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TWO NEW LYCOPOD SEEDS FROM THE ILLINOIS PENNSYLVANIAN

BY

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Two New Lycopod Seeds From the Illinois Pennsylvanian*

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INTRODUCTION

Two new representatives of the Lepidocarpaceae are the basis for the following paper.

Lepidocarpon has previously been reported[3,5] as abundant in coal balls of the Illinois coal basin, but has not been recognized from the more common impression fossils. The author has been inclined to question this anomaly in reported distribution. Recent collections obtained for the most part during the past year at the famous Mazon horizon in northern Illinois have tended to confirm the idea that *Lepidocarpon* is fairly common in occurrence in this area, although previously not recognized. Over 40 specimens of it were collected in the course of a few brief visits to the area previously stripped for coal in Grundy and Will counties. It is hoped that the information presented here will lead toward further knowledge of *Lepidocarpon* and other lycopod seeds in their different forms of preservation.

Many of the plant fossils preserved in the Mazon ironstone nodules exhibit little evidence of compression and are preserved essentially as casts. To account for this it must be assumed that the enclosing ironstone was cemented very quickly after deposition. Dorsal and ventral cast features in the nodules are often easily distinguishable. Some secondary mineral filling of iron and calcium carbonates or of iron pyrite may fill the internal cavities, but as a rule these minerals do not preserve the original plant structures. The plant tissues were apparently subject to a period of disintegration after the formation of the external cast without much impregnation by minerals. It may be that some of the minerals now present within the casts were precipitated in connection with the decomposition of the original tissues. The subsequent identification and description of *Lepidocarpon mazonensis* n. sp. is based chiefly on faithful preservation of the external outline of the seed structure by the fine-grained ironstone matrix of these casts.

Another lycopod seed similar to *Lepidocarpon* in many general features but different in significant details has been found in calcareous coal balls obtained at Nashville, Washington County, Illinois,[2] from No. 6 coal. About 20 different specimens have been located, but an adequate suite of sections is available from only three. These seeds show additional modification of the lycopod seed habit beyond that known in *Lepidocarpon* and for this reason have been assigned to a new genus. The description presented here is preliminary to a more detailed study which will require some time to complete.

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Lepidocarpon mazonensis sp. nov.
Plate I, figs. 4, 5a, b, c;
Plate II, figs. 6, 7, 8a, b, 10, 14.

Description: Large, isolated, seed-bearing sporophylls probably originally borne on a strobilus. Lamina long (7-10 cm), lanceolate, slightly acuminate at the tip; 10 to 15 mm broad at the base above the sporangial structures and increasing slightly to the greatest width below the middle. On the dorsal (lower) side the midrib is impressed as an obscure central ridge (an indentation in the lamina itself); two lateral ridges (grooves in the lamina) parallel the median ridge at about a millimeter's distance.

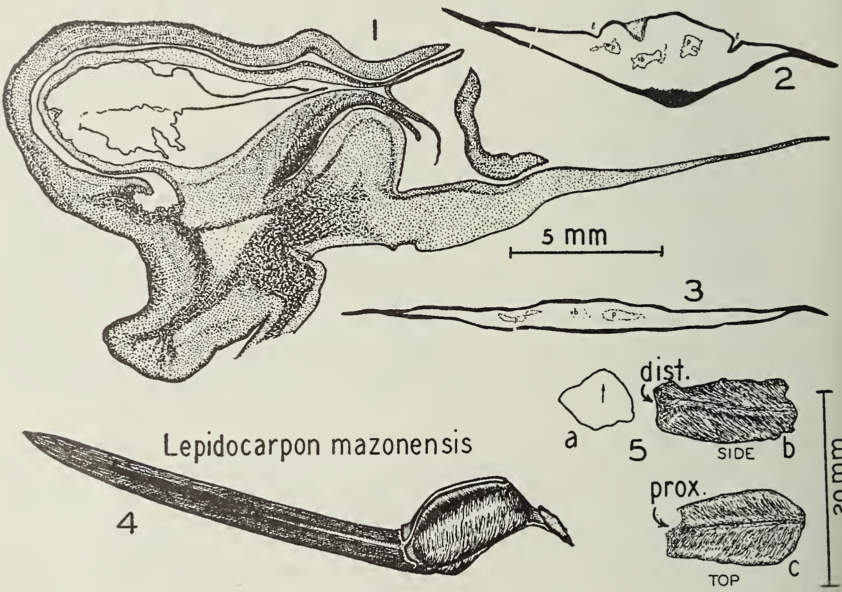

PLATE I.

(Figs. 1, 2 and 3 drawn at same magnification, scale given.)

Fig. 1. *Illiniocarpon cadyi*, longitudinal slightly oblique section. Stippling indicates various tissue configurations. Nashville coal ball 1B2, Sect. (B2).

2, 3. *Illiniocarpon cadyi*, transverse sections of lamina. Nashville coal ball 80X, from same specimen shown in figs. 12 and 13.

4. *Lepidocarpon mazonensis* reconstruction; ca. 2/3 natural size.

5. *Lepidocarpon mazonensis;* Profile sketches of iron carbonate mold obtained out of a seed cavity. Fibrous edges of the seed megaspore are visible at a few places in the original.

Toward the tip the median ridge dies out first and the lateral ridges come closer together and nearly meet when last discernible. On the ventral (upper) surface the midrib is slightly different on the basal third of the lamina where it forms a single distinct rounded depression in the cast about 2 mm broad with little or no median striation. Distally the lateral ridges become more evident and a slight central striation is present. Fig. 14, a cast of the upper surface, shows these features. The lamina on either side of the midrib is covered with a fine microscopic longitudinal striation, no doubt impressed by the cuticle which is not preserved. Margins are entire. The lamina adjoins the sporangial structures in an arc almost semi-circular in some specimens. Sometimes the surface in this area shows rugosity or minor plications radiating from the base. In Figure 14 the arcuate juncture of the lamina with the seed is minimized by foreshortening. The blade inclines upward from the axis of the seed at an angle approximating 45° (see figs. 7, 8a, b), although this varies with the attitude in which the organ was deposited. The larger size and less pronounced upward deflection of the lamina clearly distinguish this form from other species of *Lepidocarpon.* The blade probably functioned as a dispersal mechanism.

The seed structure is apparently similar to that reported by Scott[7] for *Lepidocarpon lomaxi.* In a vertical plane the form is somewhat quadrate, about twice as long as high (See figs. 7, 8a, b). Leafy integuments typical of the genus enclose the sporangial ("nucellar") cavity and almost meet above. Their margins continue upward for 3 mm or more toward the highest point and gradually decline toward the proximal upper corner of the seed where they join. Anteriorly the integument margins descend to close above the lamina and flare laterally on either side to connect with the reentrant laminal margins. They project more or less directly over the upper surface of the blade for a short distance as shown in figures 7, 8a, b. The slit between the integuments is well shown by a thin ironstone lamella which was introduced between them down to the sporangium proper at the time of burial. This slit filling is seen on part of the micropylar ridge in figure 8a, but is shown more clearly in figure 10 as it appears in a seed broken transversely. The free upper margins of the integuments along the slit were quite membranous, or at least very thin, as shown by the cavities representing them in the casts. The lower surface of the seed is keeled with a slight hump at the lower distal corner of the seed proper. At the lower proximal corner the keel is prolonged into a short stipate process which was probably adjoined to the original cone axis. Attachment was limited to this lower corner. Iron carbonate, sometimes in association with calcite, often fills the interior of these seeds more or less completely. The internal form of the seed cavity is shown by profile drawings of such a mold in figures 5a, b, c. The sporangial wall inside the integuments is not preserved structurally. It must have existed originally, however, because the ironstone mud was prevented from entering. The presence of a seed megaspore may be demonstrated in many specimens although only exceptionally is one found such as shown in figure 6. The megaspore membrane is very fibrous in texture and similar to the spores isolated from Illinois coal residues which have been compared with *Triletes giganteus* Zerndt.[8]

The reconstruction of *Lepidocarpon mazonensis* has been sketched in figure 4 to summarize the external morphology. Such a three dimensional concept of the fructification would have been more difficult to attain if it had not been for the somewhat unique character of the Mazon casts.

Lepidocarpon mazonensis was probably the form Lesquereux referred to as *Lepidophyllum majus* in the "Coal Flora" (p. 449) although he figured no specimens nor to the author's knowledge have specimens of this species been figured by anyone else. David White[6] illustrates some sporopylls from Henry County, Missouri as *Lepidophyllum missouriense* that appear very similar but on the other hand additional specimens which he figures show a more lanceolate lamina considerably more constricted above the sporangial structures. He further states that numerous large megaspores have been observed in the sporangia of some specimens. It may be that two rather distinct forms are confused as *L. missouriense* on account of their similar blades; as they are now known, Mr. White's specimens seem to have been free sporing and hence distinct from *Lepidocarpon. Lepidocarpon mazonensis* agrees in many ways with *Lepidostrobus major* as recently described by

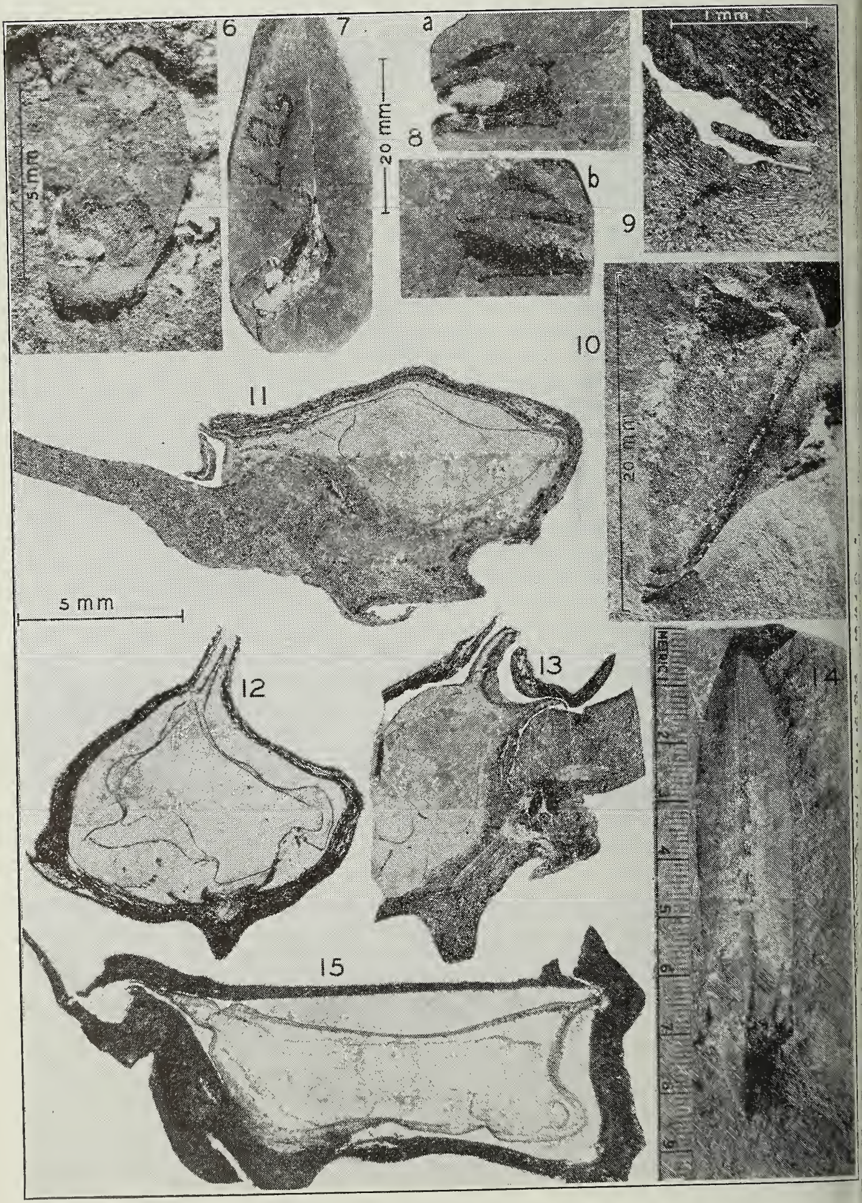

PLATE II.

Bochenski.[1] Bochenski has isolated seed megaspores from his specimens which are similar to these found in *L. mazonensis.* He has not observed integuments around the sporangium however and this is perhaps the chief objection to assigning his specimens to *Lepidocarpon.* His material was all coalified and considerably compressed in shale. Under such conditions the integumentary structures might be quite difficult to demonstrate. However Bochenski illustrates in his figures 27 and 28 what he identifies as prothallial tissue liberated out of the coaly compression by maceration methods. A cuticular layer illustrated in his figure 26 is described as derived from the sporangium wall. It is hard to believe that any remnant of the prothallus could withstand coalification and subsequent maceration. It seems more likely to the author that some of the cell patterns observed by Bochenski are derived from an unrecognized integumentary layer. A point of distinction between Bochenski's material and *L. mazonensis* is that the laminae of his specimens are minutely serrate on the margins while the Mazon material lacks any marginal irregularity.

In addition to the forms mentioned above, specimens of *Lepidophyllum auriculatum* Lesq. (Holotype, U. of Illinois Geol. Dept. Specimen No. X356, formerly in the Illinois State Museum at Springfield), *Lepidophyllum acuminatum* Lesq. (Plesiotype, Univ. of Chicago Walker Museum Specimen No. 6633) and two others probably referable to *Lepidophyllum mansfieldi* Lesq. have been compared with the Mazon material. None of these showed the sporangial structures sufficiently well to be conclusive. The likelihood is, however, that they will eventually need be referred to *Lepidocarpon* when the true structure is known. The presence or absence of a seed megaspore will not be difficult to ascertain from fresh, reasonably well-preserved material.

PLATE II

(Figs. 7, 8a, and 8b at same magnification, scale given; Figs. 11, 12, 13, and 15 at same magnification, scale given.)

Fig. 6. *Lepidocarpon mazonensis,* exposed seed megaspore from seed split vertically. This seed is one of the few which was compressed to some degree. The spore apex is hidden by and embedded in iron carbonate at the distal end of the seed (turned up in the photograph). At higher magnification the fibrous texture of the spore coat is clearly visible.

7. *Lepidocarpon mazonensis,* broken vertically parallel to but not exposing the "micropylar" flaps. At the lower left (proximal extremity) the point of attachment is shown.

8 a, b. *Lepidocarpon mazonensis,* broken vertically through the center showing the extent and form of the upturned integumentary margins. Fig. 8a shows the slit filling adhering to one side of the cast. The distal prominence of the dorsal keel is present but imperfectly shown.

9. *Illiniocarpon cadyi,* enlargement of the ligule. Taken from same section as fig. 11.

10. *Lepidocarpon mazonensis,* seed broken transversely to show view of "micropylar" slit from within. The cast filling of the slit is evident.

11. *Illiniocarpon cadyi,* longitudinal section of seed, passing through the ligule and paralleling the ventral slit. The lamina of this specimen continues slightly more than 5 cm beyond the seed, gradually decreasing in thickness. Nashville coal ball 62D2B, Sect. (B11).

12. *Illiniocarpon cadyi,* transverse section of seed posterior to the funicular swelling. The ventral slit with the sporangial wall intruding part way is at the top; below is a keel which probably contained a vascular strand. From Nashville coal ball 80X, Sect. (T30).

13. *Illiniocarpon cadyi,* longitudinal section through anterior portion of the same seed as in fig. 12. Nashville coal ball 80X.

14. *Lepidocarpon mazonensis,* surface features of a ventral cast.

15. *Illiniocarpon cadyi,* oblique section across seed intersecting the ventral slit near its posterior extremity and also at the anterior of the seed.

Illiniocarpon cadyi gen. et sp. nov.
Plate I, figures 1-3.
Plate II, figures 9, 11-13, 15.

Description: Lycopod fructification related to and homologous with isolated sporophylls of *Lepidocarpon*. Attachment by a peduncle on the lower side of the seed in the manner of a half-anatroupous ovule. The seed proper is borne on a funicular outgrowth of the peduncle. Sporophyll lamina not reflexed around distal end of seed but straight, relatively long (ca. 5 cm) distally quite thin and broad. It apparently served as a dispersal mechanism. Seed body elliptical, 1–1½ cm long, enclosed by two leafy integuments which adjoin along the top and front of the seed to provide a "micropylar slit" similar to that in *Lepidocarpon*. Ligule present at the base of sinus between anterior sporangum wall and sporophyll lamina; not situated in a pit. Sporangium contains one large fertile megaspore, nearly filling the cavity, and three abortive megaspores.

It is not known how the seed-bearing axis differed from that of a lycopod strobilus such as possessed by *Lepidocarpon* but it seems likely that if the cone were still recognizable it would be very loose and open in its construction. The peduncle is short in all the specimens studied so far. It presents a frayed irregular termination as if no abscision layer were formed.

When cross-sections of the seed are cut back of the funicular swelling an appearance similar to some diagrammatic representations of *Lepidocarpon* is obtained. Such a section is seen in figure 12. This same specimen was later sectioned through the middle and the resulting longitudinal section is shown in figure 13. Figure 11 shows a similar cut of a complete seed passing through the ligule, and figure 1 shows a drawing of a similar seed cut more obliquely. The integumentary investment is considerably elaborated beyond that of *Lepidocarpon*. A flap of the integument even extends around in front of the sporangium which otherwise would be left exposed since in these seeds the lamina is not reflexed upward. Figures 1 and 11 show the seed as if it were entirely enclosed ventrally by the integuments, since these sections essentially parallel the ventral slit. However, more oblique sections, such as figure 15, give the appearance of a "double micropyle." The slit in this case is intersected both anteriorly and near its posterior limit. The sporangium (or "nucellus") of this seed is also elaborated. The lower anterior wall, least protected by integuments, although a cushion of sporophyll tissue fits close against it, is thickened considerably in contrast to the parts altogether sheltered within the seed. The outer layer of sporangial cells is generally well preserved but tapetal cells within are more fragmentary. The sporangium is collapsed irregularly in these specimens but nearly always extends into the micropylar slit, as shown in figure 12. At the front of the seed it often bulges beyond the integuments producing the characteristic two pronged appearance shown in figures 1, 11, and 13. The termini of these two plications are split and it seems in all probability that fertilizing elements had access to the mature gametophyte through these openings.

One large fertile seed megaspore takes up most of the space inside the sporangium but three abortive megaspores are found near the anterior plications. No well preserved gametophytes have been found as yet although several seeds show a thin zone of gametophytic tissue in a few areas immediately inside the membrane of the megaspore. It may be that prothallial tissue had formed only around the periphery at the stage represented here, but it seems more likely that central gametophytic tissue was present originally and had become disintegrated prior to mineralization.

An enlarged photograph of the ligule is shown in figure 9. Aside from its unmistakable presence, further proving the relationship of *Illiniocarpon* with *Lepidocarpon* and the ligulate lycopods, there is little about it which seems to merit special attention.

The lamina is thickest in the basal part where it is attached just below the ligule. The lower surface is quite smooth and slightly keeled in the middle, the upper surface has a broad midrib and a lateral groove on either side in the basal portion. The slightly oblique cross-section outline shown in figure 2 was taken adjacent to the distal extremity shown in figure 13. The space presumably occupied by the vascular strand is indicated by the dotted outline (*vb*) in the center. On either side is another poorly preserved area (*p*); these probably are connected with the parichnos. Obviously the rigidity of the lamina was chiefly governed by hypodermal sclerotic tissue. Figure 3 is another cross-section outline from the same specimen taken about 12 mm beyond figure 2. The black outlines slightly exaggerate the extent of sclerotic tissue.

Vascular tissues are notable for their poor preservation in the specimens which have been studied. The supply after leaving the peduncle seems to divide, one strand proceeding to the seed and one to the blade.

This species has been named in honor of Dr. G. H. Cady, Senior Geologist and Head of the Coal Division of the Illinois State Geological Survey, not only because he was instrumental in obtaining the present excellent collection of Nashville coal balls, but because, as Dr. A. C. Noé records in an as yet unpublished manuscript, the first coal ball recognized as such from this country was collected in the Harrisburg region by Dr. Cady.

All specimens illustrated are in the Illinois State Geological Survey Collections, Urbana, Illinois.

DISCUSSION

Fredda Reed[5] has recently discussed the seed habit with reference to *Lepidocarpon* and her remarks apply equally well to both forms described here. Not only do these fructifications "retain" their functional megaspores but it seems that the lamina was modified into an organ for seed dispersal. Thus it forms an adaptation quite analogous with the wings of pine seeds or those of certain angiosperm fruits. As pointed out by Miss Reed, retention of the megaspore may sometimes occur in heterosporous cryptogams, e. g., *Selaginella*, but for true attainment of the seed habit, sport retention should imply marked nutritional advantage to the gametophyte. It has become more apparent that the megaspore coats of *Lepidocarpon* and related forms were particularly adapted for growth at the expense of sporophyte. The protective value of the spore coat was largely if not entirely lost and this function was assumed by the elaborated sporophyll. Consequently these fructifications had progressed much further along the road to the seed habit than is necessary to assume by mere retention of the spores. The fact that embryos have not been preserved in Paleozoic seeds found so far seems beside the point since they could have been formed only within the enclosed gametophyte. The bond between gametophyte and sporophyte had become so well established in the fossils just described that it seems necessary to conclude that lycopod fructifications such as these had become true seeds inasmuch as they possessed all the essentials of the seed habit.

SUMMARY

Two lycopod fructifications have been described. One is referable to *Lepidocarpon* Scott and is described as a new species. It seems that *Lepidocarpon* is more widely distributed than has been previously recognized and that several large bladed lycopod fructifications now known only from impressions may possibly be transferred to this genus when more completely

known. The other fructification described, while clearly comparable with *Lepidocarpon* in many respects, is assigned to a new genus *Illiniocarpon*. It shows more extreme modification of the lycopod seed habit especially in its pedunculate mode of attachment. Both *Lepidocarpon* and *Illiniocarpon* are considered to possess all the essential features of seeds although they evolved independently from "spermatophyte" lines of descent.

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