AN EARLY EOCENE FLORULE FROM CENTRAL TEXAS.

By EDWARD WILBER BERRY.

In 1916 I described [1] a florule collected by Alexander Deussen and L. W. Stephenson at the town of Earle, in Bexar County, Tex. This florule was tentatively considered of Midway age by these geologists, and examination of the fossil plants tended to confirm this assignment, particularly because of their lack of harmony with the extensive Wilcox flora described in the volume cited above and because of their resemblance to the described floras from the Raton and Denver formations of Colorado and New Mexico.

Subsequently, without any very definite evidence, the rocks in the area around Earle came to be regarded as of Wilcox age and were so mapped by Sellards.[2] I visited the locality in 1921 in company with A. C. Trowbridge and L. W. Stephenson but found no additional plant species.

Recently I received from O. M. Ball, of the Agricultural and Mechanical College of Texas, a small collection of fossil plants obtained near Sayersville, which is about 8 miles north of Bastrop, in Bastrop County. This collection was found to represent the same flora as that found at Earle and had been preserved in a lithologically identical sandstone. This locality is about 100 miles northeast of Earle and is in about the same relative position in the belt in Bastrop County mapped as Wilcox on Deussen's new map [3] as the locality at Earle in the Wilcox belt in Bexar County shown on the same map.

The Bastrop County locality is along the railroad about 100 yards north of the station at Sayersville. The sandstone in which the fossil leaves were found is overlain by about 10 feet of reddish clay and consists of mostly coarse, well-rounded grains in a highly calcareous cement. It is very similar in appearance to the concretionary masses often found in the Midway of Texas and is exactly like that containing the leaves at Earle, in Bexar County.

The florule from Earle contains the following species:

Pourouma texana Berry.
Ficus denveriana Cockerell.
Ficus occidentalis (Lesquereux) Lesquereux.
Ficus sp.
Platanus aceroides latifolia Knowlton.
Cinnamomum affine Lesquereux.
Laurus wardiana Knowlton.
Asimina eocenica Lesquereux.
Dolichites deusseni Berry.
Terminalia hilgardiana (Lesquereux) Berry.

Of these 10 species but 3—*Ficus denveriana*, *Ficus* sp., and *Terminalia hilgardiana*—had been recorded from the very extensive Wilcox flora, and in part because of this fact, coupled with the total absence of the genera *Pourouma*, *Platanus*, and *Dolichites* in the Wilcox, I was led to consider the Earle outcrop more probably Midway than Wilcox.

The recent collection from Bastrop County contains the following species:

Pourouma texana Berry.
Laurus wardiana Knowlton.
Asimina eocenica Lesquereux.
Terminalia hilgardiana (Lesquereux) Berry.
Asplenium primero Knowlton.
Viburnum sp.
Mespilodaphne precoushatta Berry, n. sp.
Rhamnites marginatus apiculatus?
Ficus post-trinervis Knowlton.
Rhamnus sp.
Terminalia lesleyana (Lesquereux) Berry.
Sapindus? sp.

Four of these species—*Pourouma texana*, *Laurus wardiana*, *Asimina eocenica*, and *Terminalia hilgardiana*—are common to the two localities and are the most abundant forms at both. The combined list from these two localities amounts to 18 species, of which four

[1] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 8–20, 1916.

[2] Sellards, E. H., The geology and mineral resources of Bexar County: Texas Univ. Bull. 1932, 1920.

[3] Deussen, Alexander, Geology of the Coastal Plain of Texas west of Brazos River: U. S. Geol. Survey Prof. Paper 126, pl. 8 (in press).

are doubtfully determined because of their fragmentary nature or lack of specific character due to the coarseness of the matrix.

The aspect of this assemblage as a whole is in rather marked contrast to that of the known Wilcox flora, which consists, according to the latest revision,[4] of 353 species and constitutes as complete and representative a flora as has been found at any geologic horizon. Of this large number of plants in the Wilcox only six, and one of these doubtfully, have been recognized at Earle or Sayersville, and this is exactly one-third of the forms represented at the two localities. Twelve species, or two-thirds of the whole, are different from anything known in the large Wilcox flora. Three of these are peculiar to the two localities in Bexar and Bastrop counties; nine have been found elsewhere. Of these nine species, one occurs in the Denver, Fort Union, and Hanna formations and doubtfully in the Mesaverde formation; six occur in the Raton formation; three occur in the true Laramie, and one of these is doubtfully recorded from the Dawson arkose. Of the forms common to the known Wilcox, three are certainly and one additional is doubtfully recorded from the Laramie, and one of these is found in the Lance.

The Wilcox flora falls naturally into lower, middle, and upper assemblages, and these have demonstrated that the Wilcox sedimentation was transgressive both northward up the Mississippi embayment and westward west of Mississippi River. No lower Wilcox plants have been recognized at any outcrops west of the Mississippi unless the plants from Earle and Sayersville are lower Wilcox.

Of the six Wilcox plants found at Earle and Sayersville one, *Ficus denveriana*, is known only from the upper Wilcox, but as this species is commoner in and characteristic of the Denver and Raton formations of the West, which I regard as older than the Wilcox, it can not be considered as indicative of age within the Wilcox. Another, *Ficus* sp., is found in the middle Wilcox. The other four—*Ficus occidentalis*, *Rhamnus marginatus apiculatus*, *Terminalia hilgardiana*, and *Terminalia lesleyana*—range from the bottom to the top of the Wilcox, and the occurrence of all of these, except the *Rhamnus* in the Raton formation of Colorado and New Mexico, which is probably older than the Wilcox, stamps these forms as abundant, long ranging, and without precise stratigraphic significance.

The Wilcox group in Alabama, where it contains marine faunas, is divided into four formations—from oldest to youngest the Nanafalia, Tuscahoma, Bashi, and Hatchetigbee. To the northwest, in Mississippi, where the sediments pass into those representing Eocene barrier beaches and lagoonal and estuarine clays, marine fossils are almost entirely absent, and the Wilcox group is divided, in ascending order, into the Ackerman, Holly Springs, and Grenada formations, each characterized by distinctive floral assemblages. In Tennessee the Wilcox deposits have not yet been differentiated into formations and are included in the Lagrange formation, although the floras of the Holly Springs and Grenada formations of Mississippi are represented in Tennessee.

There is some faunal as well as other evidence for correlating the Grenada formation of Mississippi with the Hachetigbee formation of Alabama. The Holly Springs sand of Mississippi is thought to represent the Bashi formation of Alabama, with its faunal and other evidence of the shoaling of the water; and the Ackerman formation of Mississippi is thought to represent the Tuscahoma formation of Alabama and also more or less of the upper part of the Nanafalia formation. The relations sketched above are shown graphically in a paper published in 1915,[5] and subsequent studies have fully confirmed the conclusions expressed in that paper.

Throughout the rest of the area occupied by the Wilcox to the west and southwest as far as the Mexican border it has not yet been found feasible to subdivide the deposits except in a small area in southwestern Texas, where Trowbridge[6] has recently proposed dividing them, in ascending order, into the Indio, Carrizo, and Bigford formations. The oldest of these, the Indio, contains oyster beds and marine Foraminifera, as well as lignite and poorly preserved plants. The plants, of which

[4] Berry, E. W., Additions to the flora of the Wilcox group: U. S. Geol. Survey Prof. Paper 131, pp. 1–21, 1922.

[5] Berry, E. W., Erosion intervals in the Eocene of the Mississippi embayment: U. S. Geol. Survey Prof. Paper 95, fig. 27, 1915.

[6] Trowbridge, A. C., A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, pp. 85–117, 1922.

a considerable number have been satisfactorily identified, are distinctly younger than the known lower Wilcox floras found in the eastern part of the Mississippi embayment—that is, in the Ackerman formation of the eastern Gulf area. These Indio plants could be considered as representing either the Holly Springs or the Grenada epoch of the Mississippi succession. The Indio formation is overlain in southwestern Texas by the transgressive Carrizo sandstone, which as traced toward the Rio Grande merges into the lithologically dissimilar Bigford formation. Both the Carrizo and the Bigford formations have furnished a considerable flora, which is of sufficient variety and precision to prove that they are of upper Wilcox age and is in striking contrast to the flora found near the base of the Mount Selman, the lowest formation of the overlying Claiborne group, in the same area.

As the foregoing brief sketch makes clear, nothing has thus far been discovered corresponding to the conditions found in Bexar and Bastrop counties, and there is no known paleobotanic evidence of the presence of lower Wilcox sediments in the Coastal Plain of Texas, or, in fact, anywhere west of Mississippi River.

The distribution of the plants that form the basis of the present contribution is shown in the accompanying table, from which it will be seen that several of these plants, in their distribution in other regions, are strongly suggestive of a greater age than the Wilcox. There are two alternative conclusions—either that this flora indicates a Midway age, or that it represents an early Wilcox flora that was more ancient than the flora of the Ackerman formation of the eastern Gulf area, which, as previously stated, represents the upper Nanafalia and all of the Tuscahoma of the Alabama section. Perhaps a third possibility might be added, namely, that it may represent a flora that lived in central Texas during the time which there is reason to think intervened between the deposition of the known Midway and that of the known Wilcox in the region to the east of central Texas.

I know of no method by which this question can be conclusively settled at the present time, as the Midway has never furnished satisfactorily determinable plant fossils. In 1910 I collected three species of dicotyledonous leaves from the Porters Creek Midway near Middleton, Tenn., and one of these appears to represent the Vermejo species *Ficus leei* Knowlton.[7] In 1921 Bruce Wade collected five species of plants near the base of the Porters Creek clay in Carroll County, Tenn. None of these are sufficiently well preserved to be satisfactorily determined, although one represents a fern, probably referable to the genus *Dryopteris*, and another suggests *Asimina eocenica*, which is one of the common forms at Earle and Sayersville, Tex. My own preference, which I can not say amounts to a conviction, would be to regard the flora under discussion as of Midway age. If it is really early Wilcox, as the geologists who have studied the areal relations of the Midway and Wilcox in Texas are inclined to consider it, it is of sufficient importance to merit the present discussion.

I have reproduced in Figure 8 a sketch map published originally in 1915,[8] showing the areal distribution of the lower, middle, and upper Wilcox floras. No exceptions to this interpretation have been discovered during the last 10 years unless the florules found at Earle and Sayersville form such an exception, and the abundant evidence of the transgressive character of the middle and upper Wilcox in Texas is one of the strongest reasons for considering these florules to be of Midway age.

If the Earle and Sayersville florules represent early Wilcox time, and I am frank to admit that they may, they indicate the probability that there may be other and similar areas in the western Gulf region that were not completely transgressed by the later Wilcox, which is the only part of the Wilcox that has been paleobotanically recognized in that whole region.

Such of the forms found at Sayersville as warrant the space are discussed in the following pages. The subjoined table presents the known distribution of the species found at Earle and Sayersville.

[7] Knowlton, F. H., Fossil floras of the Vermejo and Raton formations of Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 101, p. 261, pl. 39, figs. 1–6; pl. 40, figs. 1, 2, 1918.

[8] U. S. Geol. Survey Prof. Paper 95, fig. 29, 1915.

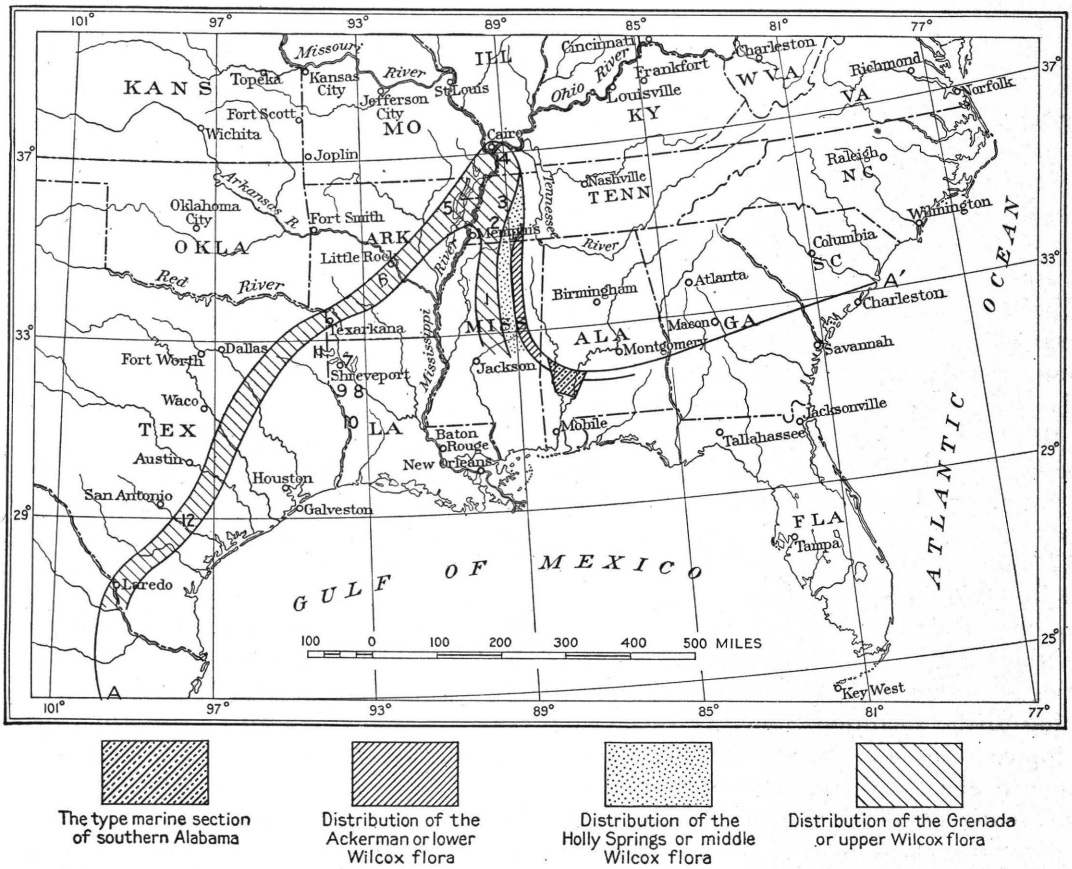


FIGURE 8.—Sketch map showing areal relations of the Wilcox floras. A–A′, Maximum extent of the Wilcox transgression. Localities at which upper Wilcox species have been collected: 1, Grenada, Miss.; 2, Somerville, Tenn.; 3, near Trenton, Tenn.; 4, Wickliffe and Boaz, Ky.; 5, Bolivar Creek, Hardys Mill, and other localities on Crowleys Ridge, Ark.; 6, Benton and Malvern, Ark.; 7, several localities at or near Shreveport, La.; 8, Coushatta, La.; 9, around Mansfield and Naborton, La.; 10, Sabine River; 11, Old Port Caddo Landing, Tex.; 12, Calaveras Creek, Tex.

Distribution of florules found at Earle and Sayersville, Tex.

	Earle.	Sayersville.	Lower Wilcox.	Middle Wilcox.	Upper Wilcox.	Raton formation.	Denver formation.	Fort Union formation.	Hanna formation.	Mesaverde formation.	Laramie formation.	Lance formation.	Dawson arkose.
Asimina eocenica	×	×					×	×	×	(?)			
Asplenium primero		×				×							
Cinnamomum affine	×										×		
Dolichites deusseni	×												
Ficus post-trinervis		(?)									×		
Ficus denveriana	×				×	×	×	×			(?)	×	
Ficus occidentalis	×		×		×	×	×						
Ficus sp	×			×									
Laurus wardiana	×	×									×		(?)
Mespilodaphne precoushatta		×											
Platanus aceroides latifolia	×					×							
Pourouma texana	×	×											
Rhamnus marginatus apiculatus		(?)	×	×	×								
Rhamus sp		×											
Sapindus? sp		×											
Terminalia hilgardiana	×	×	×	×	×	×							
Terminalia lesleyana		×	×	×	×	×							
Viburnum sp		×											

Asplenium? primero Knowlton.

Plate XXIII, Figure 1.

Asplenium? primero Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 285, pl. 44, fig. 4, 1917.

This species was based on the single specimen figured by Knowlton, which came from the Raton formation at Primero, Colo. It is described as follows by Knowlton:

Frond broadly lanceolate in general outline, twice pinnatifid; pinnae alternate, approximate, the lower ones lanceolate, the middle and upper ones linear, all decurrent on the rachis; lower pinnae deeply cut into numerous acute teeth, these becoming less and less marked until in the upper part they are merely slight indentations or at the extreme tip are wholly absent; nervation relatively simple, consisting of a strong midrib or secondary rachis in the pinnae, from which arise secondary branches passing to the tips of the segments or teeth, each of these again with from two to four pairs of simple branches.

A single specimen from Sayersville appears to represent a portion of the distal part of a pinna of this species. The venation is obscure, but the size and disposition of the pinnules and their characteristically toothed margins render the identification satisfactory. There are eight species of ferns recorded from the Wilcox, two of which have been referred to the genus *Asplenium*, but both of these are quite unlike *Asplenium? primero*.

Mespilodaphne precoushatta Berry, n. sp.

Plate XXIII, Figure 2.

Leaves of medium size, relatively broad, oval in general outline, widest medianly, and tapering about equally to the apex and base. Apex cuneate. Base acute. Margins entire, rather regularly and evenly rounded. Texture coriaceous. Length about 9.25 centimeters, maximum width about 4.1 centimeters. Petiole long and stout, about 2 centimeters in length. Midrib stout, prominent. Secondaries mediumly stout and prominent, eight or nine somewhat irregularly spaced pairs; closely spaced and opposite in the base, less closely spaced and subparallel to about the middle, above which they are about twice as far apart; they diverge from the midrib at angles of more than 45° and are camptodrome in the marginal region. Occasionally a subsecondary runs midway between and subparallel to the adjacent secondaries in the apical part of the leaf, where the true secondaries are more widely spaced, and one basal secondary shows abnormal branching. An apparently characteristic feature of this species is the crowding of the lower secondaries in the basal part of the leaf. The tertiaries are thin, transverse, and either percurrent or anastomosing.

This well-marked species appears to have been the immediate precursor of the rather abundant late middle and upper Wilcox species *Mespilodaphne coushatta* Berry.[9] It differs from that species in its larger size, slightly more coriaceous texture, relatively shorter petiole, more numerous secondaries, less frequently anastomosing tertiaries, and basal crowding of the secondaries. It is confined to the locality at Sayersville, in Bastrop County.

Terminalia lesleyana (Lesquereux) Berry.

Plate XXIII, Figure 3.

Magnolia lesleyana Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 21, figs. 1, 2, 1869; Tertiary flora, p. 248, pl. 44, figs. 1–3, 1878.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 313, pl. 82, figs. 1–2, 1918.
Terminalia lesleyana Berry, U. S. Geol. Survey Prof. Paper 91, p. 323, pl. 89, fig. 4, 1916.

The type horizon for this species was the lower Wilcox or Ackerman formation in Mississippi, but it has since been found to range into the middle and upper Wilcox and was a fairly common coastal tree along the shores of the Wilcox Mississippi embayment. It has also been recorded from the Raton formation of Colorado and New Mexico by both Lesquereux and Knowlton. I regard the Raton formation as older than the Wilcox, and it is therefore not surprising that this species should turn up in the present association in an area nearer the western occurrences than it has been hitherto found.

As Knowlton accepts Lesquereux's reference of this species to the genus *Magnolia* a few comments may not be out of place. Hilgard submitted his early collections from Mississippi, from what has since been named the Ackerman formation, to Lesquereux, who identified the present species as a *Terminalia*, and it was so listed in Hilgard's report.[10] When the similar

[9] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 307, pl. 80, fig. 6; pl. 87, fig. 3, 1916.

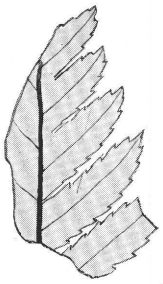
[10] Hilgard, E. W., Report on the geology and agriculture of the State of Mississippi, p. 113, 1860.

leaves that have since been considered to represent this species were collected in the Fishers Peak region of New Mexico from what has since been named the Raton formation. Lesquereux considered them identical with the European fossil species *Terminalia radobojensis* Heer. Subsequently Lesquereux transferred them to the genus *Magnolia*, comparing them with the existing species *Magnolia tripetala*. When I was preparing the report on the Wilcox flora I compared these fossil leaves with those of the existing species of both *Magnolia* and *Terminalia* and reached the conclusion that in every essential respect they differed from the former and resembled the latter. I therefore transferred them back to *Terminalia* thus confirming Lesquereux's original determination. I also reached the conclusion that a considerable number of fossil species which masquerade in the literature of paleobotany as *Magnolia* probably do not represent that genus.

Terminalia lesleyana is not, in my judgment, particularly like *Magnolia tripetala* in any features. Although smaller, it is stouter, coarser, and smoother, with a different shape and different base from any of the true Magnolias. The midrib is very stout, as are also the fewer secondaries—in fact, the venation is not that of the genus *Magnolia*. On the other hand, in all the features that are available for comparison it resembles the leaves of several recent American species of *Terminalia*, as well as certain European Tertiary species that have been referred to that genus. Moreover, American Tertiary floras of warmer climatic aspects contain several other species of *Terminalia*, in more than one locality represented by fruits that supplement and corroborate the identifications of the leaves.

Terminalia, represented by one species founded on fruits and two founded on leaves, is common in the Wilcox of the Mississippi embayment, and it is also represented in that region throughout the middle (Claiborne) and upper (Jackson) Eocene.

Terminalia lesleyana occurs at the Sayersville locality, in Bastrop County, but the associated *Terminalia hilgardiana* is present at both Sayersville and Earle, and both species are found throughout the lower, middle, and upper Wilcox of the eastern Gulf region.



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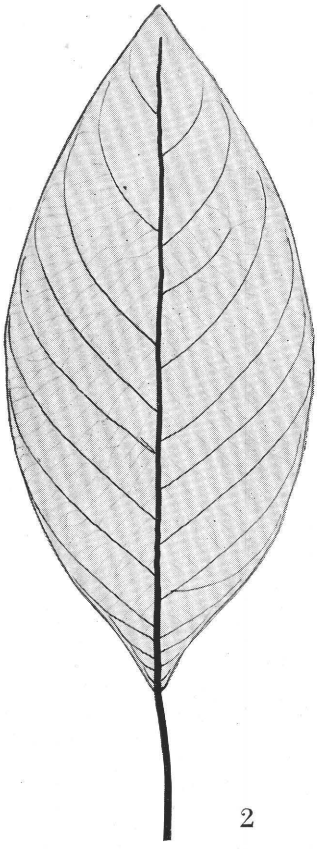

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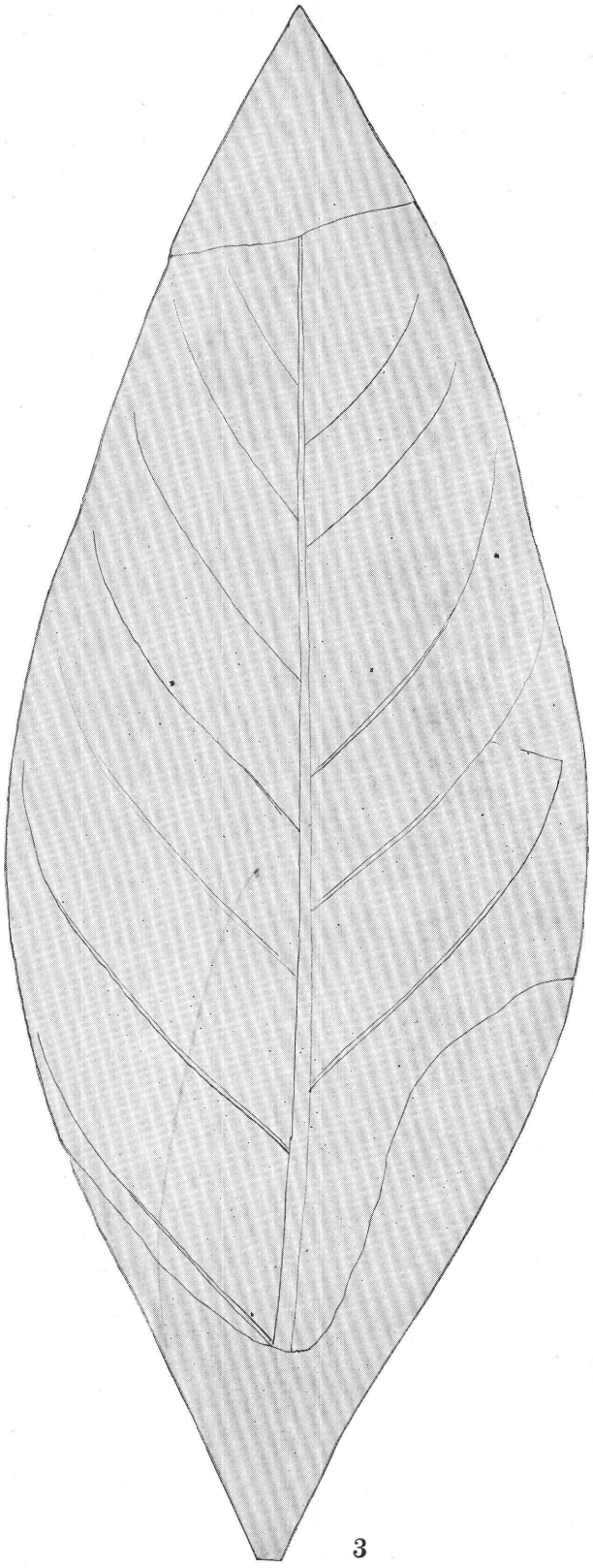

3

FOSSIL PLANTS FROM THE EARLY EOCENE AT SAYERSVILLE, TEX.

1. *Asplenium? primero* Knowlton. **2.** *Mespilodaphne precoushatta* Berry, n. sp. **3.** *Terminalia lesleyana* (Lesquereux) Berry.