CYCADEOID TYPES OF THE KANSAS CRETACEOUS.

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ABSTRACT. Two lesser fragments of medium-sized silicified cycadeoid stems are the only specimens referable to the family Cycadeoideæ (Buckland-Brown) so far found in the state of Kansas. Both are markedly contrasting types. The specific names of both rest secure in the fossil nomenclature. The first to be found, though but briefly described without illustration, was accurately enough named *Cycadeoidea munita* by F. W. Cragin, just fifty years ago. This determination yet stands valid for both genus and species. The geologic age may be either Trinity or younger,—the actual locality yet remaining in doubt, though presumably near Belvidere in the southern tier of counties.

The second Kansas specimen was found by Handel T. Martin about 1921 and is definitely from the Niobrara Chalk of Trego county. Though only a lesser armor fragment, presence of fruit-axes in all leaf-base axillæ is certain and gains an accentuated interest since the discovery of the fine series of closely similar types in the Mesaverde formation of the San Juan Basin in 1927-1928. For evidently the San Juan group lived in the low bayou country just to the west of the Niobrara sea. Free-fruiting or monocarpic species, though long exceedingly rare in collections are now seen to form a most conspicuous series with wide distribution and a long range in time. These types are conveniently set in a separate genus, *Monanthesia*.

The purpose of these notes is hence to bring into nearer view the two sole Kansas petrified cycadeoid types as seen to be clearly separable generically if not also in geologic age. Their importance rises above mere numbers and the textual references are in need of exactitude.

ISOLATED fossils of striking feature, whether because of the type of preservation or some form of specialization, are always significant. There is ever the lively expectation that further examples must sooner or later be found, fixing the horizon more surely or adding to the knowledge of structure, and so making more secure the comparisons with related forms of distant regions. The fragmentary fossil may reach uncommon value as evidence of distribution, though its structures may

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Cycadeoidea munita Cragin.

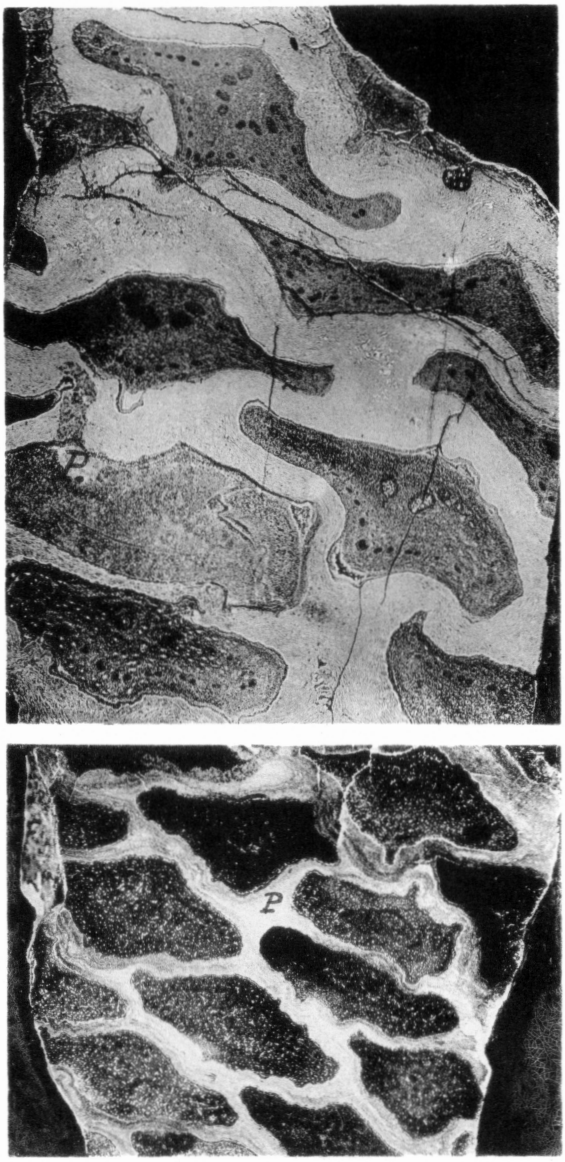
Plate I.

1889. F. W. Cragin. Paleontology of the Plains, No. 1. Bull. Washburn Coll. (Topeka, Kans.), Vol. 2, No. 10, pp. 65-68 [65, 66].

1894. L. F. Ward. Fossil cycadean trunks of North America. Proc. Biol. Soc., Wash., Vol. LX, pp. 75-88; Cretaceous formation of the Black Hills as indicated by the fossil plants. U. S. Geol. Surv., 19th Ann. Rept., p. 541.

1906. G. R. Wieland. American fossil cycads, Vol. I, p. 11.

1922. E. W. Berry. The flora of the Cheyenne sandstone of Kansas. U. S. Geol. Surv., Prof. Paper 129-I, p. 209.



Cycadeodea munita type. Transverse section through armor showing leaf-base bundle pattern and a clearly outlined axillary peduncle (P). X 2.2 above. Below in natural size.

appear to affect the nomenclature inconveniently. The cycadeoid armor fragment called *Cycadeoidea munita* is such an isolated fossil.

With the data concerning *C. munita* as a precedent species in mind, the custodians of Washburn College several years ago were requested for the loan of the original type for sectioning and needed illustration. The request was very kindly acceded to, and, the wished-for type not being found at once, another very remarkable fossil plant was sent in its stead.* But finally the armor fragment agreeing with Cragin's description was forwarded in the latter part of September, 1923, and the sawing of the specimen was taken up at once. It is in the end most fortunate that this present notice has been so long delayed.

Original description.—In giving the initial description Cragin said:

"Of especial interest as the first fossil discovered in Kansas from a stratum that I shall for convenience call the 'Cheyenne Sandstone' [of the Belvidere Section, named in allusion to Cheyenne Rock at Belvidere], a horizon which is supposed to be referable to the Trinity division of Texas and Arkansas, is a portion of the stump of a cycad, similar to those so well known from the Purbeck Dirt-beds of England. The species differs from its English congeners in form and in the size of the petioles. The type is a large and thoroughly silicified fragment. It is between eight and nine inches in length, oblique, and represents about seven inches of actual height. It consists of the false-bark only, but is sufficiently characteristic to warrant description of the plant."

It is worthy of note that Cragin must be credited with the first correct use of the generic name *Cycadeoidea* in the western world,—and this at a time when there was no finer elaboration of cycadeoid structure to enable one to detect the certain presence of the European genus.

* An illustrated account of this strange type is given in my article entitled, "Certain Fossil Plants Erroneously referred to Cycadeoids" (Botanical Gazette, Vol. LXXXVI, No. 1, Sept., 1928). A full discussion clearly reveals the fact that it is scarcely possible to know whether this handsome but dubious plant is an Angiosperm or a Gymnosperm. It is named *Williamsonia(?)hespera* and contrasted with the "*Williamsonia elocata*" *Lesquereux* of the (Dakota?) Cretaceous of Ellsworth County, Kansas. In both instances the specific names alone are defensible, and even the interrogated use of the generic term *Williamsonia* was indefensibly bad.

Further description.—The type *C. munita* Cragin (1889) is a rather dark colored, compactly silicified armor fragment 21 cm. high, 8 cm. broad, and 5 cm. thick below, 8 cm. above. From 1 to 2 cm. of the depth of the outer cortex is roughly included, carrying the large horseshoe scars of the leaf traces and showing the trunk to be one of the forms with a heavy cortex zone fully 3 cm. thick. The armor thickness varies from 3 cm. below to 6 cm. above, and along with this increase runs a very slight curvature of the cortical surface with change in the direction of the old leaf bases from horizontal to distinct upturning. Therefore the part of the armor present includes the upper lateral and lower shoulder region of the original stem, which at least tended toward the columnar form. In life the trunk was about a half meter or more in height, and very close to 30 cm. (one foot) in diameter. That is, a medium-sized elliptical to columnar form thus surely comes into view,—a true *Cycadeoidea.*

The leaf bases are of the subrhombic, rather than triangular transverse section more characteristic of monocarpic cycadeoids such as the *Monanthesia* (*Cycadeoidea*) *stantoni* and later described types of that series of species. That is, from the leaf-bases alone it would be suspected that a sparse-flowered type is present, as proves to be the fact. The leaf-base ramentum is of medium growth, varying from 2 mm. to 5 mm. thick. The size of the leaf-base slightly increases towards the trunk shoulder to about 3 cm. across the scars. On sectioning tangentially through the entire armor fragment about 2 cm. below the armor surface the outlines are clearly seen. The section so cut is oblique to the stem-axis by about 25° and shows the right and left leaf-base spirals to be of nearly equal inclination,—both running at an angle of about 60° to the trunk axis.

Also, the section cut through the armor as before noted takes the form of a scalene triangle with an area of almost exactly 100 sq. cm., or, as it chances, just the area found convenient for leaf-base comparison in general. Here, this area thus includes some 27 leaf bases 3 cm. across by 2 cm. in depth, and the sections of two peduncles of quite the same size, though without any trace of fruits borne by them. A more lush floral growth than that usual to monocarpic species is seen,—just what might be expected in some sparse-flowered type related to *Cycadeoidea dacotensis.*

In the main, the leaf bases and peduncles are of the size, form, and structure common to various Texas and Black Hills specimens; although none of the named species need be regarded as precisely the same. At this point, as elsewhere, it is regrettable that there is not at hand an adequate series of unit sections for more final comparison. As often noted in study, the armor features change with growth and the emergence of fruits, and are so varyingly conserved that the tangent sections should traverse like unit areas. The best unit is a section 10^2 cm. or its equivalent, cut with due attention both to depth and to height on the trunk. Such sections at once reveal stages of growth and fructification, and very generally specific likenesses and differences.

Confirmatory note on histology. The foregoing description, as based on a fully adequate series of saw cuts and polished surfaces, seven in all, should be read with attention to the illustrations. It can at no point be too strongly emphasized that a valid, usable description of the petrified cycadeoid specific types cannot be put in words and measurements alone, even where the trunks are quite complete. Certainly in the present instance, where all that is seen is the cortex, the armor without the fruits, and the two peduncles, full illustration is doubly essential. Only when this is given may one gain some idea as to whether some of the later Black Hills species may perchance be referred to the *C. munita.* Of all petrified plants the cycadeoidean species are quite the most difficult to determine. That is, the wealth of feature requires a correspondent elaboration,—a more rigid avoidance of stressing any one section or feature.

In the *C. minuta*, the thin section through the armor, tangent to the cortex about 1 cm. out, presents no bundle or other finer features meriting photomicrographs; but there is enough trace of the actual structure to make it certain that the bundles agree quite closely with those of *C. dacotensis* or of *C. marshiana*, and that the outlines taken to be the peduncles are really such. It is seen that there is a thin, flattened peduncle cylinder and not a succession of bundles as in the leaf bases. Also, the leaf-base bundles are clearly outlined, though not quite well enough preserved to make drawings of structure worth while. In these bundles, structures seem generally altered into secondary granulation. In the ramentum the individual cells do not show at all.

With the features of *C. munita* considered as best they may be from such an armor fragment, the conclusion reached is that the actual species is intermediate between *C. dacotensis* and *C. marshiana*. Also, it is seen even from this lesser fragment how facile was the change into, or from, the monocarpic types. The peduncles bear a few of the basal bracts, and are of medium size, which might indicate easy variation from *C. dacotensis* with uniformly large peduncles.

The total number of fruits for the entire stem is approximable from the armor fragment. It is seen that the trunk was a low-growing one, that the peduncles are from near the shoulder region, and that basal fruits would be few in number. Hence, with two fruits for the unit area of 100 sq. cm., a trunk diameter of 30 cm., and a fruiting zone about 25 cm. across, close to fifty fruits is near the maximum number for the stem. Such a trunk is inconspicuous as compared with an Australian *Macrozamia moorei* about four feet high by three feet in diameter, observed by Chamberlain to bear one hundred ovulate cones in the shoulder region.

Locality and horizon.—A further notation on locality is needed. There is in Cragin's note a curious omission of any direct reference to the locality from which the *C. munita* type might have come, although, inconsistently, there was no expression of doubt as to its horizon. It was therefore a matter of some surprise to find that the specimen is simply marked as from north of Sharon, which is in Barber County, Kansas, in the exact mid-southern tier, whereas the Cheyenne Rock at Belvidere lies some 40 miles northwesterly in Kiowa County. Rectification here should lead to some further facts and finds of new material in the field. Meanwhile, several opinions which have been ventured on the horizon of *C. munita* may be in part recorded.

In the fourth edition of Dana's *Manual of Geology* (1895), p. 832, an assertation is made which might in the end prove entirely correct, as follows: "The plants of the Trinity beds of Texas are to a large extent identical, according to Fontaine, with those of the Lower Potomac beds (1893). They include cycad stumps named *Cycadeoidea munita* by Cragin." This statement does not seem to have been based entirely on published information; but it is now known that cycadeoidean stumps do occur in the lower Trinity beds of Wise County, Texas, and

in the Comanchean near Comanche, as first reported by Doctor Emilio Boese in July, 1915, and by Mr. Bart Johnson of Comanche and Mr. J. W. Wagner at a later date; and of course there is now the fine series of Trinity cycads which has come into view since 1931. Maybe earliest of all was a specimen collected in the Glen Rose formation by the famed Texas geologist R. T. Hill. This was sent through Lester F. Ward to W. M. Fontaine who gave an identification as noted in the 21st Annual Texas Report.

What Lester F. Ward had to say (1899, p. 541) was:

"In the investigation of the Potomac formation in Maryland the subject of fossil cycads had 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 Basal Potomac. Professor Cragin had obtained a fragment from Kansas which certainly belongs to a cycad trunk, and which he described as *Cycadeoidea munita*. 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 the Reeder sandstone."

Ward may be wrong or right.

Of fullest interest here is the elaboration of the flora of the Cheyenne sandstone by Berry (1922). The plants include the cones and foliage of the fine *Sequoia condita* Lesquereux, a handsome *Sapindopsis* group of the four species, *S. belviderensis*, *magnifolia*, *brevifolia*, and *variabilis*, *Aralia ravniana* Herr and *A. polymorpha* Newberry; the two Sterculias *S. mucronata* Lesquereux and *S. towneri* Berry; *Sassafras mudgii* Lesquereux; the characteristic *Araliopsoides cretacea*, and a few less diagnostic ferns and evergreens; also the *Arundo groenlandica* Heer (possibly a bamboo). And then there is the doubtful *Cycadeoidea munita*, of Lower Cretaceous aspect but which admittedly could extend its range into Upper Cretaceous time.

These forest elements, taken with the seeming absence of much of the vegetation of the Patapsco, or certainly Lower Cretaceous of the "Iron Ore beds" of Maryland, and possibly of the Trinity beds, too, might seem to compel the paleobotanist to assign the Cheyenne sandstone to Dakotan time, and those in some degree familiar with fossil floras could reach that inference.

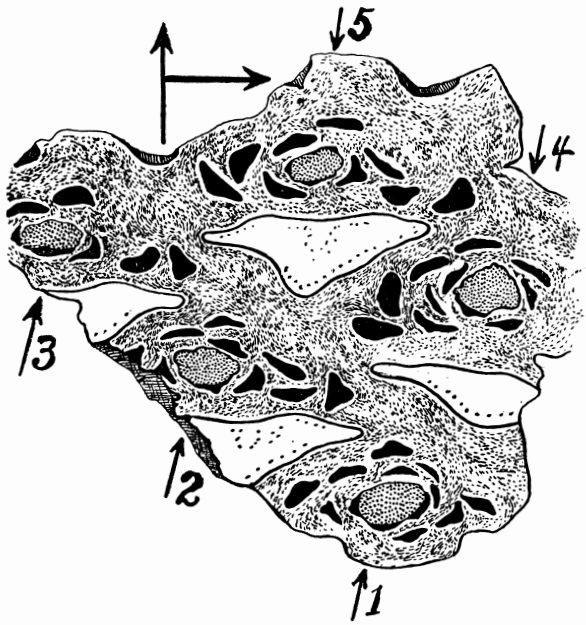
Meantime, it is probably the consensus of geologic opinion that the Cheyenne sandstone is an equivalent of the Washita of the Texas Comanchean, and that with the succeeding Mentor-Kiowa shales it would close Lower Cretaceous time in the central Kansan region (Willis 1912, Twenhofel 1920). But this entire subject is in nearly all its bearings an open one, and it is that very fact that makes a simple statement worth while. A point is reached where each newly found fossil plant helps to complete the picture of the greater cycadeoid forest as it begins in Aptian time or Potomac of Maryland. It appears, as O. M. Ball remarks,* that both the angiosperm and coniferous elements of the Cretaceous floras are much older than at first seemed likely; even nearly related types are continually found to be far more widespread, older, and more persistent than earlier supposed. He has proved the presence of three distinct dicot types from the Trinity beds in the neighborhood of Stephenville, Erath County, Texas, which also yielded a fine series of cycadeoidean species.

In *résumé*, it is seen that *Cycadeoidea munita* is a distinct and characteristic type which, because of its early date (1889) and its features, holds a fixed position in the synonymy of the genus *Cycadeoidea*. The species cannot be one of the monocarpic group, and may well occupy an exactly intermediate position among the forms of the Potomac group, the Trinity, or the great Lakotan series. Here is a type closely in the line of descent, if it actually comes from the Cheyenne sandstone, or if the Belvidere formation is somewhere intermediate to the lower Trinity beds and the upper Lakota. The point of emphasis then is this: that the types of the Arundel of Maryland, of the Trinity beds of Texas, of the lower "Lakota" of the Black Hills, all find a very close specific relative in this stray from southern Kansas. Yet it does not follow that all are of the same age. Further facts might prove such a contention. Meanwhile it must be admitted that the genus *Cycadeoidea* was virtually cosmopolitan,—to a certain extent *Monanthesia*—too. Typical species of both may be widely found where conditions favor, at least from closing Jurassic to closing Cretaceous time. Hence the isolated species and occurrence cannot be taken alone as age determinant.

* Bull. Agric. & Mechan. Coll. Texas, 1939; see review in Amer. Jour. Sci. for June, 1939, p. 440.

Monanthesia (*Cycadeoidea*) *niobrarensis*, sp. nov.
Text Figure 1.

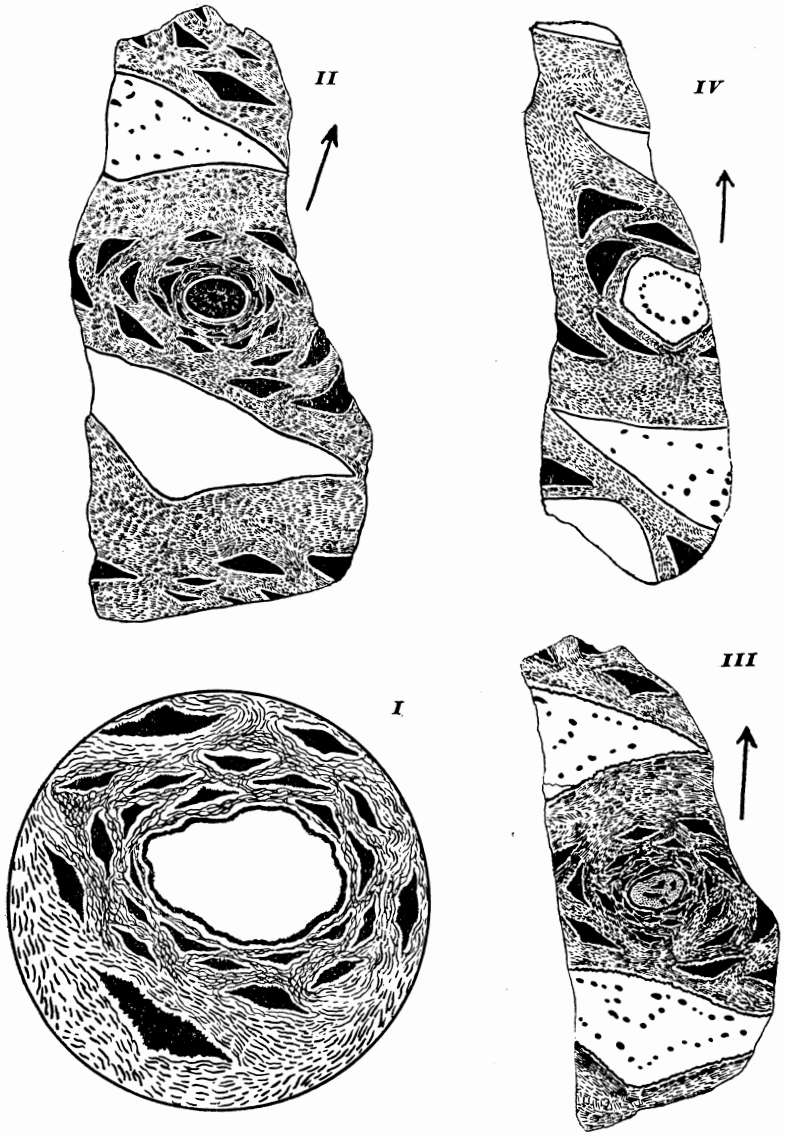
In February, 1922, Mr. Handel T. Martin of the University of Kansas forwarded for sectioning and study a small but characteristic cycadeoid armor fragment which he had found isolated in the Niobrara Chalk hills of Trego County, and which he correctly regarded as the only specimen of its kind noted in the Kansas Chalk. Its description, as put in manuscript some years ago, takes on renewed significance in view of the striking series of free-flowering types recently discovered in the Mesaverde, to the west of the Niobrara sea. The two occurrences are of interest, further, in affording some measure of the nature and likelihood of cycadeoid petrifaction under marine conditions.



Text. Fig. 1. *Monanthesia niobrarense.* Transverse section cut through type armor fragment 2.5 cm. below armor surface. The leaf-base spirals with a fruit axis in all the axillae appear in their clear outlines. The leaf-base bundle patterns are not clear in the sections, but appear to be more diffuse than in other free-fruiting species. × 1.

No other portions of the original stem were seen; but fragments of palm stems come from the vicinity; and a quarter of a mile away a more or less broken-up old conifer stump three or four feet in diameter was found in the loose shaly chalk, the

petrified pieces being mostly covered by quartz druse. Incidentally, this occurrence of palm stems along with silicified conifer stems in marine sediments is later paralleled in the Pierre,



Text. Fig. 2. *Monanthesia* (Cycadeoidea) *masseiana*. Armor sections cutting axillary bract-enveloped young floral axes as present in all leaf-base axillae. Nos. II-IV are cut at successively lower levels. At I enlarged view of III showing bract sequence. Note the clearly outlined leaf-base bundle patterns. II-III about twice natural size.

along the Cheyenne River, where the fine *Palmoxylon cheyenneense* occurs. In the Kansas Chalk, besides the cycadeoid, the palm, and the conifer, are found, as so well known, pterodactyls, toothed birds (*Ichthyornis* and *Hesperornis*), the medium-sized dinosaur *Claosaurus agilis* Marsh, the armored dinosaur *Hierosaurus sternbergii* Wieland, and many other types, marking one of the most remarkable marine horizons on the globe. The association in general indicates nearby shores, although the cycadeoid and other stems, as later petrified, could have been carried for long distances either north or south by the currents of the Niobrara sea, an abiding place of many fishes and many turtles.

The cycadeoid armor fragment is silicified throughout, though not densely chalcedonized, and is fortunately not waterworn. The form is roughly triangular-prismatic, furrowed by leaf bases, peduncles, and bracts. The length is 10 cm., width 8 cm., thickness 6 cm., and the weight half a kilo. One of the leaf-base keel contours is very perfecty indicated and covered by ramentum insertion scars, the full armor depth being present. The outer trunk surface includes several deep pits of leaf bases and many large bract scars besetting areoles of quite small bracts surrounding peduncle ends. The transverse sections disclose five peduncles with their surrounding bracts, and three of the subtending leaf bases with a portion of a fourth. The fruits themselves, however, are not determinable. (See Text Fig. 2). Over all this portion of the trunk at least there was thus a floral axis in every leaf-base axil; while the peduncle, being preserved or mineralized out beyond the older leaf bases and being enclosed in heavy bracts, gave the fragment some resistance to final breaking up. That a much larger portion of the armor or of the original trunk was earlier present is evident, though in marine beds the woody cylinders easily fail of petrifaction. There being neither droop nor ascending angle to the leaf and floral axes, a stem of not less than 35 cm. in diameter is indicated, with the habitus and probably the size of other monocarpic species like *C. nigra*, *C. dartoni*, or the Apennine *C. masseiana*. But that the form was as distinctly columnar as these could only be known from much completer specimens. A very heavy armor may mean fewer years of growth, or less periderm excision, which tends to leave this point more doubtful; while bracts of large size (beginning with

a very low-set lateral pair) are also seen in *C. stantoni*, which may be the smallest of the monocarpic trunks.

Although final petrifaction evidently took place under marine conditions, there are no very marked variations from the kind of tissue conservation found in the more numerous stems from strata laid down in fresh waters. Some maceration and some fungal effects appear. The leaf bases are quite intact, though the newer growth of the peduncles is much invaded by decay over well marked areas, or else worm bored. Various comminuted courses or borings run not only through or across the stalks but out into the ramentum. One noticeable feature of the leaf bases is the presence of the best cell preservation in the inner depths of the armor, where replacement by light chalcedonous silica is strongly contrasted with the commoner drab and brown textures. In these inner portions, which are light gray in reflected light, and darker or of the general brown ground color of the specimen in transmitted light, the bundle structure is fairly distinct, less the phloem. Some similarity to the type of silicification in the *Cycadella* trunks of the Freeze Out Hills of Wyoming is observed. There, too, brown cell walls may traverse the clear gray-toned silica with fair distinctness.

The leaf bases are dorsally flattened and of medium size, 2.5 cm. across by a scant centimeter in depth. The peduncles are 1 cm. across by a scant 0.5 cm. in depth. The large, outermost bracts arise near the cortex. But the smaller, inner bracts only appear near the armor surface, and so suggest more superficially borne fruits than in *C. dartoni*, or *C. masseiana*.

Most of the ramentum belongs to the bract series; but the lower bracts being large, and their ramentum quite like that borne by the leaf bases, it is merely seen that the leaf-base ramentum is of reduced amount. Mainly, the ramental outlines are alone present as in so many cycadeoids; although in limited areas silicification is quite perfect and the scales are seen to be of the thin type one cell thick,—in contrast to a thick-celled ramentum in several species of the monocarpic series.

The leaf-base bundles are, as just noted, well indicated in the patches of light silica. In structure they agree with the bundles of the *C. stantoni* and several other forms, and thus are of the usual type for the great majority of cycadeoids. But the grouping varies. The first (primal) or single trace

does not, on dividing, adhere to the usual cycadeoid dorsal V-alignment. Instead, the bundles soon conceal this pattern in irregular distribution, much as *Encephalartos* frays out the cycad omega pattern. This tendency to vary towards open or monocot-like distribution is noted in several of the monocarpic species, and is a minor feature of the group. It begins in the *C. nigra* and the *C. masseiana*, is more marked in the *C. stantoni*, and far more noticeable here, being taken, in fact, as one mark of a new group of species. However, too much must not be made of the feature; it is not entirely confined to monocarpic types, and is again found in modified form in *C. ingens* (Yale trunk No. 208, questionably so referred). Evidently the change toward irregular grouping may take place so variably in fronds of varying size and pinnule form, growing in varying situations, and subject to varied degrees of excision on wilting down, that bundle grouping as a feature of the old leaf bases is not always a uniformly usable specific index. To get the details may in some species require more sectioning than the point is worth.

The structure of the peduncles is usually broken down,—so much so that the outlines of the woody cylinders seem to fail at all points. Nor is there any indication of the structure or even the form of the fruits, or any certainty as to whether such were young or shed. It is much to be wished that other examples of this unique and lone specimen of the Niobrara Chalk may be found. Chance, however, twice forbids. Few horizons on the globe are better exposed mile after mile, and few yield a more remarkable glimpse of the critical details of ancient life; while few have been more ardently searched during the seventy-one years that have passed since Marsh first found along the valley of the Smoky Hill River the toothed, carnivorous, diving bird, *Hesperornis*.

And now, since the above paragraphs were first penned, there have come into full view the real relatives of this Niobrara cycadeoid, as at last noted and mainly assembled in the Mesaverde of the San Juan Basin for the Yale collections in the years 1928-1929. These are the near and true relatives of the *Monanthesia niobrarense* which in truth may likewise come from those same forested bayou lands to the west of the Niobrara sea, with their varied conifers, cycadeoids, palms, Lauraceous dicots, and dinosaurs.

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