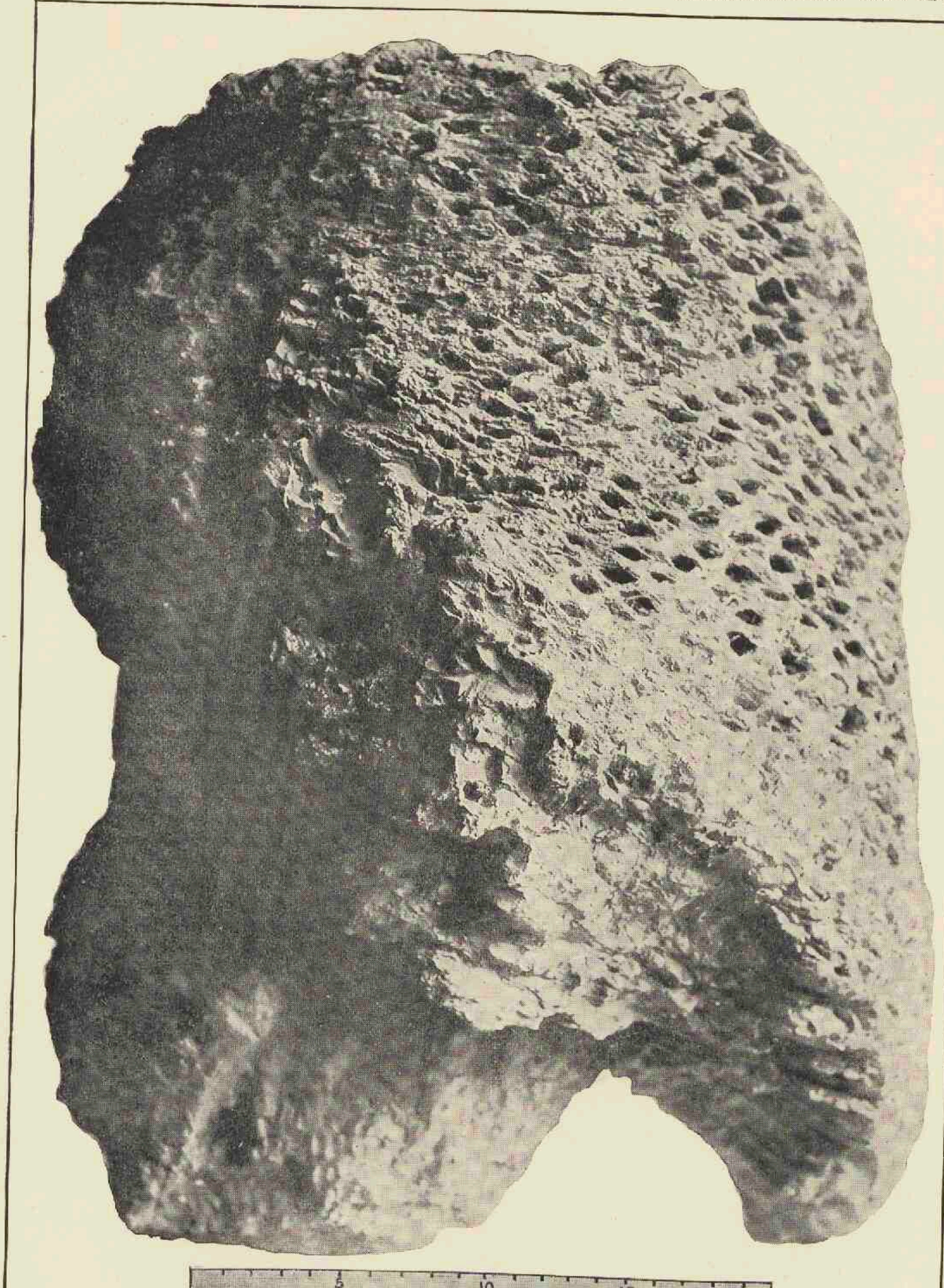
PLATE CIV.



CYCADEOIDEA MARSHIANA.

PLATE CV.

PLATE CV.



CYCADEOIDEA MARSHIANA.

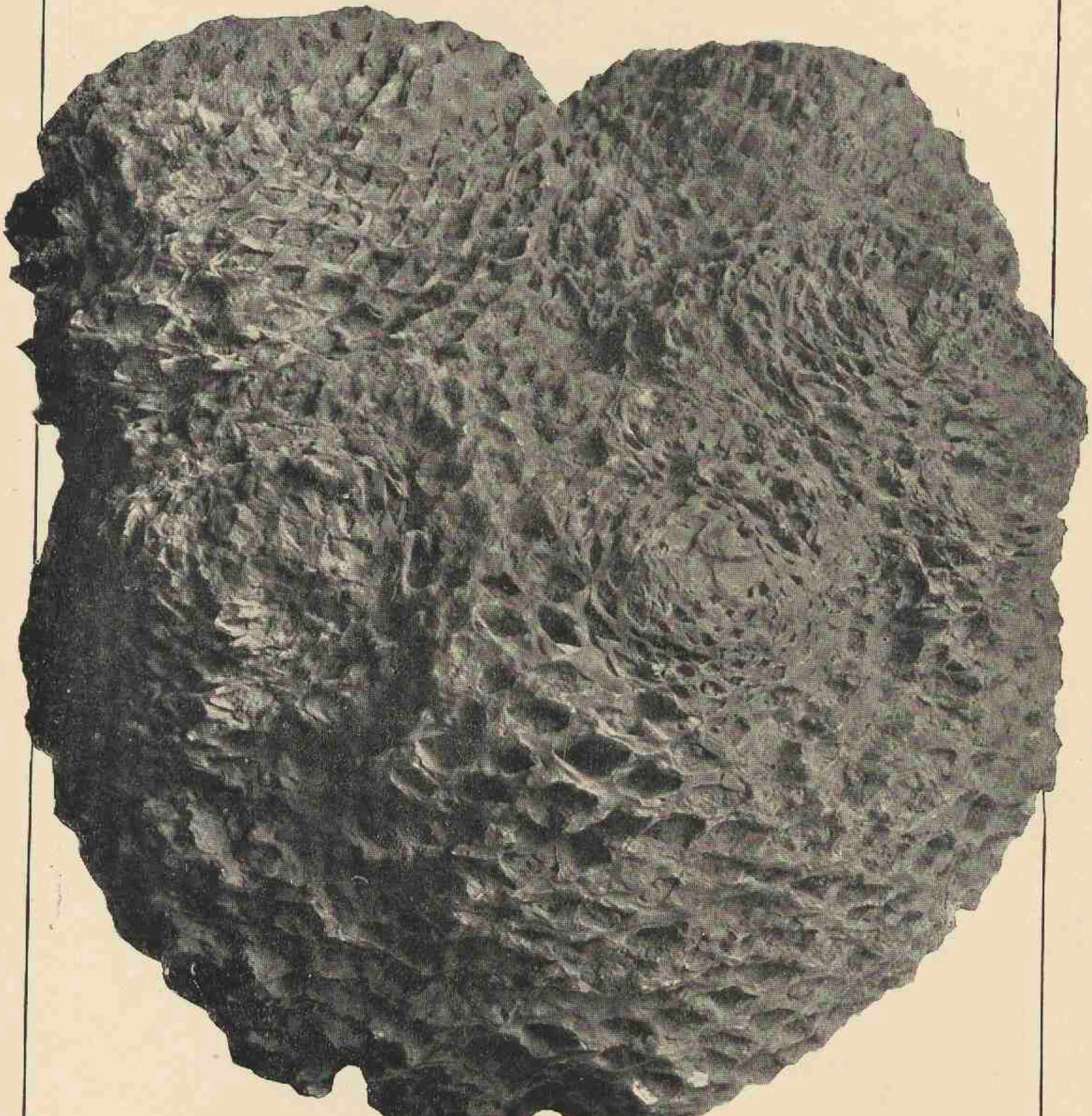
PLATE CVI.

PLATE CVI.

	Page.
CYCADEOIDEA FURCATA n. sp.	618

View of the rounded side of trunk No. 60 of the Yale collection.

Scale, 20 cm.



CYCADEOIDEA FURCATA.

PLATE CVII.

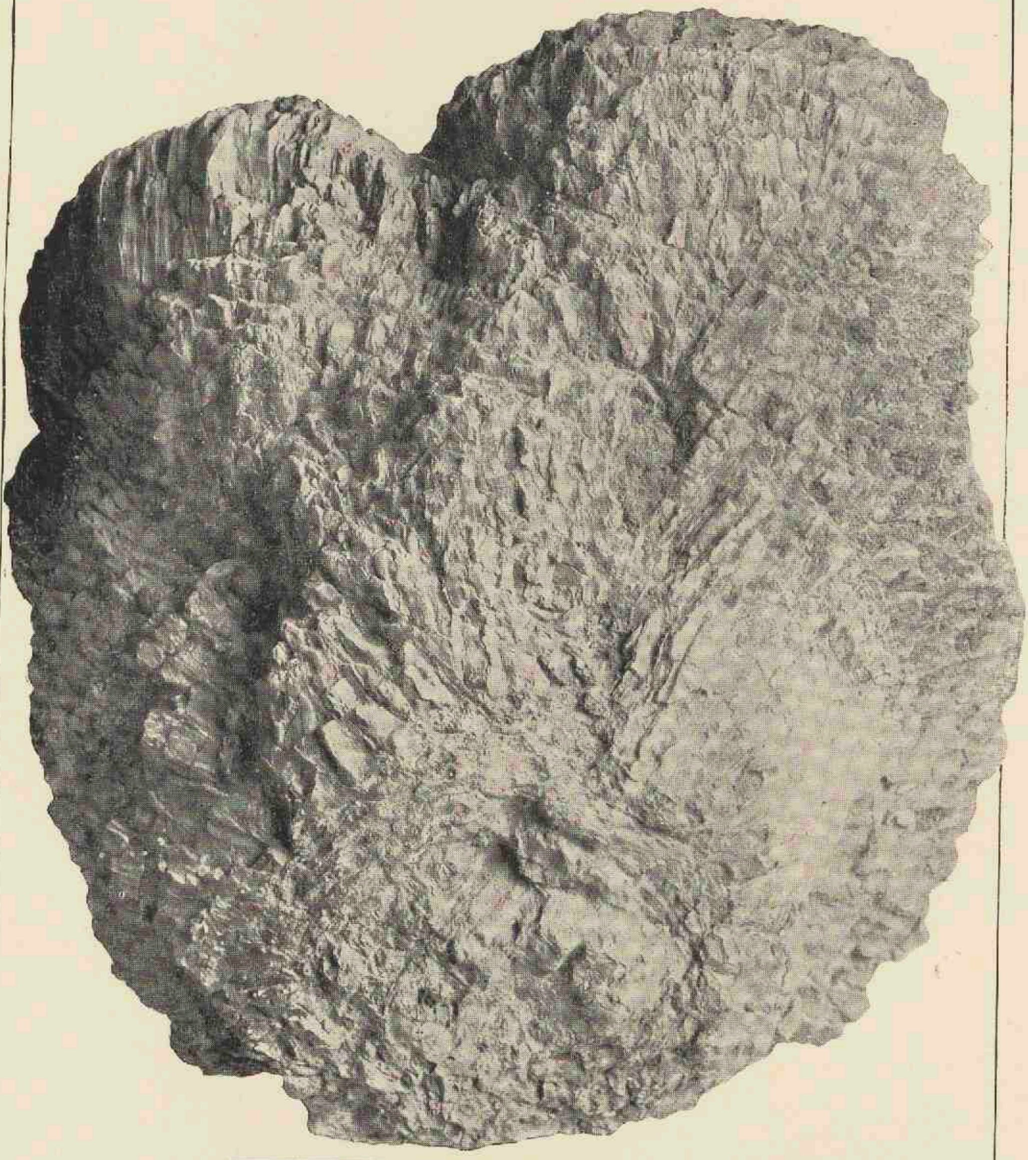
PLATE CVII.

Page.

CYCADEOIDEA FURCATA n. sp. 618

View of the flat side of trunk No. 60 of the Yale collection.

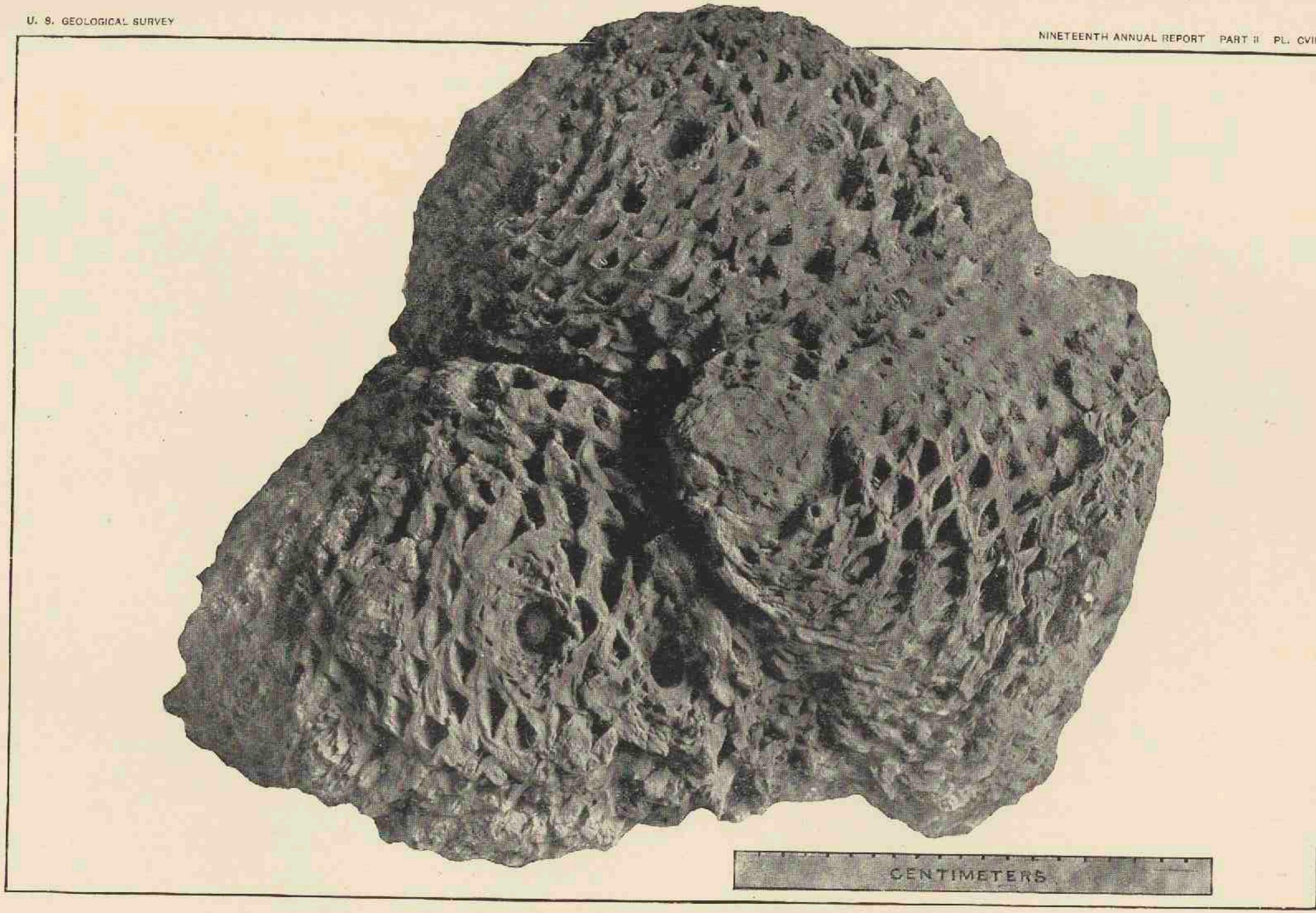
Scale, 20 cm.



CYCADEOIDEA FURCATA.

PLATE CVIII.

PLATE CVIII.



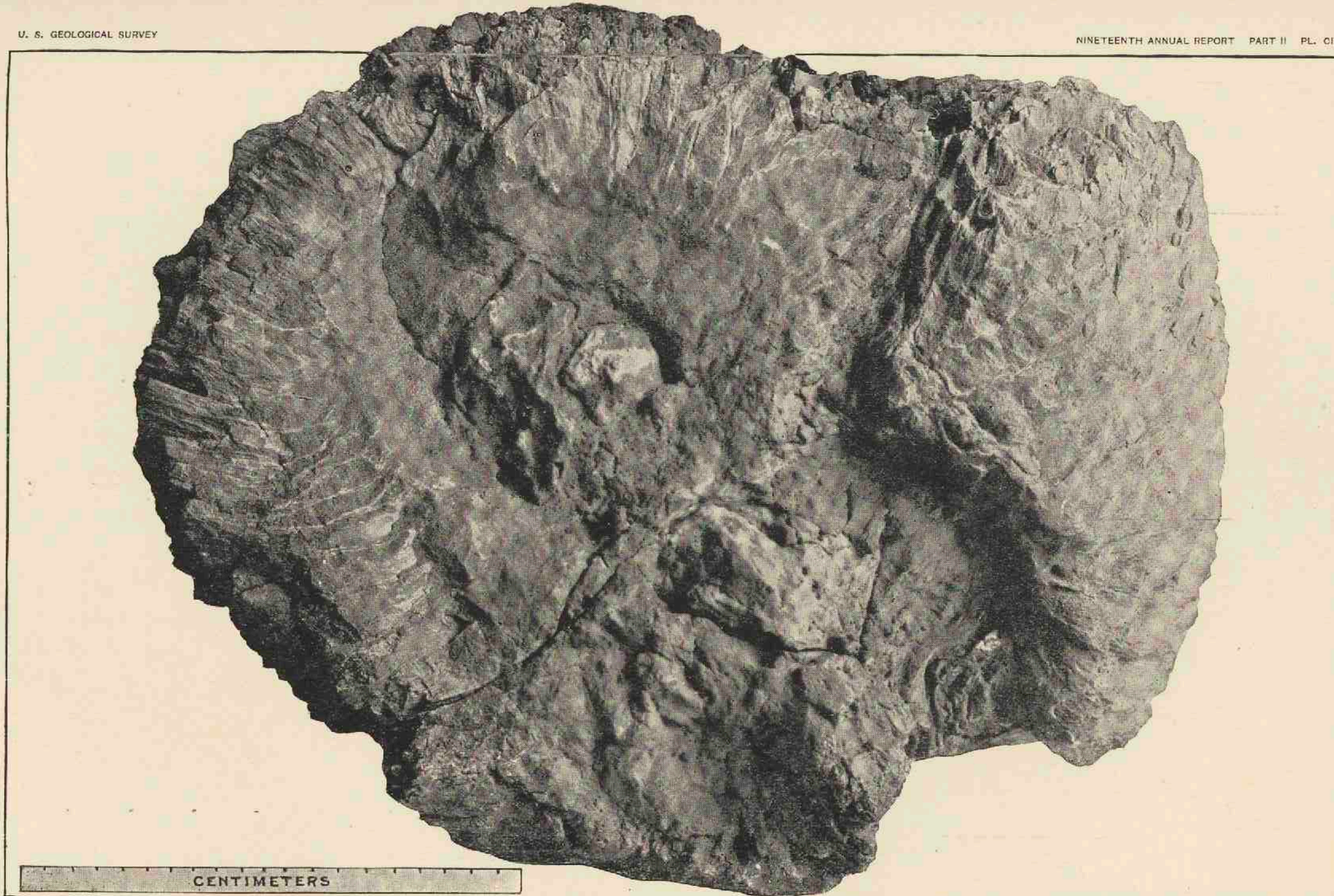
CYCADEOIDEA FURCATA.

PLATE CIX.

PLATE CIX.

	Page.
CYCADEOIDEA FURCATA n. sp	618

View of the base of trunk No. 18 of the Yale collection.
Scale, 20 cm.



CYCADEOIDEA FURCATA.

PLATE CX.

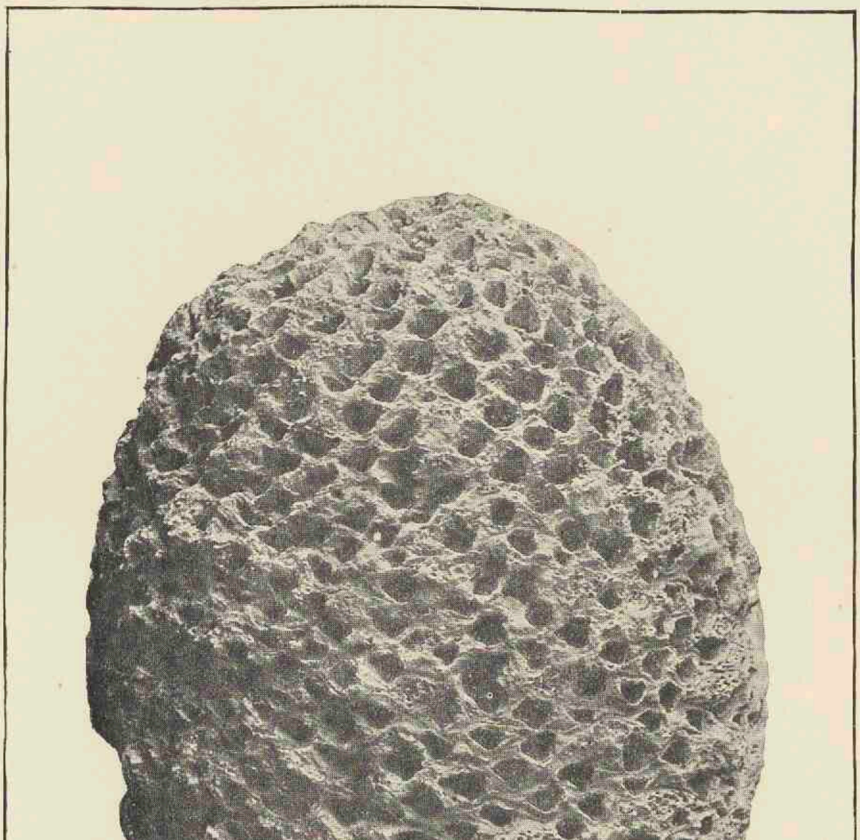
PLATE CX.

Page.

CYCADEOIDEA COLEI n. sp. 619

Side view of No. 2 of the U. S. National Museum collection.

Scale, 20 cm.

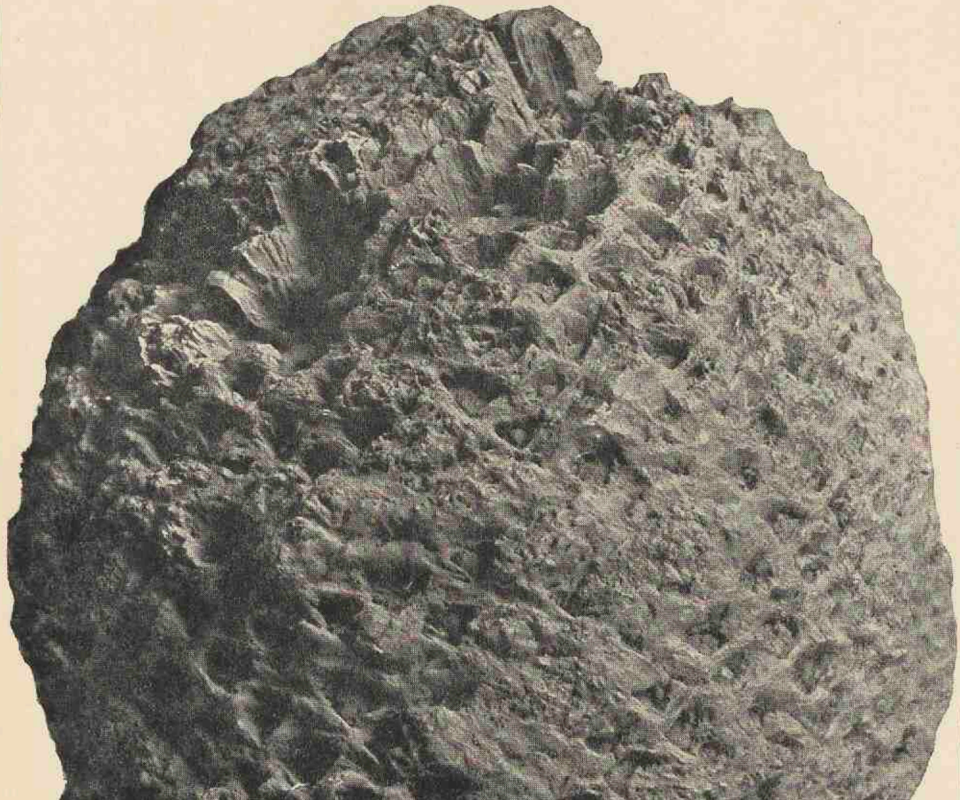


CYCADEOIDEA COLEI.

PLATE CXI.

PLATE CXI.

	Page.
CYCADEOIDEA COLEI n. sp	619
Side view of No. 48 of the Yale collection.	
Scale, 20 cm.	



CYCADEOIDEA COLEI.

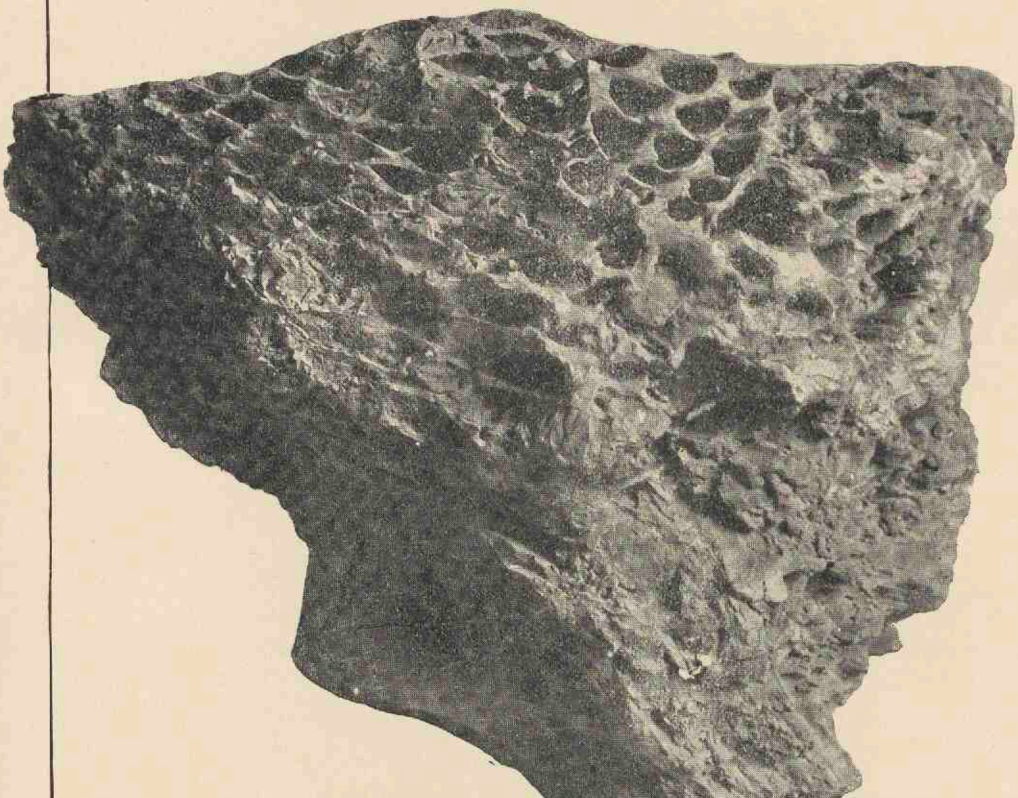
PLATE CXII.

PLATE CXII.

	Page.
Cycadeoidea Colei n. sp	619

Fragment No. 12 of the Yale collection.

Scale, 20 cm.



CYCADEOIDEA COLEI.

PLATE CXIII.

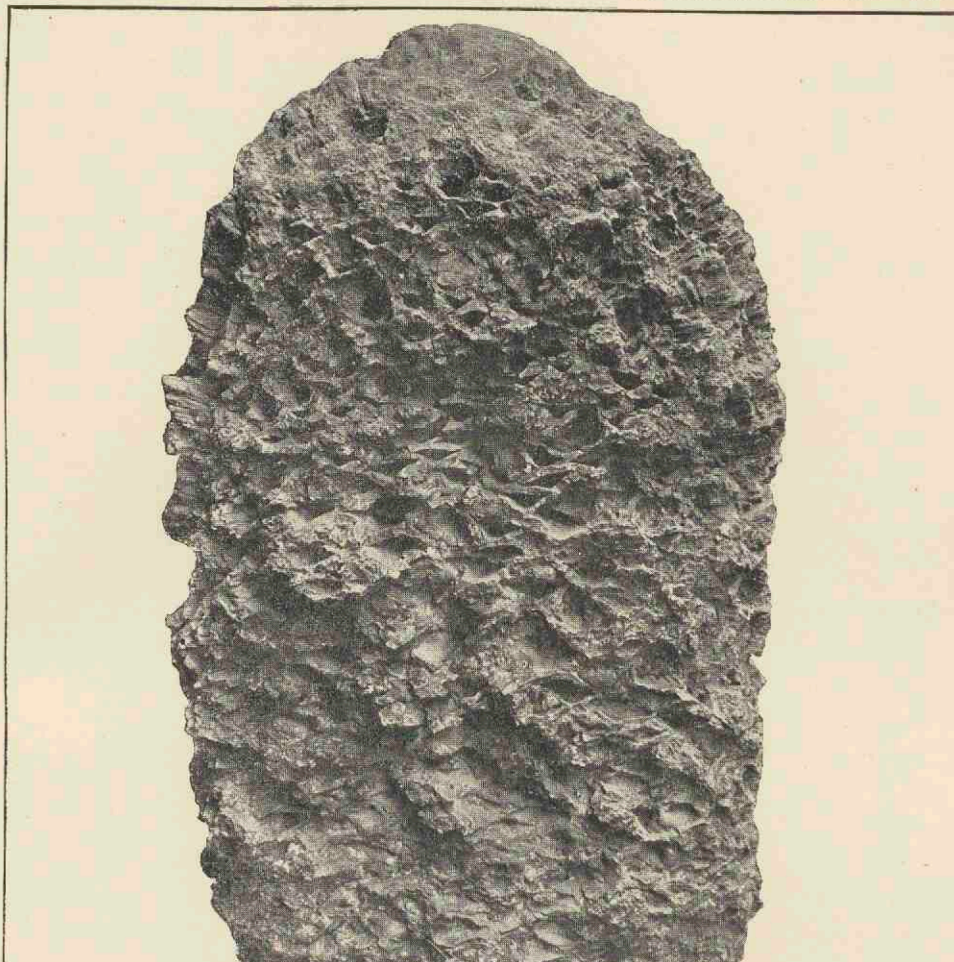
PLATE CXIII.

	Page.
Cycadeoidea Paynei n. sp	
Trunk No. 4 of the U. S. National Museum collection.	620

Fig. 1. Side view.

Fig. 2. View of the base.

Scale, 20 cm.



CYCADEOIDEA PAYNEI.

PLATE CXIV.

PLATE CXIV.

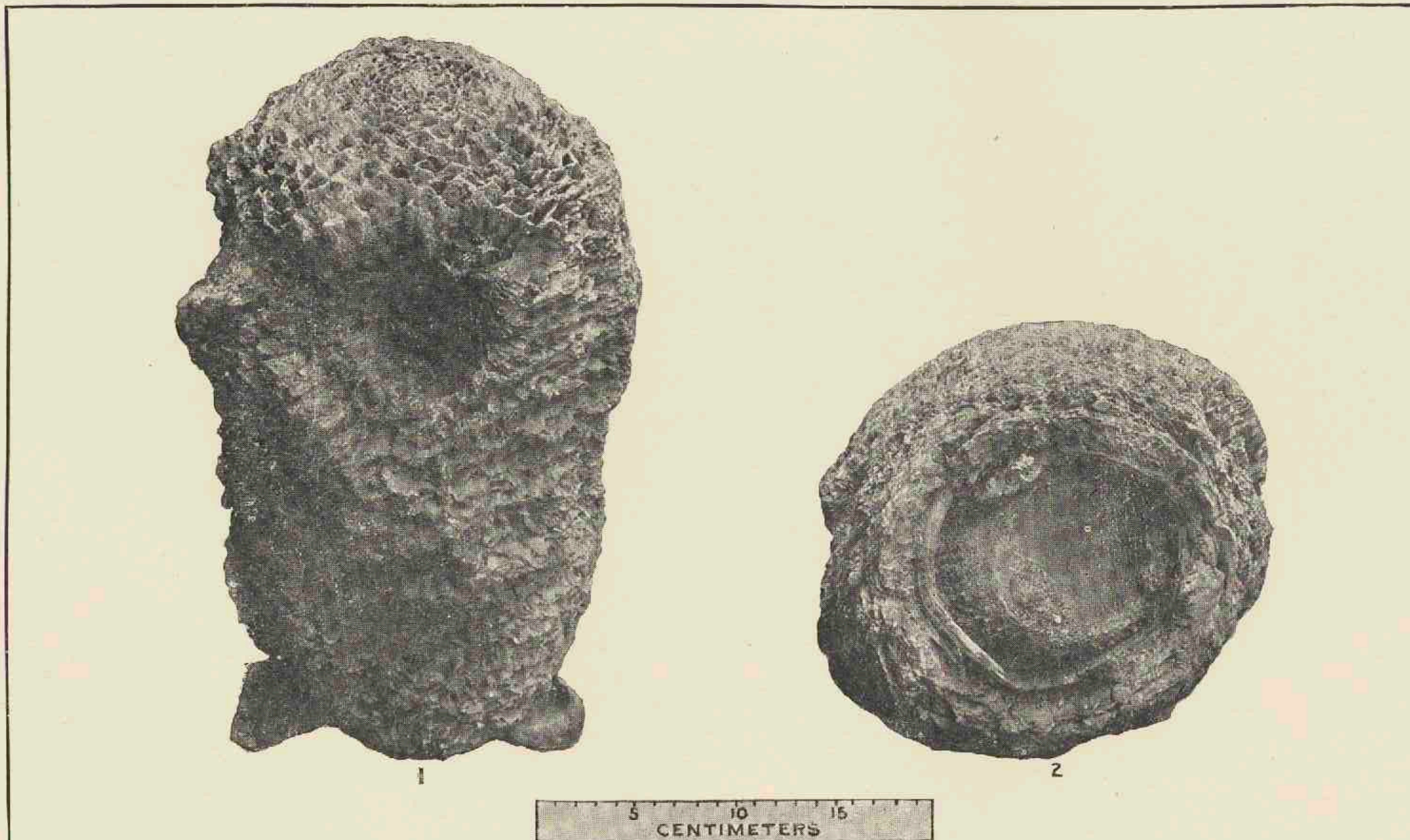
	Page.
CYCADEOIDEA PAYNEI n. sp.	620

Trunk No. 5 of the U. S. National Museum collection.

FIG. 1. Side view, also showing the apex.

FIG. 2. View of the base.

Scale, 20 cm.



CYCADEOIDEA PAYNEI.

PLATE CXV.

PLATE CXV.

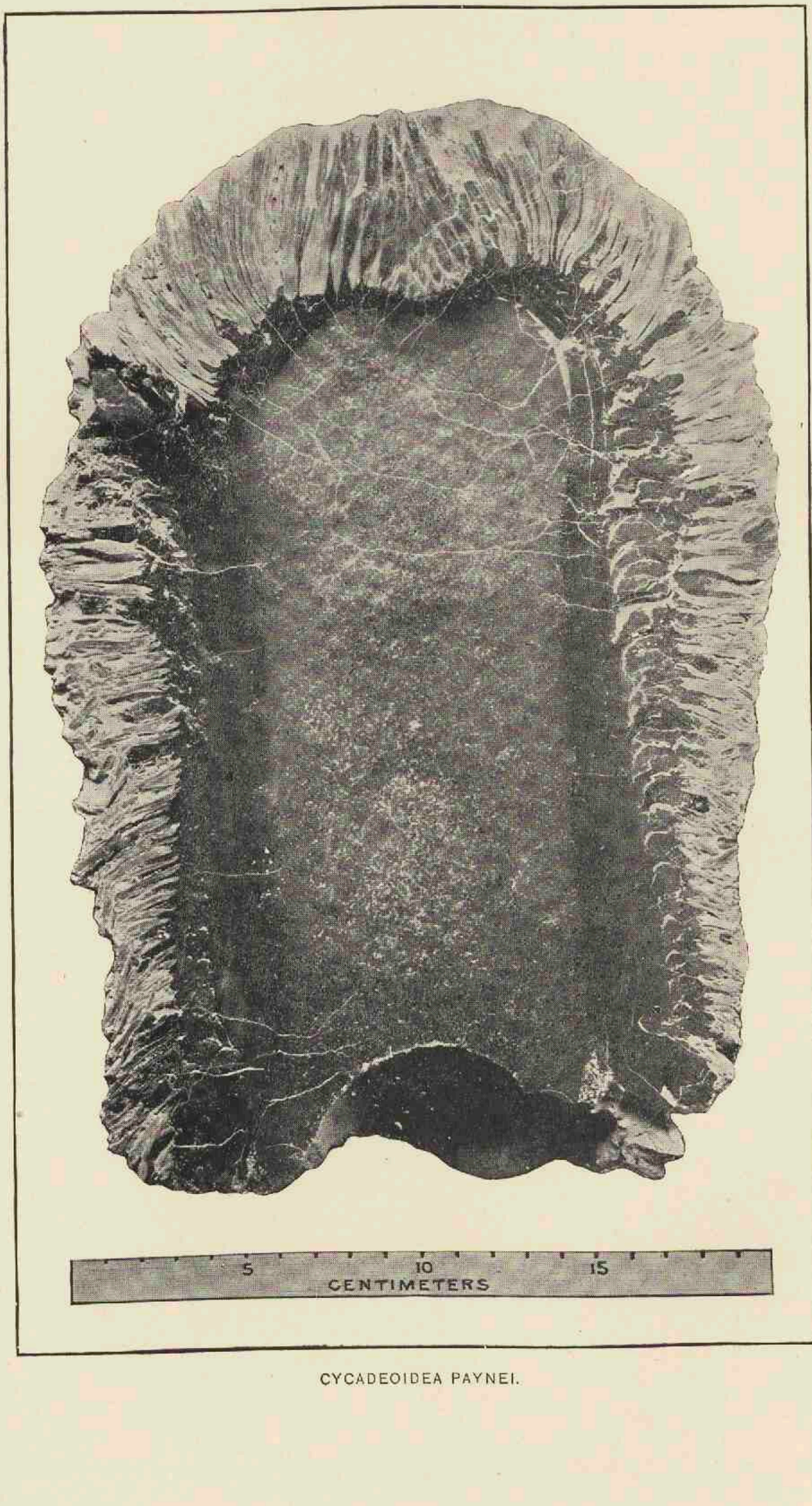
Page.

CYCADEOIDEA PAYNEI n. sp 620

Trunk No. 5 of the U. S. National Museum collection. View of the interior from a longitudinal section through the center.

Scale, 20 cm.

832



CYCADEOIDEA PAYNEI.

PLATE CXVI.

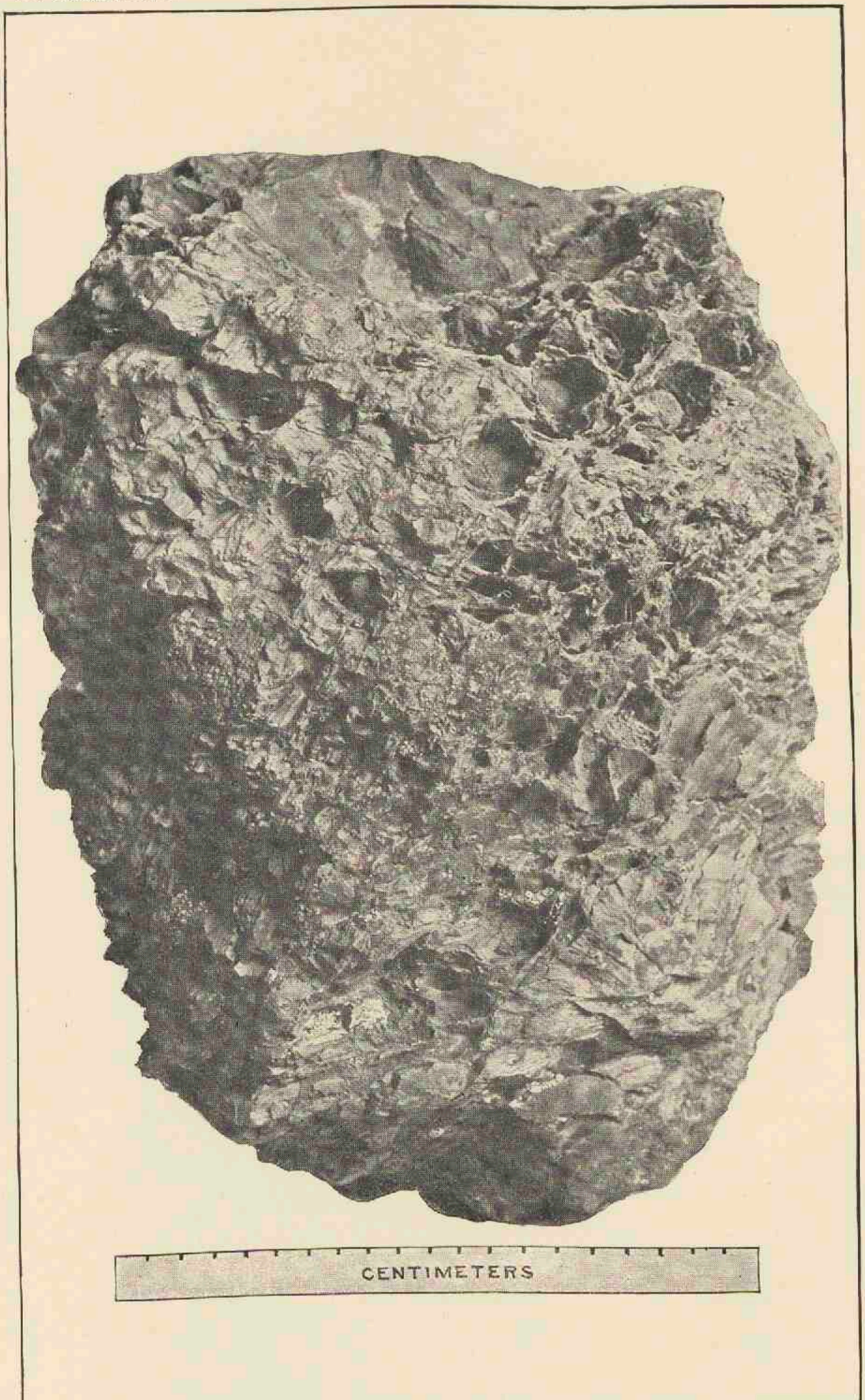
PLATE CXVI.

Page.

CYCADEOIDEA WIELANDI n. sp. 621

Side view of trunk No. 77 of the Yale collection.

Scale, 20 cm.



CYCADEOIDEA WIELANDI.

PLATE CXVII.

PLATE CXVII.

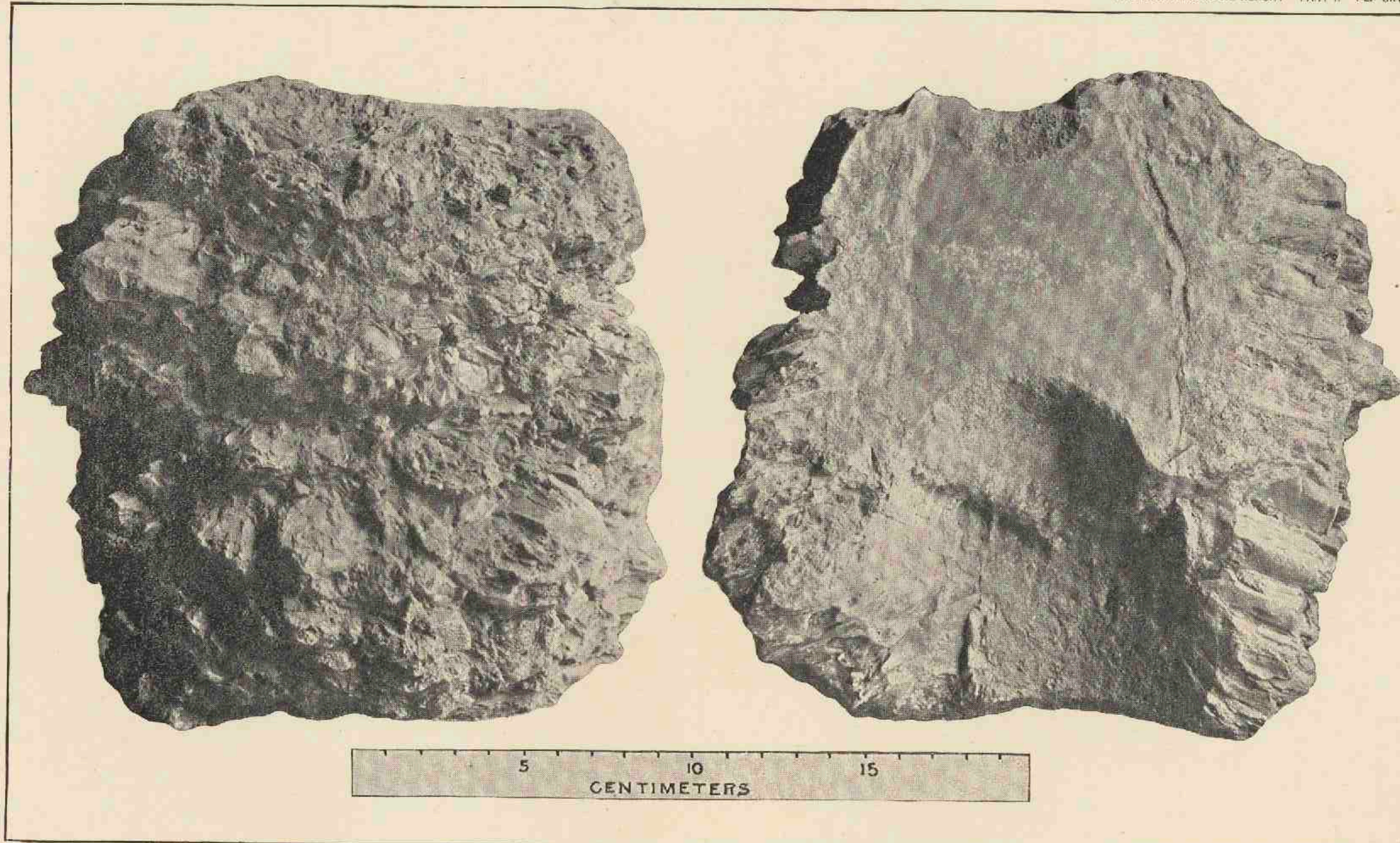
	Page.
CYCADEOIDEA ASPERA n. sp.	624

No. 104 of the Yale collection.

FIG. 1. External surface.

FIG. 2. Inner face, showing armor and axis in longitudinal section.

Scale, 20 cm.



CYCADEOIDEA ASPERA.

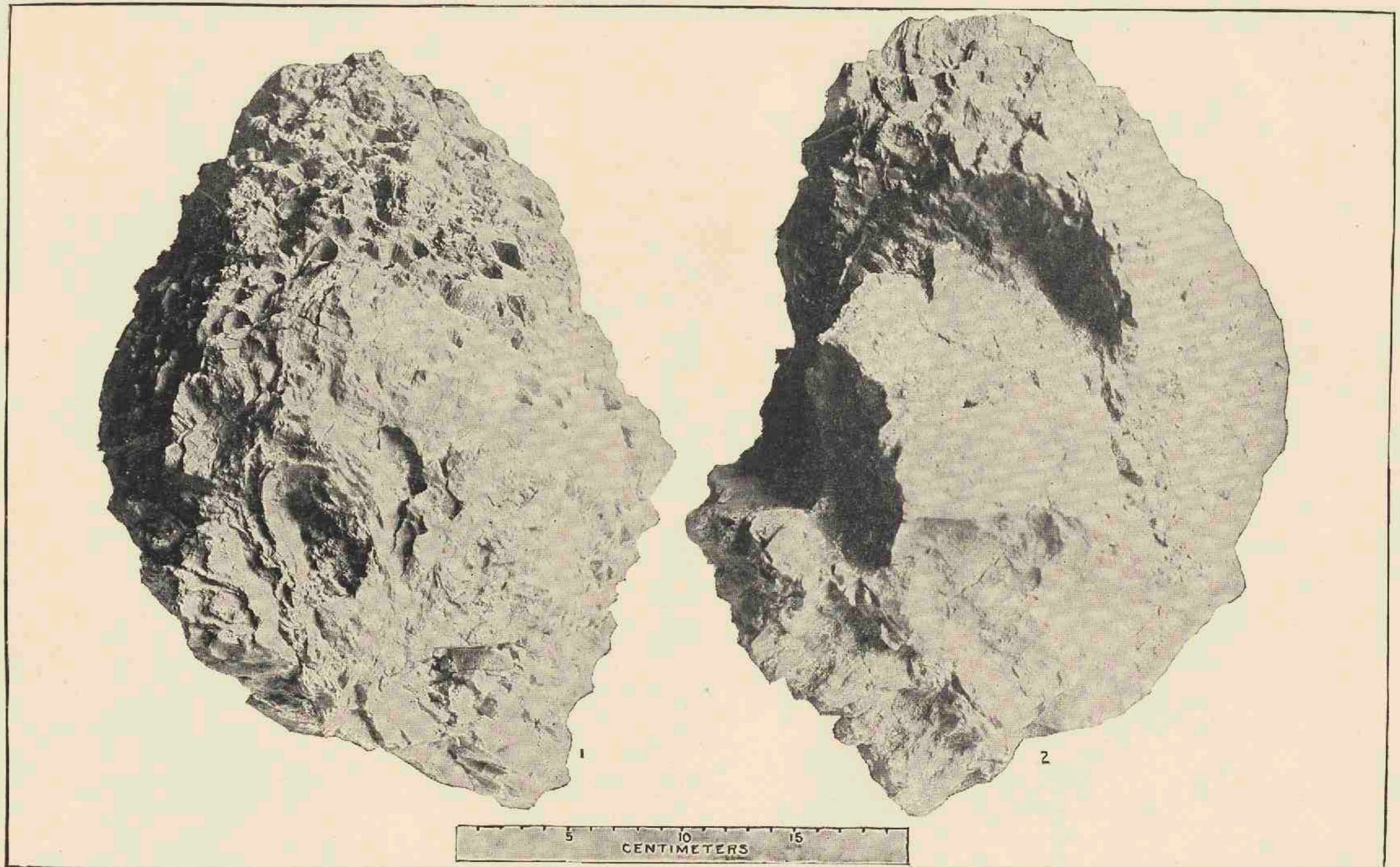
PLATE CXVIII.

PLATE CXVIII.

FIG. 1. Partially lateral view of trunk No. 64 of the Yale collection.

FIG. 2. View of the base of the same specimen.

Scale, 20 cm.



CYCADEOIDEA INSOLITA.

PLATE CXIX.

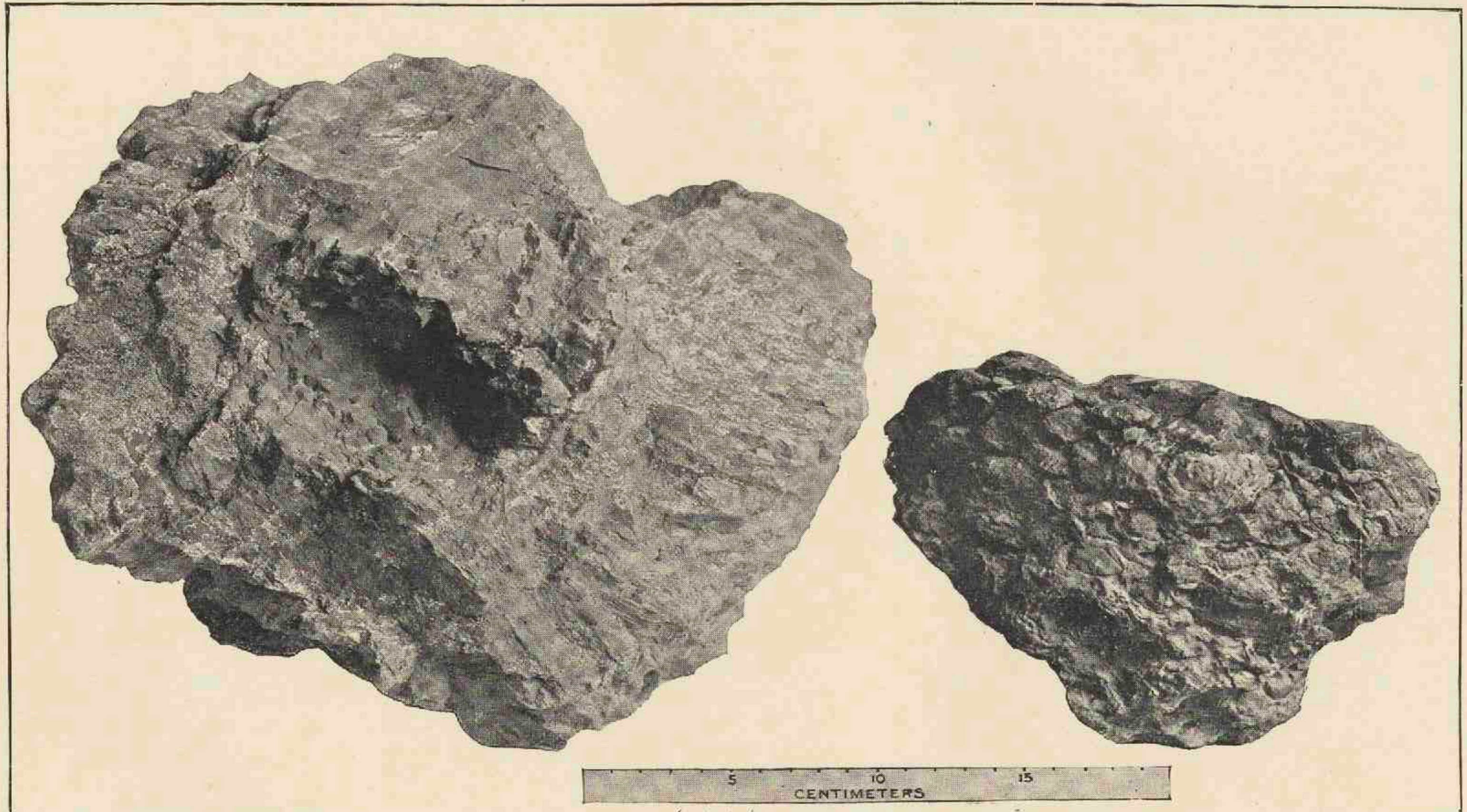
PLATE CXIX.

	Page.
CYCADEOIDEA INSOLITA n. sp.	625

FIG. 1. View of the interior of trunk No. 64 of the Yale collection.

FIG. 2. View of the external surface of fragment No. 50 of the Yale collection.

Scale 20 cm.



CYCADEOIDEA INSOLITA.

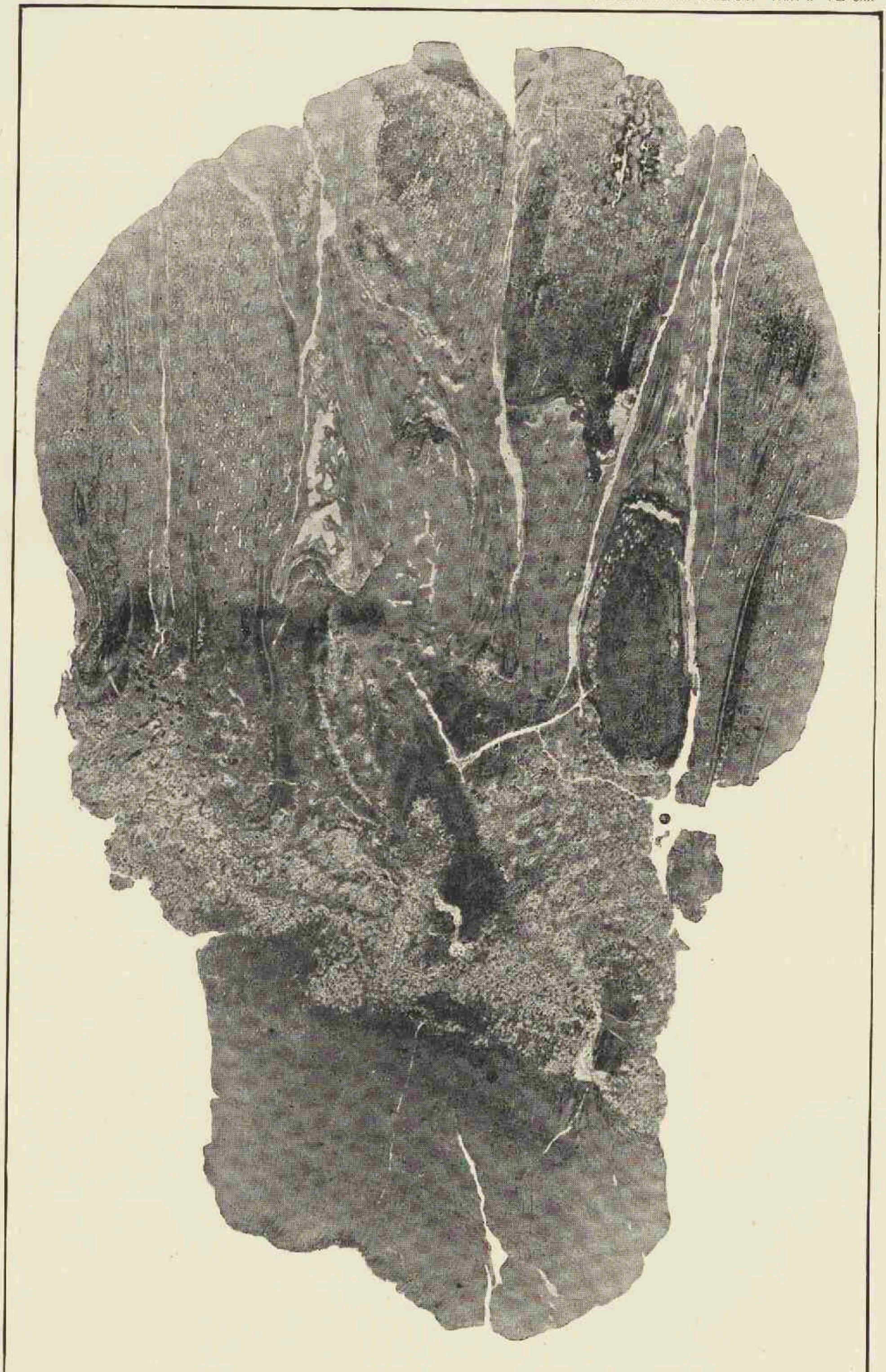
PLATE CXX.

PLATE CXX.

Page.

Cycadeoidea occidentalis n. sp 626

Enlarged view of a polished section through the armor and woody zone of fragment No. 11 of the U. S. National Museum collection, showing internal structure, including one of the fruits cut longitudinally.



CYCADEOIDEA OCCIDENTALIS.

PLATE CXXI.

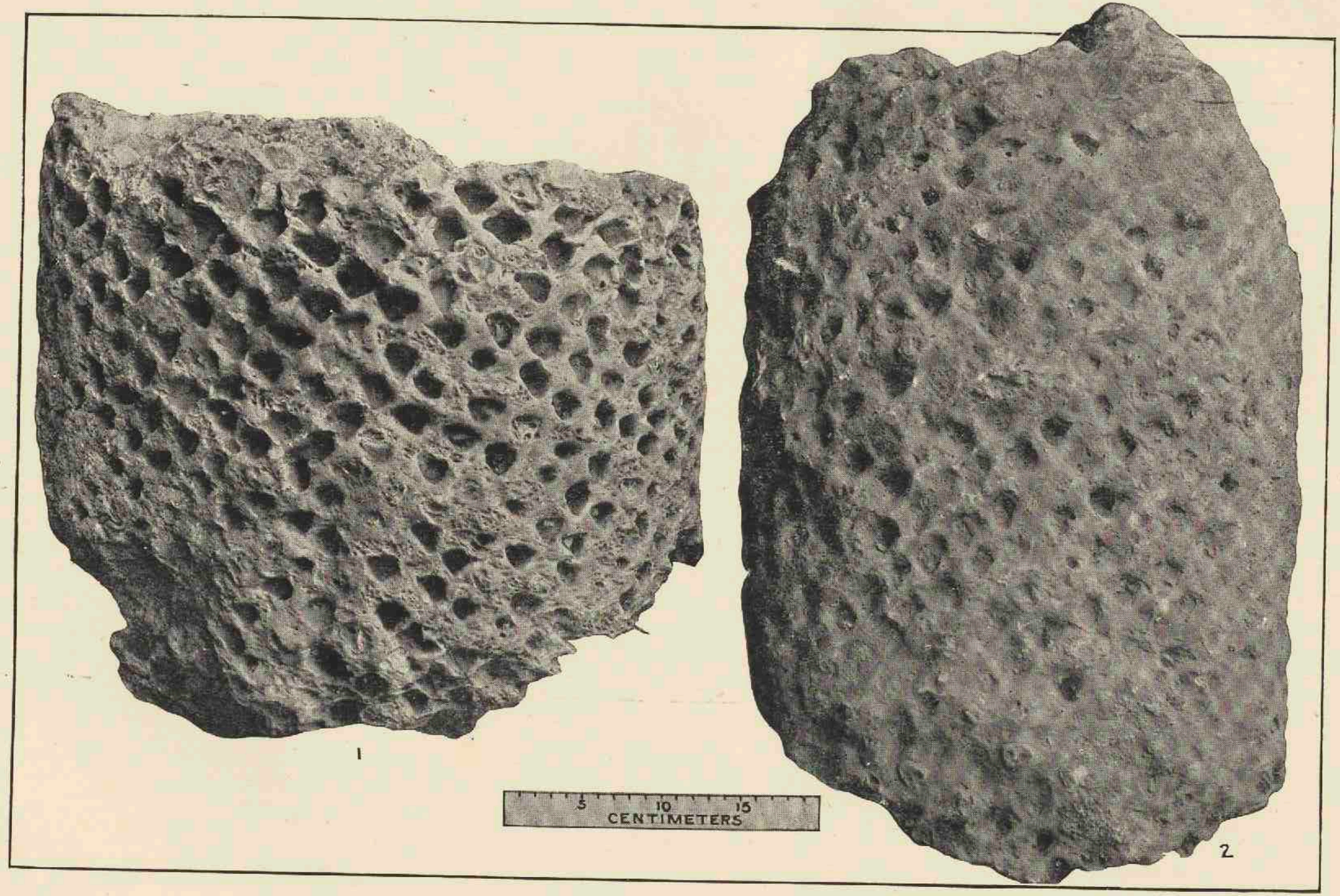
PLATE CXXI.

Specimens belonging to the State School of Mines of South Dakota.

FIG. 1. Longest side of specimen No. 1, representing the lower portion.

FIG. 2. Longest side of specimen No. 2, representing the upper portion.

Scale, 20 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXII.

PLATE CXXII.

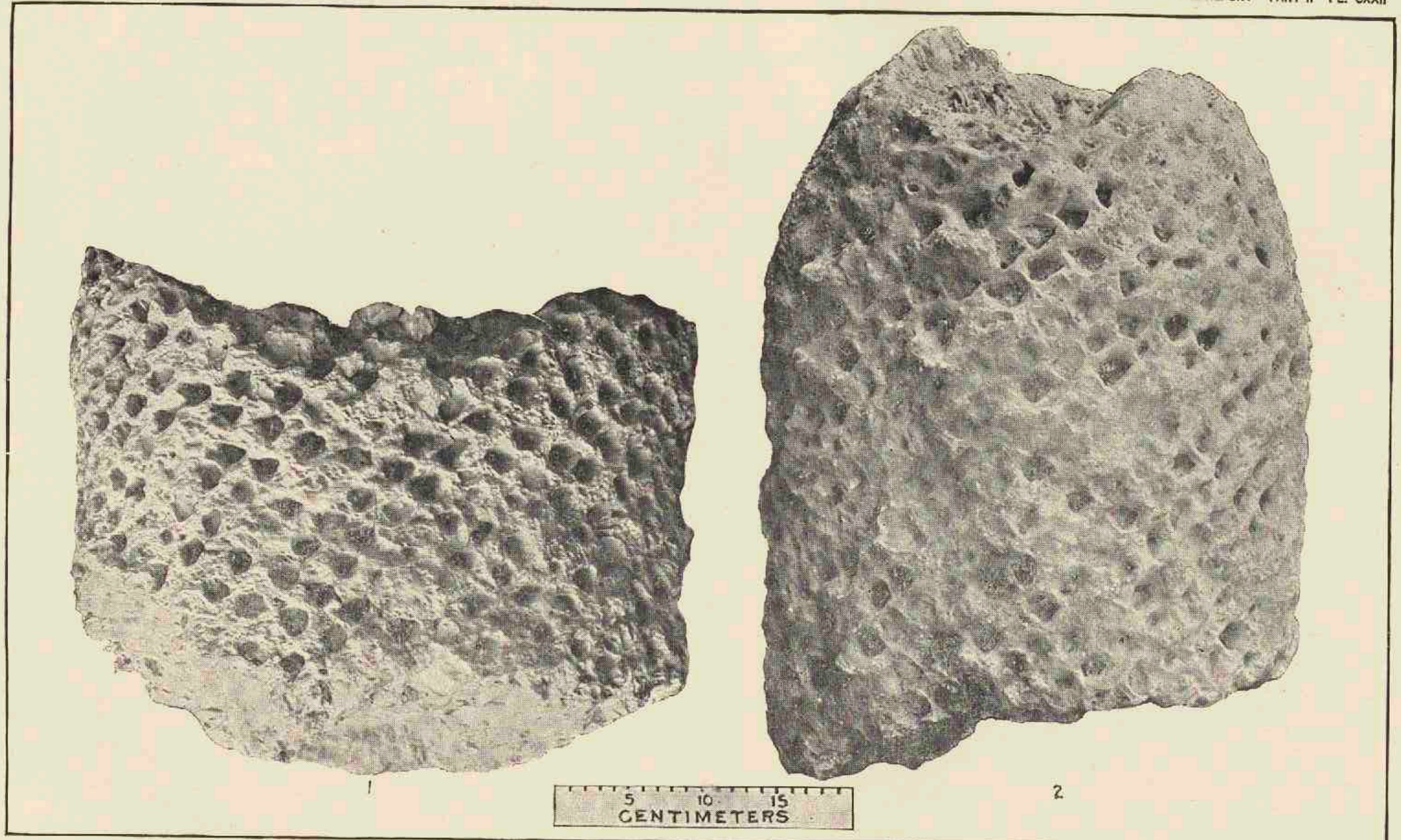
Page.

Spec mens belonging to the State School of Mines of South Dakota.

FIG. 1. Shortest side of specimen No. 1, representing the lower portion.

FIG. 2. Shortest side of specimen No. 2, representing the upper portion.

Scale, 20 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXIII.

PLATE CXXIII.

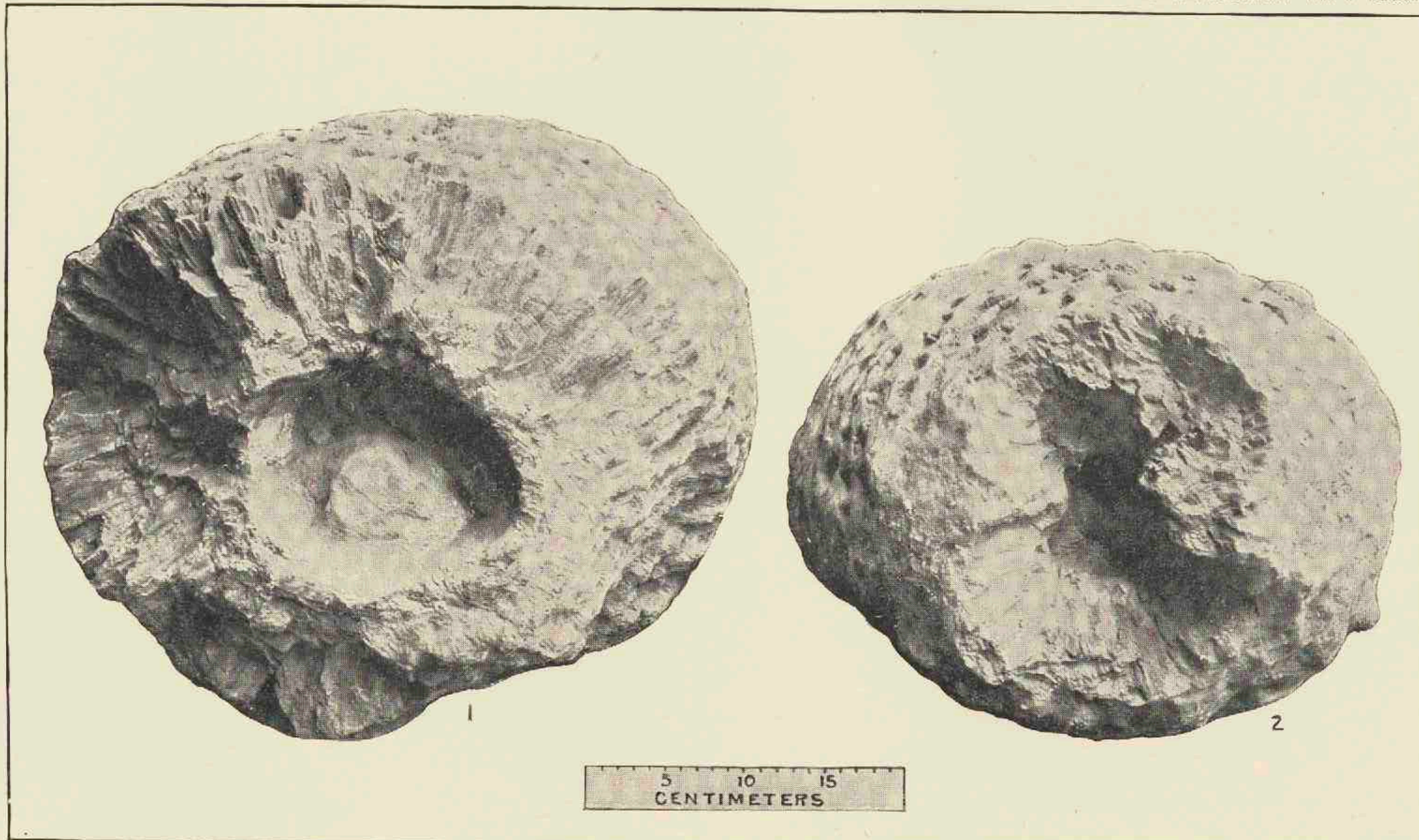
	Page.
CYCADEOIDEA JENNEYANA Ward	627

Specimens belonging to the State School of Mines of South Dakota.

FIG. 1. View of the base of specimen No. 1, representing the true base of the trunk.

FIG. 2. View of the apex of specimen No. 2, showing the "crow's nest."

Scale, 20 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXIV.

PLATE CXXIV.

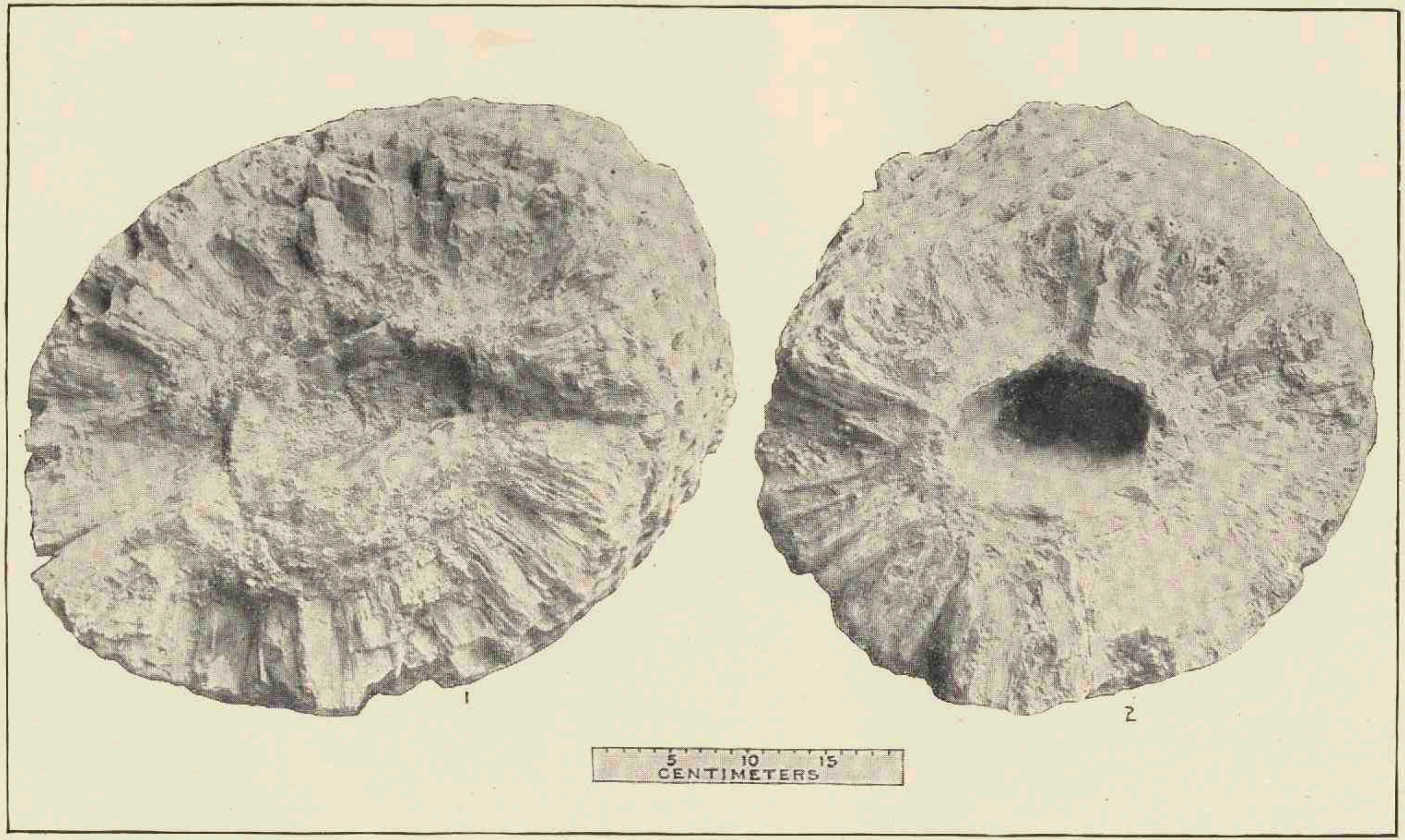
Specimens belonging to the State School of Mines of South Dakota.

FIG. 1. View of the upper end of specimen No. 1, representing the lower portion.

FIG. 2. View of the lower end of specimen No. 2, representing the upper portion.

(Between these a segment of unknown thickness is wanting.)

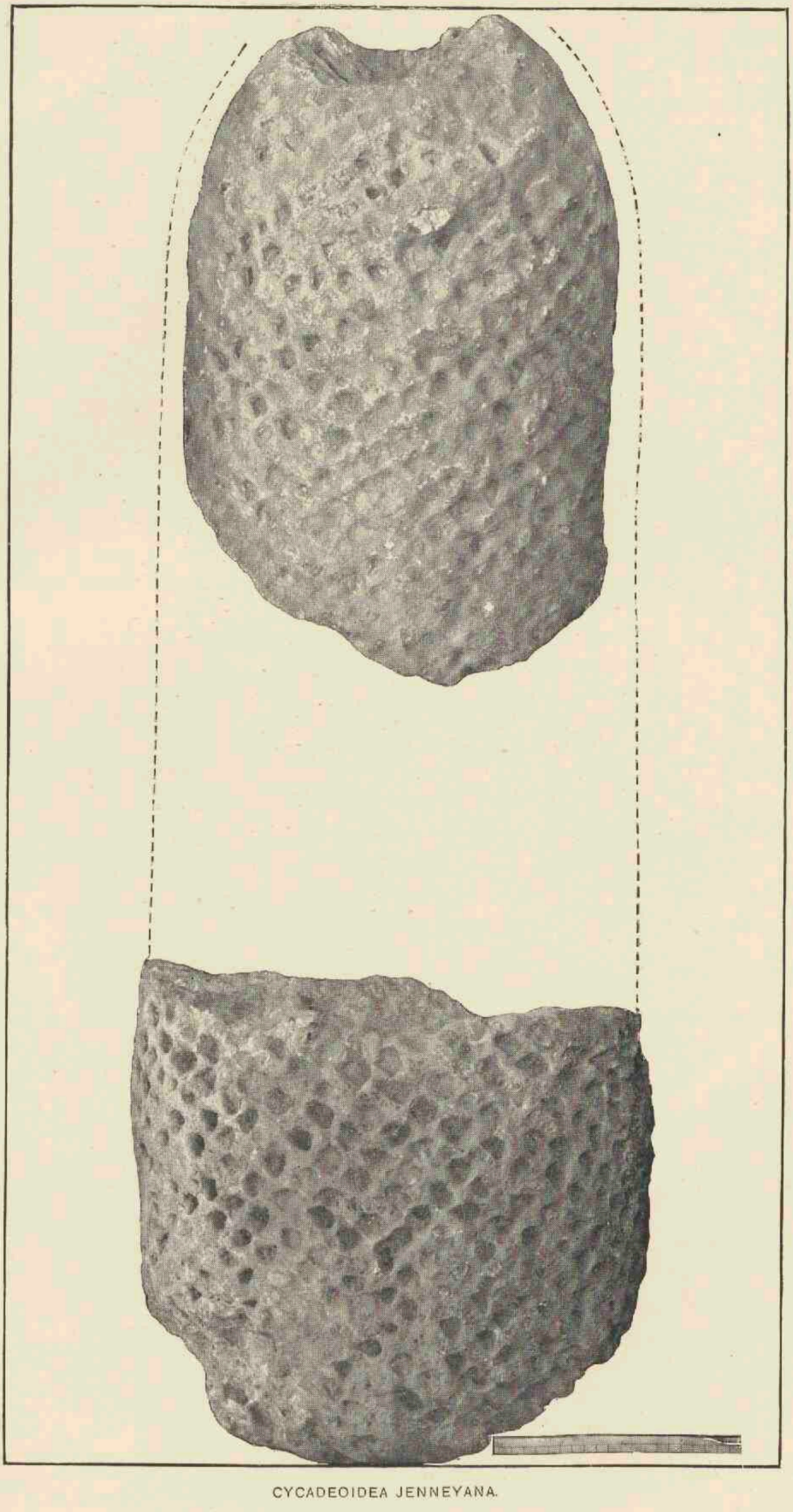
Scale, 20 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXV.

PLATE CXXV.



CYCADEOIDEA JENNEYANA.

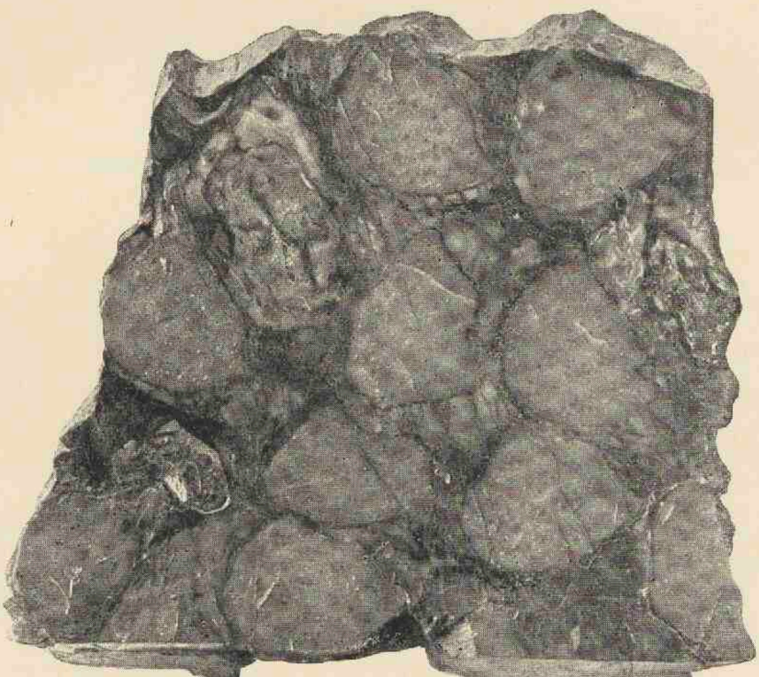
PLATE CXXVI.

PLATE CXXVI.

	Page.
Cycadeoidea Jenneyana Ward	627

View of the polished surface of No. 1501 of the Woman's College of Baltimore, showing leaf bases and fruits in cross section.

Natural size.



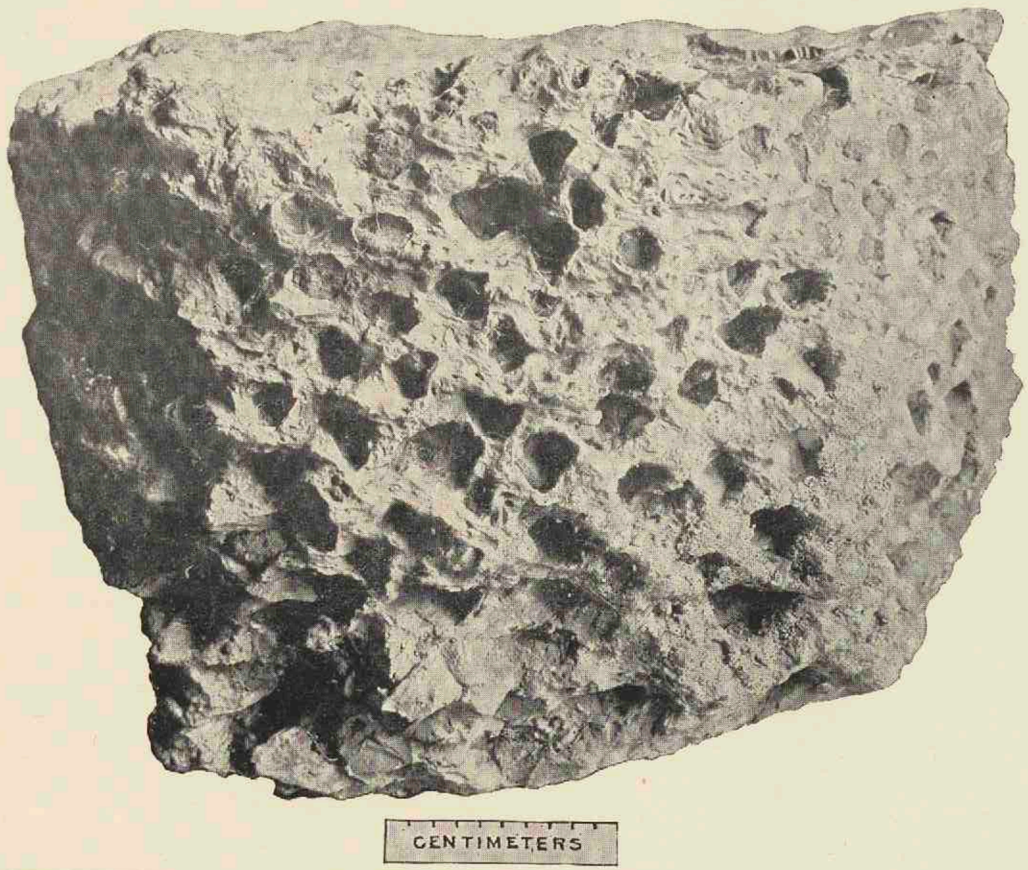
CYCADEOIDEA JENNEYANA.

PLATE CXXVII.

PLATE CXXVII.

Side view of No. 102 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXVIII.

PLATE CXXVIII.

Page

CYCADEOIDEA JENNEYANA Ward.. 627

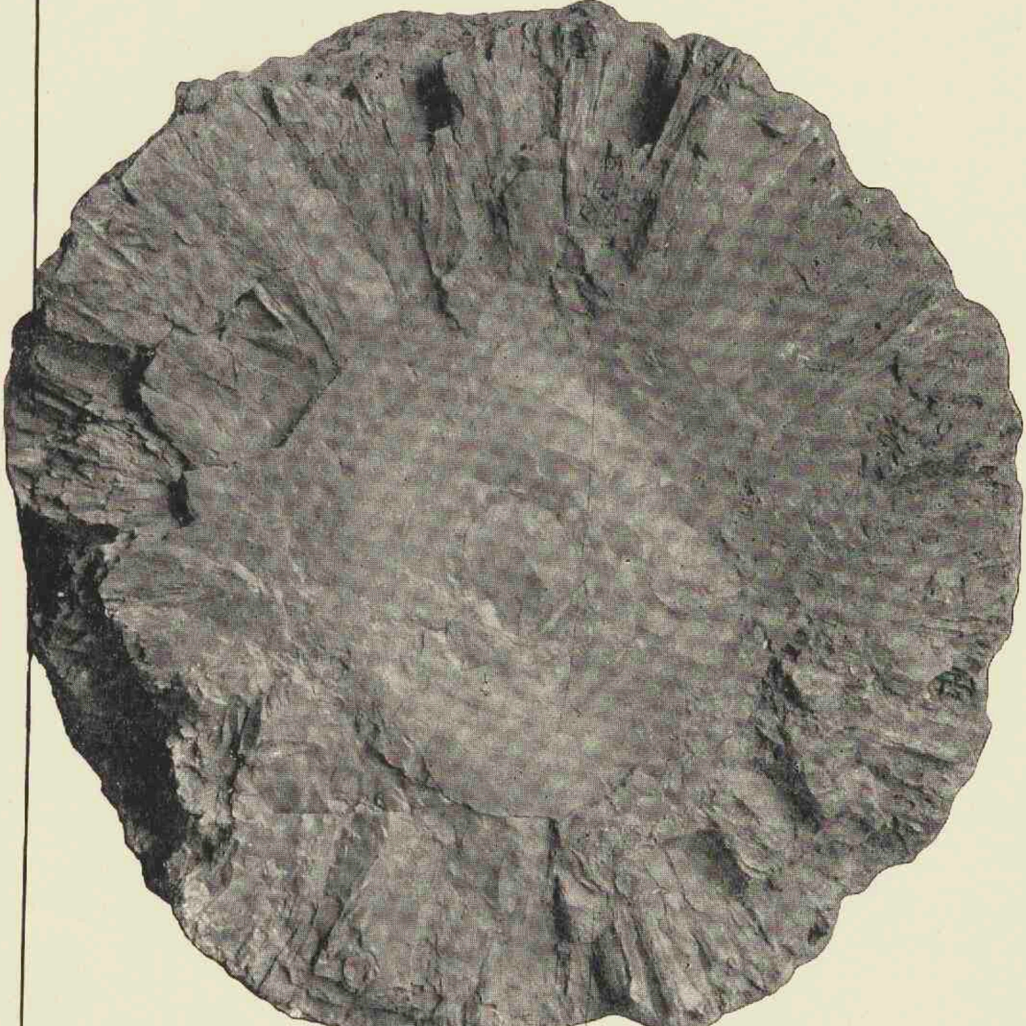
View of the base of No. 102 of the Yale collection.

Scale, 10 cm.

CYCADEOIDEA JENNEYANA.

PLATE CXXIX.

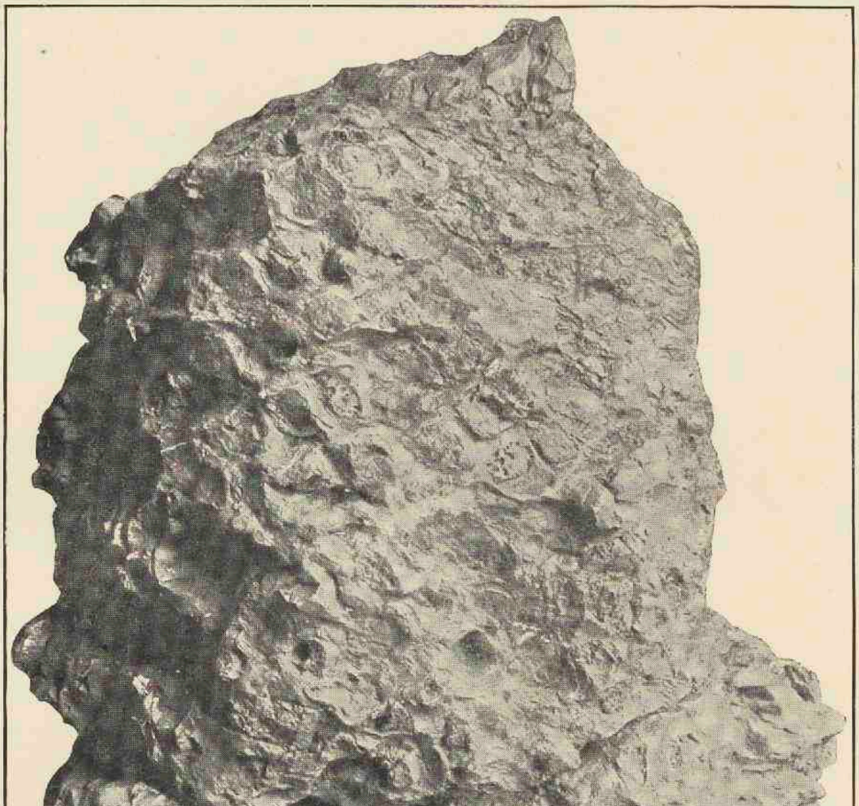
PLATE CXXIX.



CYCADEOIDEA JENNEYANA.

PLATE CXXX.

PLATE CXXX.



CYCADEOIDEA JENNEYANA.

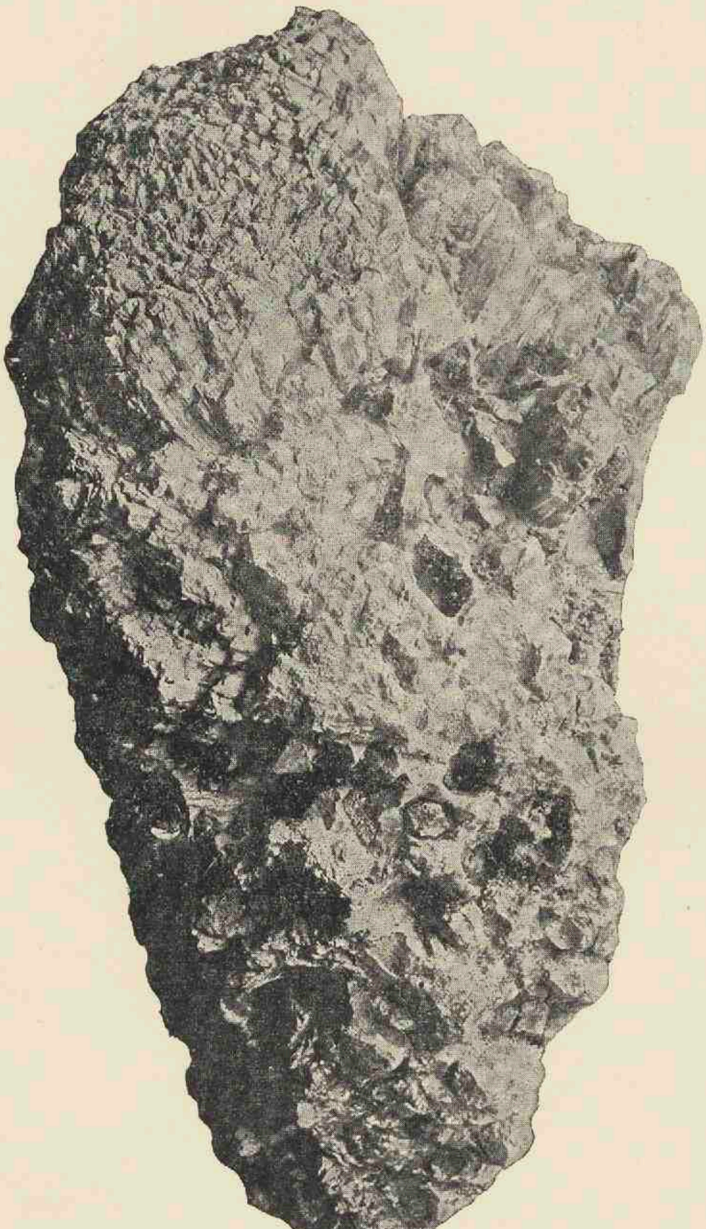
PLATE CXXXI.

PLATE CXXXI.

	Page.
CYCADEOIDEA JENNEYANA Ward?	627

View of No. 91 of the Yale collection from the side which best shows the terminal bud.

Scale, 10 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXXII.

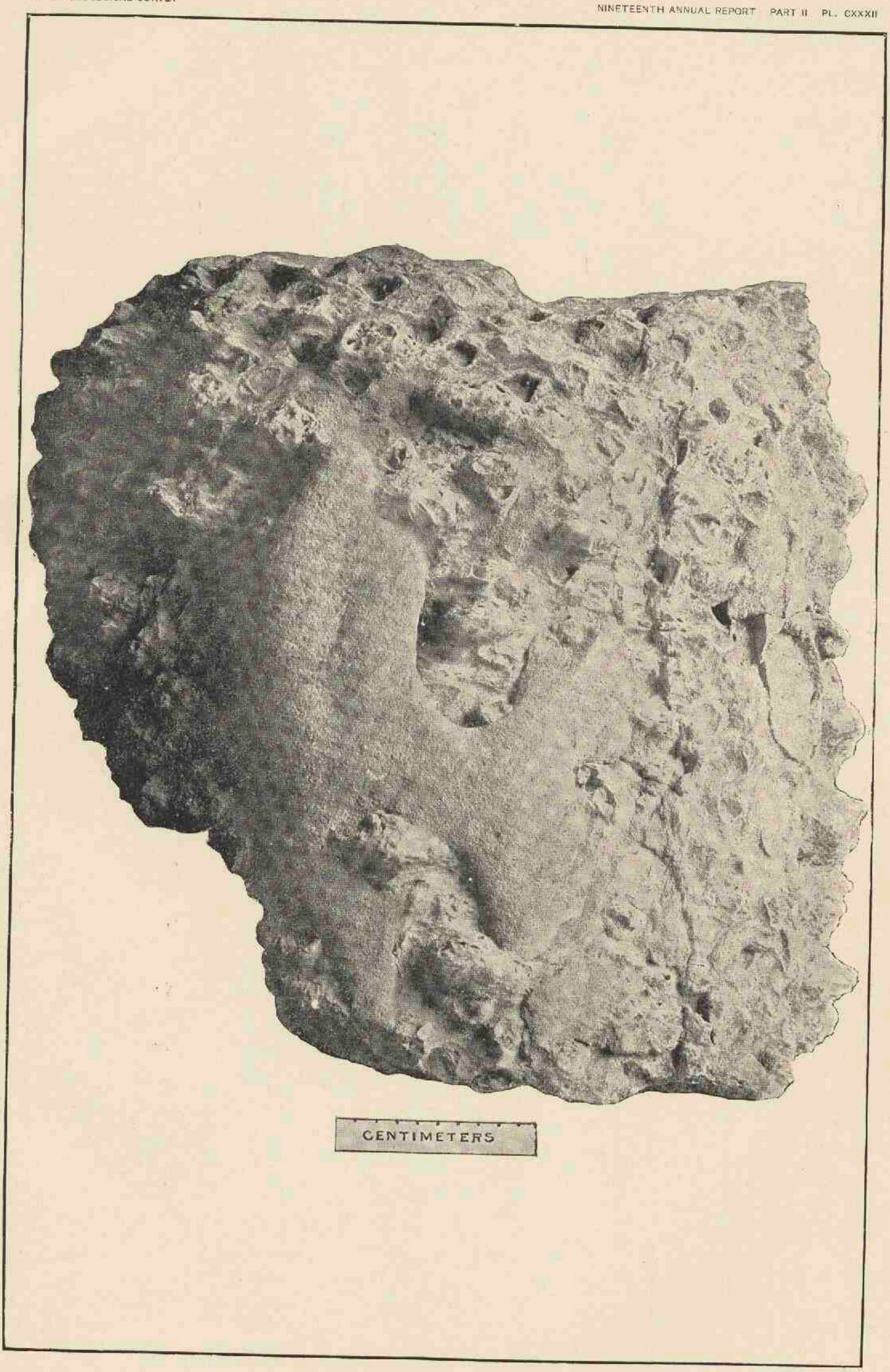
PLATE CXXXII.

Page.

Cycadeoidea Jenneyana Ward 627

View of the outer surface of No. 120 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA JENNEYANA.

PLATE CXXXIII.

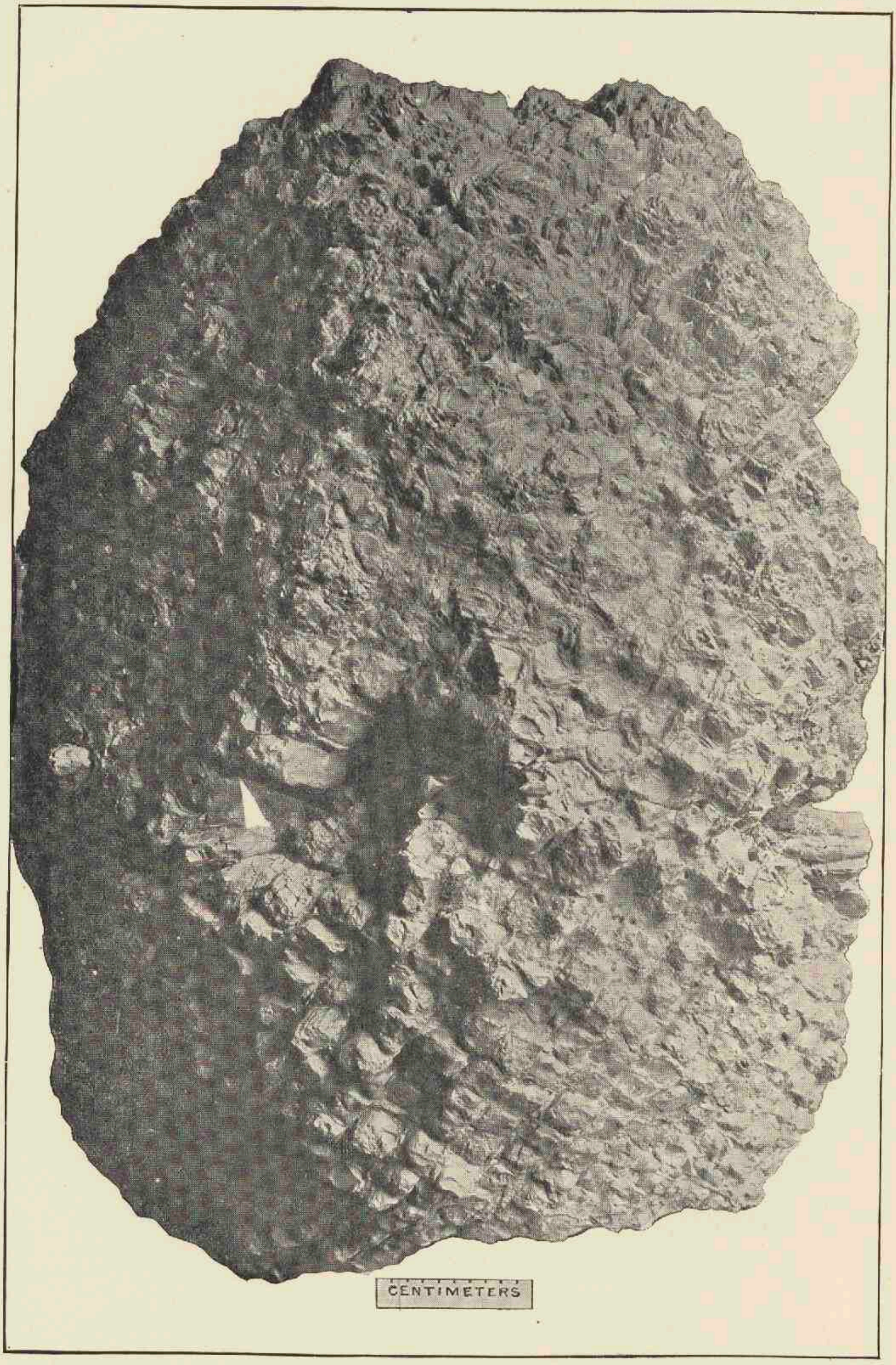
PLATE CXXXIII.

Page.

Cycadeoidea ingens n. sp 632

Side view of trunk No. 100 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA INGENS.

PLATE CXXXIV.

PLATE CXXXIV.

CYCADEOIDEA INGENS.

PLATE CXXXV.

PLATE CXXXV.

CYCADEOIDEA INGENS.

PLATE CXXXVI.

PLATE CXXXVI.

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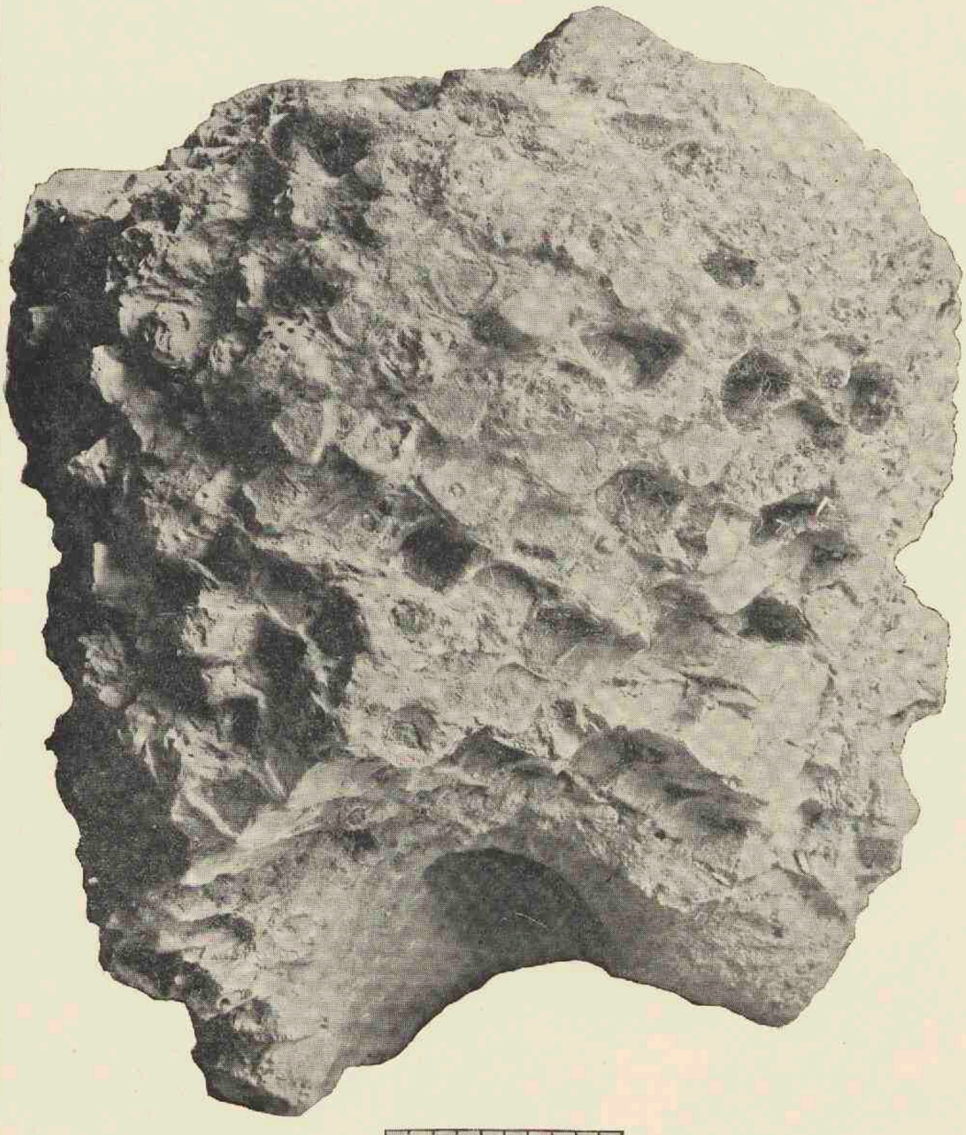
CYCADEOIDEA INGENS n. sp. 632

Side view of No. 103 of the Yale collection.

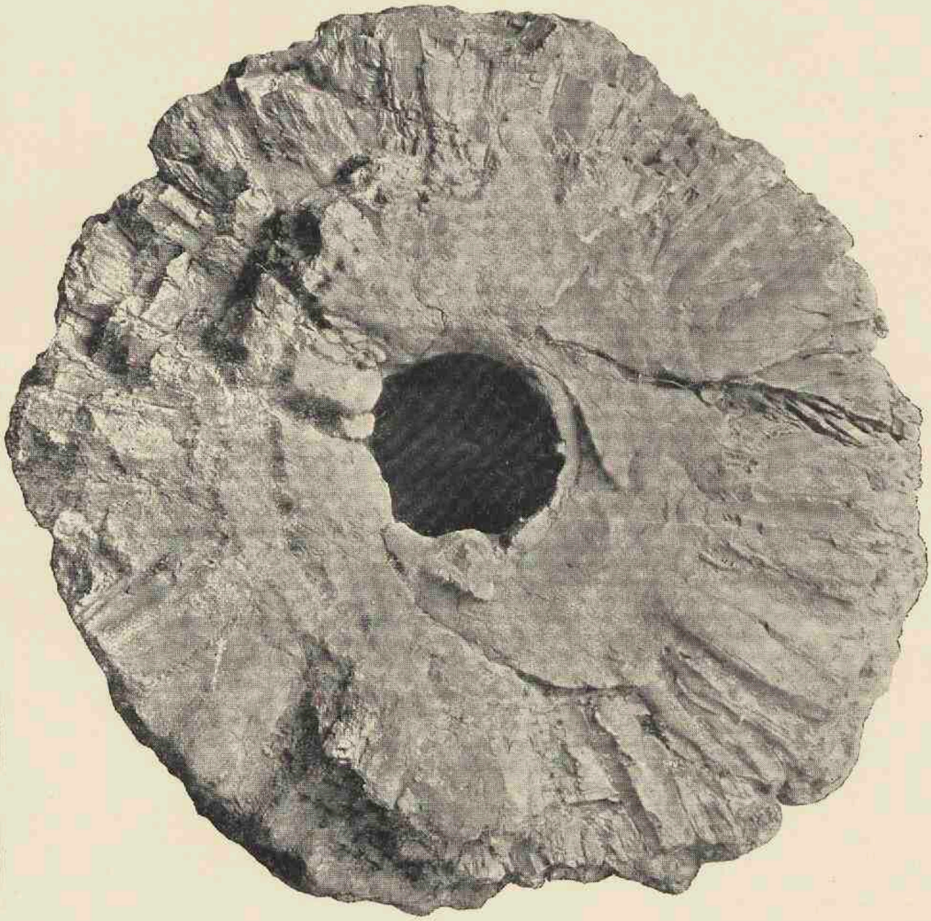
Scale, $\overset{\circ}{10}$ cm.



CYCADEOIDEA INGENS.

PLATE CXXXVII.

PLATE CXXXVII.

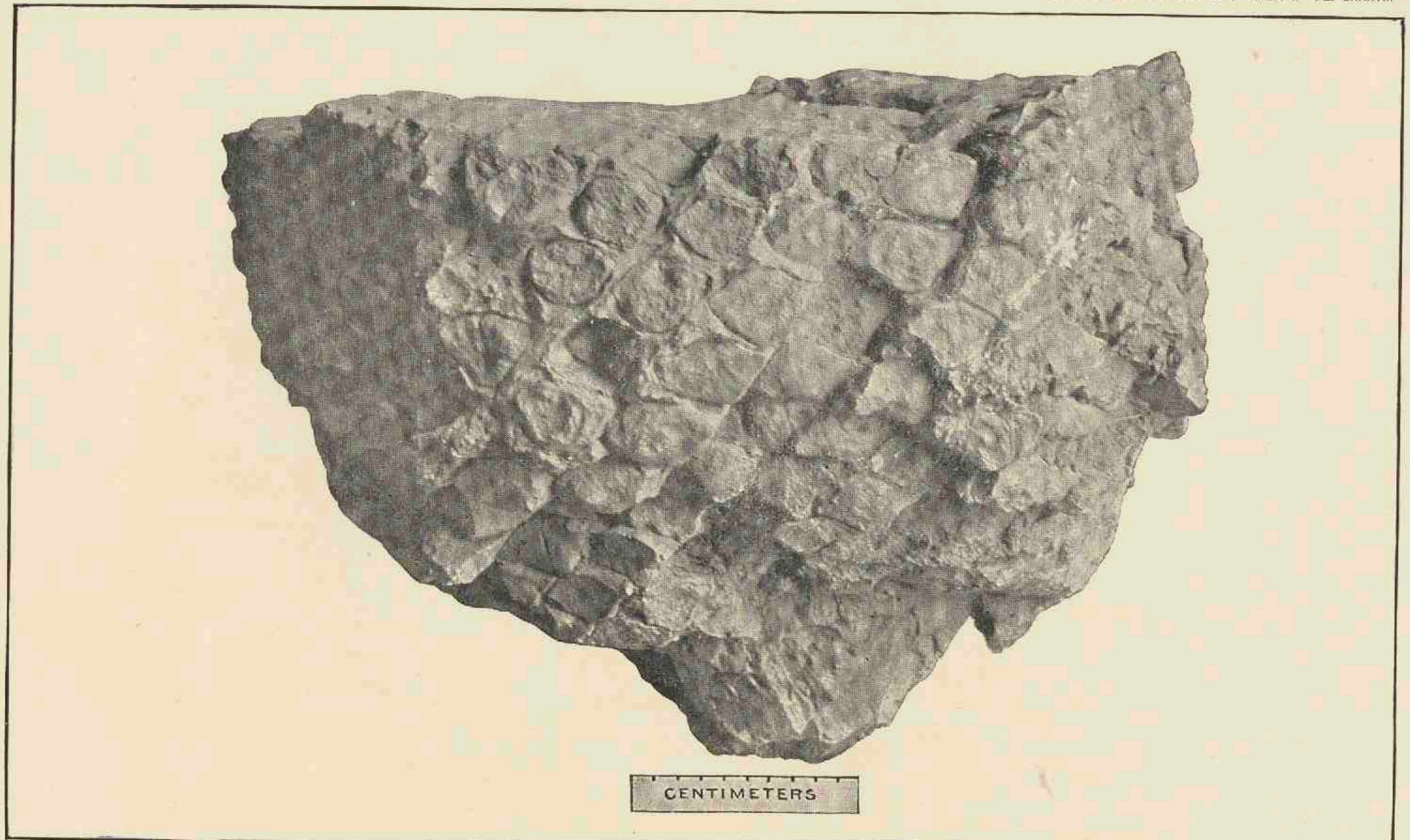


CYCADEOIDEA INGENS.

PLATE CXXXVIII.

PLATE CXXXVIII.

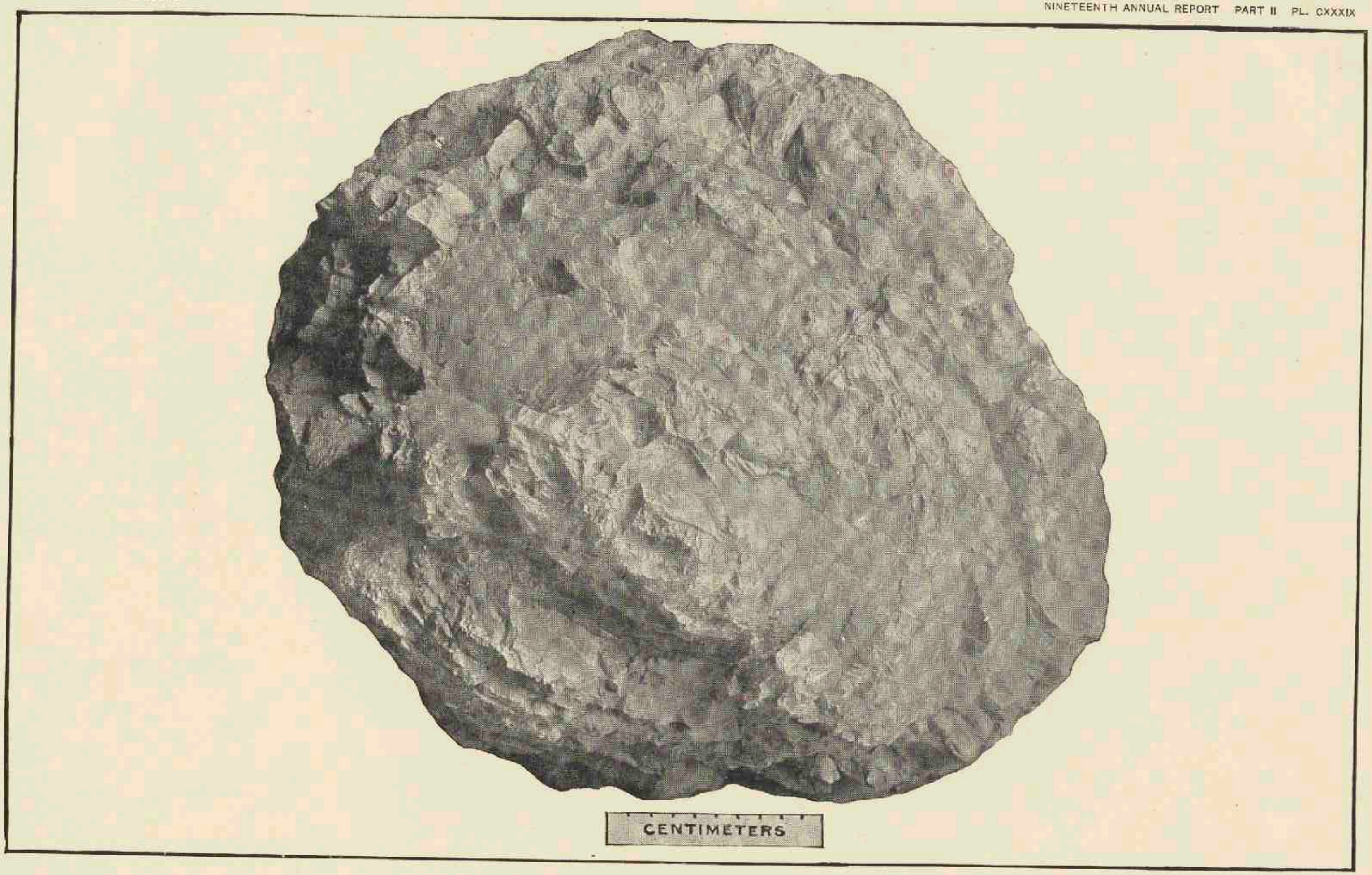
Side view of No. 117 of the Yale collection.
Scale, 10 cm.



CYCADEOIDEA INGENS.

PLATE CXXXIX.

PLATE CXXXIX.



CYCADEOIDEA INGENS.

PLATE CXL.

PLATE CXL.

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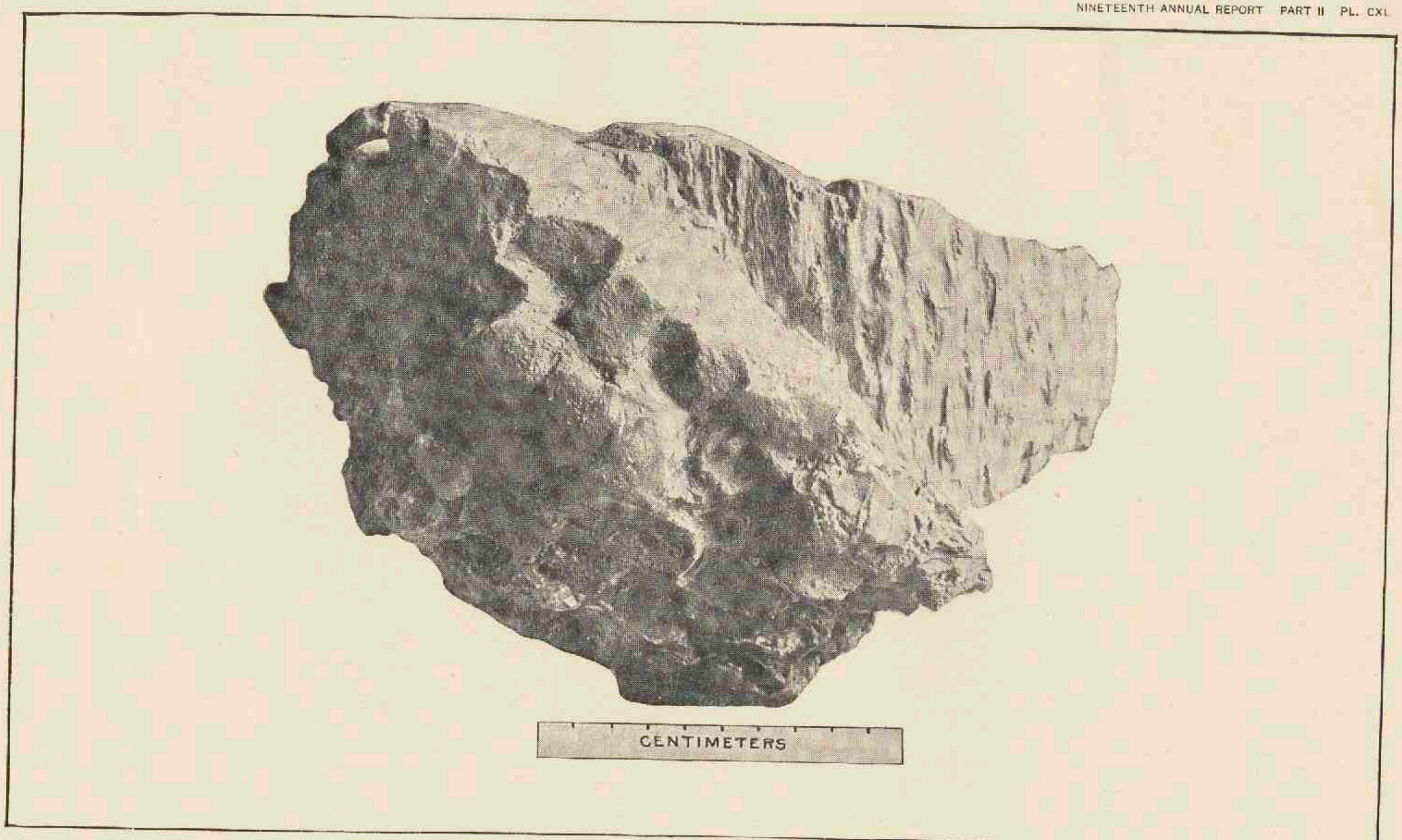
CYCADEOIDEA INGENS n. sp	632

View of a portion of the exterior and part of the exposed surface of the medulla No. 94 of the Yale collection.

Scale, 10 cm.

882



CYCADEOIDEA INGENS.

PLATE CXLI.

PLATE CXLI.

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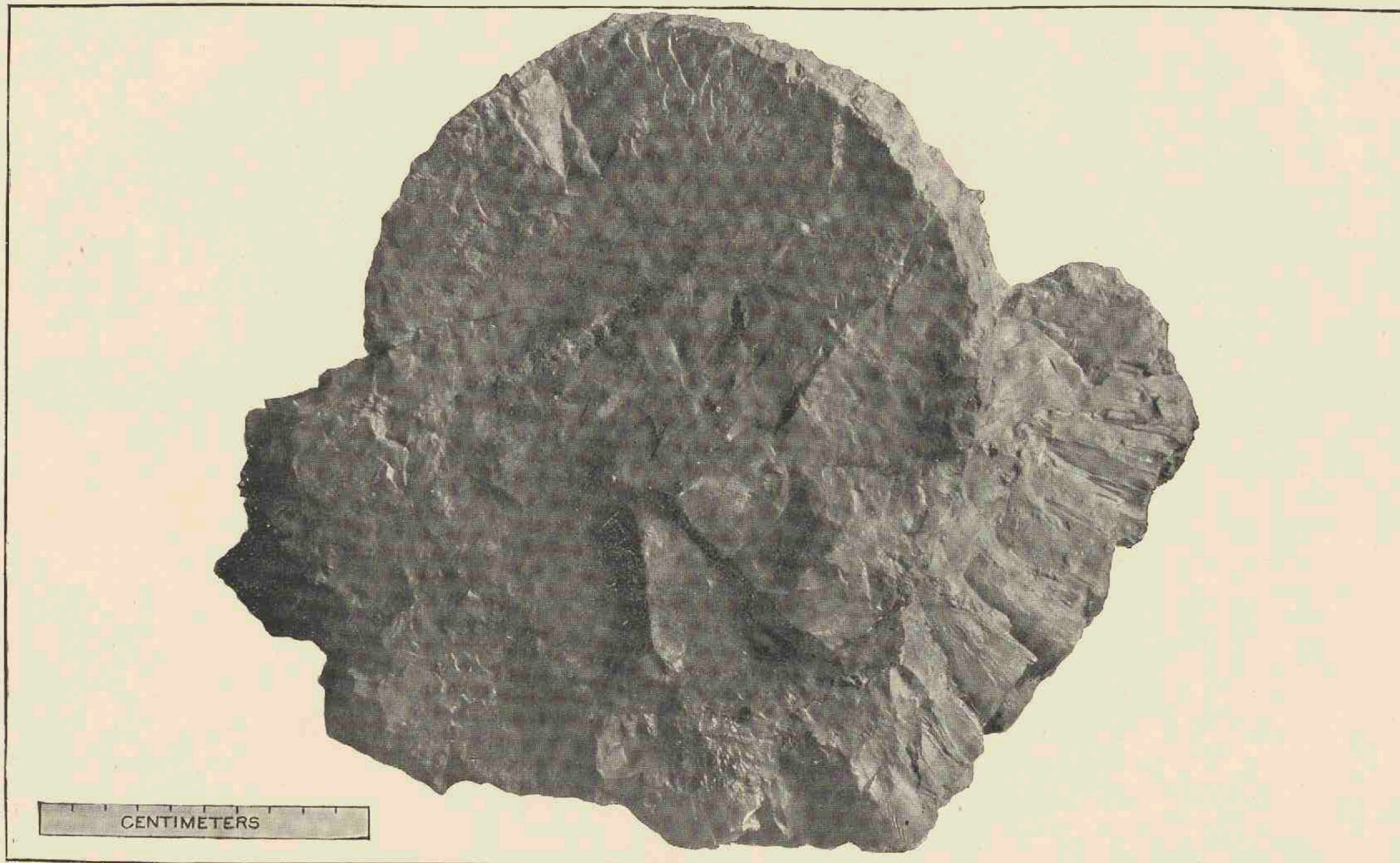
CYCADEOIDEA INGENS n. sp 632

View of the transverse fracture of the upper side of No. 94 of the Yale collection.

Scale, 10 cm.

884



CYCADEOIDEA INGENS.

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PLATE CXLII.

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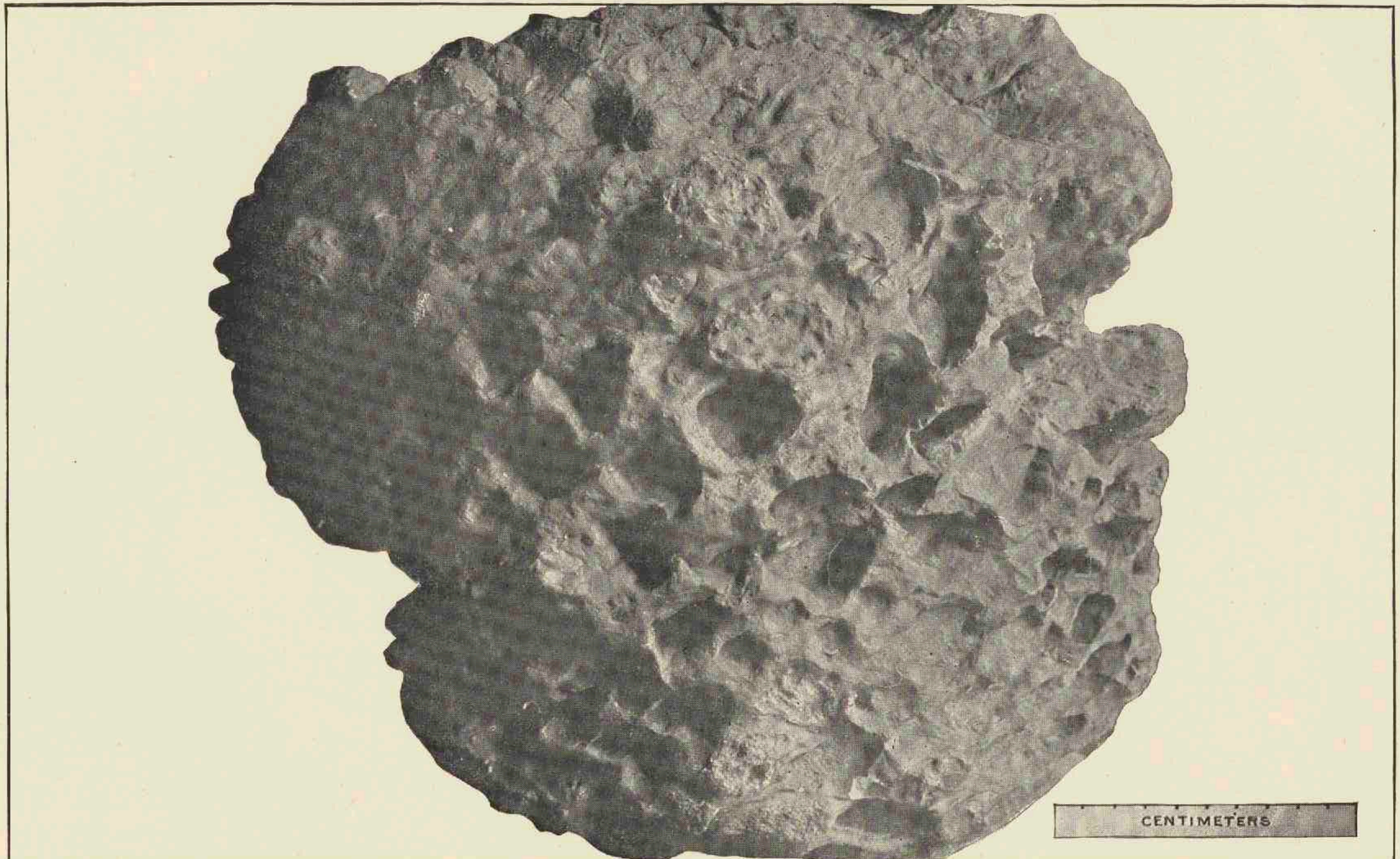
CYCADEOIDEA INGENS n. sp.	632

Side view of No. 123 of the Yale collection.

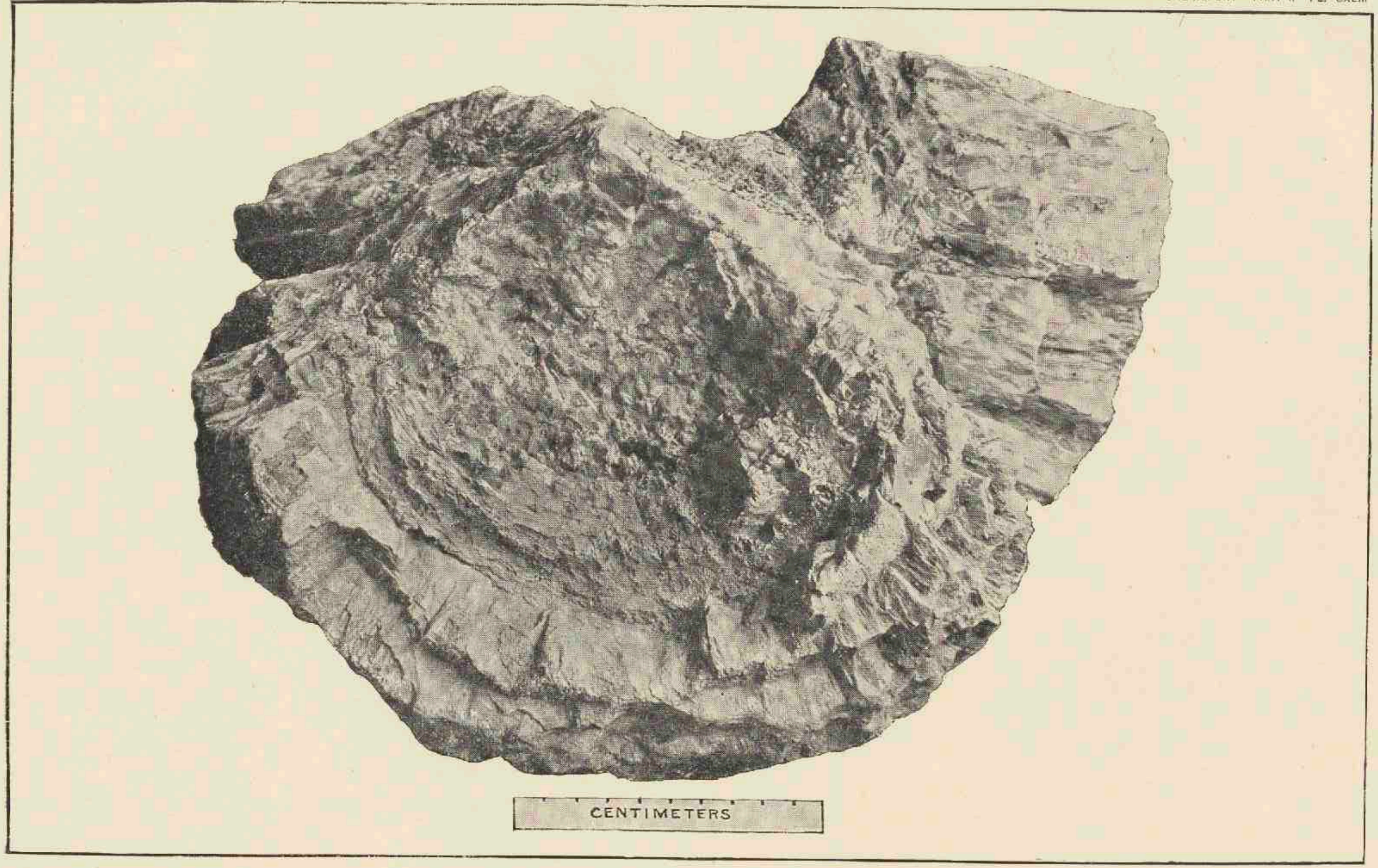
Scale, 10 cm.



CYCADEOIDEA INGENS.

PLATE CXLIII.

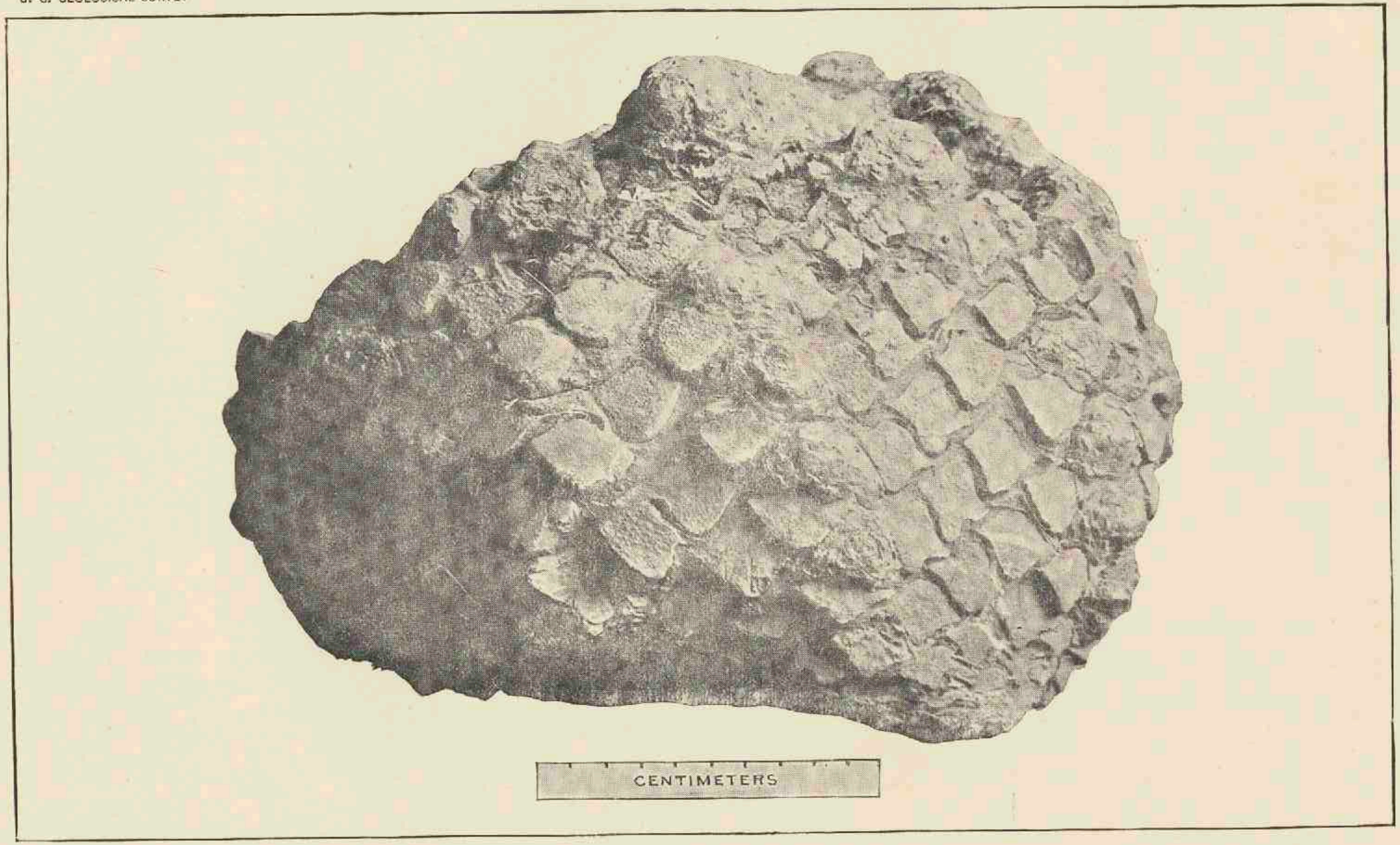
PLATE CXLIII.



CYCADEOIDEA INGENS.

PLATE CXLIV.

PLATE CXLIV.



CYCADEOIDEA FORMOSA.

PLATE CXLV.

PLATE CXLV.

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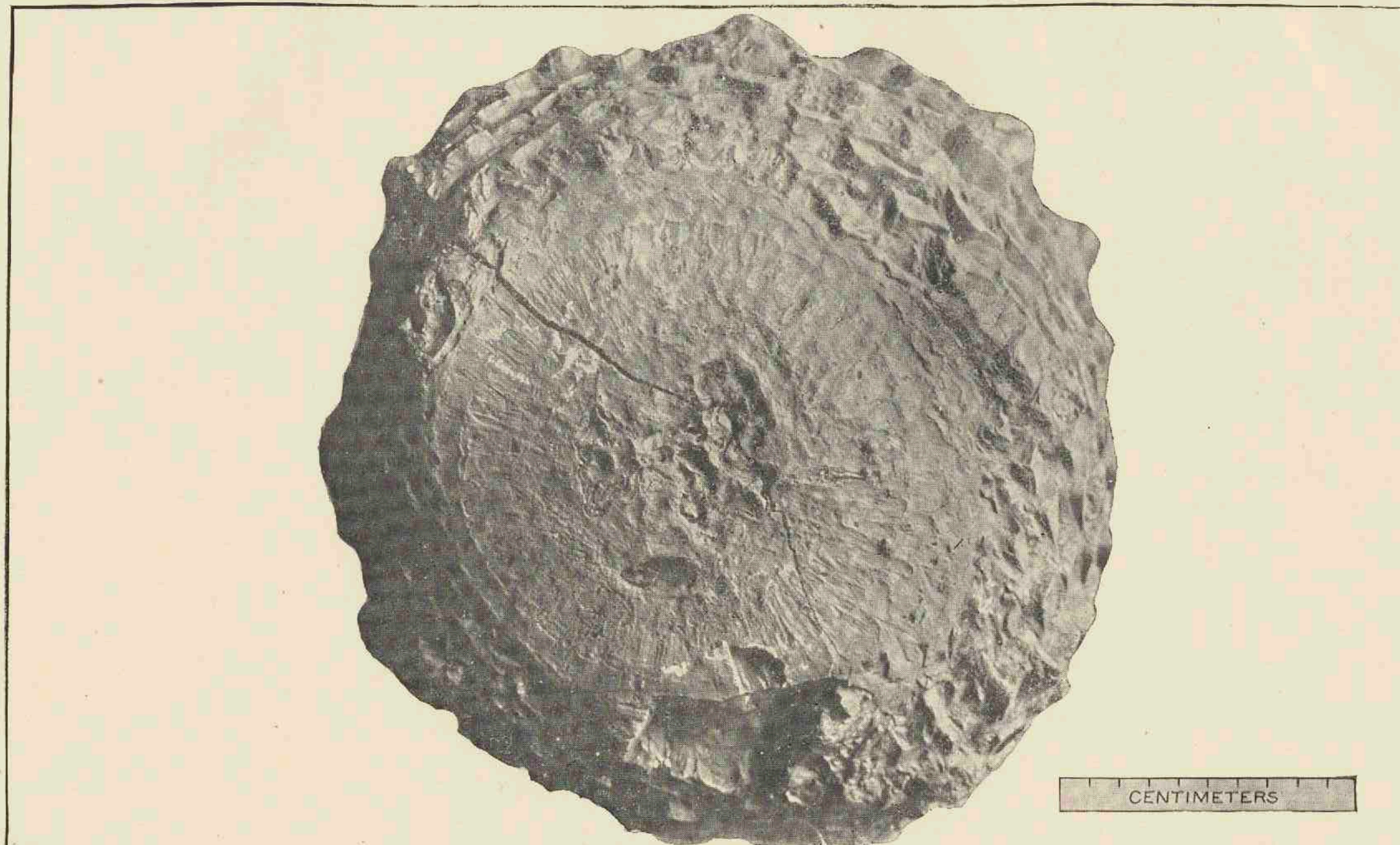
CYCADEOIDEA FORMOSA n. sp	634

View of the base of No. 89 of the Yale collection.

Scale, 10 cm.



CYCADEOIDEA FORMOSA.

PLATE CXLVI.

PLATE CXLVI.

View of the apex of No. 89 of the Yale collection.
Scale, 10 cm.

CYCADEOIDEA FORMOSA.

PLATE CXLVII.

PLATE CXLVII.

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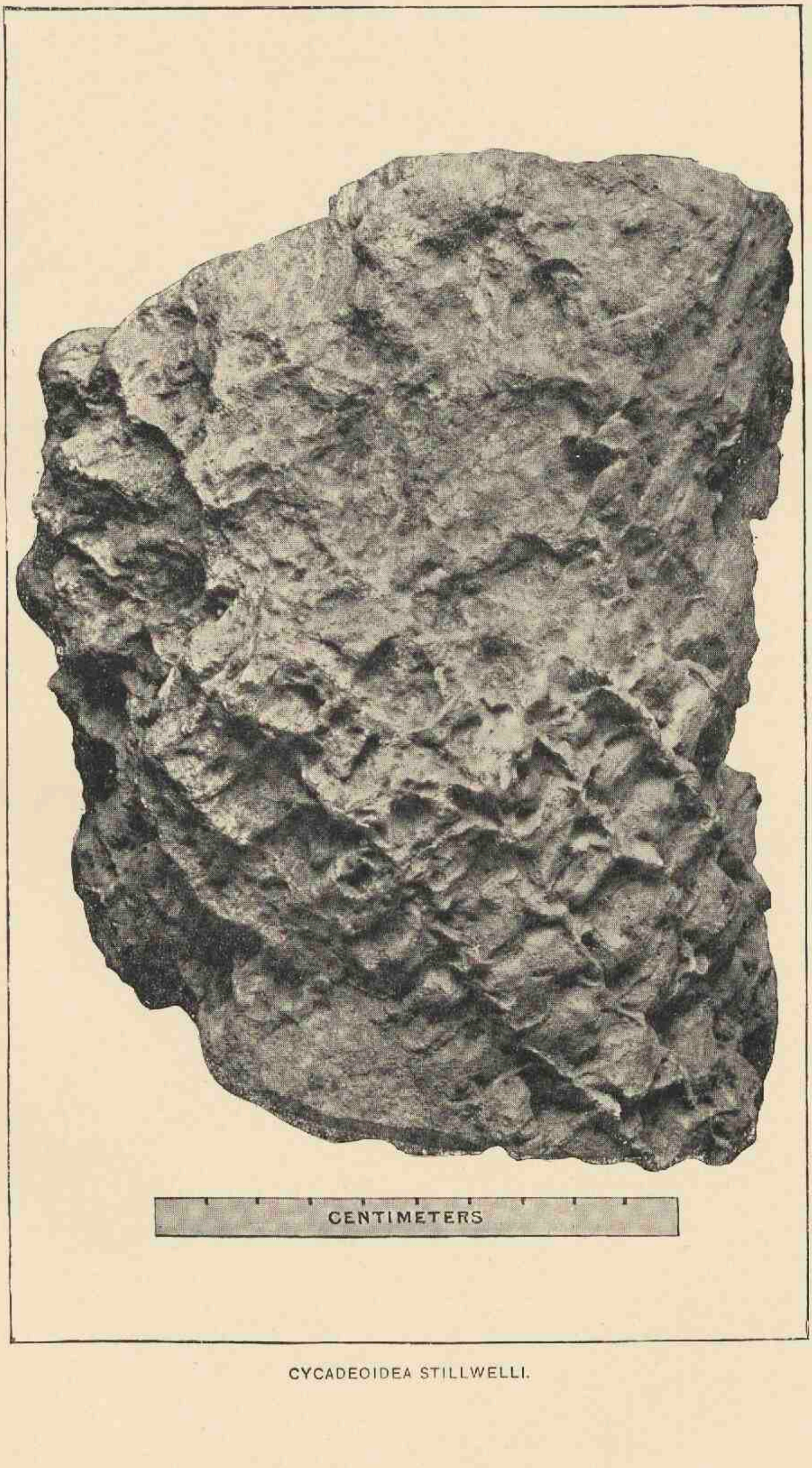
CYCADEOIDEA STILLWELLI n. sp.	635

Side view of Stillwell fragment No. 2 of the U. S. National Museum collection. Scale, 10 cm.



CYCADEOIDEA STILLWELLI.

PLATE CXLVIII.

PLATE CXLVIII.

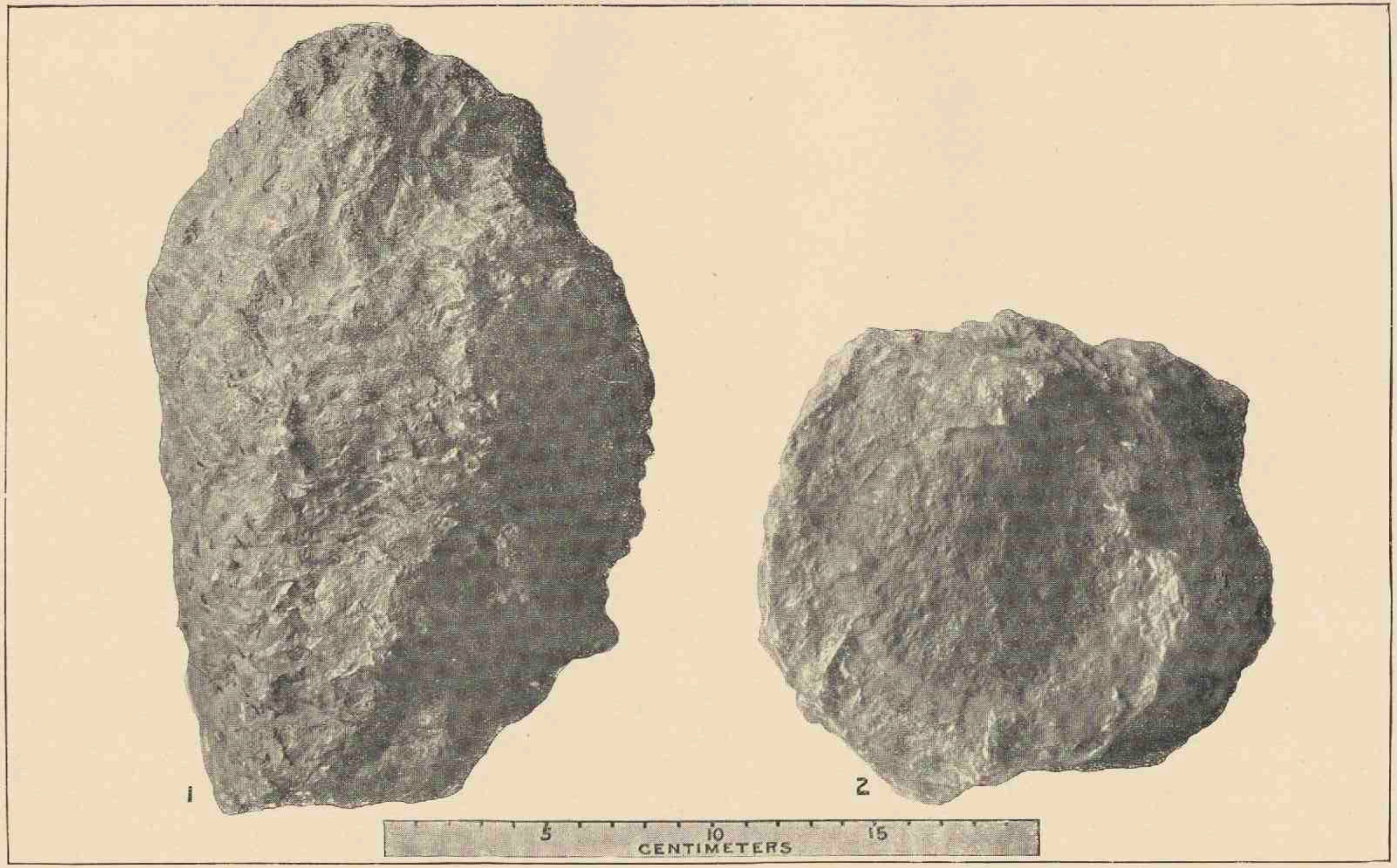
	Page.
CYCADEOIDEA STILLWELLI n. sp.	635

Trunk No. 36 of the Yale collection.

FIG. 1. Side view.

FIG. 2. View of the transverse fracture at lower end of specimen.

Scale, 20 cm.



CYCADEOIDEA STILLWELLI.

PLATE CXLIX.

PLATE CXLIX.

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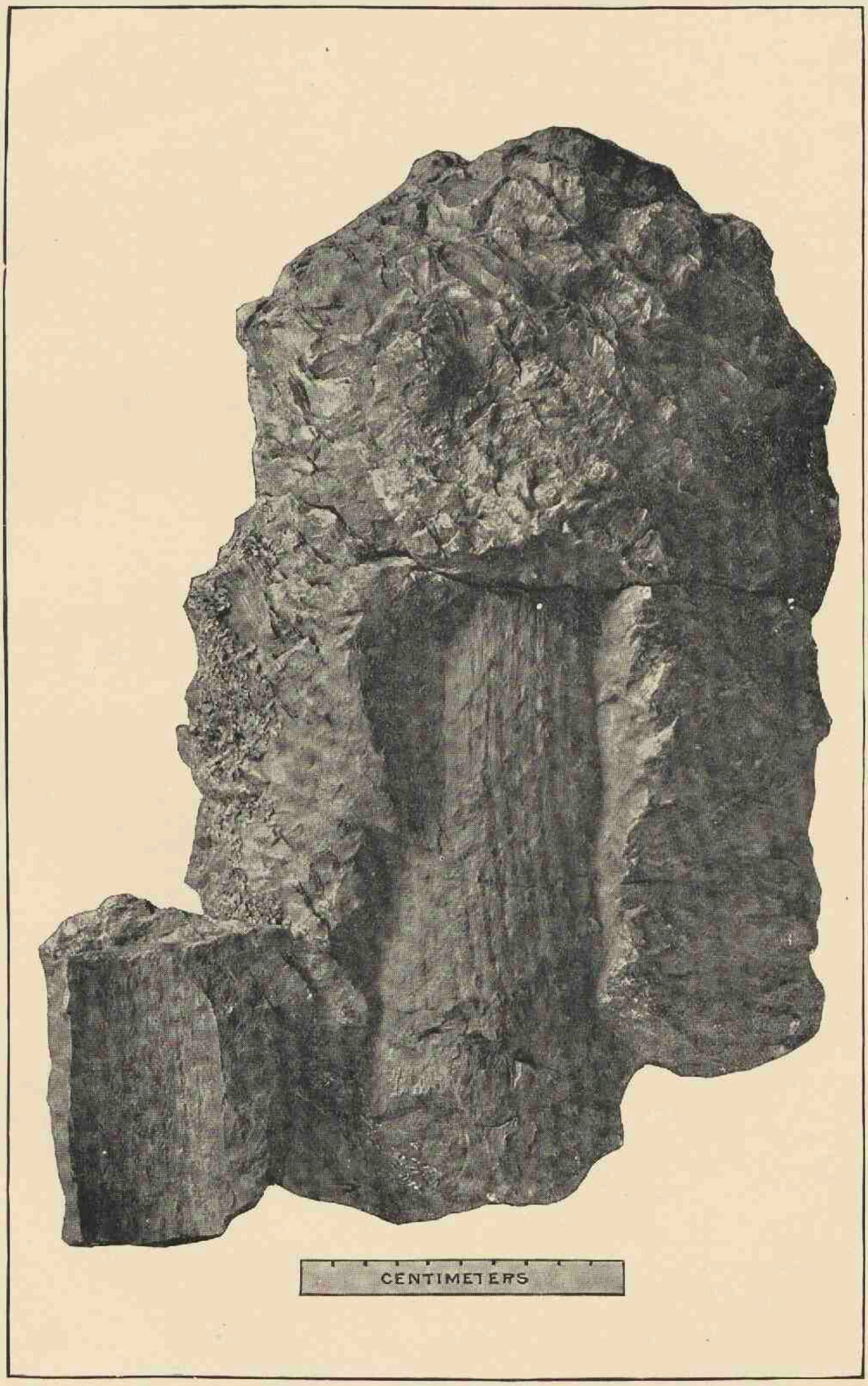
Cycadeoidea Stillwelli n. sp. 635

Trunk No. 56 of the Yale collection. Side view showing the exposed surface of the medulla and the corresponding inner wall of the woody zone in the detached fragment.

Scale, 10 cm.

900



CYCADEOIDEA STILLWELLI.

PLATE CL.

PLATE CL.

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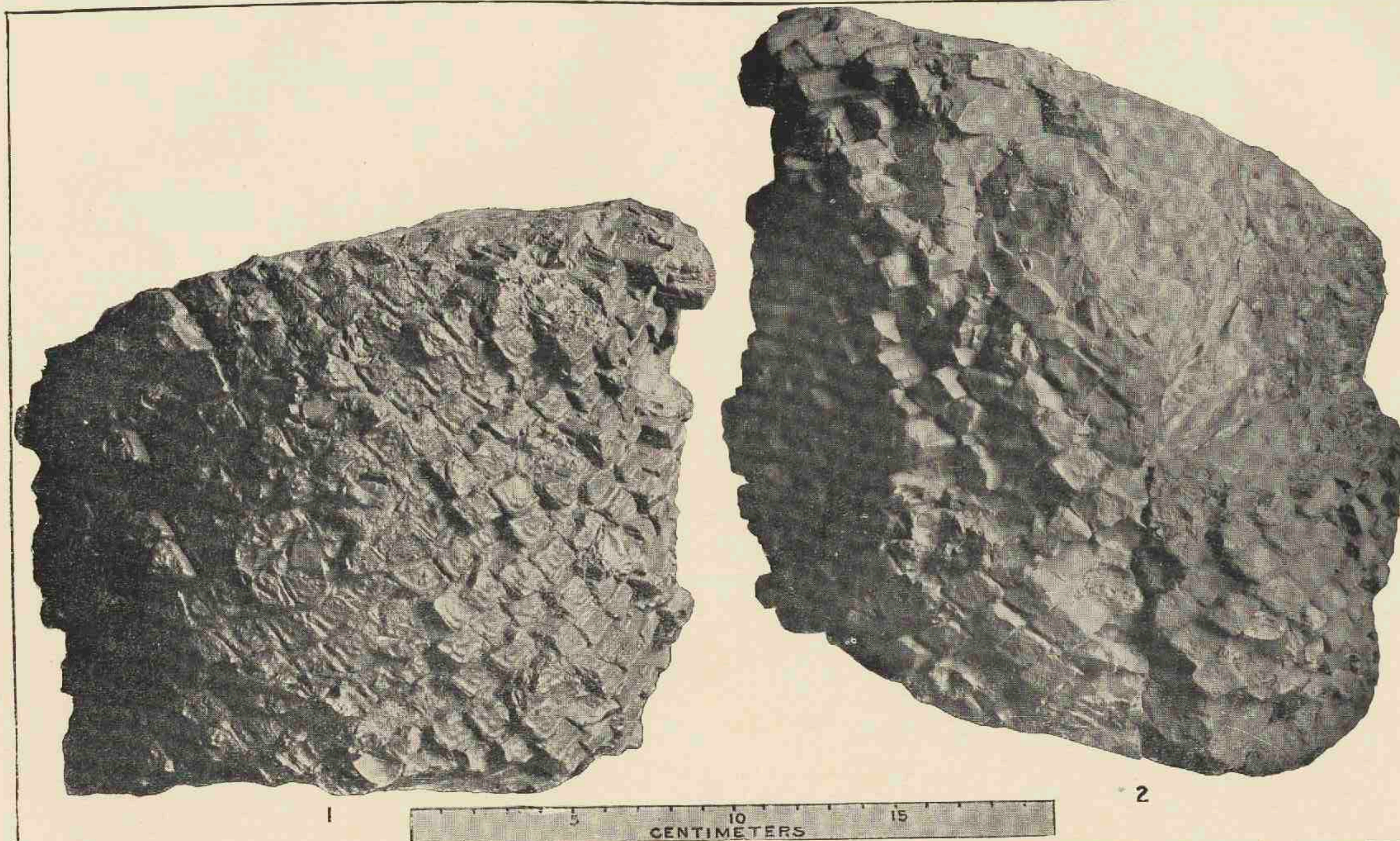
CYCADEOIDEA STILLWELLI n. sp	635

Two views of opposite sides of trunk No. 105 of the Yale collection.

Scale, 20 cm.



1 2

CYCADEOIDEA STILLWELLI.

PLATE CLI.

PLATE CLI.

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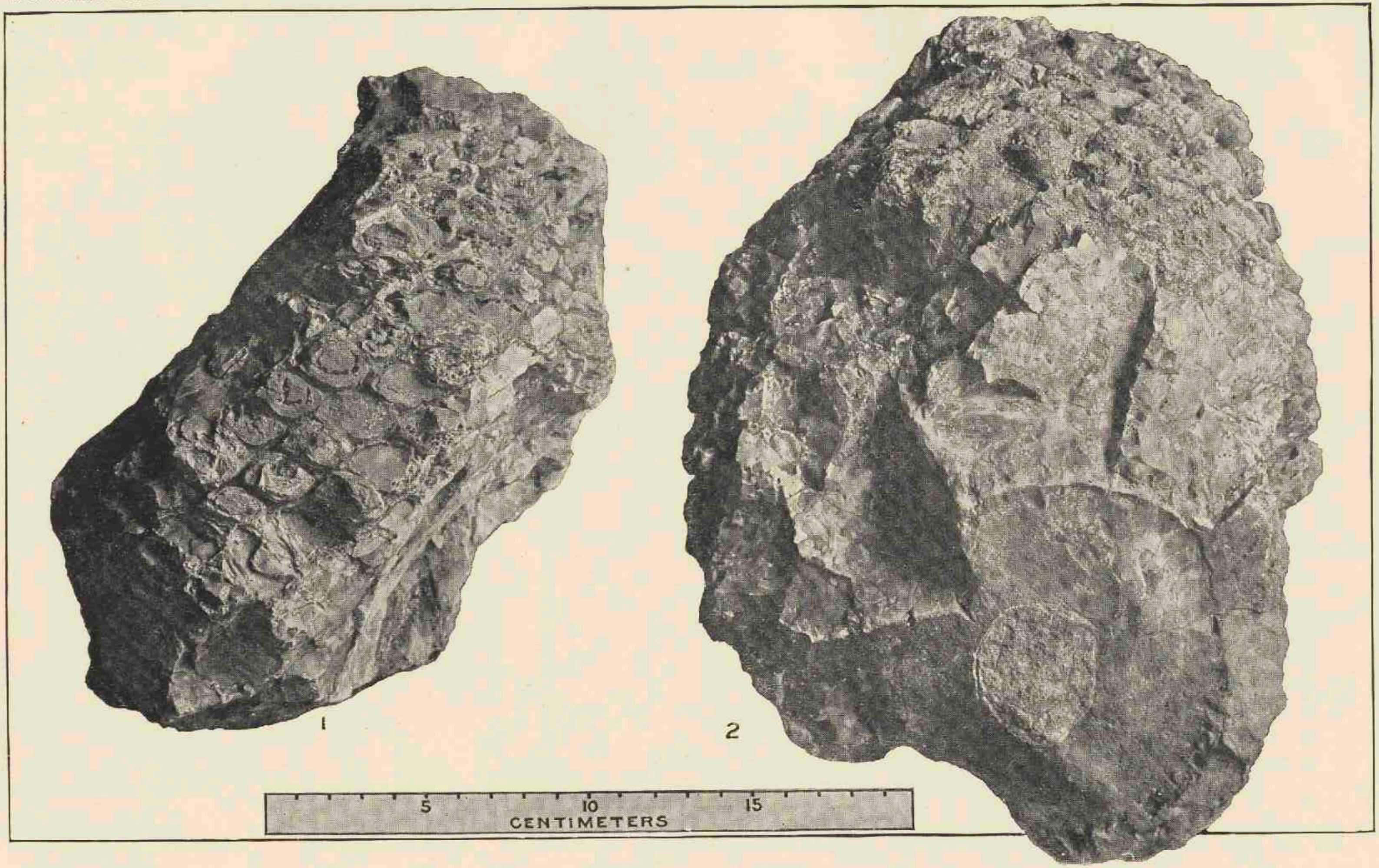
CYCADEOIDEA STILLWELLI n. sp.	635

No 107 of the Yale collection.

FIG. 1. View of the side on which the scars are most distinct.

FIG. 2. View of the oblique base and broadest side.

Scale, 20 cm.



CYCADEOIDEA STILLWELLI.

PLATE CLII.

PLATE CLII.

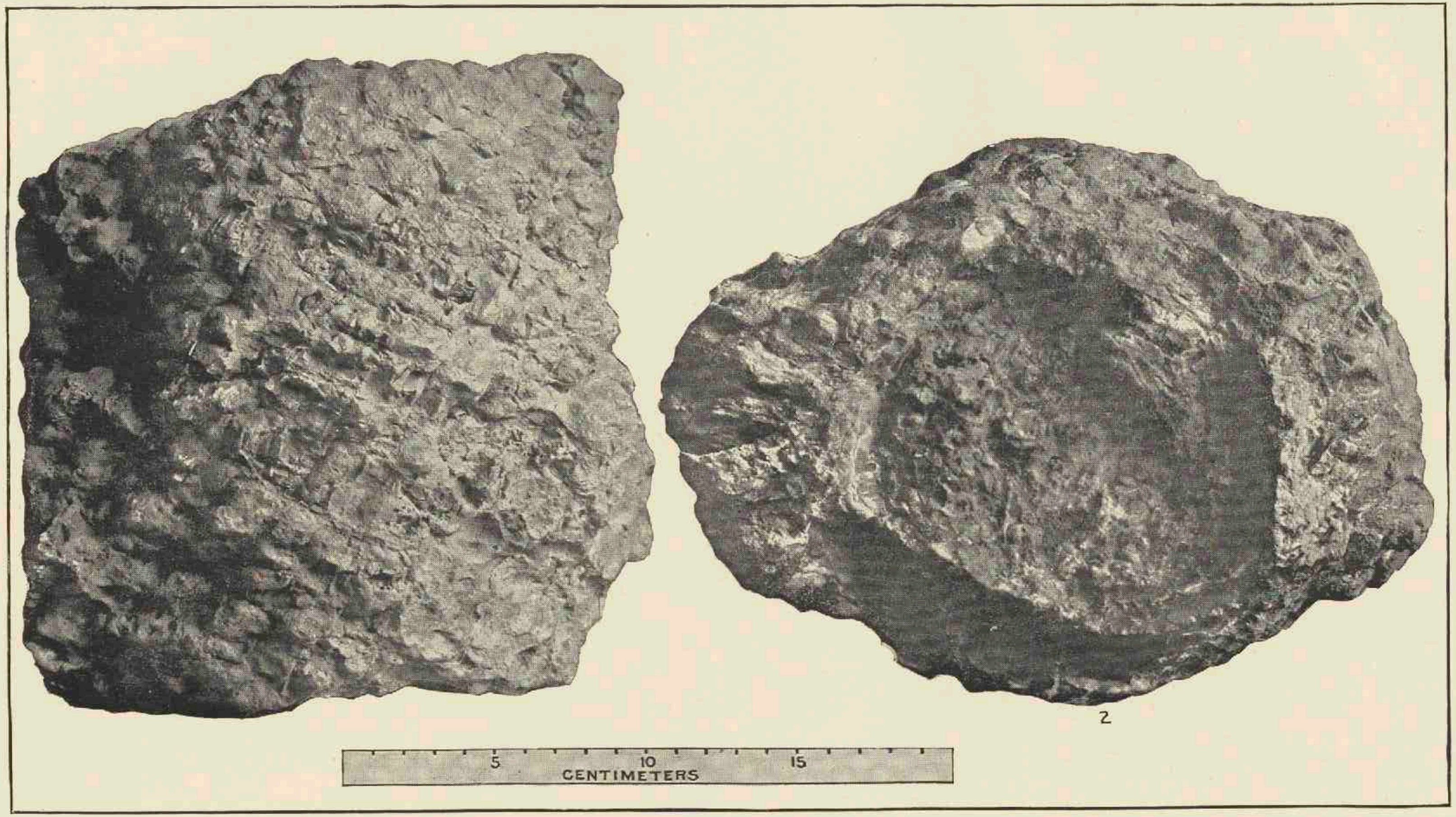
	Page.
CYCADEOIDEA STILLWELLI n. sp.	635

No. 119 of the Yale collection.

FIG. 1. Side view.

FIG. 2. View of the base.

Scale, 20 cm.



CYCADEOIDEA STILLWELLI.

PLATE CLIII.

PLATE CLIII.

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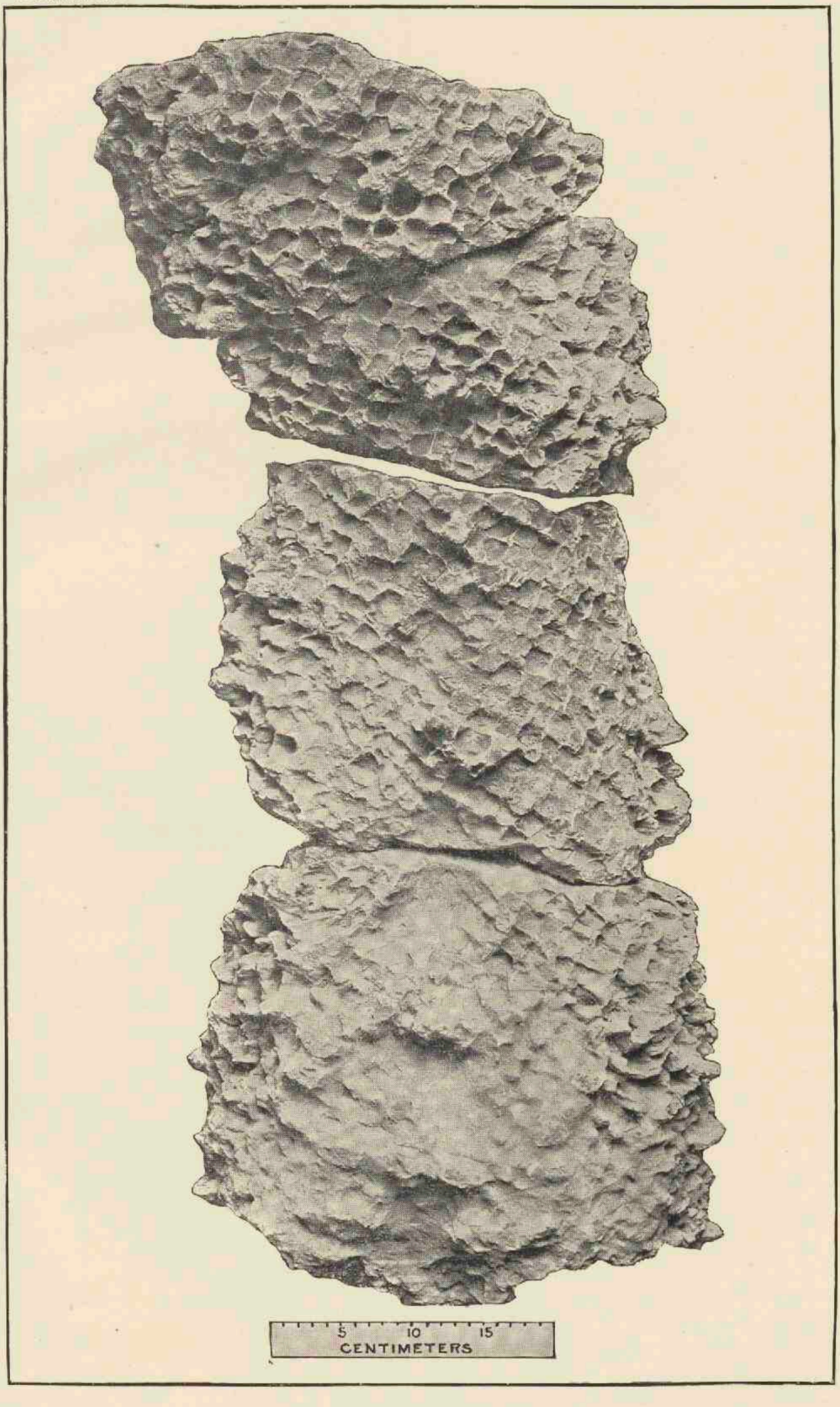
CYCADEOIDEA EXCELSA n. sp. 637

View of the best preserved side of the "Noble Cycad" of the U. S. National Museum collection.

Scale, 20 cm.



CYCADEOIDEA EXCELSA.

PLATE CLIV.

PLATE CLIV.

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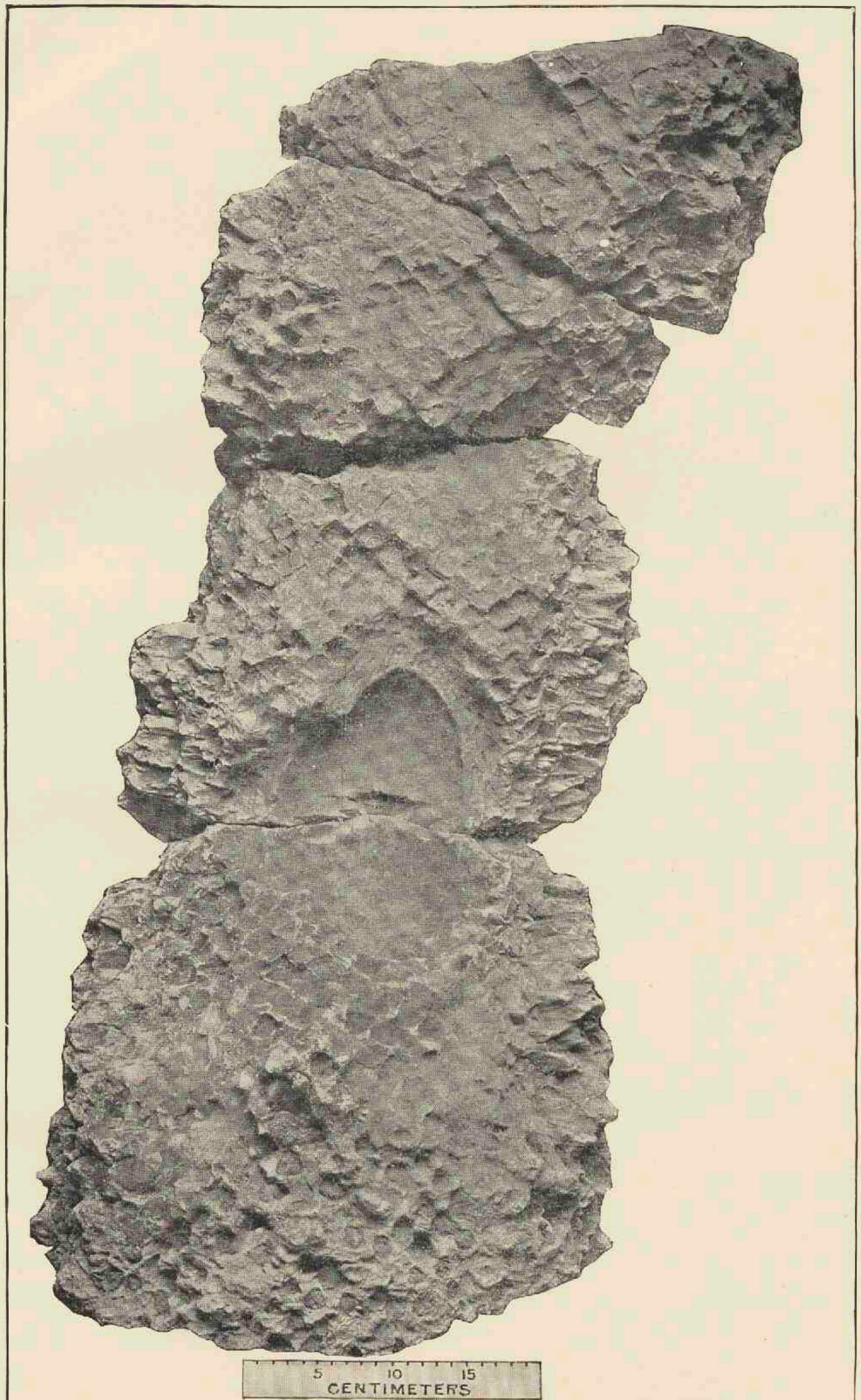
CYCADEOIDEA EXCELSA n. sp	637

View of the somewhat decayed side of the "Noble Cycad" of the U. S. National Museum collection.

Scale, 20 cm.



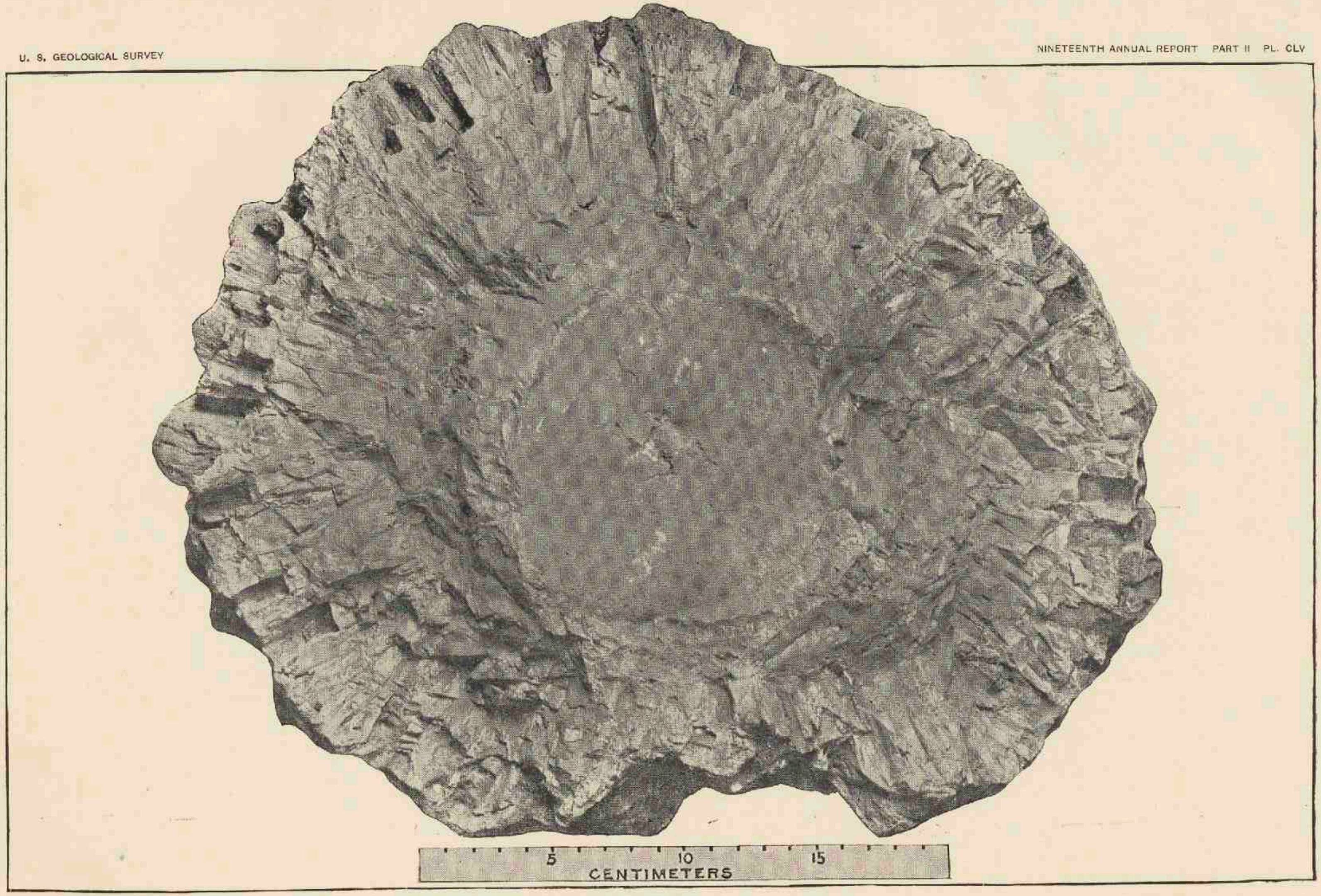
CYCADEOIDEA EXCELSA

PLATE CLV.

PLATE CLV.

View of the base of the "Noble Cycad" of the U. S. National Museum collection.

Scale, 20 cm.



CYCADEOIDEA EXCELSA.

PLATE CLVI.

PLATE CLVI.

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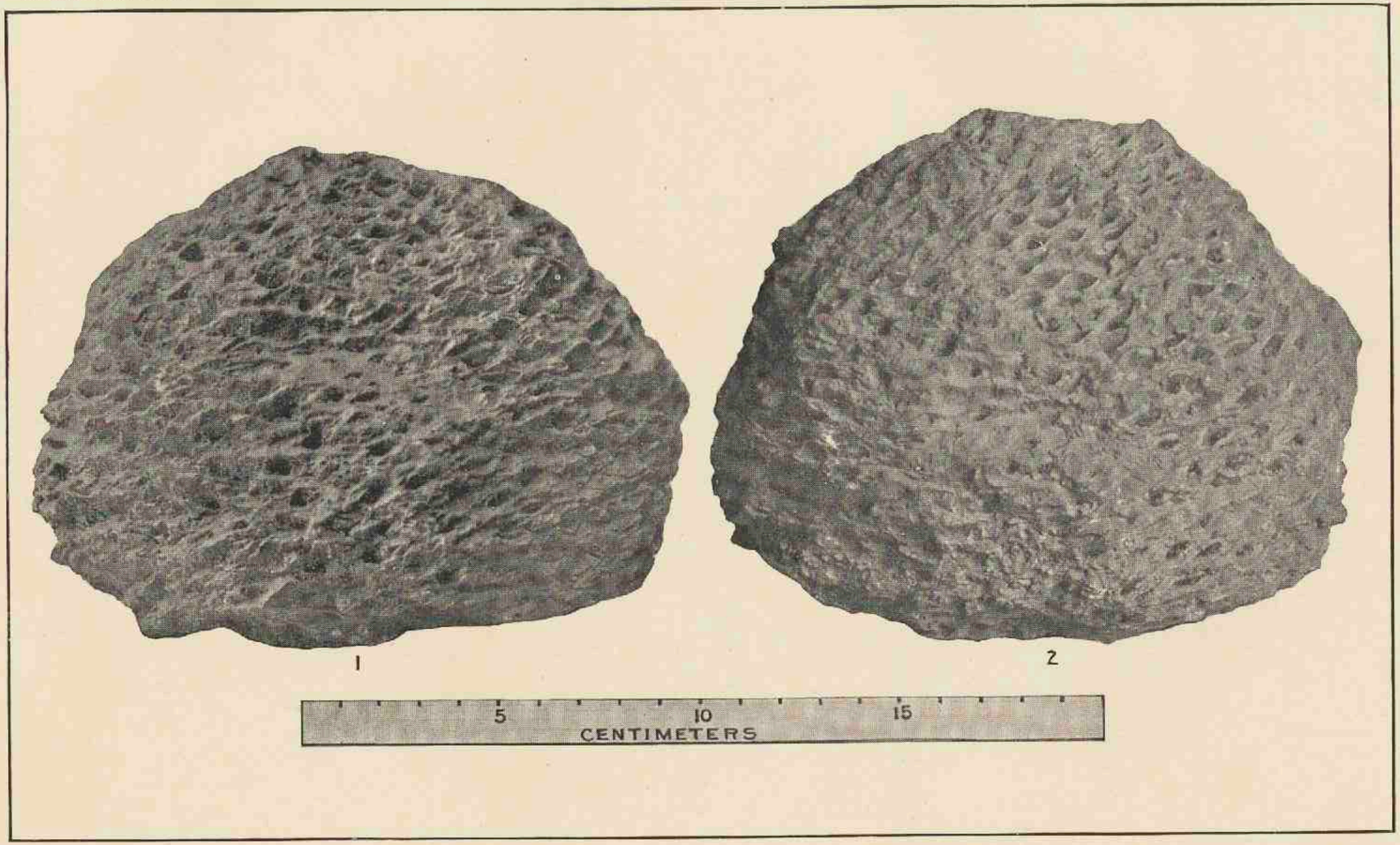
Cycadeoidea nana n. sp. 639

Two views of different sides of trunk No. 84 of the Yale collection.

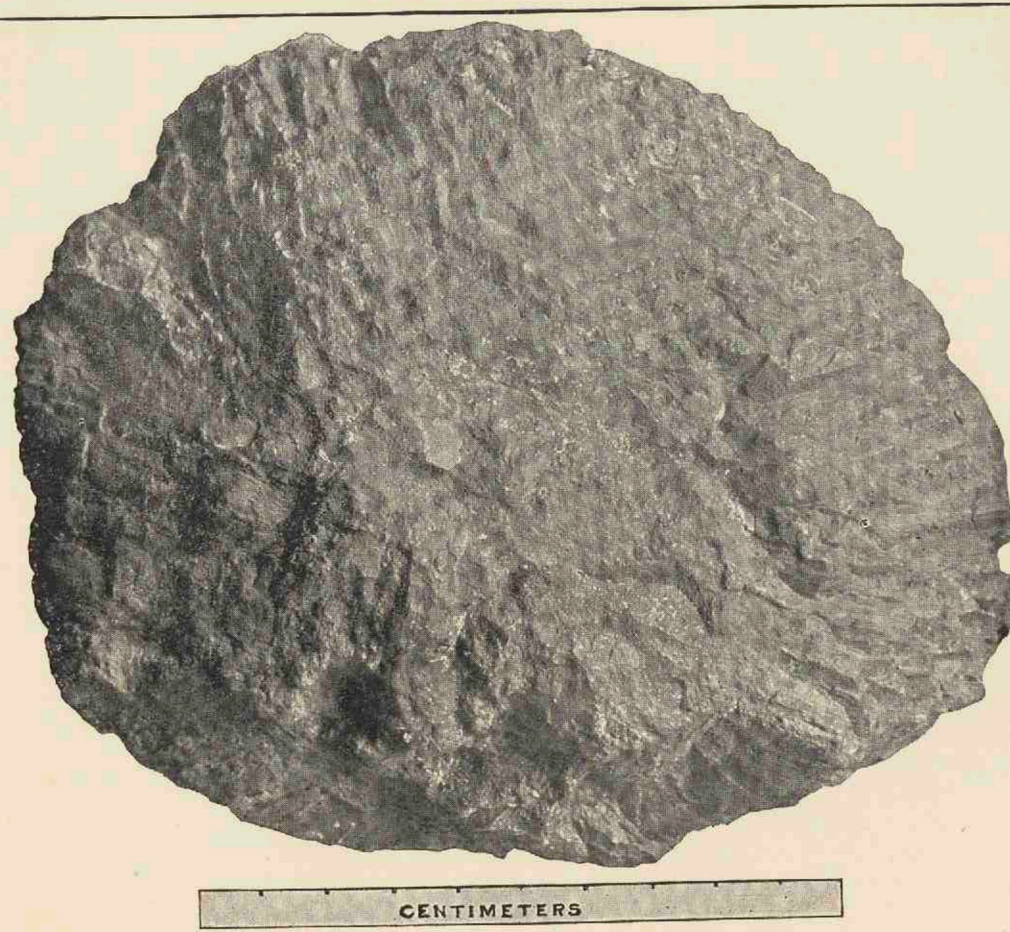
Scale, 20 cm.



CYCADEOIDEA NANA.

PLATE CLVII.

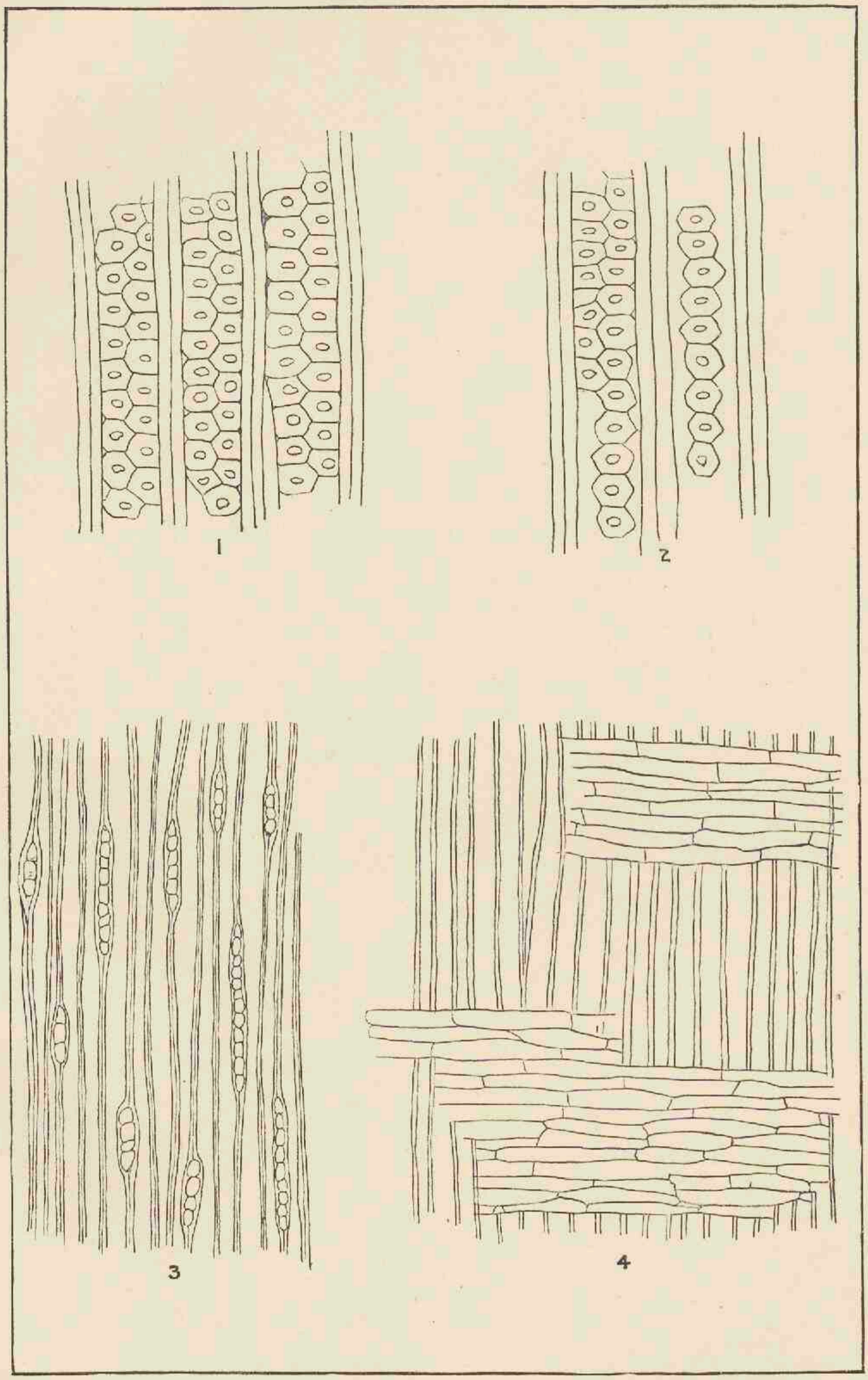
PLATE CLVII.



CYCADEOIDEA NANA.

PLATE CLVIII.

PLATE CLVIII.



ARAUCARIOXYLON HOPPERTONÆ.

PLATE CLIX.

PLATE CLIX.

Page.

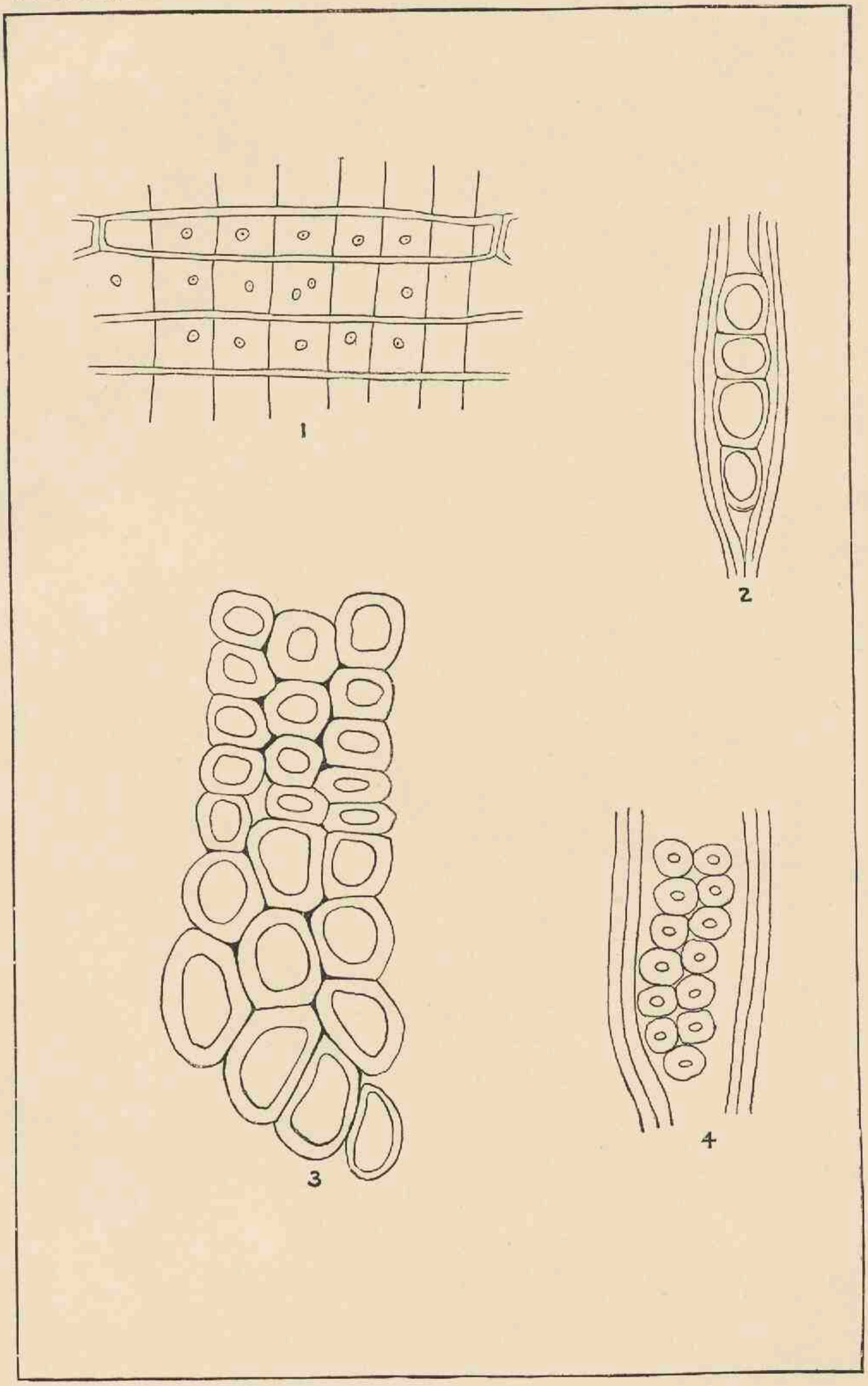
FIGS. 1–4. ARAUCARIOXYLON HOPPERTONÆ Kn. n. sp 644

FIG. 1. Radial section showing portion of medullary rays with minute bordered pits. × 320.

FIG. 2. Tangential section showing ends of medullary rays. × 320.

FIG. 3. Transverse section showing portions of fall and spring wood. × 320.

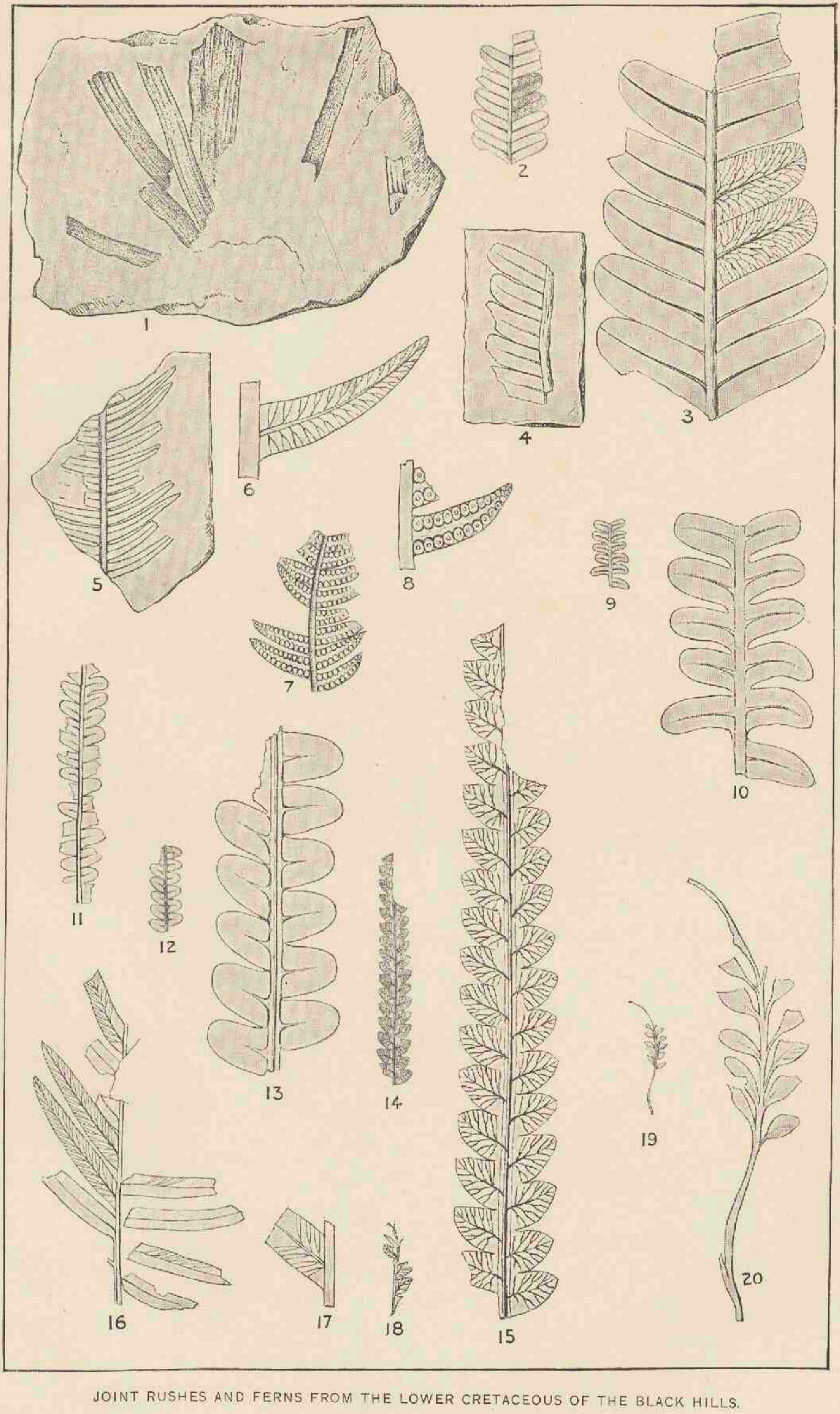
FIG. 4. Radial section showing portion of very broad wood cell with two rows of nearly circular bordered pits. × 320.



ARAUCARIOXYLON HOPPERTONÆ.

PLATE CLX.

PLATE CLX.



JOINT RUSHES AND FERNS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXI.

PLATE CLXI.

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FIG. 1. THYRSOPTERIS PINNATIFIDA Font.?	658
FIG. 2. Enlargement of Fig. 1 (4 times).	
FIG. 3. THYRSOPTERIS CRASSINERVIS Font.?	658
FIG. 4. Enlargement of Fig. 3 (4 times).	
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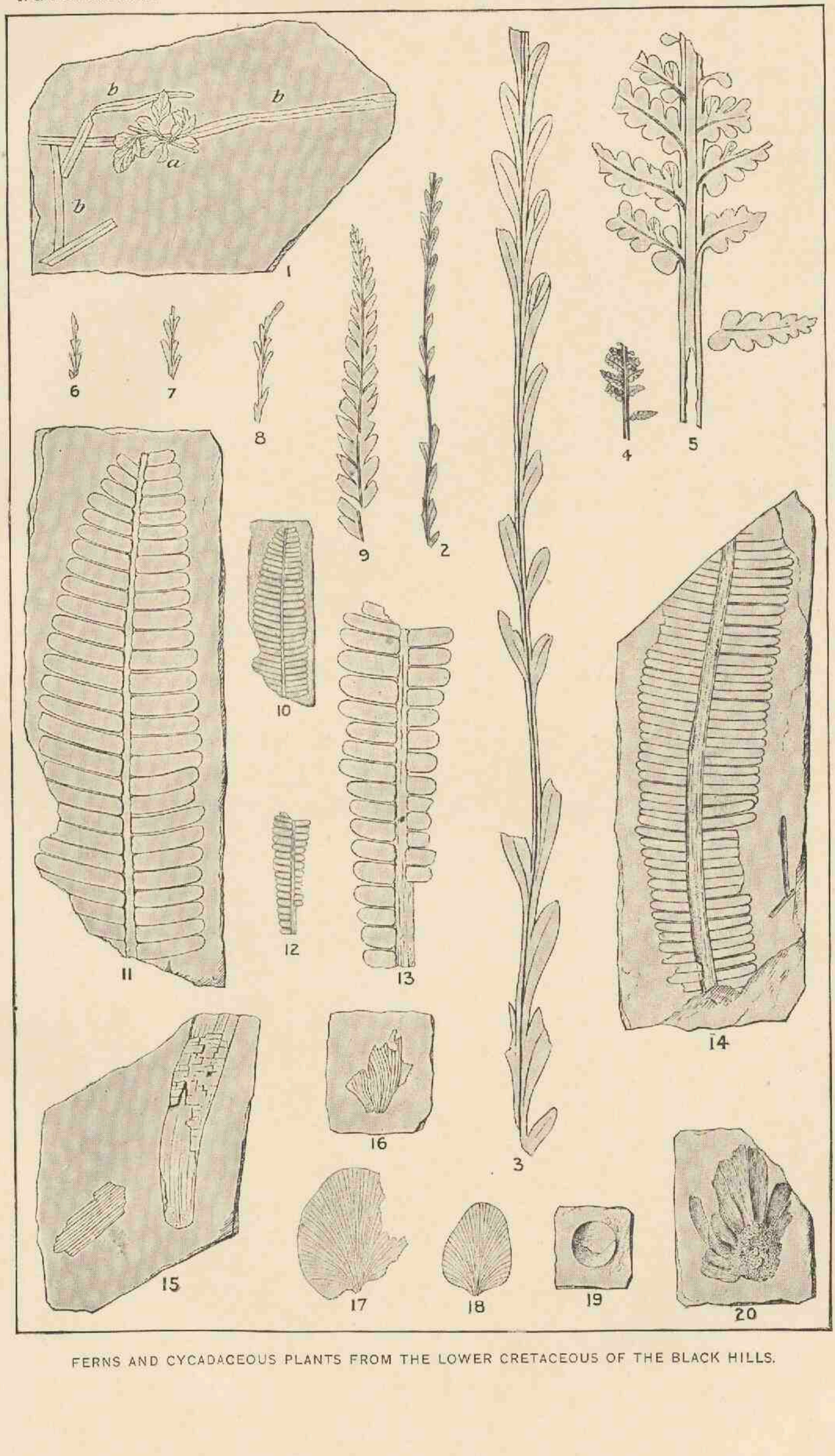
FIGS. 6–9. THYRSOPTERIS DENTIFOLIA n. sp	660
FIGS. 7 and 9. Enlargements of Figs. 6 and 8 (4 times).	
FIGS. 10–15. THYRSOPTERIS BREVIFOLIA Font	660
FIGS. 11, 13, and 15. Enlargements of Figs. 10, 12, and 14 (4 times).	
FIGS. 16–19. THYRSOPTERIS PECOPTEROIDES Font	661
FIGS. 17 and 19. Enlargements of Figs. 16 and 18 (4 times).	

FERNS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXII.

PLATE CLXII.



FERNS AND CYCADACEOUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXIII.

PLATE CLXIII.

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FIGS. 1–6, 8, 9. ARUACARITES WYOMINGENSIS n. sp. (seeds) 669

FIGS. 2, 4, 6, and 9. Enlargements of Figs. 1, 3, 5, and 8 (twice).

FIG. 7. ARAUCARITES WYOMINGENSIS n. sp. (cone scale) 669

FIG. 10. ARAUCARITES CUNEATUS Ward n. sp 670

FIGS. 11a, 12, 13. PINUS SUSQUAENSIS Dn 670

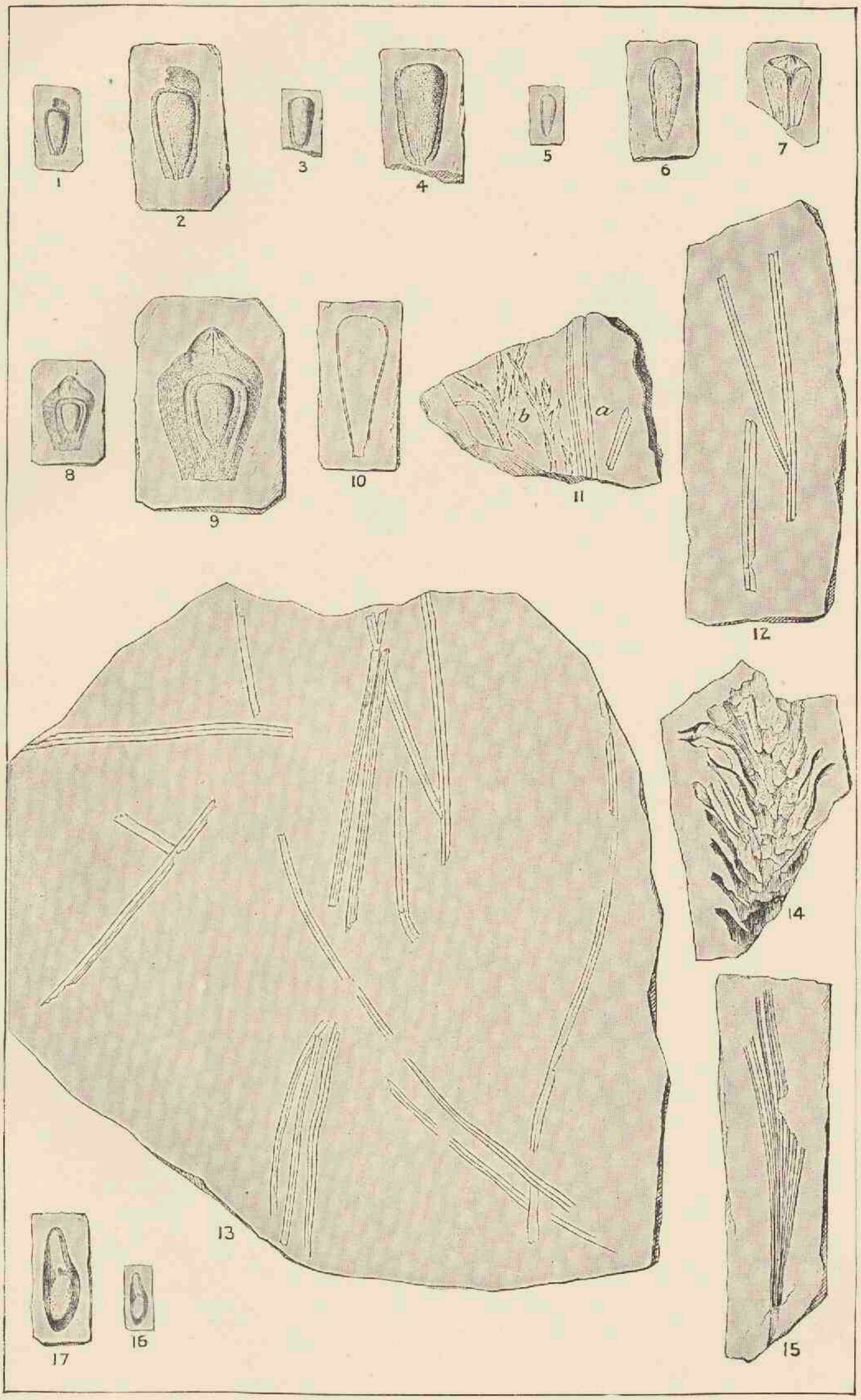
FIG. 11b. SPHENOLEPIDIUM PARCERAMOSUM Font 682

FIG. 14. ABIETITES ANGUSTICARPUS Font 671

FIG. 15. LEPTOSTROBUS LONGIFOLIUS Font 671

FIGS. 16, 17. LEPTOSTROBUS? ALATUS Ward n. sp 673

FIG. 17. Enlargement of Fig. 16 (twice).



CONIFEROUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXIV.

PLATE CLXIV.

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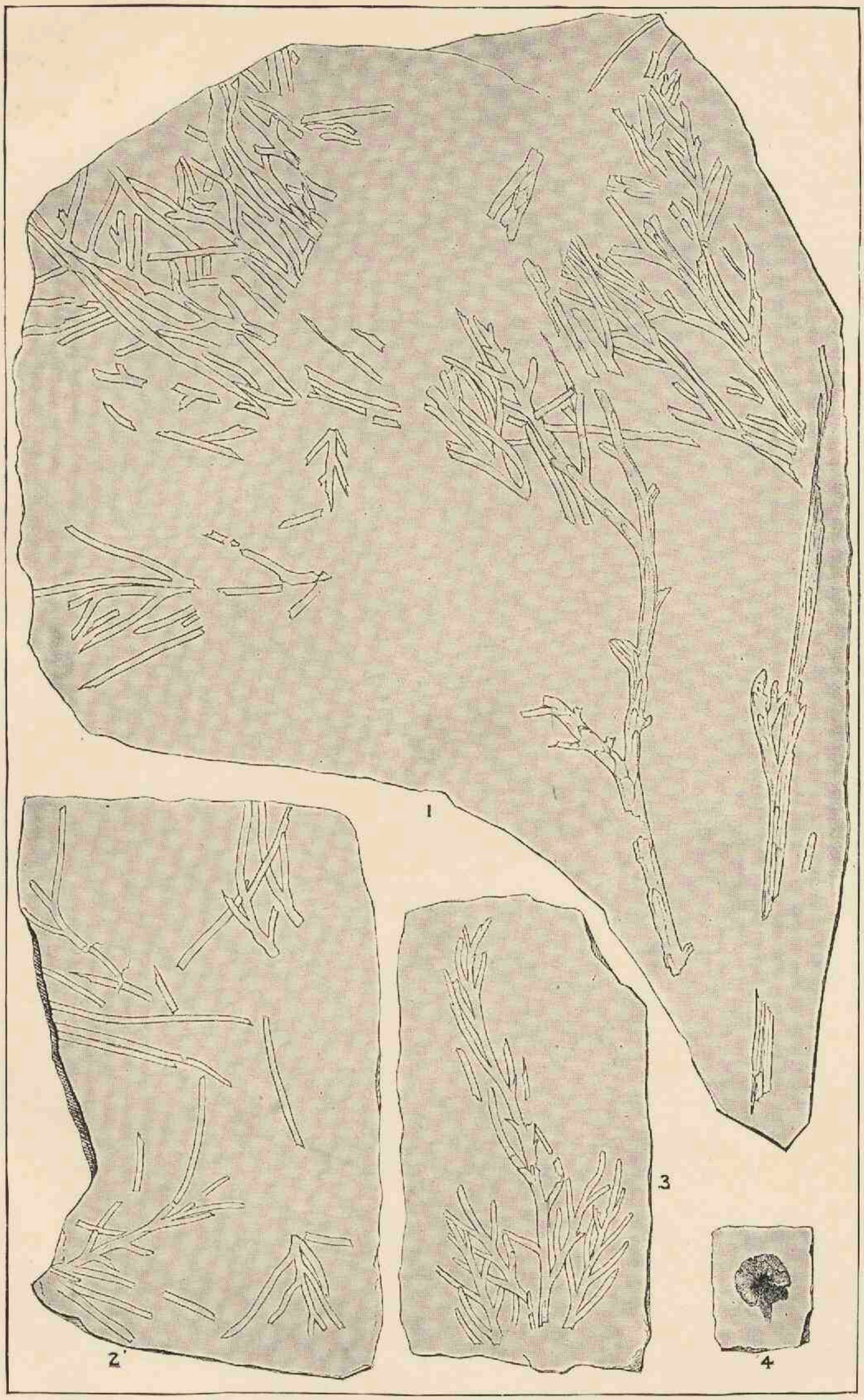
FIGS. 1–4. ATHROTAXOPSIS TENUICAULIS Font 674

FIGS. 1–3. Stems and leaves.

FIG. 4. Cone.



CONIFEROUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXV.

PLATE CLXV.

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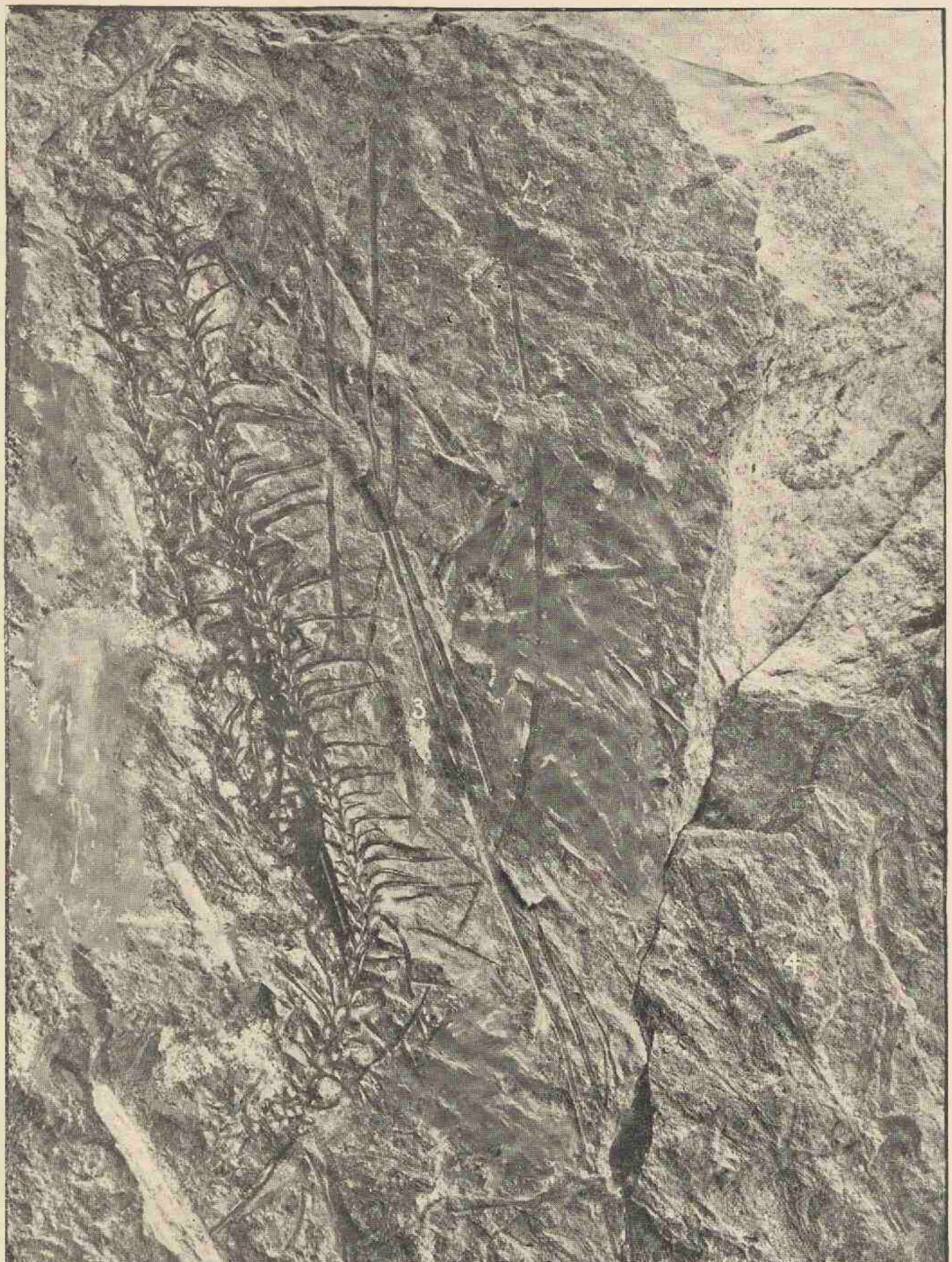
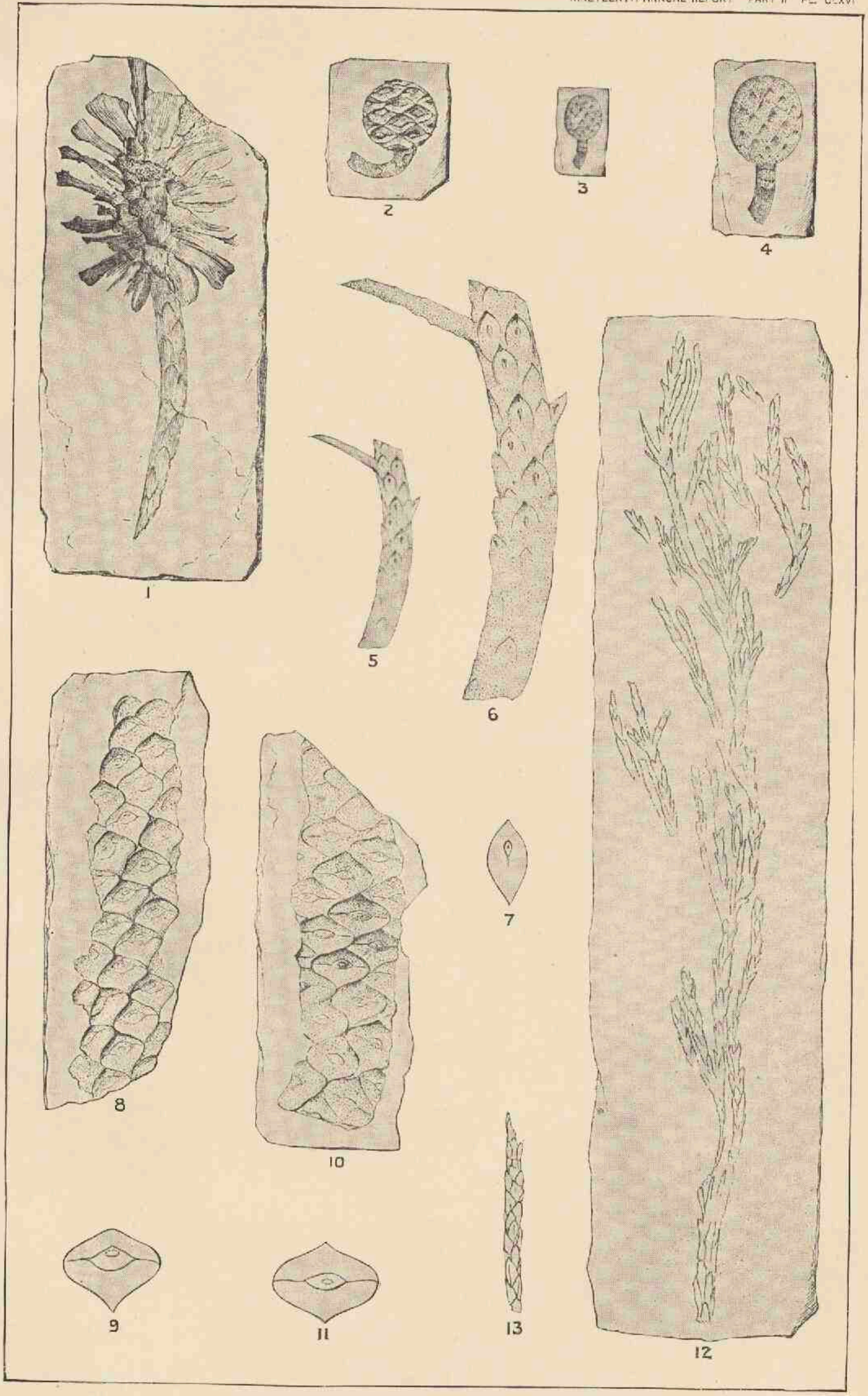
FIG. 1.	SEQUOIA REICHENBACHII (Gein.) Heer, leafy branch	674
FIG. 2.	SEQUOIA REICHENBACHI (Gein.) Heer, cone	674
FIG. 3.	LEPTOSTROBUS LONGIFOLIUS Font., long leaves with 2 nerves	671
FIG. 4.	GLYPTOSTROBUS BROOKENSIS (Font.) Ward	682



CONIFEROUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXVI.

PLATE CLXVI.



CONIFEROUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXVII.

PLATE CLXVII.

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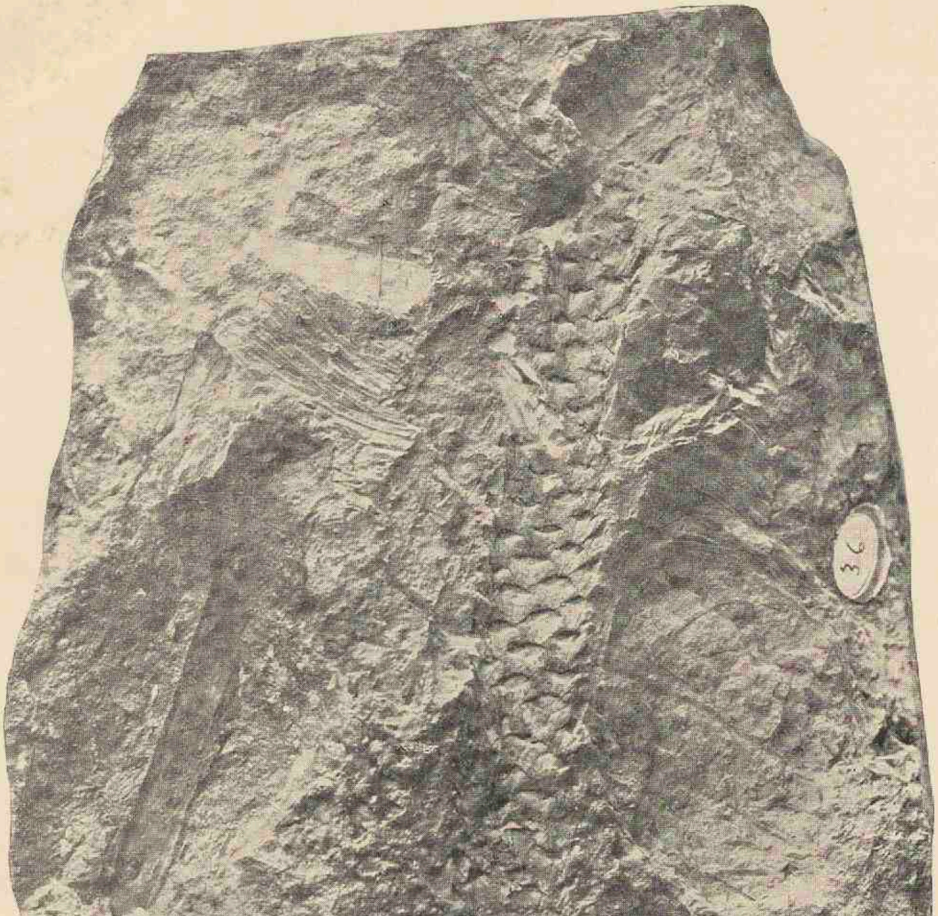
Geinitzia Jenneyi n. sp. 676

Fig. 1. Large stem natural size, from a photograph.

Fig. 2. One of the scales enlarged 3 diameters.



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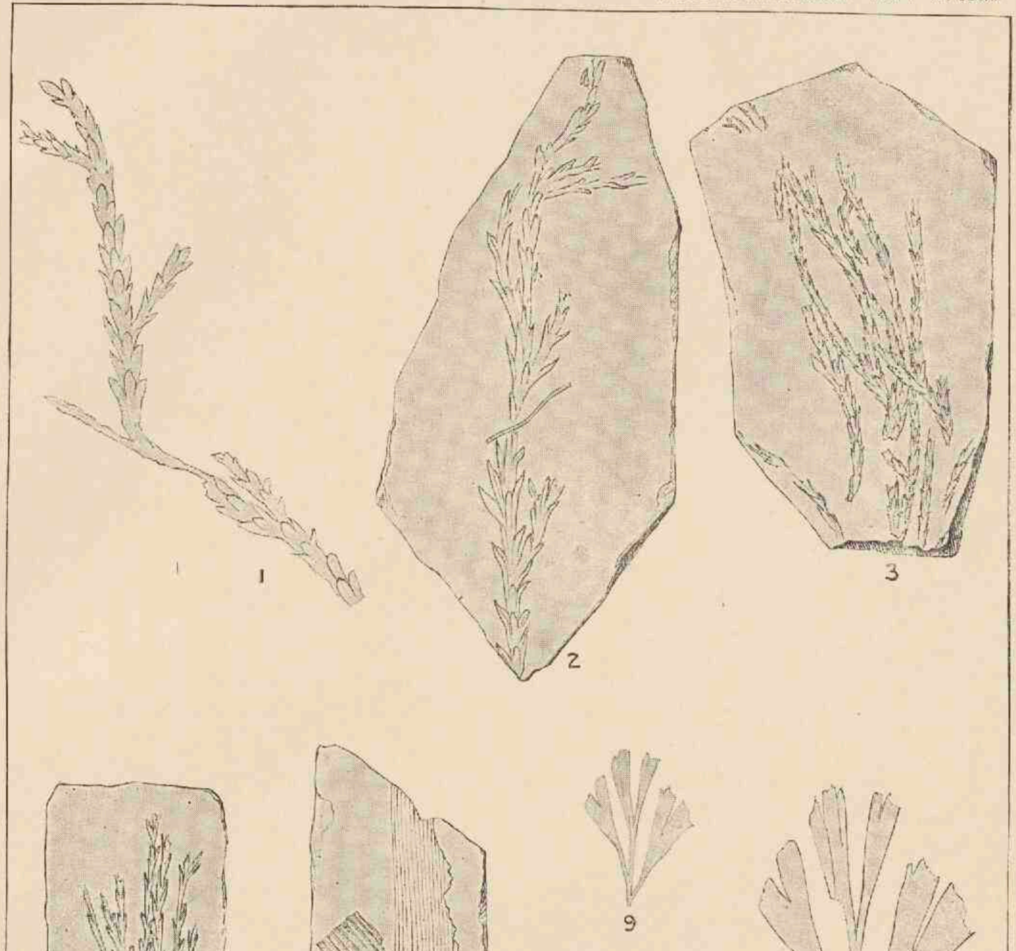
GEINITZIA JENNEYI.

PLATE CLXVIII.

PLATE CLXVIII.

FIGS. 10 and 12. Enlargements of Figs. 9 and 11 (twice).



CONIFEROUS AND TAXACEOUS PLANTS FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

PLATE CLXIX.

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FIG. 5. Male ament of a conifer	687
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FIG. 18. Enlargement of Fig. 17 (twice).	
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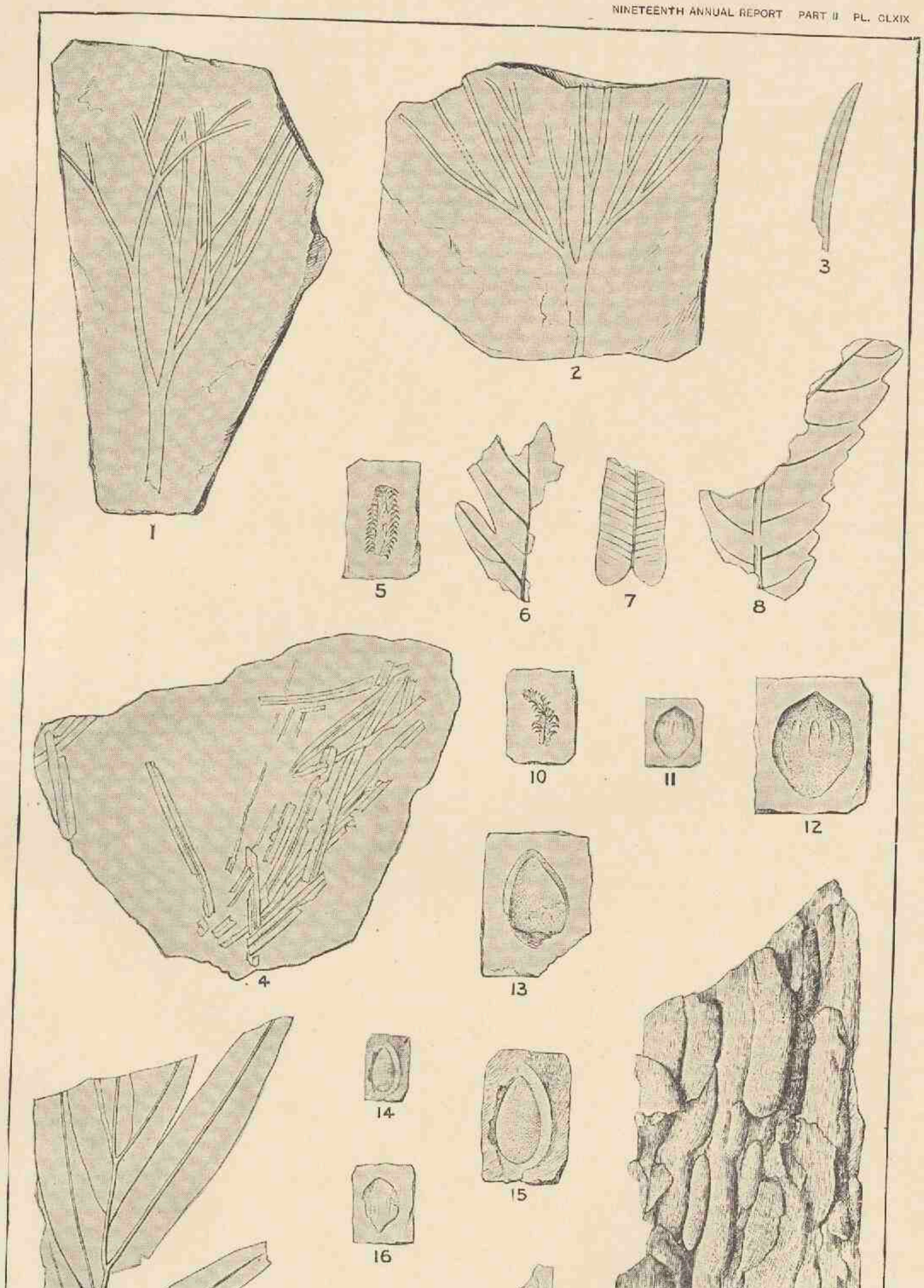

TAXACEOUS AND DICOTYLEDONOUS PLANTS AND PLANTS OF UNCERTAIN SYSTEMATIC POSITION FROM THE LOWER CRETACEOUS OF THE BLACK HILLS.

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PLATE CLXX.

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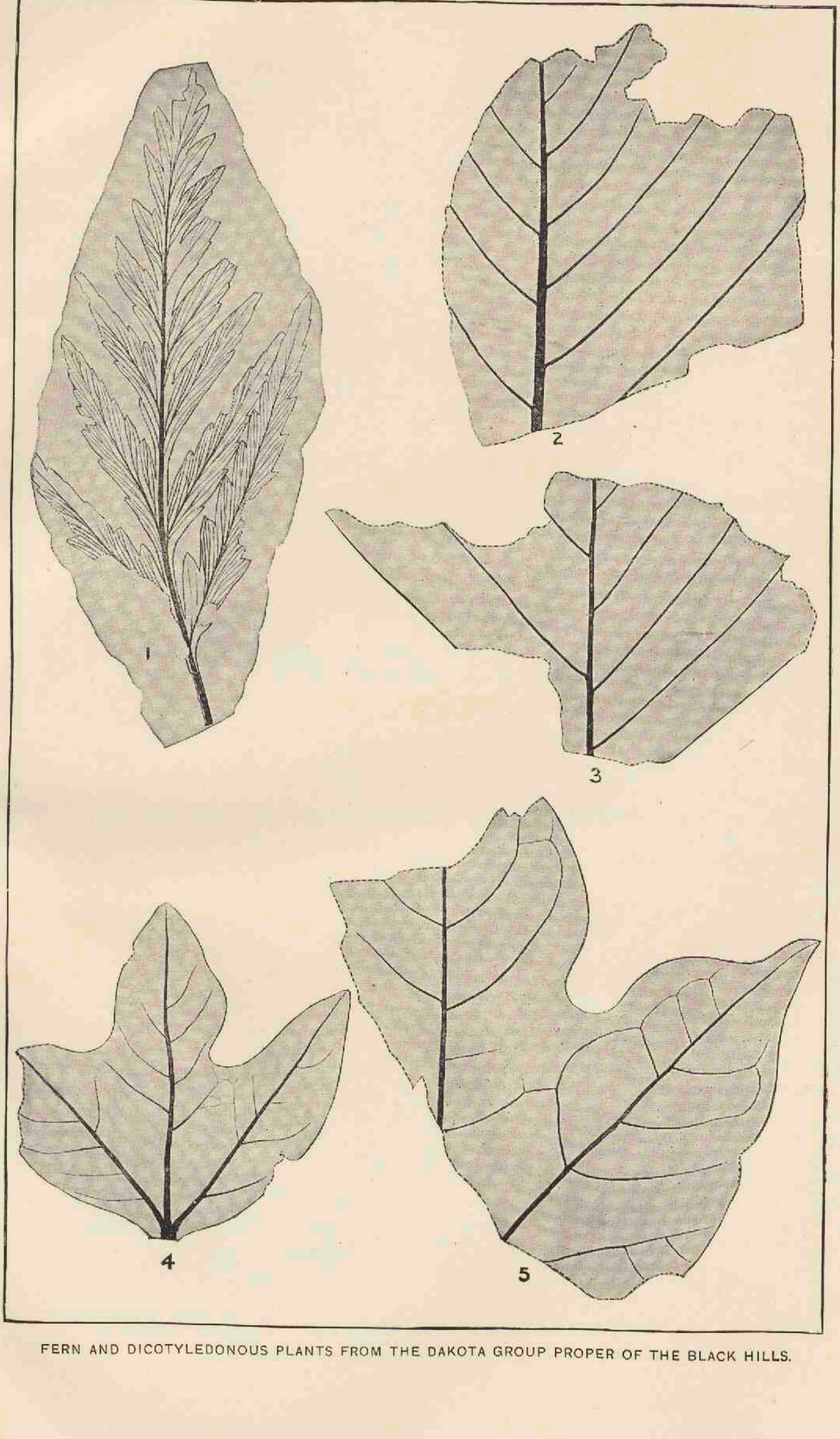
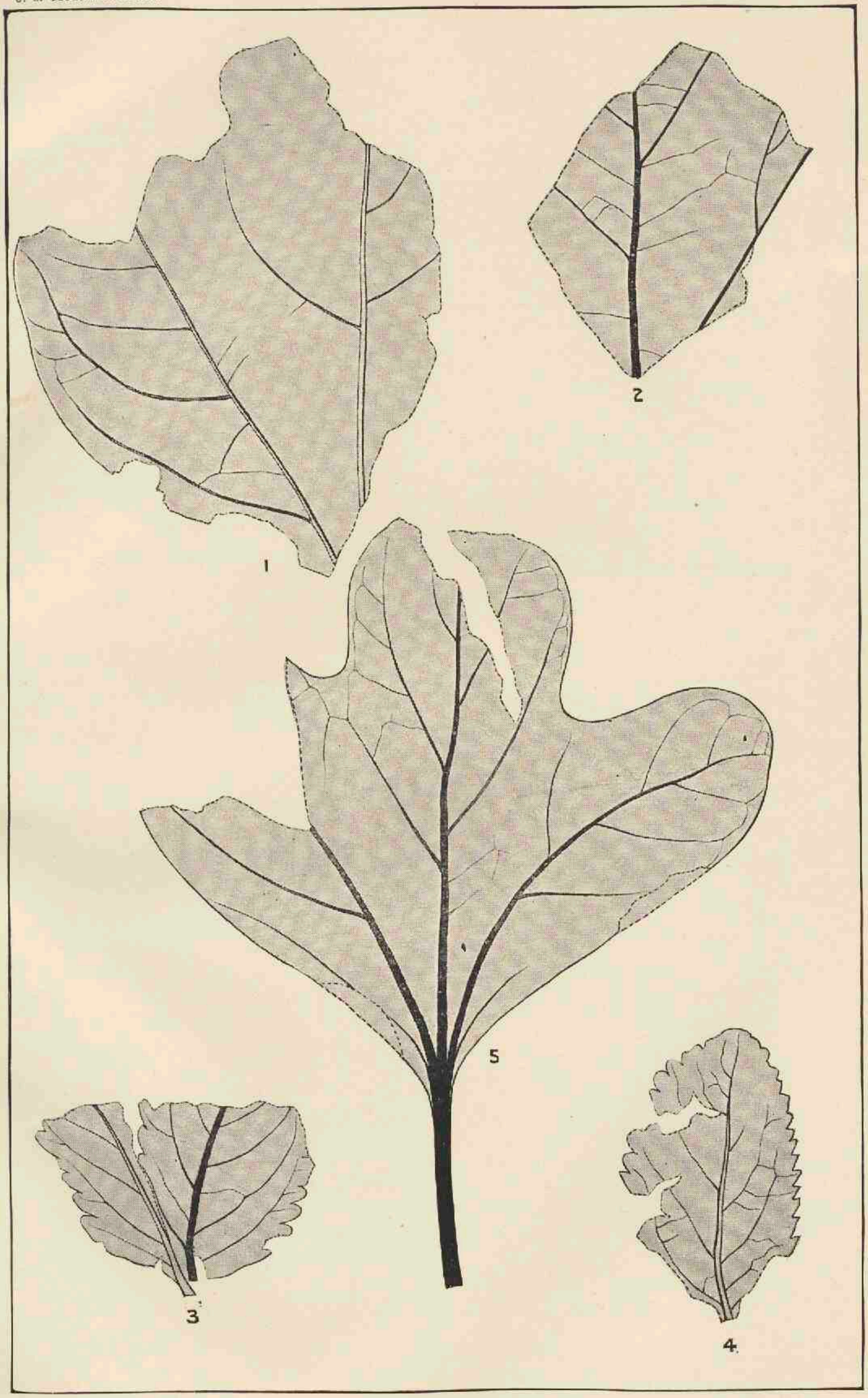


FERN AND DICOTYLEDONOUS PLANTS FROM THE DAKOTA GROUP PROPER OF THE BLACK HILLS.

PLATE CLXXI.

PLATE CLXXI.



DICOTYLEDONOUS PLANTS FROM THE DAKOTA GROUP PROPER OF THE BLACK HILLS.

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PLATE CLXXII.

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FIGS. 3, 4.	VIBURNITES EVANSANUS Ward	709

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31 JAN. 1953
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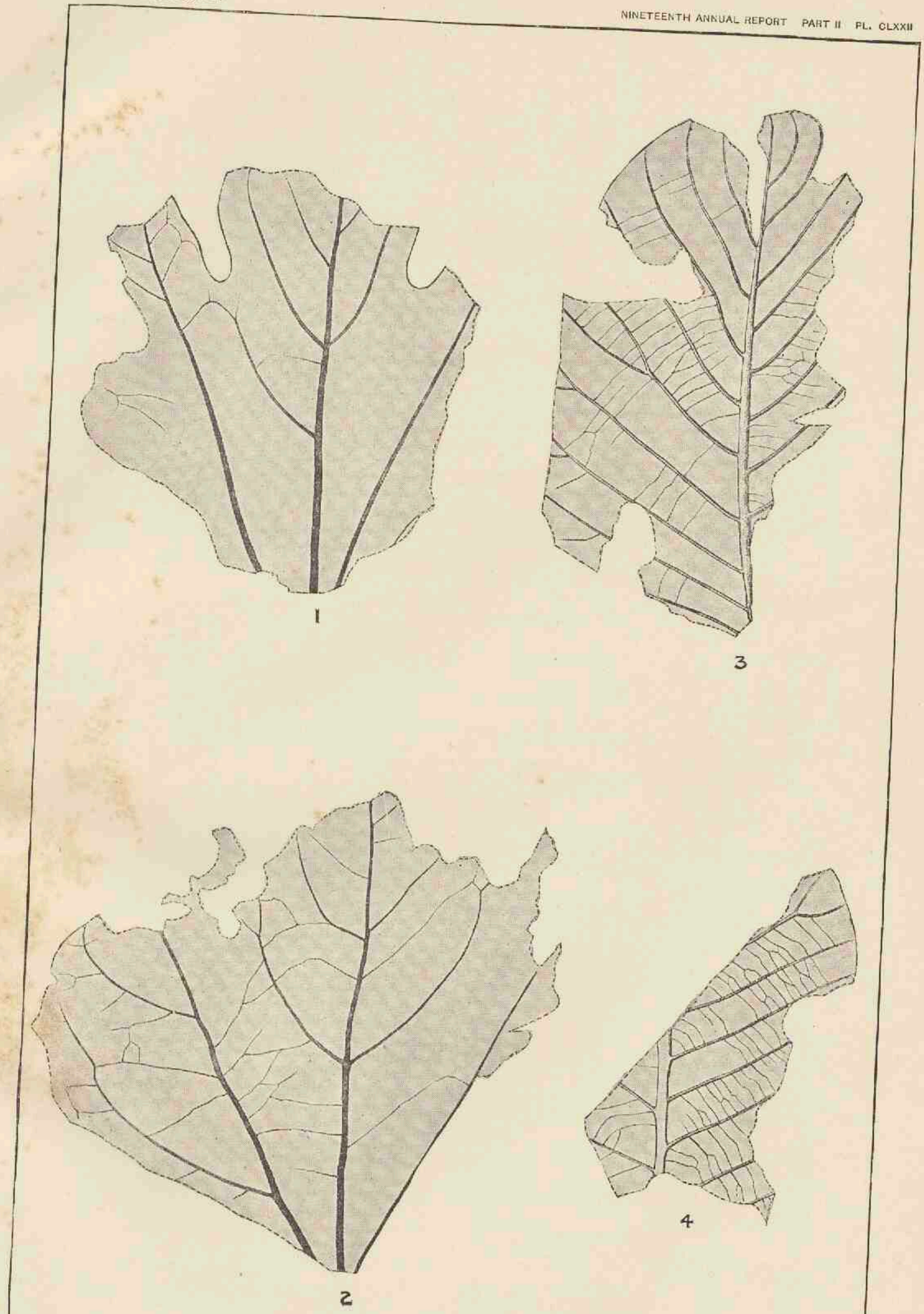

DICOTYLEDONOUS PLANTS FROM THE DAKOTA GROUP PROPER OF THE BLACK HILLS.

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Numbers in *italics* are those of pages on which illustrations (plates or figures) appear; numbers in **black-faced** type are those of pages on which detailed descriptions of species are given.

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