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REVISION OF THE LOWER EOCENE WILCOX FLORA OF THE SOUTHEASTERN STATES

WITH DESCRIPTIONS OF NEW SPECIES CHIEFLY FROM TENNESSEE AND KENTUCKY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 156

UNITED STATES DEPARTMENT OF THE INTERIOR
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Professional Paper 156

REVISION OF THE LOWER EOCENE WILCOX FLORA OF THE SOUTHEASTERN STATES

WITH DESCRIPTIONS OF NEW SPECIES, CHIEFLY FROM TENNESSEE AND KENTUCKY

BY

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REVISION OF THE LOWER EOCENE WILCOX FLORA OF THE SOUTHEASTERN STATES

By Edward Wilber Berry

INTRODUCTION

I commenced my studies of the Wilcox in 1909. Seven years afterward the first account of the flora [1] was published in what seemed at the time to be a comprehensive study, in which I brought together all that was then known of the flora, its relationships, and the environmental conditions which it indicated. In that work, in accordance with what I believe to be the proper method of studying fossil foliar remains, specific lines were rather finely drawn, resulting, as has since been proved, in an overmultiplication of species.

During the last 10 years field work in Texas, the activity of geologists in Arkansas and Louisiana, and especially the detailed areal work of Messrs. Collins and Roberts in western Tennessee have yielded a large amount of additional material, which has enabled me constantly to review the earlier work and to effect numerous syntheses which should follow the first and analytic discussion of a fossil flora.

The unexcelled abundance and preservation of the flora of the Wilcox permits the determination of the limits of foliar variation of many species, as, for example, in *Ficus mississippiensis* (Lesquereux) Berry. A really vast assortment of fruits, seeds, calices, flowers, and bracts has also been collected, and it has been possible, with the aid of more complete material, to reconstruct the compound leaves of a number of species or to correlate leaves with fruits or flowers.

Wherever the evidence was sufficient I have made restorations, bringing together the scattered parts on the basis of comparisons with the most closely related existing species. This work has never before been attempted on any considerable scale, but it has, I believe, a great scientific value, if the restorer is content not to let imagination serve as a substitute for observation.

Another circumstance that renders the present discussion necessary grows out of the fact that since the first account of this flora was published I have had the good fortune to have described the middle and upper Eocene floras, as well as a considerable flora from the Upper Cretaceous (Ripley formation) from this same region.

Consequently it is now possible, and for the first time, to place the lower Eocene flora in its true perspective with relation to antecedent and partly ancestral floras of the region and to subsequent and partly derivative floras of the same region and also to get a partial insight into the autochthonous elements and those that were introduced and some idea as to whence the latter came. All this work has a bearing on the centers of origin and paths of dispersal of the flowering plants, and however poorly these larger problems may be understood at the present time, their discussion can not fail to afford the materials upon which future more refined studies may be based as our science advances.

Particular attention has been devoted over what is now a long period of years to a comparative study of herbarium material of recent related forms and to existing plant societies, both within and outside this region. Although the inadequacy of many of the comparisons instituted is fully realized, I believe that I am justified in asserting that these comparisons and the restorations here given rest upon observed facts and have little of the subjective, so conspicuous in the works of earlier describers of Tertiary floras.

The whole problem of the place, time, and manner of the origin of the angiosperms is almost as much of a mystery as when Darwin first wrote about it. I have endeavored not to advance opinions and have abstained from speculation upon this most interesting and significant topic, believing that at the present stage of the subject the accumulation of facts and the completion of the record are the more desirable forms of activity.

In the paper alluded to above as having been published in 1916, a somewhat exhaustive chapter was devoted to the botanic composition and ecologic significance of this flora, and in particular the geologic and geographic ranges of the genera represented were given in considerable detail. Although this description might be much improved in the light of subsequent discoveries, the result would scarcely warrant

[1] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 21–466, 1916.

the time and space necessary for its proper consideration, and a considerable part would be mere repetition. I have therefore endeavored to give an outline of the geologic and the geographic distribution of all the more noteworthy generic types that have been discovered since 1916 in the Wilcox under the description of the species that are added to this flora in the present contribution.

Doubtless detailed areal work in Arkansas, Louisiana, and Texas will result in the discovery of many additional plant localities in the Wilcox, and I would not be surprised if many such localities remain undiscovered at the present time in Mississippi; so that the Wilcox flora, large as it is now, is destined to be much augmented in the future. However, I can scarcely hope to have another opportunity to contribute an elaborate study of this interesting flora, so that the present contribution, which may be regarded as a summation of the work of the last 10 years, may also be regarded as my valedictory on the subject.

GEOLOGIC HISTORY

GENERAL FEATURES

The recession of the Midway sea would have been followed by forested swamps in those parts of the new land surface where the topography was favorable, and this, no doubt, accounts for the basal lignites that mark the unconformity between the Midway and Wilcox in many places as far south as Coal Bluff, on Alabama River, and Nanafalia Landing, on Tombigbee River.

That the oscillations of the Wilcox strand were not nearly so simple as I have shown them diagrammatically is indicated by the 2-foot bed of autochthonous lignite at the base of the Bashi formation at Woods Bluff, on Tombigbee River, about 350 feet above the base of the Wilcox in that region. It is not possible, however, to determine the detailed history of the strand line throughout the great extent of the Wilcox coast, except in a most generalized way.

The northward transgression of the lower Wilcox sea, whose sediments in northeastern Mississippi constitute the Ackerman formation, was relatively inconsiderable, barely reaching the southern boundary of Tennessee.

The major transgression of the Wilcox sea in the eastern Gulf region was marked by the sediments that constitute the Holly Springs sand. This expansion of the Mississippi embayment took place over a low and nearly featureless forested coastal plain. Hence the conditions were ideal for the formation of barrier beaches, which are especially typical of subsiding coastal plains. A long succession of such barrier beaches, with the variety of argillaceous and carbonaceous sediments that accumulated in the resulting lagoons,[2] together with the contemporary littoral, delta, and lower stream valley deposits, furnishes the key to the understanding of the sediments of the Wilcox group in that part of the Coastal Plain where plants are the prevailing fossils.

The extremely slight gradient of the Wilcox coastal plain caused these impounded lagoon waters to be often rather distant from the open sea of the embayment, especially during the shallowing (partial emergence) in the later half of Holly Springs time (represented by the upper part of the Tuscahoma formation and lower part of the Bashi formation of the Alabama section).

Hence, although marine faunas have not been discovered north of eastern Mississippi in the eastern part of the embayment nor north of Sabine River in the western part, the dominant influence in the geologic history of the Wilcox Mississippi embayment consisted of changes in marine conditions rather than changes in the attitude of the land—that is, it was thalassocratic rather than geocratic—so that it is not strictly proper to speak of the Wilcox sediments as continental deposits, although they are partly continental in origin. In other words, the guiding influence in the Wilcox deposition consisted in the shifting embayment waters, as exemplified in the shifting lithology and faunas disclosed in the marine Wilcox section of southern Alabama.

CLAY CONGLOMERATES

Clay conglomerates, of considerable thickness, and courses of clay pellets occur at numerous outcrops, chiefly in the basal beds of the Holly Springs sand along the eastern border of the Wilcox belt. They are especially prominent in the abandoned workings near Pinson, Tenn., where they lie directly on the Midway along Bear Creek. Plate 1, *A*, shows a clay conglomerate on the Bolivar-Hornsby Road just east of Hatchee River and is typical of several similar exposures in Hardeman County, Tenn. Similar clay balls and pellets can be seen in the making at the present time, especially along the divide on the Ten-

[2] Purists restrict the term "lagoons" to designate bodies of water that retain their connection with the sea and use for those bodies of water of similar origin that have lost connection with the sea, the term "seashore lakes." As lagoons exhibit every degree of separation, from those with open inlets through those separated at low tide to those permanently isolated, it seems to me more easy to visualize all these stages as lagoons, and that it tends to confusion of thought to introduce the term "seashore lake," however descriptive such a term may be. All science, especially physiography, tends to develop a top-heavy terminology, which in the hands of the field geologist gradually becomes loosely and incorrectly applied, so that the terms of greater precision invented in the office eventually defeat the ends for which they are proposed.

nessee-Mississippi boundary in the much-gullied Wilcox deposits, where weathered pieces of clay of all sizes are taken up by hard showers, rounded, and deposited over the sand that normally floors the gullies. These clay conglomerates of the Holly Springs sand can be pictured as having been formed in periodically dry erosion channels after heavy rains and also by the undercutting and slumping of clay fragments into active streams. This last process would seem to account for the large clay boulders in the cuts along the railroad near Oxford, Miss.

PLANT LOCALITIES ILLUSTRATING GEOLOGIC HISTORY

Locality at Meridian, Miss.—The interesting locality at Meridian, Miss., was described in considerable detail in 1917.[8] It is especially noteworthy in the succession of sediments shown. At the base about 12 feet of glauconitic sand, carrying a marine fauna characteristic of the Bashi ("Woods Bluff") formation, is overlain by about 30 feet of sandy lignitic clay carrying fossil plants characteristic of the Grenada formation of Mississippi and undoubtedly the equivalent of the marine Hatchetigbee formation of Alabama. Above this clay lies a fine sand with disklike clay pebbles and ripple-marked clays that represent a local unconformity at the top of the Wilcox or the initial deposits of the Claiborne.

Fourteen species of plants have been identified from the middle member, the most abundant and significant of which is a large *Nelumbo*. The clays are full of the rootstocks of this lotus and prove that after the marine Bashi deposits were laid down a withdrawal of the strand line southward permitted the occupation of the area by a fresh-water pond, in which grew a profusion of lotus. This withdrawal of the strand line presumably corresponded in time with the deposition of the shallowest-water marine formation of the upper Wilcox in Alabama—the Hatchetigbee. After this interval a readvance of the sea covered the pond deposits with the upper sands and clays, which are thus unconformable on the pond deposits.

The accompanying photograph of a *Nelumbo* association in the shallows of Reelfoot Lake in western Tennessee (pl. 6, *A*) probably gives a good representation of the appearance of this upper Wilcox (Grenada) pond at Meridian.

Locality at Taylor farm, on Silerton road, Chester County, Tenn.—The outcrop at the Taylor farm, in Chester County, Tenn., is one of particular interest not only because of the variety of fruits and seeds that it contains but also because it is the only known plant locality in the county and is within a short distance of the Midway contact. The section exposed is as follows:

	Feet
Fine cross-bedded sand	Undetermined.
Coarse grit with ironstone fragments	3
Light-colored sandy clay	3–5
Black, highly lignitic clay with fine sand partings, containing logs, stems, fruits, and other vegetable material and scattered concretions of marcasite	8–10
Fine grayish sandy clay; exposed	5

In the lignitic bed about 3 feet above its base occurs a seam of pure lignite 10 to 12 inches thick, which is made up predominantly of twigs of *Glyptostrobus*. This seam of lignite—or peat, as it might properly be termed, for it is but slightly consolidated—is of unusual interest because it is obviously allochthonous and because of the millions of twigs of *Glyptostrobus* that it contains.

A considerable sample has been washed and searched for identifiable remains. Among the specimens found are quantities of the tiny detached leaves of *Taxodium*, the characteristic fruits (stones) of *Chrysobalanus*, *Cinnamomum*, *Nyssa*, *Cyperacites*, and *Potamogeton*, and a variety of botanically undeterminable fruits and seeds that have been referred to the form genera *Leguminosites* and *Carpolithus*.

The complete list of plants from the *Glyptostrobus* peat follows:

Carpolithus collinsi Berry.
Carpolithus cronovi Berry.
Carpolithus silertonensis Berry.
Carpolithus taylorensis Berry.
Chrysobalanus eocenica Berry.
Cinnamomum ovoides Perkins.
Cyperacites minutus Berry.
Cyperacites wilcoxensis Berry.
Glyptostrobus europaeus (Brongniart) Heer.
Leguminosites chesterensis Berry.
Nyssa curta Perkins.
Potamogeton? fructus Berry.
Taxodium wilcoxianum Berry.

The abundance of *Glyptostrobus*, with the remains of sedges and a variety of drift fruits, suggests to me a stream swamp rather than a pond, although the lignitic clay member as a whole may well be a pond deposit, of which the *Glyptostrobus* peat may represent a transient phase during which there was a lack of sediments in the incoming waters.

A considerable number of species based on leaves have been found in the clay, but I can not say whether the fruits and seeds are common to it or not. I should imagine that the floral facies did not differ greatly at the time of deposition, but the splitting of about a ton of the clay failed to furnish any specimens of most of the peat fruits and seeds and yielded no trace of *Glyptostrobus*, so that whatever the interpretation it

[8] Berry, E. W., U. S. Geol. Survey Prof. Paper 108, pp. 61–72, 1917.

is evident that the *Glyptostrobus*-bearing peat represents special environmental conditions somewhat different from those represented by the underlying and overlying lignitic clay.

The following species have been identified from this clay:

Anona eolignitica Berry.
Apocynophyllum sapindifolium Hollick.
Apocynophyllum wilcoxense Berry.
Artocarpoides balli Berry.
Artocarpus pungens (Lesquereux) Hollick.
Celastrus taurinensis Ward.
Dryophyllum puryearensis Berry.
Dryophyllum tennesseense Berry.
Euonymus splendens Berry.
Ficus mississippiensis (Lesquereux) Berry.
Ficus wilcoxensis Berry.
Magnolia angustifolia Newberry.
Nectandra lancifolia (Lesquereux) Berry.
Nectandra pseudocoriacea Berry.
Oreodaphne obtusifolia Berry (?).
Parrotia cuneata (Newberry) Berry (?).
Proteoides wilcoxensis Berry (?).
Rhamnites knowltoni Berry.
Rhamnus coushatta Berry (?).
Sideroxylon ellipticus Berry (?).
Sterculia wilcoxensis Berry.

Section in big cut at Pine Top, Hardeman County, Tenn.—Some of the most interesting and instructive sections in the whole Wilcox are those just above the contact of the transgressive Holly Springs sand with the underlying Midway in eastern Hardeman County, Tenn. Among these sections that in the big cut on the Gulf, Mobile & Northern Railroad near Pine Top is easily the most significant. (See pl. 2 and fig. 1.)

Rising a few feet above the base on the east side of the cut toward its north end is a massive, somewhat argillaceous greenish-gray compact micaceous sand.

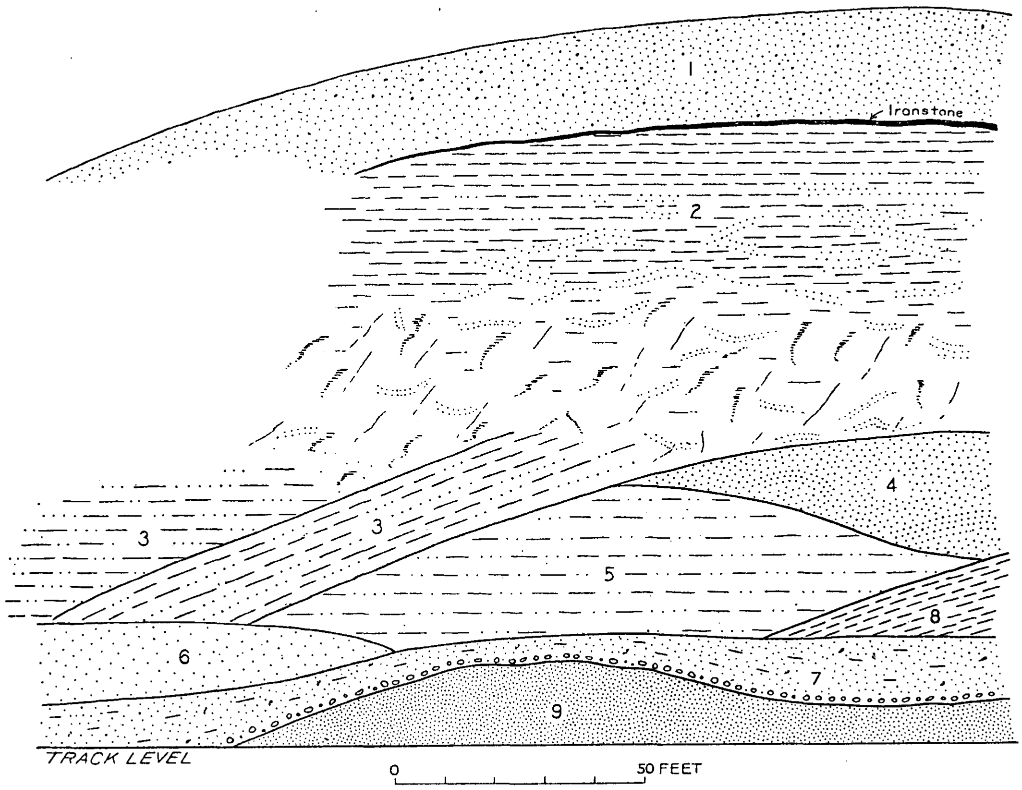
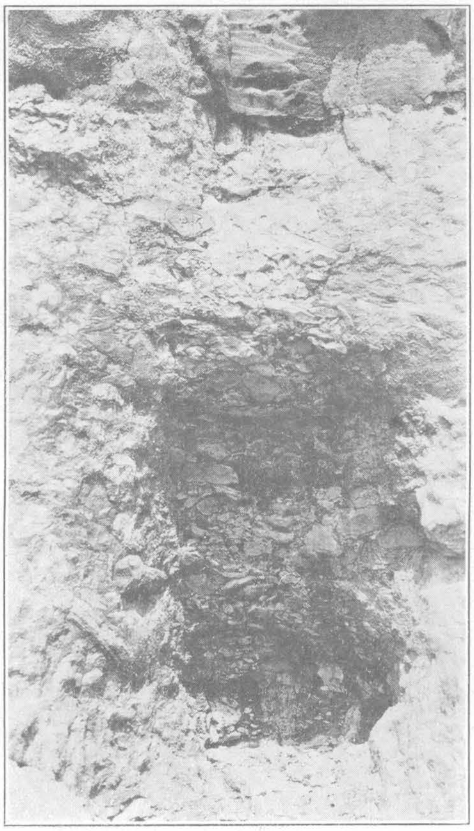


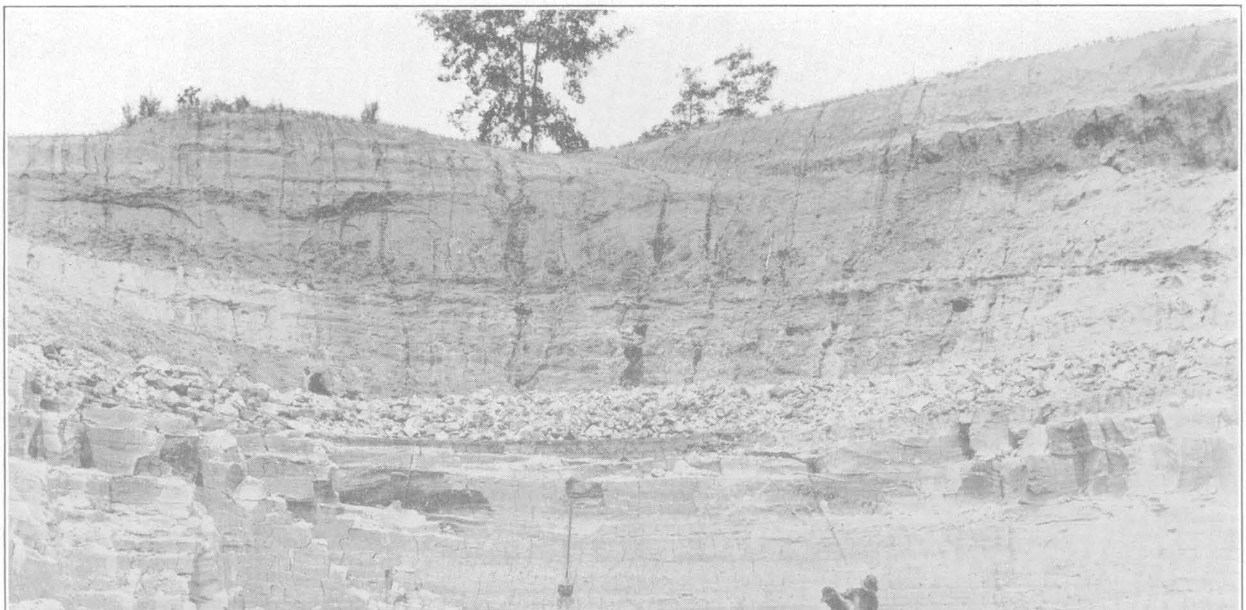
FIGURE 1.—Diagrammatic section of the north end of the east side of the big cut on the Gulf, Mobile & Northern Railroad near Pine Top, Hardeman County, Tenn. 1, Angular sand with scattered small lenses of clean white sand, 0–25 feet; 2, yellow, finely sandy clay with fossil plants, grading downward into dark-gray, very irregularly bedded sand and clay, more or less concealed by slumping, about 95 feet; 3, laminated sandy clay; 4, sand; 5, gray sandy clay; 6, massive sand; 7, argillaceous lignitic sand with plants, small quartz pebbles, and bauxite, 0–5 feet; 8, clay; 9, massive greenish-gray fine micaceous sand

No fossils were found in it at this outcrop, but it is lithologically similar to that in adjacent sections along the railroad near milepost 385, immediately south of Pine Top, where a similar sand contains small calcareous ledges of similar composition to the material in the Clayton limestone, carrying *Leda*, *Turritella*, *Cucullaea*, *Calyptrophorus*, *Ostrea*, and other typical Midway invertebrates, so that there seems to be no doubt but that this member in the Pine Top cut is of Midway age. There is hence a marked erosional unconformity between the Midway and the Wilcox in this county, as is indeed shown by the irregular contact and the pebbles of quartz and bauxite that imme-



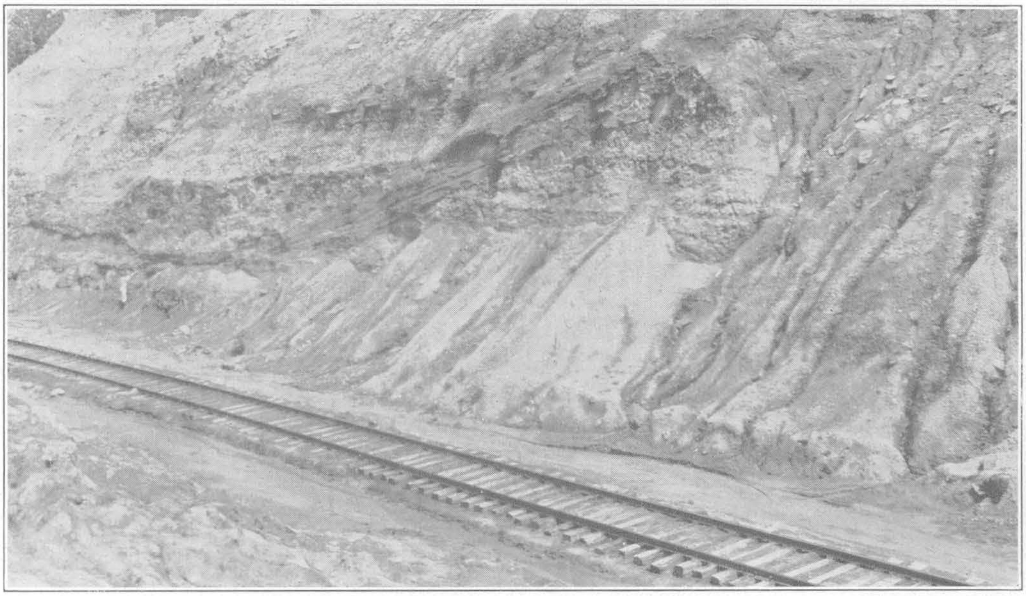
A. CLAY CONGLOMERATE JUST EAST OF THE HATCHIE RIVER, BOLIVAR-HORNSBY ROAD, HARDEMAN COUNTY, TENN.

Photograph by Jos. K. Roberts.



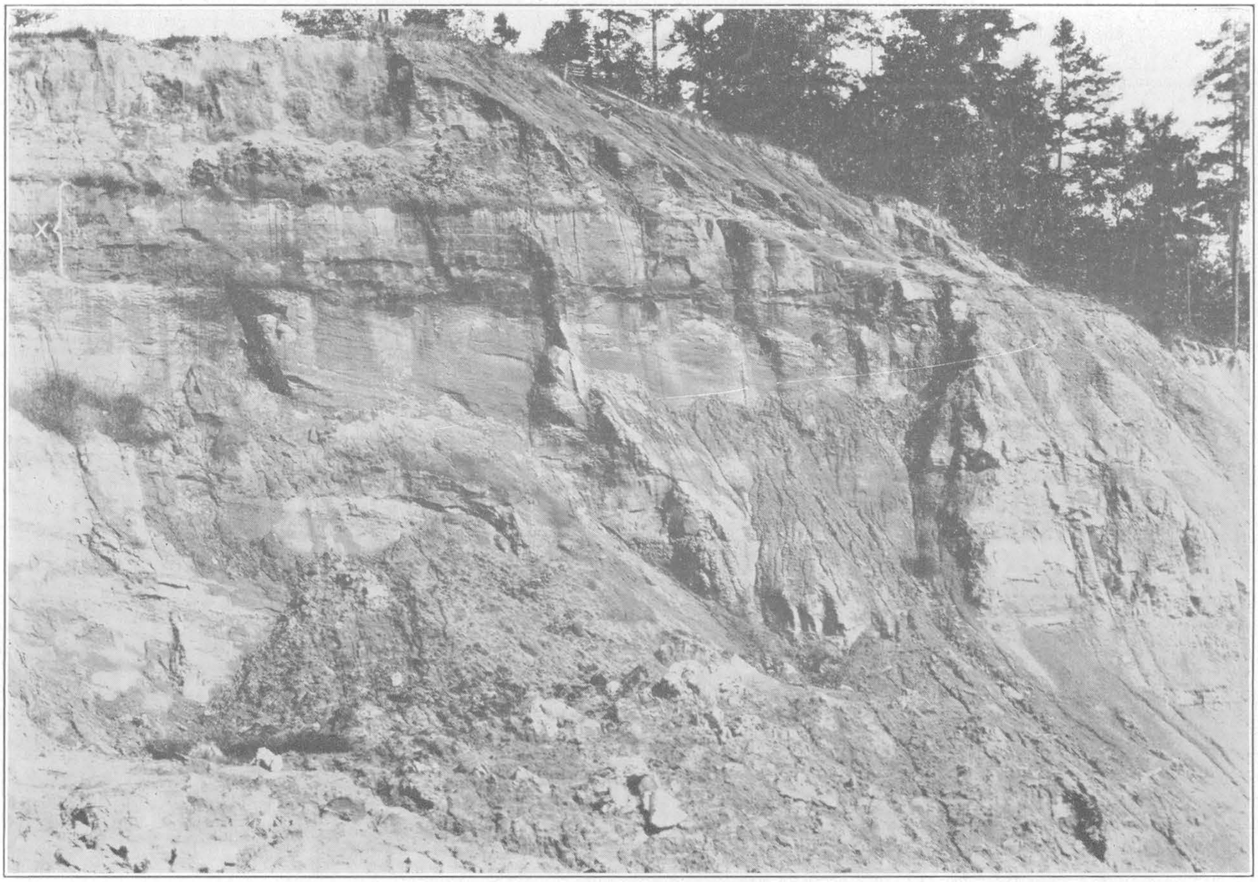
B. COURSES OF CLAY IN THE HOLLY SPRINGS SAND AT THE MONROE PIT, HENRY COUNTY, TENN.

Photograph by Jos. K. Roberts.



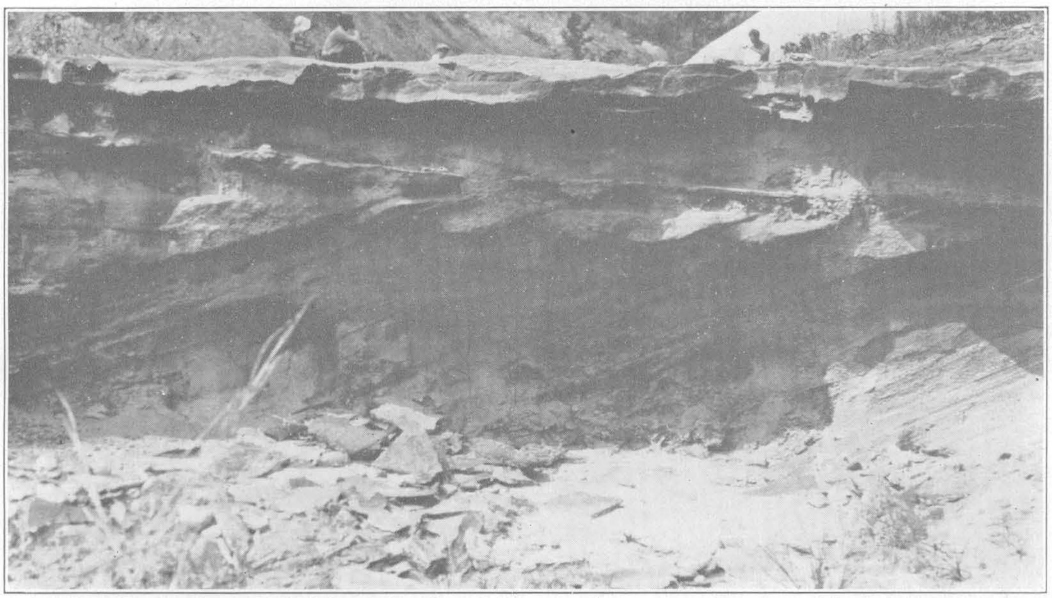
A. LOWER PART OF BIG CUT AT PINE TOP, IN NORTHEASTERN HARDEMAN COUNTY, TENN.

Man is pointing to plant bed in the Holly Springs sand immediately above the contact with the Midway. Photograph by Jos. K. Roberts.



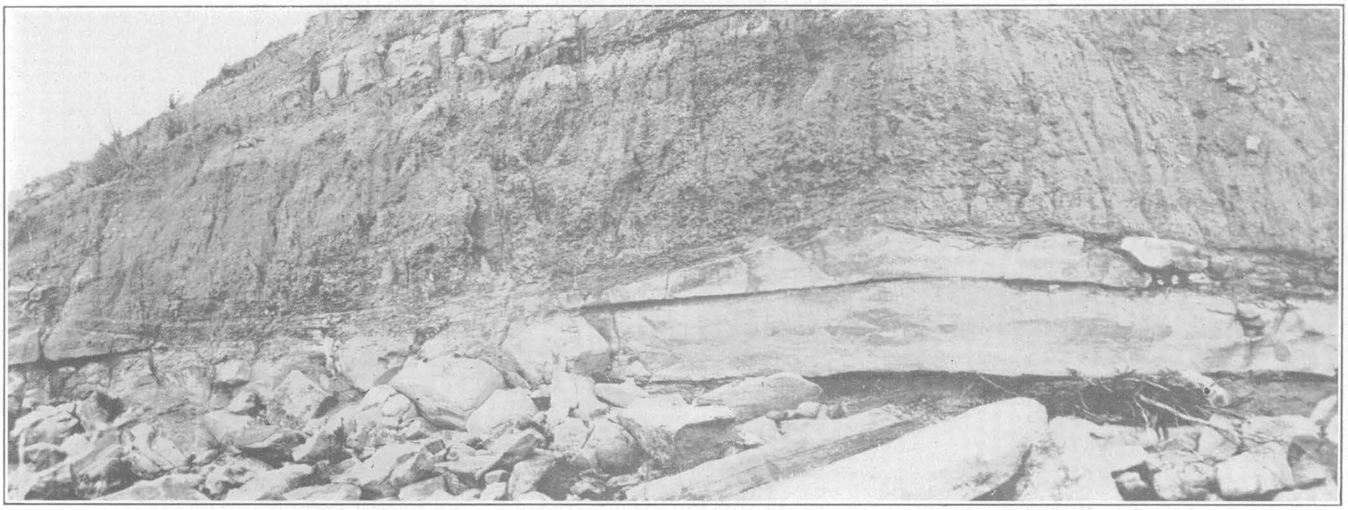
B. UPPER PLANT HORIZON NEAR THE TOP OF THE EXPOSURE SHOWN IN *A*

Photograph by Jos. K. Roberts.



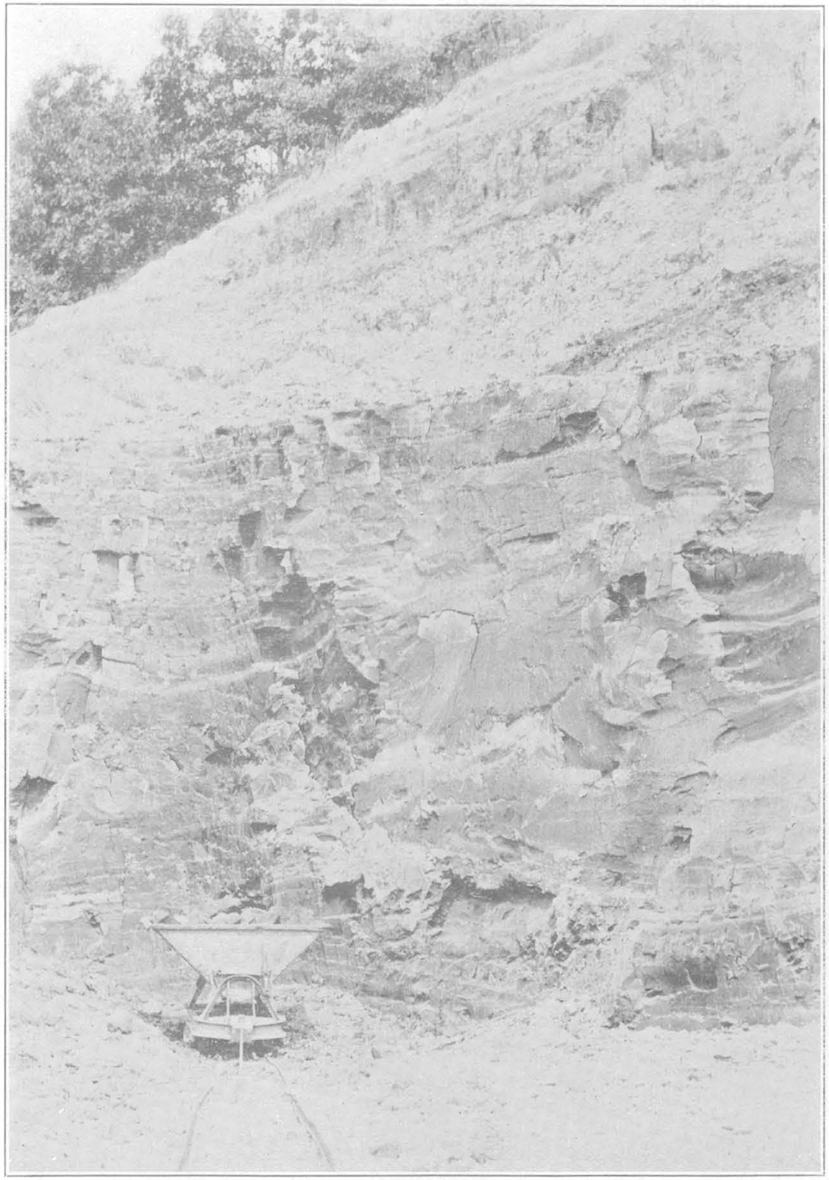
A. FORESET BEDS BENEATH HARDPAN OVERLAIN BY HORIZONTALLY BEDDED PLANT-BEARING CLAY OF THE GRENADA FORMATION AT LOCALITY NORTH OF THE LOOSAHATCHIE RIVER AND 1 MILE NORTH OF SOMERVILLE, FAYETTE COUNTY, TENN.

Photograph by Jos. K. Roberts.



B. UNCONFORMITY WITHIN THE WILCOX AT THE PLANT LOCALITY NEAR THE MOUTH OF CONCILLAS CREEK, WEBB COUNTY, TEX.

Photograph by A. C. Trowbridge.

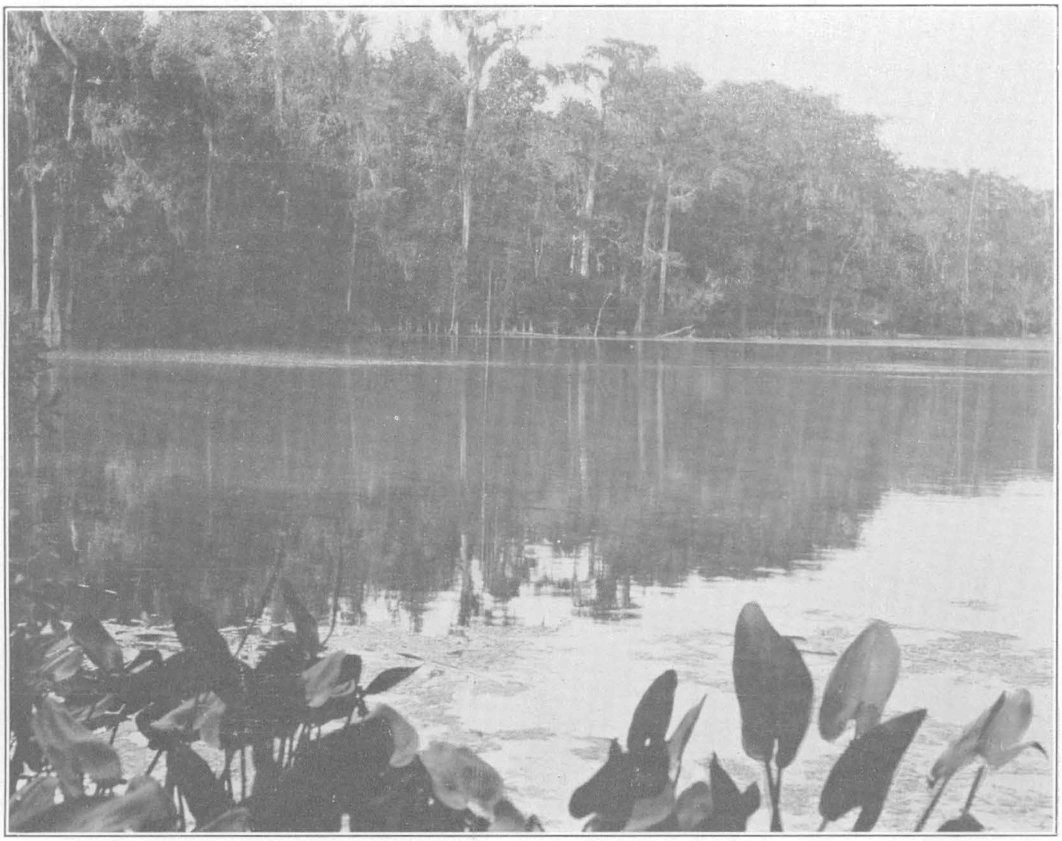


A. THICK-BEDDED PLASTIC CLAY NEAR THE TOP OF THE HOLLY SPRINGS SAND AT THE FOUNDRY CHURCH PIT, HENRY COUNTY, TENN.

Photograph by Jos. K. Roberts.

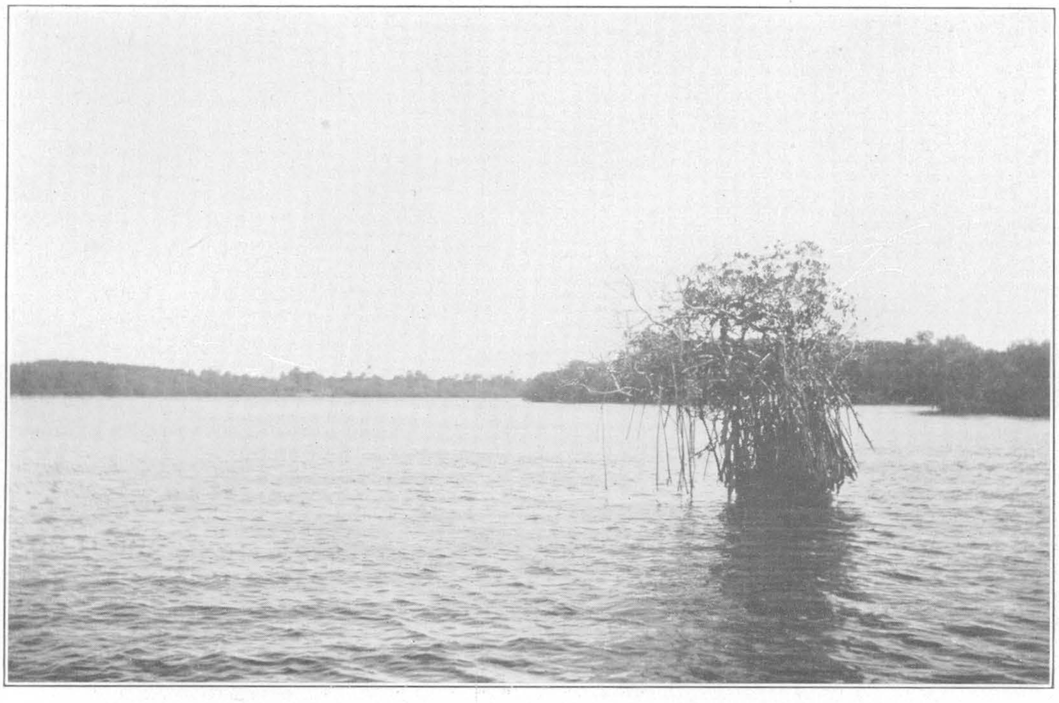
B. GREAT THICKNESS OF THICK-BEDDED PLASTIC CLAY AT THE COLE PIT, HENRY COUNTY, TENN.

Photograph by Jos. K. Roberts.



A. WAKULLA SPRINGS, FLA., ILLUSTRATING THE PROBABLE APPEARANCE OF A WILCOX FRESH-WATER LAGOON

Photograph by Walter B. Jones.



B. SAWFISH BAY, JUPITER, FLA., ILLUSTRATING THE PROBABLE APPEARANCE OF A WILCOX BRACKISH-WATER LAGOON

Photograph by Pownall Studio.

A. NELUMBO LUTEA ALONG THE MARGIN OF REELFOOT LAKE, TENN., ILLUSTRATING THE ECOLOGY OF THE WILCOX POND AT MERIDIAN, MISS.

Photograph by Jos. K. Roberts.

B. WAKULLA RIVER, FLA., ILLUSTRATING THE PROBABLE APPEARANCE OF A WILCOX BAYOU

Photograph by Walter B. Jones.

diately overlie it. This interval is believed to represent all of the time required for the deposition of the Ackerman formation of Mississippi and perhaps the basal part of the Holly Springs sand of the region toward the south.

Above this irregular contact is exposed from a thin layer to as much as 5 feet of highly carbonaceous, conglomeratic argillaceous bauxitic sand with clay pellets and quartz gravel. This layer contains quantities of waterworn sticks, bits of lignite, fragments of bark, *Glyptostrobus* twigs, palm petioles, reed stems, a few leaves, and large quantities of a variety of drift fruits and seeds, such as those of *Anona*, *Palmocarpon*, *Rubiacites*, *Amygdalus*, *Leguminosites*, and *Laurus* cupules. The most abundant of these are gum balls (*Liquidambar*) and pods of *Leguminosites arachioides* of all sizes. The leaf species recognized occur along argillaceous films, are relatively few in number and poorly preserved, and for the most part represent coriaceous forms.

The following plants have been recognized within a few feet of the Midway contact:

Amygdalus wilcoxiana Berry.
Anona robertsi Berry.
Apocynophyllum mississippiense Berry.
Apocynophyllum sapindifolium Hollick.
Artocarpus pungens (Lesquereux) Hollick.
Dryophyllum tennesseense Berry.
Echitonium lanceolatum Ettingshausen.
Ficus mississippiensis (Lesquereux) Berry (common).
Glyptostrobus europaeus (Brongniart) Heer.
Grewiopsis tennesseensis Berry (one small leaf).
Juglans occidentalis Newberry.
Laurus hardemanensis Berry.
Leguminosites chesterensis Berry.
Leguminosites arachioides minor Berry.
Liquidambar wilcoxianum Berry.
Menispermites hardemanensis Berry.
Nectandra glenni Berry.
Nectandra pseudocoriacea Berry.
Palmocarpon butlerense Berry.
Platanus nobilis Newberry.
Rubiacites? pellicieraformis Berry.
Sabalites cf. S. grayanus Lesquereux.
Sterculia wilcoxensis Berry.

All the foregoing forms, except the *Ficus*, *Menispermites*, *Platanus*, and *Sterculia*, are confined to the basal part of this section and have not been found at the upper plant horizon.

About this fossiliferous bed there is a thickness of 50 to 75 feet of irregularly bedded clay and sand from which no fossils have been collected and which has every appearance of being a delta deposit. The sediments gradually become more uniform in lithology and bedding higher in the section, and the upper few feet is composed of nearly horizontally bedded, lighter yellow, finely sandy clay, in many places considerably indurated and carrying scattered flat leaves of large size which were evidently buried beneath rather quiet water. This upper fossiliferous clay is capped with a thin ironstone layer, above which there is a maximum of 25 feet of angular sand containing small lenses of clean white sand.

The whole section above the Midway, with a maximum thickness of about 130 feet, appears to represent the Holly Springs sand and gives a clear picture of the course of events at that time in this region. The upper plant bed or slumped material from it has furnished the following plants:

Dillenites ovatus Berry.
Ficus mississippiensis (Lesquereux) Berry.
Menispermites hardemanensis Berry.
Platanus nobilis Newberry (large leaves).
Sterculia wilcoxensis Berry (common and of large size).

Of these the *Dillenites* is the only one not found in the basal part of the section. I can not see that there is any chronologic difference in the plants found at these two horizons, and it is also doubtful whether there is any considerable ecologic difference. They are obviously not strictly comparable, as all the drift fruits that make up so considerable a percentage of the forms at the lower horizon are absent at the upper horizon.

This is one of the most convincing sections showing the erosion interval between the Midway and the Wilcox, and the fortunate presence of a middle Wilcox florule of over 20 species at the contact proves conclusively that the interpretation of lower Eocene history put forward in 1915 was correct in all its essential details.[4]

Outcrop north of Somerville, Fayette County, Tenn.—An interesting section is shown in the northern valley scarp of Loosahatchie River about 1 mile north of the town of Somerville and half a mile north of the tracks of the Nashville, Chattanooga & St. Louis Railway, where the wagon road forks to the hamlet of Yum Yum, in Fayette County, Tenn.

This section reveals a lower member of grayish cross-bedded sand, showing conspicuous foreset bedding toward the southwest. (See pl. 3, *A*.) This sand is exposed for a thickness of about 15 feet and, except for its lighter color, is the sort of material that the older geologists referred to the so-called "Lafayette formation." At the top the bedding is beveled by thin, nearly horizontal sands interbedded with more argillaceous materials, which have become ferruginized since their deposition to form a more or less sandy bed of clay ironstone in several courses a few inches thick. Above the lowest layer there is an interval of a few inches to 2 feet of nearly horizontal

[4] Berry, E. W., Erosion intervals in the Eocene of the Mississippi embayment: U. S. Geol. Survey Prof. Paper 95, pp. 73–82, 1915.

argillaceous sand, above which lies a second ironstone layer about a foot in thickness. This layer is overlain by a 15 to 20 foot exposure of horizontally bedded, rather pure brownish laminated clay carrying abundant leaf impressions and generally colored by iron oxide. At intervals measured in inches there are very subordinate films of fine sand. (See fig. 2.)

The lower sand is either a river sand bar or, more probably, part of the delta of a southwestward-flowing stream. As this delta was built toward the southwest slight subsidence or the ponding and shifting of its distributaries resulted in the deposition, perhaps seasonally, of the nearly horizontal sands and clays of the ironstone layers that mark the base of the recent erosion channel in the upper fossiliferous clay.

The upper clay represents a long interval of quiet-water deposition of fine material that might be interpreted as either flood-plain sediments in the lower valley of a Wilcox stream or lagoon deposits in a ponded part of a Wilcox delta. The fossils show no evidence of transportation but must have grown near at hand, for there is no accumulation of drift fruits or mutilated leaves, large leaves have their margins and acuminate tips intact, and many compound leaves retain several of their leaflets.

Twenty-five species of fossil plants, indicative of a Grenada age, have been identified from the upper clay. This florule is of sufficient interest for separate enumeration and is clearly indicative of a plant association somewhat different from the other ecologic groups that can be differentiated in the flora of Wilcox time. Although some allowance should be made for the uncertain value of purely negative evidence, it would seem justifiable, where fossils are so abundant, to consider the absence of certain types as indicating that these were absent in the immediate vicinity at the time of the deposition of the containing sediments.

The following species are identified from this outcrop:

Amygdalus wilcoxiana Berry.
Anacardites inequilateralis Berry.
Anacardites minor Berry.
Apocynophyllum mississippiense Berry.
Carpolithus hiraeaformis Berry.
Carpolithus pilocarpoides.
Carpolithus puryearensis.
Carpolithus somervillensis.
Cupanites formosus Berry.
Euonymus splendens Berry.
Ficus mississippiensis (Lesquereux) Berry.
Ficus mississippiensis gigantea Berry.
Ficus tennesseensis Berry.
Grewiopsis tennesseensis Berry.
Hicoria crescentia Knowlton.
Maytenus puryearensis Berry.
Myrcia grenadensis Berry.
Negundo knowltoni Berry.
Osmanthus pedatus (Lesquereux) Berry.
Reynosia wilcoxiana Berry.
Rhamnites knowltoni Berry.
Sapindus formosus Berry.
Sophora sp.
Ternstroemites ovatus Berry.
Rutaphyllum trifoliatum Berry.

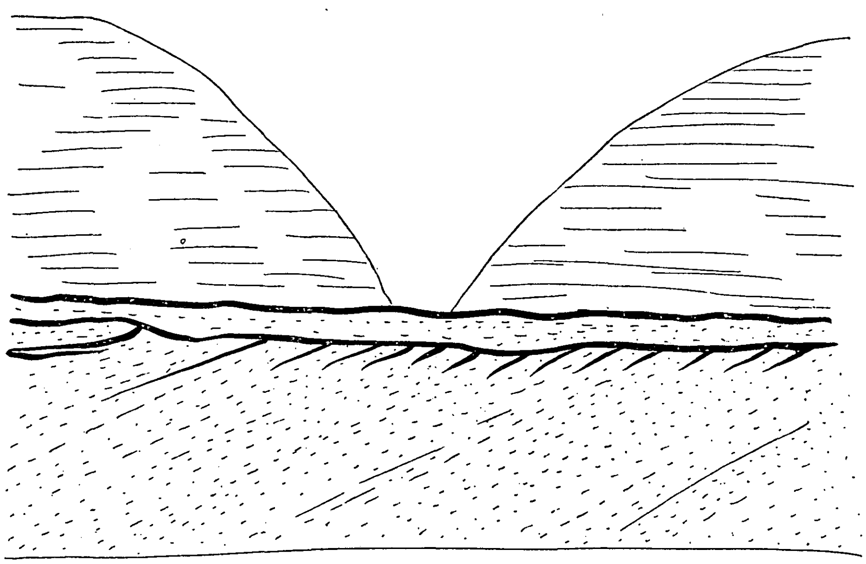


FIGURE 2.—Diagrammatic sketch of the relations at the fossiliferous locality 1 mile north of Somerville, Fayette County, Tenn.

Omitting from consideration the species that are based upon fruits or seeds as being of uncertain significance, we may note that the following four species are known only from this outcrop:

Anacardites inequilateralis.	Negundo knowltoni.
Ficus tennesseensis.	Rutaphyllum trifoliatum.

Two of these, the *Negundo* and the *Rutaphyllum*, belong to genera not otherwise represented in the whole Wilcox flora.

The commonest species is *Hicoria crescentia*, which is sparingly represented in the later Wilcox at a few other localities. About equally common are *Euonymus splendens* and *Grewiopsis tennesseensis*, both widely distributed Wilcox species which can hardly be considered as having been restricted to a single environment. In addition to these two the following five are all common and widely distributed in the Wilcox and hence can not be considered to have any special ecologic significance in the present connection:

Apocynophyllum mississippiense.
Ficus mississippiensis.
Rhamnites knowltoni.
Sapindus formosus.
Ternstroemites ovatus.

A peculiarity of this florule is the entire absence of any representatives of the family Lauraceae, which is present in the Wilcox of other localities to the extent of 9 genera and 36 species. A still more remarkable feature is the almost complete absence of members of the leguminous alliance, the only traces of which are specifically undeterminable leaflets thought to represent the genus *Sophora*. Leguminosae of the three families Mimosaceae, Caesalpiniaceae, and Papilionaceae are normally present in large numbers in most Wilcox fossiliferous outcrops, the total number described amounting to about 90 species.

A general survey of the distribution of the Wilcox species as a whole shows a relative diminution of both Lauraceae and Leguminosae in the Grenada formation as compared with the Holly Springs sand, but this is not sufficient to account for their absence in this locality. There is no other known locality in the Wilcox with anything like the number of species found here that does not contain some representation of both these alliances.

The small florule near Mandy in Madison County, Tenn., also lacks both and, like that near Somerville, contains an abundance of *Grewiopsis tennesseensis*, as well as the two hydrophytes—*Salvinia* and *Potamogeton*—and also many fish scales and caddis cases. There are no Leguminosae at the outcrop at Huckleberry Schoolhouse, in Carroll County, Tenn.; in the gully 1 mile west of Laconia, Fayette County, Tenn., or at the Murrell property in Hardeman County, Tenn. At the locality last mentioned are found *Salvinia* and *Unio*.

At the locality near Rogers Spring, in Hardeman County, Tenn., which I have supposed to be a delta deposit on account of the lithology and bedding, there are no members of the family Lauraceae. The locality at the big cut near Pine Top, in Hardeman County, has all the lithologic and organic features of a delta, as has been described on another page, and here there are a few Lauraceae and the only Leguminosae collected are fruits which seem to have drifted. Finally, at the locality on the Taylor farm, in Chester County, Tenn., the only Leguminosae consist of fruits and not foliage.

Just what this material may indicate environmentally is difficult to say. The accompanying remains of especially mesophytic plants, along with hydrophytes such as *Salvinia* and *Potamogeton*, fish scales, unios, and caddis cases built of water-logged leaves, is surely indicative of a moist substratum. It is true that unios, fish scales, and the remains of aquatic insect larvae merely mean that the sediments were water-laid, and we know of many localities where the caddis cases are found amid an abundance of leguminous and lauraceous leaves, but the fairly constant paucity or absence of these two alliances in beds that otherwise give more or less evidence of delta conditions seems more than a coincidence.

A delta of any size affords a variety of habitats, and it is perhaps impossible to sharpen the picture of the probable environment in which the plants from the locality north of Somerville lived. Furthermore, although the basal sands of this section show delta features, the flora all comes from the overlying clay, which may be a delta-pond or a flood-plain deposit, so that our argument does not advance perceptibly.

Henry County, Tenn.—Across the central part of Henry County, Tenn., the divide between the creeks that constitute the headwaters of Obion River on the west and the tributaries of Big Sandy River, an affluent of Tennessee River, on the east, is a conspicuous upland, relatively high and rolling to the west and relatively low to the east, where the easily eroded sediments of the McNairy sand member of the Ripley formation of the Upper Cretaceous have permitted the valley to advance westward 10 or 12 miles from Tennessee River to the Eocene contact. Here erosion had to operate on a series of thick clay lenses in the Wilcox, and these now constitute the core of the eastern border of this upland. These clay lenses have been extensively worked from the Kentucky line southward through Puryear, Whitlock, Paris, and Henry. (See pl. 1, *B*.) Some of them show the thickest clay banks that I have seen in the Wilcox throughout its extent. In none of these exposures is the Midway-Wilcox contact visible, but it is not many feet away, for the Midway crops out on the northern edge of Paris, where the north road crosses the Louisville & Nashville tracks.

Most of these Wilcox outcrops carry fossil plants; in fact, the most extensive florule known to me from a single Tertiary outcrop in North America occurs at Puryear, where over 200 different species have been found.

It is significant that this large florule, which is clearly at approximately the same horizon as those from the Atkins and Grable pits, in the southern part of Henry County, should occur very near the top of the Holly Springs sand. This position clearly shows the northward transgression of the Holly Springs sand and proves that the Midway-Wilcox contact is considerably younger in Henry County than it is in Hardeman County. These clay banks across Henry County are not continuous but lenticular. In general, like the somewhat similar clay lenses of the Upper Cretaceous in this region, their long axis is parallel to the old coast of the embayment, and their occurrence surrounded by sand, the remarkable thickness and purity of some of the clays, and the quantities of leaves which they contain all indicate deposition in coastal lagoons behind extensive vegetation-covered barrier beaches and sand flats, so that most of them, especially in Henry County, were beyond the reach of tidal influences and received the slow drainage from the land to the east through streams whose lower courses were drowned bayous or estuaries. The varying environments along this low coast, as I picture them, are illustrated by several recent photographs, which I have selected as especially realistic portrayals of lower Eocene conditions in this region.

Plates 5, *A* and *B*, and 6, *B*, picture the low Wilcox coast as I conceive it to have been, with slow stream distributaries, lined with forests, the waters inhabited by unios and other mollusks, gar pikes, and crocodiles, containing water chestnuts (*Trapa*), lotus (*Nelumbo*), and other aquatic vegetation, the banks clothed with bald cypress, gum, palms like the modern cabbage palmetto, and a great variety of leguminous and lauraceous forms, among which clambered *Smilax*, *Banisteria*, and other climbing plants.

Plate 5, *B*, may be taken to illustrate a Wilcox lagoon which had maintained or established a connection with the open Gulf waters and which was therefore tidal and more or less brackish. Here the muddy shallows would support *Avicennia*, *Laguncularia*, *Combretum*, and other members of the mangrove association, as well as the *Nipadites* palm; the bordering marshes would contain *Acrostichum;* along their borders would be found various Sapotaceae, bowers of wild figs and many other types; the barrier beaches would be covered with a variety of leguminous shrubs and trees, *Terminalia*, *Coccolobis*, *Chrysobalanus*, small palms, and a great variety of other plants.

Many of the Wilcox lagoons were closed, and in their more quiet waters and mud slowly accumulated and formed the great thicknesses of dark plastic clay, such as those of the Cole pit. (See pl. 4, *B*.) The color of these clays indicates a considerable percentage of carbonaceous material, but they usually furnish few and faint impressions of leaves, and I have assumed that the rate of accumulation of such deposits was comparatively slow, the water was almost stagnant, relatively few entire leaves were swept into the basin, and these usually had time to become thoroughly distintegrated.

Similar carbonaceous clays of less thickness, such as the clay exposed in the Atkins pit, where beautiful and entire leaves, many of large size, are preserved, may be considered to have been accumulated in pockets in quiet bayous or oxbows in the adjacent forests, the leaves from which had ample time to settle to the bottom.

Many of these clays in Henry County are thinner and lighter in color and contain considerable amounts of disseminated silica or films of fine sand. Many of them contain a great variety of plant species, and whatever may have been the variation in conditions in the immediate vicinity, it is difficult to conceive of over 200 species of vascular plants as having lined the shores of a single lagoon. Such a variety of plants and the presence of grit indicate a considerable influx of streams laden with forest litter, but this material could not have come quickly or from great distances, as the bulk of the plant material is not broken—petioles are preserved as well as slender tips, toothed margins, and such extremely attenuated forms as *Banksia tenuifolia* Berry.

Cole pit.—The opening known as the Cole pit is 2¼ miles west of south of Puryear, in Henry County, Tenn., and immediately west of the highway. The section is as follows:

1. Brownish sand and loam.
2. Thin chert gravel.
3. Yellowish sand.
4. Plastic clay, the upper 5 or 6 feet dove-colored, the lower 30 to 35 feet almost black fat clay without perceptible bedding, except thin films of sand from 5 to 10 inches apart, with scattered faint impressions of leaves, of which the only form recognized is *Euonymus splendens* Berry.

The horizon is the same as that exposed in the Foundry Church pit (pl. 4, *A*), about a quarter of a mile to the south, and approximately the same as that in the highly fossiliferous Puryear pit.

This is by far the thickest body of uniform-textured clay that I have seen anywhere in the Wilcox, the lighter upper portion differing merely in loss of water. It is extremely difficult to picture the exact method of accumulation of such a thickness. I have assumed that the water was quiet and that only the finest sort of sediment was brought into the basin. This condition would indicate a very small yearly accumulation by colloid precipitation. Very little is known of the rate of such a process under varying conditions, but it seems necessarily slow. The thin films of sand every 5 or 10 inches are hard to explain.

They are too widely spaced and too thin to represent seasonal phenomena, and one is tempted to connect them in some way with the Penck and Bruckner 33-year climatic cycle. If this explanation has any basis, which I much doubt, as it seems highly speculative, it would mean that it took about 2,000 years for this clay bank to accumulate. Or, if the 11-year sunspot cycle were appealed to, it would mean a period of accumulation of about 700 years.

The opening at the Cole pit is too small to determine the character of the clay at the edges of the lens. In the Foundry Church pit, a quarter of a mile south of the Cole pit, there is a bed of similar dark plastic clay about 25 feet thick, and this clay becomes lighter in color and sandier toward the east, which is in the assumed direction of the source of the sediments.

A long-interval periodic increase in storminess would account for the sand films in one of several ways. They might be attributed to increased run-off bringing in the sand or to increased windiness bringing the sand from the barrier beaches and sand flats lying toward the sea, perhaps at a time when the beach jungle was largely leafless, or to the increased run-off raising the water level enough to enable the water, now more agitated, to take up surface sand films from beaches ordinarily separated from the water by a belt of mud covered with palustrine vegetation. The sand partings are so thin that it does not seem probable that they are due to increased carrying power of entering waters, and much the same argument weighs against the suggestion that the sand may be wind-blown. The third suggestion appeals to me as offering the most likely explanation. Views of both the Cole pit and the adjacent Foundry Church pit are shown in Plate 4.

The Wilcox formations of southwestern Texas.—The lithologic variations and possibly the time involved in the Wilcox deposits of southwestern Texas are greater than in the deposits farther east in that State. The local relations in this region have been given in considerable detail in a report by Trowbridge[5] published in 1923, and the fossil plants found there were listed and described in 1922.[6]

In this part of Texas the Wilcox, particularly its middle sandy phase, is clearly transgressive, in some places passing over the Midway and coming to rest on the Upper Cretaceous, as on Nueces River near the San Antonio, Uvalde & Gulf Railroad bridge.

The general relations of the lithologic units within the Wilcox of this region are as follows:

	Mount Selman contact
Wilcox group	Bigford formation (about 700 feet or less)
	Carrizo sandstone (0–400 feet)
	Indio formation (80–470 feet)
	Midway (Eocene) or Upper Cretaceous contact

The fossil plants that have been discovered in the Wilcox throughout Texas are all indicative of upper Wilcox age. In the past marine fossils in the Wilcox have not been known west of the eastern border of the Texas coastal plain, and this so-called Sabinetown fauna has generally been regarded as of upper Wilcox age. More recently rather sparse marine faunas have been discovered in Bexar and Wilson Counties and in the Indio formation of the southwestern part of the State. Miss Gardner, in a recent paper,[7] has discussed these faunas, and she regards the Sabinetown fauna and that from Bexar and Wilson Counties as upper Wilcox, corresponding to the Bashi ("Woods Bluff") formation of Alabama, thus agreeing with the evidence of the fossil plants. The fauna from the Indio formation in Dimmit and Maverick Counties she considers to represent the lower Wilcox, because of the absence in it of characteristic Sabinetown species, such as *Alectrion exilis* (Conrad) and *Leda aldrichiana* Harris; and the presence of earlier Wilcox forms, such as *Turritella mortoni* Conrad, *T. humerosa* Conrad, and *Ostrea thirsae* Gabb (?).

The Wilcox faunas of Alabama have been recently revised by Hoffmeister.[8] According to his tables of distribution the only form of the Gardner list which is restricted to the Nanafalia or lowest Wilcox formation in Alabama is *Cardium tuomeyi* Aldrich, and the Indio fossil is not positively identified as such; the only form restricted to the Tuscahoma, or next younger Wilcox formation in Alabama, is *Callocardia nuttalliopsis greggi* Harris, and here again the Indio material is not positively determined. The genera of Indio Mollusca all range upward long distances, as indicated by the following list of the only species from the Indio positively named:

Cornulina armigera Conrad	Bashi, Hatchetigbee, and Claiborne.
Pseudoliva vetusta Conrad	Bashi, Hatchetigbee, and Claiborne.
Turritella mortoni Conrad	Recorded from Claiborne, probably erroneously.
Turritella humerosa Conrad	Bashi.

[5] 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. 85–107, 1923.

[6] Berry, E. W., Additions to the flora of the Wilcox group: Idem, pp. 1–21, pls. 1–18, 1922.

[7] Gardner, J. A., Fossiliferous marine Wilcox in Texas: Am. Jour. Sci., 5th ser., vol. 7, pp. 141–145, 1924.

[8] Hoffmeister, W. S., Johns Hopkins Univ. Dissertation, May, 1926.

Ostrea thirsae Gabb	Bashi, also Claiborne, probably erroneously.
Venericardia planicosta Lamarck	Through the Wilcox and into the Claiborne.
Calyptraea aperta Solander	Bashi and Claiborne.

If, then, this Indio fauna indicates a lower Wilcox age, it must be admitted that the criteria upon which this correlation is based can not be said to be obvious. Turning our attention to the plants, we find that the following florule has been identified from the Indio:

Anona ampla Berry.
Anona eolignitica Berry.
Cyperites sp. Hollick.
Ficus mississippiensis (Lesquereux) Berry.
Nectandra sp.
Oreodaphne obtusifolia Berry.
Rhamnus coushatta Berry.
Sabalites grayanus Lesquereux.
Sapindus linearifolius Berry.

Four of these species have been found in the Carrizo sandstone and one additional in the Bigford formation. Two, *Ficus mississippiensis* and *Oreodaphne obtusifolia*, occur throughout the Wilcox, and the rest are unknown below the horizon of the Holly Springs sand. I therefore feel justified in concluding that the Indio formation is not lower Wilcox. It may be as old as the Holly Springs sand of Mississippi, but it can hardly be older.

Section near mouth of Concillas Creek, Webb County, Tex.—About a quarter of a mile above the junction of Concillas Creek with the Rio Grande a section is exposed which is described here because of its fossiliferous character and also because of the clear evidence it affords of an erosional unconformity within the Wilcox, a not unusual occurrence but one that is ordinarily determined by overlap and not shown so diagrammatically in a single outcrop.

The section shown in Plate 3, *B*, and Figure 3 is in the Bigford formation, the uppermost of the three formational units recognized by Trowbridge in this region. A gray clay at the base is overlain by a horizontally bedded sandstone carrying sticks and leaf fragments, including good specimens of *Canna eocenica* Berry, a characteristic species of the Holly Springs. This sandstone is capped by a thin clay parting, above which is a similar sandstone with ripple marks from which no fossils were collected. The upper surface of the sandstone was conspicuously eroded, apparently by stream action, before the deposition of the overlying clay, which is brownish and laminated and contains an abundance of fossil plants. The following species have been identified from this bed:

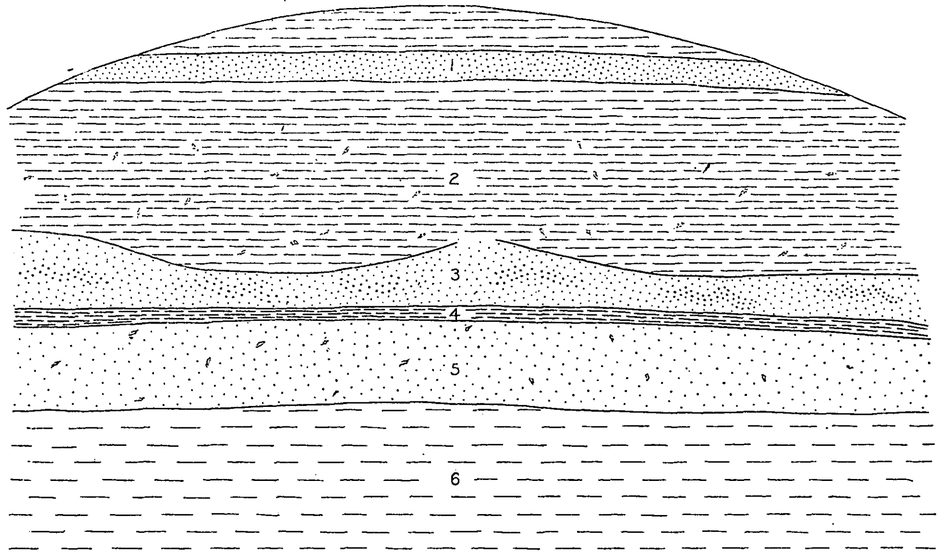


FIGURE 3.—Diagram of section a quarter of a mile above the mouth of Concillas Creek, Webb County, Tex. 1, Sandstone; 2, brownish laminated clay with leaves; 3, sandstone, ripple-marked in places; 4, clay parting; 5, sandstone with fragmentary leaves; 6, gray clay

Anarcardites grevilleafolia Berry.
Banksia puryearensis Berry.
Cassia marshallensis Berry.
Cyperites sp. Hollick.
Inga wickliffensis Berry?
Juglans schimperi Lesquereux.
Mimosites variabilis Berry.
Mimusops mississippiensis Berry.
Myrica wilcoxensis Berry.
Sabalites grayanus Lesquereux.
Sophora wilcoxiana Berry.

The number of forms in the list is too small to warrant any ecologic speculation. The plants, to the extent that they are represented at this outcrop, constitute just the sort of an assemblage that is commonly found in the upper part of the Holly Springs sand.

LOWER EOCENE FLORAS

The origin of angiosperms.—The much greater contrasts between the floras of the Upper Cretaceous and the older Tertiary in regions like southeastern North America and Mediterranean Europe as compared with the corresponding changes in the floras of higher latitudes strongly suggests that after the initial dispersal of the flowering plants in the Cretaceous, which is generally believed to have started from a northern center, there was an extensive evolution of forms in low latitudes, and that these forms subsequently during the period of genial climate that culminated in the Oligocene radiated northward to a greater or less degree according to the paths of dispersal that were available. This suggestion is strikingly supported by the floral history of the southeastern United States during the earlier half of the Tertiary period and is similarly emphasized by the south Asiatic and African affinities of both the terrestrial floras and the faunas of that time in Europe.

We are really profoundly ignorant of the early history of the angiosperms, and their supposed origin in the north may be entirely illusory. Their appearance in considerable numbers in the late Lower Cretaceous deposits (Aptian and Albian) in such widely scattered regions as Maryland and Virginia, England, Portugal, and New Zealand, without showing any especially primitive characters, which are notably absent in the petrified woods described from England, throws the problem farther back in the Mesozoic than has generally been appreciated and raises the question whether the real place of origin may not have been equatorial uplands, as some students have suggested.

It seems to me to be quite futile to speculate about this problem at the present time, or to endeavor to build up a theory from collateral evidence. What we really need before we can hope to make any substantial contribution to this fascinating problem is a more complete knowledge of Mesozoic floras, especially in equatorial regions and in nonpalustrine environments.

In 1925 Thomas [9] described what he considered to be an order of primitive angiosperms from the Jurassic of Yorkshire which involved the widespread Mesozoic type known as *Sagenopteris.* Should this author's conclusions be substantiated, and it seems wise to withhold judgment until they are fully demonstrated, they introduce us to the first really primitive angiosperms that have been discovered, which combine fernlike foliage with gymnospermous seeds inclosed in angiospermous carpels.

Early Eocene plants in Texas.—No account of the Wilcox flora would be complete without some reference to the fossil plants discovered at Earle, in Bexar County, and near Sayersville, in Bastrop County, in the Coastal Plain of Texas. These plants have been tentatively considered as referable to the Midway, or basal Eocene, and were discussed by me [10] in 1924. The following representatives of 18 different plants have been recognized from these outcrops:

Asimina eocenica Lesquereux.
Asplenium primero Knowlton.
Cinnamomum affine Lesquereux.
Dolichites deusseni Berry.
Ficus denveriana Cockerell.
Ficus occidentalis Lesquereux.
Ficus sp. Berry.
Ficus post-trinervis Knowlton.
Laurus wardiana Knowlton.
Mespilodaphne precoushatta Berry.
Pourouma texana Berry.
Platanus aceroides latifolia Knowlton.
Rhamnus marginatus apiculatus Berry.
Rhamnus sp. Berry.
Sapindus? sp. Berry.
Terminalia hilgardiana (Lesquereux) Berry.
Terminalia lesleyana (Lesquereux) Berry.
Viburnum sp. Berry.

If these plants were really of Wilcox age it would seem that all should be present elsewhere in the abundantly preserved Wilcox flora. However, in spite of the fact that the Wilcox flora numbers considerably more than 500 species, 12 of these central Texas forms have not been found in the Wilcox, and moreover, the general resemblances are with the plants of the Raton formation and other pre-Wilcox floras of the western United States.

The areal mapping in Texas by both State and Federal geologists places the beds at Earle and Sayersville in the Wilcox. Until a representative flora has been discovered in acknowledged Midway beds it will be impossible to prove whether the plants listed represent Midway or earlier Wilcox than that represented by the plants found in the Ackerman formation of the eastern Gulf area. They clearly break the unity of the Wilcox flora as a whole, but it must be borne in mind that they may eventually be proved to be of early Wilcox age, and if so they will add 12 additional forms to this already extensive flora, including the two interesting and noteworthy types *Dolichites* and *Pourouma.* Until this is positively determined I prefer to ignore them in the discussion of the Wilcox flora, and they are therefore not mentioned on later

[9] Thomas, H. H., Roy. Soc. London Philos. Trans., vol. 213, pp. 299–363, pl. 11–15, 1925.

[10] Berry, E. W., An early Eocene florule from central Texas: U. S. Geol. Survey Prof. Paper 132, pp. 87–92, 1924.

pages. This treatment is the more warranted because they do not affect the questions there considered.

Relations of the Wilcox and Ripley floras.—At the time that the original paper on the Wilcox was written the bulk of the known Upper Cretaceous plants from the Atlantic Coastal Plain had come from formations belonging to the earlier half of the Upper Cretaceous (Raritan, Magothy, and Tuscaloosa formations). The contrast between these floras and those of the Wilcox was very great indeed. The few plants then known from the later Upper Cretaceous (Eutaw and Ripley formations) were too scanty and unrepresentative to afford any basis for discussion.

Subsequently Bruce Wade discovered well-preserved and abundant plants in the Ripley, which were described in 1925.[11] This Ripley flora is fairly representative. It comprises 135 species in 71 genera, 40 families, and 28 orders, and it has an additional advantage for comparison with the Eocene flora in that the bulk of it comes from clay lenses deposited in coastal lagoons in Henry and Carroll Counties in western Tennessee—that is, in the same latitude and the same environment in the embayment that has furnished the bulk of the Wilcox flora. There is thus an unusual opportunity for endeavoring to reconstruct the evolution and immigration of plant types which took place in this region between the deposition of the Ripley and that of the Wilcox.

The following 28 genera recorded from the Ripley are unknown in the Wilcox:

Acer.	Halymenites.
Alismaphyllum.	Liriodendron.
Andromeda.	Malapoenna.
Araucaria.	Manihotites.
Celastrophyllum.	Monheimia.
Celtis.	Moriconia.
Cornophyllum.	Myrtophyllum
Cunninghamites.	Pachystima.
Dammara.	Protophyllocladus.
Dioscorites.	Raphaelia.
Doryanthites.	Salix.
Fagus.	Selaginella.
Geinitzia.	Taeniopteris.
Geonomites.	Widdringtonites.

Of these genera, *Geonomites* and *Celtis* occur in the later Eocene of this region and therefore may have been present during Wilcox time. In addition, the genera *Manihot*, *Negundo*, and *Myrcia* of the Wilcox may have represented *Manihotites*, *Acer*, and *Myrtophyllum* of the Ripley, respectively.

This leaves two outstanding contrasts between the Ripley and Wilcox floras. One is the survival in the Ripley of many Mesozoic types that apparently became extinct before the dawn of the Wilcox. *Araucaria* and *Dammara* are not extinct, being austral in existing floras, but disappeared from the United States during the Upper Cretaceous epoch.

The second and less conspicuous element of contrast is that furnished by genera such as *Salix*, *Fagus*, *Liriodendron*, *Cornophyllum*, and *Andromeda*, which are temperate genera with an ancient history and probably originated in Holarctica but were banished from the embayment region subsequent to Ripley time by the same amelioration of environmental conditions that permitted a very considerable invasion of the region by the flora from lower American latitudes.

When the flora of the Wilcox is compared with older Upper Cretaceous floras of the same region the contrast is found to be very much greater than that exhibited by the Ripley. For example, about 40 per cent of the genera of these earlier Upper Cretaceous floras are extinct, and the following genera, which were present in the embayment region during earlier Upper Cretaceous time, have not been found in the Wilcox:

Abietites.	Liriodendron.
Andromeda.	Liriodendropsis.
Androvettia.	Malapoenna.
Araucaria.	Manihotites.
Bauhinia.	Marattia.
Brachyphyllum.	Myrsine.
Celastrophyllum.	Palaeocassia.
Cephalotaxospermum.	Panax.
Cocculus.	Persoonia.
Colutea.	Pinus.
Cornophyllum.	Piperites.
Cunninghamites.	Podozamites.
Cycadinocarpus.	Populus.
Dammara.	Protodammara.
Dermatophyllites.	Protophyllocladus.
Dewalquea.	Pterospermites.
Dicksonia.	Salix.
Doryanthites.	Sapotacites.
Dryopterites.	Sassafras.
Eorhamnidium.	Sequoia.
Geinitzia.	Tricalycites.
Gleichenia.	Tumion.
Jungermannites.	Widdringtonites.
Kalmia.	

These genera are almost twice as many as in the Ripley flora—47 as against 28—and although in both floras there are some uncertainties due to the presence of form genera of somewhat doubtful botanic affinities, it is clear that there was a progressive modification of the floras in this region during Upper Cretaceous time. This modification consisted of a certain amount of evolution of new forms, a considerable dying out of the older Mesozoic types, and an immigration of species into the region and an emigration of species from it. The immigrants came chiefly from the lands to the south and consisted of warmer tem-

[11] Berry, E. W., The flora of the Ripley formation: U. S. Geol. Survey Prof. Paper 136, 1925.

perate types, which arrived in still greater force in the interval between the Ripley and the Wilcox.

Modernization of Eocene floras.—The terrestrial floras throughout the world exhibit a striking contrast between the Upper Cretaceous and the Eocene, and this, it seems to me, is quite as marked in the plants as in the terrestrial vertebrates or the marine invertebrates. A careful analysis would be futile, because the subject is so obscured by differences of opinion among geologists and paleontologists as to the position of the boundary between Cretaceous and Tertiary.

General considerations warrant the conclusion that in those regions where there was an interval between the deposition of sediments of the two periods, as there was in the Atlantic Coastal Plain, the biotic contrasts are profound; whereas in regions where deposition was more or less continuous or where breaks in sedimentation are of slight magnitude or separate sediments of genetic similarity, as appears to have been the case in the western interior, the question of a general boundary becomes purely academic and subjective.

There seems to be a rather widespread impression among both geologists and botanists that with the appearance of a considerable number of flowering plants (angiosperms) toward the end of the Lower Cretaceous time (Albian), terrestrial floras were rapidly transformed from Mesozoic to Cenozoic assemblages, and the statement is frequently made that the Upper Cretaceous floras were essentially Cenozoic in character. This is a most uncritical statement. It is true that a considerable number of still existing types of flowering plants make their appearance in the geologic record during the Upper Cretaceous, and if one has a weakness for making dramatic statements or striking generalizations—both of which are usually false—there is a temptation to say that the age of flowering plants commenced in the mid-Cretaceous. This is a nonscientific statement of no greater exactness than the statement that the Mesozoic is the age of reptiles or that the Cenozoic is the age of mammals. Such statements may be perfectly proper as popular characterizations of the outstanding feature of an era or period, in the same way that we commonly speak of the Mesozoic as the age of ammonites or the age of gymnosperms, but all of them are only half truths.

I have already mentioned certain contrasts between the floras of Ripley and Wilcox time. In the section in which the probable sources of the Wilcox flora are discussed (pp. 14–16) the definite points of contact between Upper Cretaceous floras and those of the Eocene are considered. Here I wish to give the evidence for the belief that the Eocene was characterized by a great modernization of the floras of the world.

The evidence does not permit a conclusion as to whether the major factor in this modernization was evolutionary processes or whether it is only apparent, resting simply upon invasions into known areas from unknown areas, such, for example, as Asia on the one hand or tropical America on the other. Both of these factors were doubtless operative, but I am inclined to think that immigration was and is always the more important in enabling us to recognize seeming high and low points in the continuously unfolding drama of life.

That there is a well-defined basis for the statement of this apparent Eocene modernization of floras is indicated by the following list of 83 genera that are present in the Wilcox flora but have not yet been found in Upper Cretaceous floras anywhere:

Acorus.
Amygdalus (probably).
Anacardites.
Aracaeites.
Artocarpoides.
Asimina.
Avicennia.
Banara.
Banisteria.
Berchemia.
Bignonicapsula.
Bombacites.
Buettneria.
Caenomyces.
Caesalpinia.
Calatoloides.
Calyptranthes.
Canavalia.
Carapa.
Celastrocarpus.
Ceratophyllum.
Chamaedorea.
Cheilanthes.
Chrysobalanus.
Citheroxylon.
Cladrastis.
Clusiaphyllum.
Coccolobis.
Combretanthites.
Combretum.
Conocarpus.
Copaifera?
Cryptocarya.
Cupanites.
Dodonaea.
Drypetes.
Engelhardtia.
Exostema.
Fagara.
Gleditsia?
Glyptostrobus.
Guettarda.
Helictoxylon.
Heterocalyx.
Hiraea.
Icacorea.
Knightiophyllum.
Laguncularia.
Liquidambar (probably).
Manihot.
Maytenus.
Melastomites.
Meniphylloides.
Mespilodaphne.
Metopium.
Mimusops.
Monocarpellites.
Nipadites.
Oreopanax.
Osmanthus.
Ouratea.
Palaeodendron.
Paraengelhardtia.
Parkinsonia.
Pithecolobium.
Pseudolmedia.
Psychotria.
Ptelea.
Pterobalanus.
Reynosia.
Rubiacites.
Rutaphyllum.
Salvinia.
Schefflera.
Sideroxylon.
Simaruba.
Solanites.
Sophora.
Sterculiocarpus.
Taxodium.
Terminalia.
Vantanea.
Zygophyllum?

Some of these genera, such as *Celastrocarpus* and *Combretanthites*, may suggest duplication, but on the other hand these are greatly offset by such genera as *Anacardites*, *Melastomites*, *Apocynophyllum*, *Leguminosites*, and *Carpolithus*, which almost certainly represent more than single botanic genera.

Some of the names in the foregoing list are also represented by Upper Cretaceous forms that, because of some uncertainty of identification, have been given different names. Thus *Conocarpites* or *Manihotites* of the Cretaceous may represent *Conocarpus* and *Manihot* of the Eocene, and *Sapotacites* of the Cretaceous may represent some of the Eocene genera of Sapotaceae.

These possible exceptions do not, however, greatly affect the significance of the list, and I think that it is obvious, without further discussion, that the Wilcox flora is very decidedly more modern in its facies than any Upper Cretaceous flora in this or any other known region, and the general question of Eocene modernization could be made still more impressive by including in such a survey the known Eocene floras of the world.

This is believed to be unnecessary in the present connection, but if the reader wishes to investigate this subject further he should compare the list of Ettingshausen's determinations of the lower Eocene floras of southern England[12] with the most extensive Upper Cretaceous floras of Europe, such as those from the Bohemian Basin,[13] or, if it is objected that Ettingshausen's list are largely nomina nuda, Engelhardt's monograph of the Eocene flora of Hesse[14] may be substituted. The same results may be obtained from a consideration of the Eocene floras of the Paris Basin, but the literature on those floras is so scattered that it is not easily available for rapid consultation.

THE FLORA OF THE WILCOX GROUP

Sources.—In a short paper published in 1919[15] I made a preliminary analysis of the Tertiary floras of the Atlantic Coastal Plain with regard to their place of origin and direction of radiation. The progress of discovery in this region has been so rapid during the last few years that much new material is now available, and this has been subjected to a rather more critical study than was possible at the time that the preliminary paper was published.

The general floral history of the Eocene of southeastern North America may be considered under two heads—(1) the proportion of generic types that may be considered to have been indigenous in the region and their origin, whether immigrants from the north or the south or evolved in the region; (2) the more immediate history of the lower Eocene origin and immigration of such types as are not known in the antecedent Cretaceous floras of the embayment region.

Complete lists of the Upper Cretaceous floras of the world were compiled in 1916,[16] and since then several important papers have been published, the more significant of which are cited below.[17] We are thus in a position to make a fairly reliable estimate of the essential elements of what might be called the cosmopolitan floras of the northern continents toward the end of the Upper Cretaceous epoch.

The following genera which are present in the Wilcox flora may be considered as having attained a holarctic distribution during the Mesozoic, or at least in pre-Wilcox time:

Anemia.	Magnolia.
Apocynophyllum.	Marchantites.
Aralia.	Menispermites.
Asplenium.	Myrica.
Bumelia.	Oreopanax.
Cinnamomum.	Pistia.
Cissites.	Platanus.
Dalbergia.	Proteoides.
Diospyros.	Pteris.
Dryophyllum.	Smilax.
Dryopteris.	Sterculia.
Equisetum.	Taxites.
Ficus.	Ternstroemites.
Lycopodites.	

To this list may be added the following genera, which, because of incomplete records, can not be proved to have been holarctic but which appear to belong to that northern flora:

Acerates.	Nectandra.
Acorus.	Nelumbo.
Amygdalus.	Nyssa.
Banksia.	Oreodaphne.
Celastrus.	Paliurus.
Crotonophyllum.	Persea.
Cyperacites.	Poacites.
Eugenia.	Potamogeton.
Euonymus.	Prunus.
Euphorbiophyllum.	Pterospermites.
Fraxinus.	Rhamnus.
Glyptostrobus.	Sapindus.
Grewiopsis.	Sparganium.
Ilex.	Taxodium.
Myrcia.	Zizyphus.

[12] These were published in Royal Soc. London Proc., vol. 30, 1880, and I have reproduced them in U. S. Geol. Survey Prof. Paper 84, pp. 148–153, 1914.

[13] Summarized in the work of Frič, Anton, Studien im Gebiete der böhmischen Kreideformation: Naturwiss. Landesd. Böhmen Archiv, Band 11, 1901, and earlier volumes in this series.

[14] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hessischen geol. Landesanst. Abh., Band 7, Heft 4, 1922.

[15] Berry, E. W., Paleogeographic significance of the Cenozoic floras of equatorial America and the adjacent regions: Geol. Soc. America Bull., vol. 29, pp. 631–636, 1919.

[16] Berry, E. W., The Upper Cretaceous floras of the world: Maryland Geol. Survey, Upper Cretaceous, pp. 183–313, 1916.

[17] Berry, E. W., Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia: U. S. Geol. Survey Prof. Paper 112, 177 pp., 33 pls., 1919; The flora of the Ripley formation: U. S. Geol. Survey Prof. Paper 136, 94 pp., 23 pls., 1925. Knowlton, F. H., The Laramie flora of the Denver Basin: U. S. Geol. Survey Prof. Paper 130, 175 pp., 28 pls., 1922; A catalogue of the Mesozoic and Cenozoic plants of North America: U. S. Geol. Survey Bull. 696, 815 pp., 1919.

These Upper Cretaceous holarctic floras of Eurasia and extratropical America include a considerable number of additional elements which have not been found to be represented in the Wilcox. Among these the following generic types are prominent, either throughout or in North America:

Acer.	Liriodendron.
Andromeda.	Liriodendropsis.
Androvettia.	Macclintockia.
Araucaria.	Moriconia.
Aspidiophyllum.	Myrsine.
Betula.	Nilssonia.
Brachyphyllum.	Osmunda.
Celastrophyllum.	Pinus.
Cocculus.	Podozamites.
Cornus.	Populus?
Credneria.	Protophyllocladus.
Cunninghamites.	Protophyllum.
Dammara.	Pseudocycas.
Dewalquea.	Quercus (so called).
Fagus.	Salix.
Geinitzia.	Sapotacites.
Gleichenia.	Sassafras.
Hedera.	Sequoia.
Juniperus.	Viburnum.
Laurus.	Widdringtonites.

These genera are for the most part indicative of temperate climatic conditions and contain a number of elements and a general facies which find many close parallels in existing temperate rain forests.

The physical changes that occurred in southeastern North America during the interval between the Cretaceous and the Tertiary, or in the earliest Eocene, accompanied if they were not the direct cause of the extinction of the following genera:

Androvettia.	Liriodendropsis.
Aspidiophyllum.	Moriconia.
Brachyphyllum.	Nilssonia.
Credneria.	Podozamites.
Cunninghamites.	Protophyllocladus.
Dewalquea.	Protophyllum.
Geinitzia.	Pseudocycas.

The genera *Araucaria*, *Cocculus*, *Dammara*, and *Gleichenia* appear to have retired toward the south at that time. The following genera appear to have withdrawn toward the north:

Acer.	Liriodendron.
Andromeda.	Pinus.
Arundo.	Populus?
Betula.	Quercus (so called).
Cornus.	Salix.
Fagus.	Sassafras.
Hedera.	Sequoia.
Juniperus.	Viburnum.

It may therefore be considered that the following genera represent the indigenous element in the Wilcox flora, and that these are survivors from the essentially northern holarctic flora of the late Cretaceous:

Acerates.	Marchantites.
Ancorus.	Menispermites.
Amygdalus.	Myrcia.
Anemia.	Myrica.
Apocynophyllum.	Nectandra.
Aralia.	Nelumbo.
Asplenium.	Nyssa.
Bumelia.	Oreodaphne.
Celastrus.	Oreopanax.
Cinnamomum.	Paliurus.
Cissites.	Persea.
Crotonophyllum.	Pistia.
Cyperacites.	Platanus.
Dalbergia.	Poacites.
Diospyros.	Potamogeton.
Dryophyllum.	Proteoides.
Dryopteris.	Prunus.
Equisetum.	Pteris.
Eugenia.	Rhamnus.
Euonymus.	Sapindus.
Euphorbiophyllum.	Smilax.
Ficus.	Sparganium.
Fraxinus.	Sterculia.
Grewiopsis.	Taxites.
Ilex.	Ternstroemites.
Lycopodites.	Zizyphus.
Magnolia.	

These genera have 187 species in the Wilcox flora, and although it must be conceded that these generic types were indigenous in southeastern North America, many of the species certainly were not, and this is especially true in all the more prolifically represented genera, such as the following:

Celastrus.	Nectandra.
Dalbergia.	Oreodaphne.
Dryophyllum.	Oreopanax.
Eugenia.	Rhamnus.
Ficus.	Sapindus.
Menispermites.	Sterculia.
Myrcia.	Ternstroemites.

These genera have 97 species in the Wilcox flora, and a large majority of these species undoubtedly represent local products of evolution or immigrants into the embayment area, either from the north or from the south. For example, in the large genus *Ficus*, which has 22 species and varieties in the Wilcox, but two of these, *Ficus mississippiensis* (Lesquereux) and *Ficus myrtifolius* Berry, are represented by similar species in the antecedent Ripley flora of the region, in which they are related respectively to *Ficus cooperensis* Berry and *Ficus carrollensis* Berry. *Ficus mississippiensis* is also common in the late Cretaceous and basal Eocene of the West. Its Wilcox varieties *cordata* and *gigantea* are, however, apparently new products of evolution.

Among the other supposed figs found in the Wilcox, *Ficus* sp. Berry is represented in the supposed Midway of central Texas, and the following appear to be either new products of evolution or invaders of the region from the unknown south—which it is not possible to determine:

Ficus eolignitica Berry.
Ficus myrtifolia ovata Berry.
Ficus pandurifolia Berry.
Ficus puryearensis Berry.
Ficus puryearensis elongata Berry.
Ficus pseudocuspidata Berry.
Ficus pseudolmediafolia Berry.
Ficus schimperi Lesquereux (doubtful).
Ficus tennesseensis Berry.
Ficus vaughani Berry.
Ficus wilcoxensis Berry.

The rest of the supposed figs of the Wilcox show the following affinities: *Ficus cinnamomoides* Lesquereux is uncertain in every way, and perhaps it should be dropped from the literature altogether, as it is based upon poorly defined and subsequently lost material. The following are present or are represented by related forms in the pre-Wilcox of the West:

Ficus artocarpoides Lesquereux?
Ficus denveriana Cockerell?
Ficus harrisiana Hollick.
Ficus monodon (Lesquereux) Berry.

Ficus myrtifolia ampla Berry may be a derivative of *Ficus stephensoni* Berry of the Upper Cretaceous Black Creek formation of the Atlantic Coastal Plain. Other Wilcox genera that are represented in the Ripley Cretaceous of this same region have entirely different species at the two horizons and are not closely affiliated. The genera in which this lack of affiliation prevails are

Artocarpus.	Grewiopsis.
Caesalpinites.	Myrcia.
Euphorbiophyllum.	Zizyphus.
Dillenites.	

The palm genus *Geonomites* is present in the Ripley Cretaceous as well as in the basal Eocene of the Barrilla Mountains of western Texas and in Colorado, Wyoming, and New Mexico. It reappears in the lower Claiborne of Texas and therefore may have been a member of the Wilcox flora that has not yet been discovered, or it may have withdrawn from the embayment region at the end of the Ripley epoch and reinvaded the Coastal Plain from the Southwest during lower Eocene time.

The following Wilcox species, which are for the most part equatorial types, seem to be directly related to the correspondingly named Ripley species and to have been derived from these late Cretaceous immigrants into the embayment region:

Wilcox species	Ancestral Ripley species
Juglans schimperi Lesquereux	Juglans tennesseensis Berry.
Capparis eocenica Berry	Capparis proeocenica Berry.
Mimosites lanceolatus Berry	Mimosites cooperensis Berry.
Dalbergia eocenica Berry	Dalbergia perryana Berry.
Dalbergia wilcoxiana Berry	Dalbergia prewilcoxiana Berry.
Gleditsiophyllum eocenicum Berry.	Gleditsiophyllum proeocenicum Berry.
Gleditsiophyllum ovatum Berry	Gleditsiophyllum preovatum Berry.
Cedrela wilcoxiana Berry	Cedrela prewilcoxiana Berry.
Ternstroemites preclaibornensis Berry.	Ternstroemites ripleyensis Berry.
Ternstroemites eoligniticus Berry.	Ternstroemites cretaceus Berry.
Cinnamomum affine Lesquereux	Cinnamomum newberryi Berry.
Cinnamomum buchii Heer	Cinnamomum praespectabile Berry.
Nectandra pseudocoriacea Berry	Laurophyllum ripleyensis Berry.
Myrcia vera Berry	Myrcia havanensis Berry.
Myrcia grenadensis Berry	Myrcia dubia Berry.
Acerates wilcoxiana Berry	Acerates cretacea Berry.
Bumelia wilcoxiana Berry	Bumelia prewilcoxiana Berry.
Apocynophyllum crassum Berry	Apocynophyllum giganteum Berry.
Apocynophyllum wilcoxense Berry.	Apocynophyllum ripleyense Berry.
Canavalia eocenica Berry	Leguminosites canavalioides Berry.

Of the 83 genera that have already been enumerated as having made their appearance in the geologic record in the Wilcox sediments, the following 51, or over 60 per cent, are tropical in their modern affinities and probably also in their ancestry, and they may therefore be considered to have invaded North America from equatorial America:

Anacardites.	Fagara.
Araceaeites.	Guettarda.
Avicennia.	Heterocalyx.
Banara.	Hiraea.
Banisteria.	Icacorea.
Bignonicapsula.	Laguncularia.
Bombacites.	Maytenus.
Buettneria.	Meniphylloides.
Caesalpinia.	Mespilodaphne.
Calatoloides.	Metopium.
Calyptranthes.	Mimusops.
Canavalia.	Osmanthus.
Carapa.	Ouratea.
Chamaedorea.	Pithecolobium.
Chrysobalanus.	Pseudolmedia.
Citharexylon.	Psychotria.
Clusiaphyllum.	Renyosia.
Coccolobis.	Schefflera.
Combretum.	Sideroxylon.
Conocarpus.	Simaruba.
Copaifera?	Solanites.
Cryptocarya.	Sophora.
Cupanites.	Terminalia.
Dodonaea.	Vantanea.
Drypetes.	Zygophyllum?
Exostema.	

These genera have 106 Wilcox species.

Present composition of the Wilcox flora.—The Wilcox flora with the additions made to it in the present contribution now numbers 543 species in 180 genera, 82 families, and 43 orders. The table of distribution gives a completely revised list of the flora, taxonomically arranged.

The orders with the largest number of families represented are the Rosales and Sapindales, with 6 families each; the Ranales and Parietales, with 5 each; the Rutales, Malvales, and Myrtales, with 4 each; the Gentianales and Personales, with 3 each; and the Polypodiales, Coniferales, Graminales, Urticales, Malpighiales, Rhamnales, Umbellales, and Ebenales, with 2 each. The remainder have but a single family each.

The families with the largest number of genera represented are the Caesalpiniaceae and Lauraceae, with 9 genera each; the Polypodiaceae, with 7; the Rhamnaceae, with 6; the Papilionaceae, Sterculiaceae, and Combretaceae, with 5 each; the Cupressinaceae, Arecaceae, Juglandaceae, Moraceae, Proteaceae, Mimosaceae, Rutaceae, Euphorbiaceae, Celastraceae, Sapotaceae, and Rubiaceae, with 4 each; the Araceae, Anacardiaceae, Sapindaceae, Myrtaceae, and Araliaceae, with 3 each; and the Schizaeaceae, Anonaceae, Hamamelidaceae, Drupaceae, Meliaceae, Malpighiaceae, Oleaceae, Apocynaceae, and Verbenaceae, with 2 each. The rest have but a single genus each.

The genera having the largest number of species, with their specific representation, are the following:

Carpolithus	33	Cedrela	6
Ficus	22	Celastrus	6
Leguminosites	22	Cinnamomum	6
Cassia	14	Diospyros	6
Sapindus	10	Myrcia	6
Anacardites	9	Rhamnus	6
Apocynophyllum	9	Calycites	5
Gleditsiophyllum	8	Dalbergia	5
Nectandra	8	Dillenites	5
Oreodaphne	8	Dryophyllum	5
Antholithes	7	Mimosites	5
Bumelia	7	Pisonia	5
Caenomyces	6		

It should be noted that the following are form genera and probably represent more than a single botanic genus: *Anacardites*, *Antholithes*, *Apocynophyllum*, *Calycites*, *Carpolithus*, *Caenomyces*, *Dillenites*, *Gleditsiophyllum*, *Leguminosites*, and *Mimosites*. This is certainly true of such form genera as *Antholithes*, *Calycites*, *Carpolithus*, and *Leguminosites*. There is also probably some duplication in giving separate names to leaves and fruits, as in the genera *Ficus*, *Cinnamomum*, and *Diospyros*.

When this flora is considered from the angle of the number of species described in single families and orders, we obtain the following figures:

The 14 largest orders have the following relative specific representation:

Rosales	92	Rutales	17
Sapindales	44	Ranales	14
Laurales	39	Umbellales	14
Rhamnales	36	Gentianales	14
Urticales	32	Polypodiales	13
Myrtales	26	Parietales	13
Ebenales	20	Juglandales	10

The 20 largest families have the following relative specific representation:

Lauraceae	39	Combretaceae	11
Caesalpiniaceae	33	Juglandaceae	10
Moraceae	28	Sterculiaceae	10
Papilionaceae	17	Araliaceae	10
Rhamnaceae	17	Apocynaceae	10
Sapindaceae	17	Celastraceae	10
Mimosaceae	14	Polypodiaceae	9
Sapotaceae	14	Arecaceae	7
Anacardiaceae	11	Rutaceae	7
Myrtaceae	11	Meliaceae	7

The relative standing of the first 6 families is the same in this list as in that given in 1916,[18] when the known Wilcox flora was much smaller, showing that there is a considerable reliability to such statistics.

Thus, as plants are now segregated into families the Lauraceae is the largest, but if the number of species of the three leguminous families which are represented in the Wilcox are combined with the species of *Leguminosites*, the Leguminosae has 86 species and is by far the largest alliance in the Wilcox, even when allowance is made for the fact that there is obvious duplication of leaves and fruit and probably more nominal leaf species recognized than there were botanic species, because of our lack of knowledge of the limits of foliar variation in this alliance. The Leguminosae are at the present time the most numerous alliance of the Choripetalae and, except for the Compositae, the largest angiospermous group. In view of the multiplicity of species of Compositae that I believe were certainly of post-Eocene origin, there is considerable evidence for believing that the Leguminosae was the largest alliance of flowering plants during Eocene time. This conclusion would seem to have some bearing on the geniality of climate during the Wilcox epoch, for in existing floras the Leguminosae is the largest angiospermous alliance in the British West Indies, Porto Rico, Celebes, and British Guiana.

Relative abundance of Wilcox species.—The differences in extent to which the several plant-bearing outcrops of the Wilcox have been studied and the great differences in preservation of the plants from different outcrops, as well as the obvious selective effect of maceration and trituration, precluded the keeping of any reliable statistics of the individual abundance of species at the different localities, al-

[18] U. S. Geol. Survey Prof. Paper 91, p. 78, 1916.

though usually notes were kept of those which are most and least abundant. This is less regrettable because such a statistical record is open to serious objection in that it can not take into account the circumstances of preservation, for obviously leaves of a few trees of a single species dropped into a single pool from which any great number of other species were excluded by reason of their absence from the immediate locality would convey an altogether erroneous idea of the relative abundance of that species.

Thus *Meniphylloides tennesseensis* and *Nelumbo protolutea* are present at but a single one of the 132 localities, and both are exceedingly abundant at these localities. I can not believe that the former grew only in the vicinity of Cottage Grove, Tenn., or the latter only at Meridian, Miss. I would expect the *Nelumbo* to have been present in almost any Wilcox pond or slow stream, but it so happens that the locality at Meridian was either the only one where the species has been preserved or the only one where it has been discovered. Similarly *Oreopanax oxfordensis* is known from but two localities in the Wilcox—Oxford, Miss., and Benton, Ark., 200 miles distant as the crow flies and approximately 300 miles apart along the Wilcox coast—and yet it is one of the most abundant species at the first locality and must have been present along at least this 300 miles of Wilcox coast.

Instances of this sort might be multiplied, but I think that it is obvious without citing others that any method based upon the relative abundance of species at a single outcrop or a few outcrops is likely to give unreliable results regarding the dominant members of a flora.

A more reliable method is, I believe, to consider those species as commonest in a fossil flora which occur at the largest number of localities, particularly if these localities are widely scattered geographically. Naturally environmental location, accessibility of preserving sediments, coriaceous or perishable nature of the leaves, and similar features will be factors, but the weight to be attached to them will be reduced to a minimum if the localities are numerous and varied as regards their particular mode of origin. For example, leaves of *Ficus myrtifolia* and *Capparis eocenica*, which are very durable, have been found at 15 and 18 localities respectively, but all these localities are confined to the eastern shores of the Wilcox-Mississippi embayment, and I believe that this indicates that these species were entirely absent or exceedingly rare along the western shores of the embayment, or else they would have been detected in the material from some one of the 38 plant-bearing localities scattered from Arkansas to the Mexican border.

I have therefore sought to obtain the dominant members of the Wilcox flora by preparing a list of all forms found at 10 or more localities. To a certain extent these forms have been successfully fossilized because they grew in available situations; the durability of their leaves is a factor, and accidents of discovery play a small part; nevertheless, this method is the most trustworthy available.

The total number of Wilcox species occurring at 10 or more localities is 46. These species represent 22 different families and the following 17 natural orders: Arecales, Juglandales, Fagales, Urticales, Proteales, Ranales, Papaverales, Rosales, Rutales, Malpighiales, Sapindales, Rhamnales, Malvales, Parietales, Laurales, Myrtales, and Gentianales. The Laurales lead, with 10 species out of the 46; the Rosales are second, with 7 species; the Sapindales are third, with 5; and the Gentianales are fourth, with 4. In the Wilcox flora as a whole the Lauraceae is the largest family and the Rosales the largest order, so that the most widely represented orders are those with the largest number of Wilcox species. All these dominant species are angiosperms; there are no conifers, ferns, or lower plants present at as many as 10 localities; and if the relative durability of coniferous cones and foliage is considered, it must be admitted that the conifers were an inconspicuous element in the Wilcox flora and that in the low, wet Wilcox coastal regions, which were seemingly admirably suited to the cypress (*Taxodium*), it grew much less abundantly than in the Miocene, Pliocene, Pleistocene, and Recent Coastal Plain region.

Only one monocotyledon appears on the list—*Sabalites grayanus*. It has been found at 40 localities and at all horizons in the Wilcox and along the Wilcox coast from the State of Mississippi around the head of the embayment and along its west coast to Texas. As this species occurs also outside the Wilcox area, it must be considered a long-lived and dominant form, and its ubiquity also suggests that its habits were like our modern *Sabal palmetto*, which frequents sandy soil near the coast from North Carolina to western Florida. It is possible that *Sabalites grayanus* represents more than a single botanic species. The determination rests on leaves and leaf fragments, which show minimal specific characters, but no differential criteria have been found among the large number of specimens of *Sabalites grayanus* seen. It differs greatly in abundance at different localities but tends to be common. At Puryear, Tenn., it is common immediately below the richest fossiliferous clay; at Oxford, Miss., the clay exposed in the ravine contains hundreds of large leaves.

A species also represented at 40 widely distributed localities is *Nectandra pseudocoriacea*. The number of individual specimens is greater than those of the palm, doubtless because of its small, coriaceous leaves. Obviously such leaves resist decay, but selective trituration can hardly account for their ubiquity, for they have extended acuminate apices and bases, and these are rarely broken off, as they would be if the leaves had had rough usage in the waters that deposited the Wilcox sediments.

The third on the list is *Dryophyllum tennesseense*, which is found at 39 widely distributed localities and is the most abundant form at many individual outcrops. It is one of the commonest types in the great variety of forms found at Puryear, Tenn., and is equally common at a great many other localities. I can think of no reason for doubting that it was one of the most abundant and widespread types during Wilcox time.

Next in abundance is *Sapindus linearifolius*, which occurs at 32 localities and doubtless represents a widespread seashore species. Detailed comment is probably unnecessary for the remainder of the list. All were doubtless common strand plants. The Leguminosae are represented by seven species, *Sophora wilcoxiana* being seventh on the list, *Mimosites variabilis* twelfth, *Cassia fayettensis* thirteenth, *Gleditsiophyllum eocenicum* nineteenth, *Cassia glenni* twenty-fifth, *Canavalia eocenica* twenty-sixth, and *Cassia puryearensis* fortieth. There are three species of figs on the list, four species of *Sapindus*, three Apocynophyllums, a *Cedrela*, an *Anona*, a *Magnolia*, and two Banksias.

The following five species are confined to the eastern shores of the embayment, where they have been found at 10 to 18 localities: *Capparis eocenica*, *Ficus myrtifolia*, *Cassia glenni*, *Cassia puryearensis*, and *Cedrela wilcoxiana*. They serve to emphasize a considerable floral difference between the two shores of the embayment, which will be discussed in the section devoted to that topic.

The list of dominant Wilcox species, with the number of localities at which each has been found, follows:

Wilcox species found at 10 or more localities

	Number of localities		Number of localities
Sabalites grayanus	**40**	Mimosites variabilis	20
Nectandra pseudocoriacea	**40**	Cassia fayettensis	19
Dryophyllum tennesseense	39	Oreodaphne mississippiensis	19
Sapindus linearifolius	**32**	Sapindus eolignitica	19
Euonymus splendens	**31**	Capparis eocenica	18
Apocynophyllum sapindifolium	28	Engelhardtia ettingshauseni	18
Sophora wilcoxiana	**27**	Banksia saffordi	16
Ficus mississippiensis	**24**	Gleditsiophyllum eocenicum	16
Sapindus formosus	**24**	Mespilodaphne eolignitica	16
Oreodaphne obtusifolius	**23**		
Nectandra lancifolia	**22**		

Wilcox species found at 10 or more localities—Continued

	Number of localities		Number of localities
Juglans schimperi	15	**Magnolia angustifolia**	11
Ficus myrtifolia	15	**Mespilodaphne coushatta**	11
Ficus puryearensis	15	Apocynophyllum wilcoxense	11
Banksia tenuifolia	15	Dryophyllum puryearense	10
Cassia glenni	15	**Cassia puryearensis**	10
Canavalia eocenica	15	Banisteria pseudolaurifolia	10
Anona ampla	14	**Metopium wilcoxianum**	10
Cedrela wilcoxiana	14	Ternstroemites **eolignitícus**	10
Sapindus mississippiensis	14	**Cinnamomum oblongatum**	10
Grewiopsis tennesseensis	14	Mespilodaphne pseudoglauca	10
Nectandra lowii	14	**Myrcia bentonensis**	10
Apocynophyllum mississippiense	14		
Rhamnites knowltoni	13		
Melastomites verus	13		
Oreodaphne pseudoguianensis	12		

Wide-ranging Wilcox species.—I have brought together in the following list the Wilcox localities from which 25 or more species have been identified. It is of interest, as bearing on the chronologic range of the several Wilcox florules, that there is only one locality with over 25 species that is referred to the Ackerman formation. This locality is Hurleys, Miss., from which 32 species have been recorded. Only three localities—Grenada, Cottage Grove, and the locality 5 miles southwest of Williston—are referred to the Grenada formation, and these have yielded 57, 38, and 25 species, respectively. The remaining localities, except Naborton, Mansfield, and Coushatta in Louisiana and Nevada County in Arkansas, which are along the western shore of the Mississippi embayment and which are not precisely allocated stratigraphically more definitely than that they are upper and not lower Wilcox, are localities in the Holly Springs sand along the eastern shore of the Mississippi embayment, and all but three of these—two in Mississippi and one in Kentucky—are in western Tennessee.

The most prolific locality, indeed the most prolific single locality for fossil plants of any age or in any region that I know, is that at Puryear, Henry County, Tenn. Here 205 different forms have been identified from a single clay lens. The variety found here is partly due to the completeness of preservation of all sorts of plant fragments, both large and small; it is also partly due to the very exhaustive collecting, the owners of the property having furnished facilities for splitting tons of the clay as it passed from the pit to the pottery. This is only a partial explanation of the profusion of forms discovered, however, for each subsequent visit has resulted in adding new species, and one is forced to conclude that an unusual variety of forms grew in this vicinity and were preserved in the sediments of the Puryear lagoon.

No other locality has yielded as many as 100 species, but I have no doubt that if the clays exposed at Mill Creek and Bolivar or in unworked pits, such as the Grable, Atkins, and LaGrange pits, were being mined, so that the collector could examine an amount of material comparable to that examined at Puryear, the number of species discovered would be comparable.

Localities in the Wilcox with more than 25 species

Puryear	205	¾ mile northwest of Pattersonville	34
Mill Creek	87	Clover Creek	33
Bolivar	75	Hurleys	32
Grable pit	61	Taylor farm	32
Grenada	57	Will Brooks farm	32
La Grange	56	Coushatta	30
Naborton	54	1½ miles west of Grand Junction	29
Thompson & Barksdale prospect	45	Early Grove	28
2.9 miles southwest of Somerville	43	Atkins pit	28
Jim Tomphson farm	42	Nevada County locality	28
Mansfield	40	Wickliffe	26
Holly Springs	39	5 miles southwest of Williston	25
Cottage Grove	38		
Shandy	38		

Wilcox species found at but a single locality.—The Wilcox species which have been recognized at but a single locality number 213. The list of these species is instructive. Thirty-seven forms belong to the Leguminosae, and my conclusion from this would be that species have probably been overrefined in this alliance and that several are probably foliar variants of more widely distributed forms. That there were not anything like 200 species of local occurrence in the Wilcox is made clear when attention is called to the nature of the remains upon which at least half of these 213 nominal species are founded. Thus there are 38 species based upon flowers or fruits that would not be expected to occur except under special conditions, and these, to a certain extent at least, duplicate species founded on foliar remains.

These 38 forms are in addition to 9 forms referred to *Antholithes*, 5 referred to *Calycites*, and 29 referred to *Carpolithus*, which again undoubtedly represent some duplication and which would not be expected at numerous localities. For example, but 10 of the 39 species of *Carpolithus* have been found at more than one locality.

There are five forms of spot fungi, which were doubtless widespread but which I usually ignored unless they were especially well characterized. There are six ferns, and these, as well as the *Marchantites* and *Lycopodites*, must be regarded as accidents of preservation and discovery rather than as indicating a restricted distribution. Two represent petrified wood and probably reflect the number of sections cut rather than the range of the species concerned.

Forms like the *Pistia*, *Trapa*, and *Nelumbo* represent special environmental conditions. *Dryophyllum juvenalis* is frankly a young leaf of one of the commoner species, the three Laurophyllums represent simply different stages of development, *Cinnamomum obovatum* is obviously pathologic, and a great many are probably foliar variants of more common species.

A certain number, however, do not appear to represent any of the categories mentioned above but show evidence of being species of uncommon occurrence and narrow range. These are

Ficus eolignitica.
Acacia wilcoxensis.
Inga puryearensis.
Hymenaea eocenica.
Hymenaea wilcoxiana.
Citrophyllum bifoliolatum.
Citrophyllum wilcoxianum.
Fagara eocenica.
Fagara hurleyensis.
Fagara puryearensis.
Drypetes prelateriflora.
Anacardites serratus.
Ilex eolignitica.
Negundo knowltoni.
Sapindus coushatta.
Paliurus angustus.
Paliurus pinsonensis.
Rhamnus puryearensis.
Buettneria eocenica.
Dillenites serratus.
Clusiaphyllum eocenicum.
Cryptocarya eolignitica.
Nectandra parvula.
Eugenia puryearensis.
Myrcia puryearensis.
Melastomites ovatus.
Bumelia grenadensis.
Mimusops sieberifolia.
Sideroxylon premastichodendron.
Diospyros asper.
Apocynophyllum crassum.

Wilcox species found at but a single locality

Caenoymces (5 species).
Marchantites stephensoni.
Lycopodites? eoligniticus.
Lygodium hastataforme.
Acrostichum sp.
Asplenium hurleyense.
Cheilanthes eocenica.
Dryopteris cladophleboides.
Meniphylloides tennesseensis.
Zamia mississippiensis.
Zamia tennesseeana.
Athrotaxis? eolignitica.
Cupressinoxylon calli.
Cyperacites minutus.
Cyperacites wilcoxensis.
Potamogeton fructus.
Potamogeton? glücki.
Araceaeites friteli.
Acorus heeri.
Pistia wilcoxensis.
Sparganium sp.
Palmocarpon cf. P. sessile.
Phyllites wilcoxensis.
Hicoria antiquorum.
Juglans saffordiana.
Dryophyllum amplum.
Dryophyllum juvenale.
Planera? crenata.
Ficus eolignitica.
Ficus fructus.
Aristolochia wilcoxiana.
Coccolobis eolignitica.
Pisonia fructifera.
Pisonia praejacksoniana.
Asimina leiocarpa.
Menispermites cebathoides.
Menispermites wilcoxensis.
Ceratophyllum incertum.
Nelumbo protolutea.
Acacia wilcoxensis.
Inga puryearensis.
Pithecolobium? tennesseense.
Caesalpinites bentonensis.
Cassia lowii.
Cassia bolivarensis.
Cassia nictitanioides.
Cassia glenni var.
Cassia robertsi.
Copaifera? wilcoxiana.
Gleditsiophyllum constrictum.
Gleditsiophyllum ellipticum.
Gleditsiophyllum entadaforme.
Gleditsiophyllum hilgardianum.
Gleditsiophyllum ovatum.
Cryptocarya eolignitica.
Nectandra parvula.
Oreodaphne wilcoxensis.
Persea fructifera.
Laurus hardemanensis.
Laurus versus.
Laurophyllum florum.
Laurophyllum juvenale.
Laurophyllum preflorum.
Eugenia densinervia.
Eugenia hilgardiana.

Eugenia puryearensis.
Myrcia puryearensis.
Terminalia wilcoxiana.
Trapa wilcoxensis.
Melastomites ovatus.
Aralia jorgenseni.
Aralia? semina.
Oreopanax minor.
Schefflera elliptica.
Nyssa curta.
Nyssa tennesseensis.
Bumelia grenadensis.
Bumelia hurleyensis.
Bumelia pseudohorrida.
Bumelia pseudolycioides.
Hymenaea eocenica.
Hymenaea wilcoxiana.
Cladrastis eocenica.
Dalbergia attenuatus.
Dalbergia monospermoides.
Dalbergia tennesseensis.
Dalbergites ovatus.
Sophora lesquereuxi.
Leguminosites (14 species).
Citrophyllum bifoliatum.
Citrophyllum wilcoxianum.
Fagara eocenica.
Fagara hurleyensis.
Fagara puryearensis.
Ptelea eocenica.
Rutaphyllum trifoliatum.
Zygophyllum? eocenicum.
Simarubites eocenicus.
Cedrela mississippiensis major.
Banisteria fructuosa.
Banisteria repandifolia.
Crotonophyllum appendiculatum.
Crotonophyllum eocenicum.
Drypetes prelateriflora.
Euphorbiophyllum fayettense.
Manihot eocenica.
Anacardites inequilateralis.
Anacardites serratus.
Ilex affinis.
Ilex eolignitica.
Celastrus bolivarensis.
Celastrus bruckmannifolia.
Euonymus? fructescens.
Negundo knowltoni.
Dodonaea knowltoni.
Dodonaea parvula.
Sapindus coushatta.
Sapindus fructiferus.
Calatoloides eocenicum.
Paliurus angustus.
Paliurus pinsonensis.
Reynosia praenuntia longepetiolata.
Rhamnites berchemiaformis.
Rhamnus puryearensis.
Grewiopsis wadii.
Monocarpellites perkinsi.
Buettneria eocenica.
Helictoxylon wilcoxianum.
Pterospermites cf. P. minor.
Sterculia zavalana.
Sterculiocarpus sezannelloides.
Dillenites serratus.
Clusiaphyllum eocenicum.
Cinnamomum obovatum.
Mimusops sieberifolia.
Sideroxylon premastichodendron.
Diospyros asper.
Diospyros madisonensis.
Diospyros sp.
Fraxinus wilcoxiana.
Apocynophyllum crassum.
Apocynophyllum parvulum.
Apocynophyllum preplumiera.
Avicennia eocenica.
Solanites saportana.
Solanites sarrachaformis.
Bignonicapsula formosa.
Psychotria grandifolia.
Rubiacites pellicieraformis.
Antholithes (9 species; all).
Calycites (5 species; all).
Carpolithus (29 species; 10 at more than one locality).
Pterobalanus texanus.
Phyllites (3 species).

Flora of the Ackerman formation.—No detailed examination of the outcrop of the Ackerman formation has been made. The three localities in northeastern Mississippi from which fossil plants are reported were discovered by Hilgard many years ago, and I have visited but one of these—that at Hurleys. Consequently the number of plants reported from the formation is small and would doubtless be greatly increased by field studies.

The known flora of the Ackerman formation numbers but 36 species. This is less than one-fourth the number known from the Grenada formation and about one-tenth that of the Holly Springs sand. It is fairly well distributed, however, for these few species represent 18 families in 16 orders. Only the orders Ranales and Myrtales are represented by more than a single family, and both these have 2 families present. The Lauraceae, with 6 species, is the largest family, and the Moraceae is second, with 5 species. There are 3 ferns, a palm, 5 figs, and a single member of the Leguminosae supposed to represent the family Caesalpiniaceae. No species of *Sapindus* have been discovered.

Of the 36 species 9 are restricted to the Ackerman formation, 4 are common to the Midway(?) of central Texas, 25 extend up into the Holly Springs sand, and 14 certainly and 3 doubtfully are found in the Grenada formation. Twelve are identical with and two others are closely related to species found in the Raton formation of Colorado and New Mexico. This serves to emphasize the somewhat more ancient facies of the Ackerman flora as compared with those of the later Wilcox, as the Raton formation is somewhat older than the Wilcox.

Flora of the Ackerman formation

	Peculiar	Midway(?) of central Texas	Holly Springs sand	Grenada	Raton	Denver	Fort Union
Asplenium eoligniticum	----	----	----	----	----	×	----
Asplenium hurleyense	×	----	----	----	([a])	----	----
Asimina leiocarpa	×	----	----	----	----	----	----
Bumelia hurleyensis	×	----	----	----	----	----	----
Bumelia pseudotenax	----	----	×	----	----	----	----
Chamaedorea danai	----	----	×	----	([a])	----	----
Combretum ovale	----	----	×	(?)	×	----	----
Cordia? lowii	×	----	----	----	----	----	----
Dillenites ovatus	----	----	----	(?)	----	----	----
Dryophyllum moorii	----	----	×	(?)	×	----	----
Eugenia hilgardiana	×	----	----	----	----	----	----
Fagara hurleyensis	×	----	----	----	----	----	----
Ficus mississippiensis	----	----	×	×	×	×	×
Ficus monodon	----	----	×	×	×	----	----
Ficus occidentalis	----	×	----	----	×	×	----
Ficus puryearensis	----	----	×	×	----	----	----
Ficus schimperi	----	----	×	×	×	----	----
Gleditsiophyllum hilgardianum	×	----	----	----	----	----	----
Lygodium binervatum	×	----	----	----	----	----	----
Magnolia leei	----	----	×	----	×	----	----
Mespilodaphne eolignitica	----	----	×	×	----	----	----
Mimusops eolignitica	----	----	×	----	----	----	----
Myrcia bentonensis	----	----	×	×	----	----	----
Myrcia elaeanoides	----	----	×	----	----	----	----
Nectandra lancifolia	----	----	×	×	×	----	----
Nectandra pseudocoriacea	----	----	×	×	----	----	----
Oreodaphne mississippiensis	----	----	×	×	----	----	----
Oreodaphne obtusifolia	----	----	×	×	----	----	----
Oreodaphne puryearensis	----	----	×	----	----	----	----
Osmanthus pedatus	----	----	×	×	×	----	----
Pisonia chlorophylloides	×	----	----	----	----	----	----
Rhamnus marginatus	----	----	×	----	----	----	----
Rhamnus marginatus apiculatus	----	(?)	×	×	----	----	----
Terminalia hilgardiana	----	×	×	×	×	----	×
Terminalia lesleyana	----	×	×	×	×	----	----
Zizyphus meigsii	----	----	×	----	×	----	----

[a] Closely related species.

Flora of the Holly Springs sand.—The flora found in the Holly Springs sand is so extensive that an enumeration and discussion of it would be in large part a repetition of a discussion of the Wilcox flora as a whole. I therefore simply present below a list of the species that have been found in the Holly Springs sand of the eastern Gulf area, which have not been detected in either the Ackerman or the Grenada formations.

These number 238 species in 118 genera, 68 families, and 39 orders. Their most noteworthy feature is the extraordinary abundance and variety of the Leguminosae. The flora, as a whole, numbers well over 350 species and abounds in representatives of the families Apocynaceae, Caesalpiniaceae, Combretaceae, Juglandaceae, Lauraceae, Mimosaceae, Moraceae, Myrtaceae, Papilionaceae, Proteaceae, Sapindaceae, Sapotaceae, Sterculiaceae, and Ternstroemiaceae. It receives 25 species from the flora of the underlying Ackerman formation and contributes 127 species to the flora of the overlying Grenada formation.

The list of peculiar species in the Holly Springs flora follows:

Acacia wilcoxensis.
Acerates wilcoxiana.
Acorus heeri.
Anacardites eocenicus.
Anacardites falcatus.
Anacardites marshallensis.
Anacardites metopifolia.
Anacardites puryearensis.
Anacardites serratus.
Anemia eocenica.
Antholithes (6 species).
Apocynophyllum crassum.
Apocynophyllum parvulum.
Apocynophyllum preplumiera.
Apocynophyllum tabellarum.
Apocynophyllum wilcoxense.
Aristolochia wilcoxiana.
Artocarpoides wilcoxensis.
Arthrotaxis? eolignitica.
Avicennia eocenica.
Avicennia nitidaformis.
Banara eocenica.
Banisteria fructuosa.
Banisteria repandifolia.
Banisteria wilcoxiana.
Banksia puryearensis.
Bignonicapsula formosa.
Bombacites eocenicus.
Bombacites formosus.
Bombacites wilcoxianus.
Buettneria eocenica.
Bumelia pseudohorrida.
Bumelia pseudolycioides.
Caenomyces (5 species).
Caesalpinites mississippiensis.
Caesalpinites pinsonensis.
Caesalpinites wilcoxensis.
Calycites (5 species).
Calyptranthes eocenica.
Canavalia acuminata.
Carpolithus (33 species).
Carapa eolignitica.
Cassia bolivarensis.
Cassia emarginata.
Cassia eolignitica.
Cassia marshallensis.
Cassia nictitanioides.
Cassia tennesseensis.
Cassia wilcoxiana.
Cedrela mississippiensis.
Cedrela puryearensis.
Celastrus bolivarensis.
Celastrus bruckmannifolia.
Celastrocarpus eocenicus.
Ceratophyllum incertum.
Cercis wilcoxiana.
Cheilanthes eocenica.
Cinnamomum oblongatum.
Cinnamomum obovatum.
Cinnamomum ovoides.
Cissites collinsi.
Citrophyllum bifoliolatum.
Citrophyllum wilcoxianum.
Cladrastis eocenica.
Coccolobis eolignitica.
Coccolobis uviferafolia.
Combretanthites eocenica.
Conocarpus eolignitieus.
Copaifera? wilcoxiana.
Cordia eocenica.
Crotonophyllum eocenicum.
Cupanites eolignitieus.
Cyperacites minutus.
Cyperacites wilcoxensis.
Dalbergia attenuatus.
Dalbergia monospermoides.
Dalbergia tennesseensis.
Dalbergia wilcoxiana.
Dillenites microdentatus.
Dillenites serratus.
Diospyros asper.
Diospyros eolignitica.
Diospyros madisonensis.
Diospyros wilcoxiana.
Dodonaea knowltoni.
Dodonaea parvula.
Dodonaea wilcoxiana.
Dryophyllum amplum.
Dryophyllum anomalum.
Drypetes prekeyensis.
Drypetes prelateriflora.
Engelhardtia mississippiensis.
Engelhardtia puryearensis.
Equisetum sp.
Eugenia puryearensis.
Euphorbiophyllum fayettense.
Exostema pseudocaribaeum.
Fagara eocenica.
Fagara puryearensis.
Ficus cinnamomoides.
Ficus fructus rostrata.
Ficus pandurifolia.
Ficus pseudocuspidata.
Fraxinus wilcoxiana.
Gleditsiophyllum constrictum.
Gleditsiophyllum entadaforme.
Gleditsiophyllum ellipticum.
Gleditsiophyllum minor.
Gleditsiophyllum ovatum.
Grewiopsis elegans.
Heterocalyx saportana.
Hiraea wilcoxiana.
Hymenaea eocenica.
Hymenaea wilcoxiana.
Icacorea prepaniculata.
Ilex eolignitica.
Ilex vomitoriafolia.
Inga puryearensis.
Inga wickliffensis.
Juglans berryi.
Juglans saffordiana.
Laurus collinsi.
Laurus hardemanensis.
Laurophyllum florum.
Laurophyllum juvenale.
Laurophyllum preflorum.
Leguminosites (21 species).
Liquidambar wilcoxianum.
Lycopodites? eolignitieus.
Magnolia angustifolia.
Manihot eocenica.
Melastomites ovatus.
Melastomites verus.
Menispermites americanus.
Menispermites cebathoides.
Menispermites hardemanensis.
Menispermites wilcoxensis.
Mespilodaphne puryearensis.
Mimosites acaciafolius.
Mimosites inaequilateralis.
Mimosites lanceolatus.
Mimosites wilcoxensis.
Mimusops prenuntia.
Mimusops sieberifolia.
Monocarpellites perkinsi.
Myrcia parvifolia.
Myrcia puryearensis.
Myrcia wortheni.
Myrica puryearensis.
Nyssa curta.
Nyssa eolignitica.
Nyssa tennesseensis.
Nyssa wilcoxiana.
Oreodaphne intermedius.
Oreodaphne wilcoxensis.
Oreopanax minor.
Oreopanax oxfordensis.
Oreopanax wilcoxensis.
Palaeodendron americanum.
Paliurus angustus.
Paliurus pinsonensis.
Palmocarpon syagrusioides.
Parkinsonia eocenica.
Persea fructifera.
Pisonia eolignitica.
Pisonia fructifera.
Pisonia praejacksoniana.
Pisonia puryearensis.
Pithecolobium eocenicum.
Pithecolobium? tennesseense.
Potamogeton glücki.
Potamogeton incertus.
Potamogeton fructus.
Pseudolmedia eocenica.
Psychotria grandifolia.
Ptelea eocenica.
Rhamnites berchemiaformis.
Rhamnus eolignitieus.
Rhamnus puryearensis.
Rubiacites pellicieraformis.
Rubiacites sphericus.
Rubiacites wilcoxensis.
Salvinia preauriculata.
Sapindus fructiferus.
Sapindus knowltoni.
Sapindus pseudaffinis.
Schefflera elliptica.
Sideroxylon ellipticum.
Sideroxylon premastichodendron.
Simaruba eocenica.
Simarubites eocenicus.
Smilax wilcoxensis.
Solanites crassus.
Solanites pusillus.
Solanites saportana.
Solanites sarrachaformis.
Sophora henryensis.
Sophora mucronata.
Sophora palaeolobifolia.
Sophora puryearensis.
Sophora repandifolia.
Sparganium sp.
Sterculiocarpus sezannelloides.
Taxites? sp.
Taxodium dubium.
Taxodium wilcoxianum.
Terminalia vera.
Ternstroemites crassus.
Trapa wilcoxensis.
Vantanea wilcoxiana.
Zamia tennesseeana.
Zamia wilcoxensis.
Zygophyllum? eocenicum.

Flora of the Grenada formation.—It does not appear to be possible at present to correlate the Wilcox plants found in the region southwest of Louisiana with the threefold divisions of the Wilcox established in Mississippi. The most that can be done is to determine them to be later instead of earlier Wilcox; consequently they are not included in the following list of the known flora of the Grenada formation and its precise equivalents.

This list comprises the species identified from the following 15 localities in the States of Mississippi and Tennessee: Grenada (the type locality of the formation) and Meridian, Miss.; Cottage Grove, 1⅕ miles south of Somerville; Brinkley property, 2.9 miles southeast of Somerville; float in orange sand, north of the Loosahatchie, Whiteville gully, near Trenton; Safford-Lesquereux locality, 1 mile north of Dancyville; 1½ miles northeast of Williston; 4¾ miles southwest of Williston; and 5 miles southwest of Williston, Tenn.

Flora of the Grenada formation

	Peculiar	Found in Ackerman formation	Found in Holly Springs sand	Near top of Holly Springs sand
Amygdalus wilcoxiana			×	
Anacardites grevilleafolia				×
Anacardites inequilateralis	×			
Anacardites minor				×
Anona ampla				×
Anona eolignitica			×	
Anona robertsi			×	
Anona wilcoxiana				×
Antholithes amentiferus	×			
Antholithes iliciformis	×			
Antholithes wilcoxensis	×			
Apocynophyllum mississippiense			×	
Apocynophyllum sapindifolium			×	
Aralia acerifolia	×			
Aralia jorgenseni	×			
Artocarpoides balli			×	
Artocarpus pungens			×	
Banisteria pseudolaurifolia			×	
Banksia saffordi			×	
Banksia tenuifolia			×	
Berchemia eocenica				×
Bumelia americana				×
Bumelia grenadensis	×			
Bumelia wilcoxiana			×	
Caenomyces pestalozzites			×	
Canavalia eocenica			×	
Canna eocenica			×	
Capparis eocenica			×	
Carpolithus grenadensis	×			
Carpolithus hiraeformis	×			
Carpolithus pilocarpoides	×			
Carpolithus puryearensis				×
Carpolithus somervillensis	×			
Carpolithus sophorites	×			
Cassia fayettensis			×	
Cassia glenni			×	
Cassia lowii	×			
Cassia puryearensis			×	
Cassia robertsi	×			
Cedrela odoratifolia(?)			×	
Cedrela wilcoxiana			×	

Flora of the Grenada formation—Continued

	Peculiar	Found in Ackerman formation	Found in Holly Springs sand	Near top of Holly Springs sand
Celastrus eolignitica			×	
Celastrus minor			×	
Celastrus veatchi			×	
Chrysobalanus eocenica			×	
Chrysobalanus inaequalis				×
Chrysophyllum ficifolium				×
Cissites asymmetrica			×	
Citharexylon eolignitícum				×
Combretum leve				×
Combretum obovale				×
Combretum ovale		(?)		
Combretum wilcoxense				×
Cryptocarya wilcoxiana				×
Cupanites amplus				×
Cupanites formosus				×
Cupanites loughridgii				×
Dalbergia puryearensis				×
Dalbergites ellipticifolius	×			
Dalbergites ovatus	×			
Dillenites ovatus		(?)		
Dillenites tetracerafolia				×
Dillenites texensis				×
Diospyros brachysepala				×
Dryophyllum moorii		(?)		
Dryophyllum puryearense			×	
Dryophyllum tennesseense			×	
Engelhardtia ettingshauseni			×	
Eugenia densinervia	×			
Eugenia grenadensis				×
Euonymus splendens			×	
Ficus artocarpoides?			×	
Ficus fructus pedicellata	×			
Ficus mississippiensis		×		
Ficus mississippiensis gigantea	×			
Ficus monodon		×		
Ficus myrtifolia			×	
Ficus puryearensis		×		
Ficus pseudolmediafolia				×
Ficus schimperi		×		
Ficus tennesseensis			×	
Ficus vaughani			×	
Ficus wilcoxensis			×	
Fraxinus johnstrupi				×
Gleditsia? mississippiensis			×	
Gleditsiophyllum eocenicum			×	
Glyptostrobus europaeus			×	
Grewiopsis tennesseensis			×	
Guettarda ellipticifolia			×	
Hicoria crescentia				×
Inga laurinafolia				×
Inga mississippiensis			×	
Juglans occidentalis			×	
Juglans schimperi			×	
Knightiophyllum wilcoxianum				×
Laguncularia preracemosa?			×	
Leguminosites collinsi			×	
Leguminosites contortus	×			
Lygodium trilobatum			×	
Magnolia leei		×	×	×
Maytenus puryearensis				×
Melastomites americanus			×	
Meniphylloides ettingshauseni	×			
Meniphylloides tennesseensis	×			
Mespilodaphne eolignitica		×		
Mespilodaphne pseudoglauca				×
Metopium wilcoxianum			×	
Mimosites variabilis			×	
Mimusops mississippiensis			×	
Myrcia bentonensis		×		
Myrcia grenadensis	×			
Myrcia vera			×	
Myrica elaeanoides				
Myrica wilcoxensis				×

Flora of the Grenada formation—Continued

	Peculiar	Found in Ackerman formation	Found in Holly Springs sand	Near top of Holly Springs sand
Nectandra glenni?			×	
Nectandra lancifolia		×		
Nectandra lowii			×	
Nectandra parvula	×			
Nectandra pseudocoriacea		×		
Nectandra puryearensis				×
Nectandra wilcoxensis				×
Negundo knowltoni	×			
Nelumbo protolutea	×			
Nipadites burtini umbonatus	×			
Oreodaphne mississippiensis		×	×	
Oreodaphne obtusifolia		×		
Oreodaphne pseudoguianensis				×
Oreodaphne salinensis				×
Osmanthus pedatus		×		
Ouratea eocenica				×
Paliurus mississippiensis			×	
Paraengelhardtia eocenica				×
Persea wilcoxiana	×			
Phanerophlebites knowltoni				×
Phyllites grenadensis	×			
Phyllites wilcoxensis	×			
Pithecolobium oxfordense?			×	
Planera crenata?	×			
Platanus nobilis?			×	
Proteoides wilcoxensis			×	
Pteris pseudopinnaeformis			×	
Reynosia praenuntia?			×	
Reynosia wilcoxiana				×
Rhamnites knowltoni			×	
Rhamnites cleburni	×			
Rhamnus coushatta			×	
Rhamnus marginatus apiculatus		×		
Rutaphyllum trifoliatum	×			
Sabalites grayanus			×	
Sapindus eoligniticus			×	
Sapindus formosus			×	
Sapindus linearifolius			×	
Sapindus mississippiensis			×	
Sapindus oxfordensis			×	
Schefflera formosa			×	
Sophora lesquereuxi	×			
Sophora wilcoxiana			×	
Sterculia knowltoni				×
Sterculia puryearensis			×	
Sterculia wilcoxensis			×	
Sterculiocarpus sphericus			×	
Terminalia hilgardiana		×		
Terminalia lesleyana		×		
Terminalia wilcoxiana	×			
Ternstroemites eoligniticus			×	
Ternstroemites lanceolatus			×	
Ternstroemites ovatus				×
Ternstroemites preclaibornensis			×	
Zamia mississippiensis	×			
Zizyphus falcatus				×

The total number of species enumerated is 163, which is a much smaller number than is recorded from the Holly Springs sand. This smaller number is due primarily to the large number of excellently preserved plants collected toward the top of the Holly Springs sand, the conditions for preservation in late Holly Springs time seeming to have been unexcelled. This fact also obscures the normal floral contrast that might be expected to have existed between the two formations, a majority of the members of the flora of the Grenada formation making their appearance in the upper part of the Holly Springs sand.

The Grenada flora has little in common with the flora of the early Wilcox Ackerman formation, only the following 14 species certainly extending into it from that earlier horizon, although 3 additional are doubtfully represented:

Ficus mississippiensis (24).
Ficus monodon.
Ficus puryearensis (15).
Magnolia leei.
Mespilodaphne eolignitica (16).
Myrcia bentonensis (10).
Nectandra lancifolia (22).
Nectandra pseudocoriacea (40).
Oreodaphne mississippiensis.
Oreodaphne obtusifolia (23).
Osmanthus pedatus.
Rhamnus marginatus apiculatus.
Terminalia hilgardiana.
Terminalia lesleyana.

Seven of these have been found at 10 to 40 different localities (as indicated) widely distributed in the Wilcox area; *Ficus mississippiensis*, *Ficus monodon*, *Magnolia leei*, and *Osmanthus pedatus* were abundant in the early Eocene along the southern Rocky Mountain front, and the two species of *Terminalia* are known to have had a wide range, both chronologic and geographic, so that all the forms enumerated except *Oreodaphne mississippiensis* and *Rhamnus marginatus apiculatus* may legitimately be considered to have been dominant, wide-ranging, and long-lived forms, altogether lacking any close chronologic value.

Considered in this light the contrast between the floras of the Ackerman and Grenada formations is profound. Naturally, if the known flora of the Ackerman formation was more extensive the prevailing contrasts would probably be considerably modified. No such striking contrasts can be drawn between the floras of the Holly Springs sand and Grenada formation, and this is due in part to the fine-textured clays of the lagoons during the later part of Holly Springs time, in which was preserved so abundant a representation of the plants that mantled the Holly Springs coasts.

All but 36 of the 163 Grenada species have been found in the Holly Springs sand. Of the 127 common species, however, 40 have not been recorded from the Holly Springs sand at horizons below its uppermost beds as developed in Henry County, Tenn., and although these greatly increase the difficulty of drawing the boundary between the two formations, they emphasize, on the other hand, the essentially more modern facies of the Grenada flora.

The following 36 Grenada species were restricted to that horizon in the Wilcox. On the whole the generic facies of the Grenada is similar to that which existed during earlier Wilcox time, but seven genera (*Dalbergites*, *Meniphylloides*, *Negundo*, *Nelumbo*, *Nipadites*, *Planera*, and *Rutaphyllum*) are unknown from horizons earlier than the Grenada and are therefore of considerable significance.

The species peculiar to the Grenada are

Anacardites inequilateralis.	Ficus mississippiensis gigantea.
Antholithes amentiferus.	Leguminosites contortus.
Antholithes iliciformis.	Meniphylloides ettingshauseni.
Antholithes wilcoxensis.	Meniphylloides tennesseensis.
Aralia acerifolia.	Myrcia grenadensis.
Aralia jorgenseni.	Nectandra parvula.
Bumelia grenadensis.	Negundo knowltoni.
Carpolithus grenadensis.	Nelumbo protolutea.
Carpolithus hirneaformis.	Nipadites burtini umbonatus.
Carpolithus pilocarpoides.	Persea wilcoxiana.
Carpolithus somervillensis.	Phyllites grenadensis.
Carpolithus sophorites.	Phyllites wilcoxensis.
Cassia lowii.	Planera crenata?
Cassia robertsi.	Rhamnus cleburni.
Dalbergites ellipticifolius.	Rutaphyllum trifoliatum.
Dalbergites ovatus.	Sophora lesquereuxi.
Eugenia densinervia.	Terminalia wilcoxiana.
Ficus fructus pedicellata.	Zamia mississippiensis.

THE WILCOX FLORA AS DEVELOPED ON THE EASTERN AND WESTERN SHORES OF THE MISSISSIPPI GULF

Because of the differences of climate between the eastern and western shores of the Gulf embayment, and because the eastern shore with its warmer climate is geographically tributary to the Antillean region, whereas the western shore is tributary to Mexico and Central America and is in direct connection with the site of extensive early Eocene floras in the Rocky Mountain region, it is important to see whether the Wilcox floras along the two shores of the Gulf show any differences in facies that can be attributed either to climate or to geographic sources of origin.

To some extent the evidence is incomplete, because so many more plant localities and species are known from the eastern than from the western shores of the embayment, but this is unavoidable and is necessarily true of all discussions of fossil floras and faunas. In the evaluation of negative evidence one must always remember that the recorded geographic range of an organism as well as its geologic range is purely an expression of the state of knowledge at any particular time and that discovery is constantly changing these limits. This is just as true of the distribution of a recent organism. Recent years have seen the discovery of such typical American genera as *Liriodendron*, *Sassafras*, and *Hicoria* in China; and the range of our existing bald cypress, which was formerly thought to die out in the Florida peninsula, has been extended southward with the exploration of the southern part of the peninsula.

An additional factor that should be borne in mind throughout the following discussion is that all the plants thus far discovered in the western Gulf area, except the small florule from the Midway(?) or early Wilcox in central Texas alluded to in a former section, are referable to the upper Wilcox, whereas the flora of the eastern Gulf area falls naturally into an older (Ackerman); an intermediate (Holly Springs sand), and a younger (Grenada) division. Precise correlation of the western Gulf plants can not be made in terms of this threefold eastern Gulf aggregation. The upper Wilcox as used in the western Gulf area corresponds to the upper part of the Holly Springs sand and the Grenada of the eastern Gulf area.

As the larger part of the flora of the Holly Springs sand came from beds toward the top of that formation in western Tennessee, and as the lower part of the Holly Springs sand and the underlying Ackerman formation are sparingly fossiliferous, the disparity in the following comparisons between the floras of the eastern and the western Gulf areas is not greatly modified by differences in the age of the two.

The total number of Wilcox plant forms to date is 543. More than one-fourth of this number are common to the two areas. The following 144 species distributed among 77 genera represent these common forms:

Equisetum sp.	Magnolia angustifolia.
Anemia eocenica.	Magnolia leei.
Lygodium trilobatum.	Anona ampla.
Asplenium eolignitieum.	Anona eolignitica.
Meniphylloides ettingshauseni.	Anona wilcoxiana.
Pteris pseudopennaeformis.	Parrotia cuneata.
Zamia wilcoxensis.	Chrysobalanus inaequalis.
Glyptostrobus europaeus.	Amygdalus wilcoxiana.
Poacites sp.	Prunus nabortensis.
Chamaedorea danai.	Inga laurinafolia.
Palmocarpon butlerense.	Inga wickliffensis.
Sabalites grayanus.	Mimosites variabilis.
Canna eocenica.	Cassia eolignitica.
Engelhardtia ettingshauseni.	Cassia fayettensis.
Juglans berryi.	Cassia marshallensis.
Juglans schimperi.	Cassia tennesseensis.
Myrcia wilcoxensis.	Gleditsiophyllum eocenicum.
Dryophyllum anomalum.	Gleditsiophyllum fructuosum.
Dryophyllum moorii.	Canavalia eocenica.
Dryophyllum tennesseense.	Sophora repandifolia.
Ficus artocarpoides?	Sophora wilcoxiana.
Ficus denveriana?	Leguminosites prefoliatus.
Ficus harrisiana.	Simaruba eocenica.
Ficus mississippiensis.	Vantanea wilcoxiana.
Ficus puryearensis.	Banisteria pseudolaurifolia.
Ficus puryearensis elongata.	Banisteria wilcoxiana.
Ficus pseudocuspidata.	Hiraea wilcoxiana.
Ficus pseudolmediafolia.	Anacardites eocenicus.
Ficus schimperi.	Anacardites grevilleafolia.
Ficus vaughani.	Anacardites puryearensis.
Artocarpus pungens.	Metopium wilcoxianum.
Artocarpoides balli.	Ilex sp.
Artocarpoides wilcoxensis.	Celastrus taurinensis.
Banksia puryearensis.	Celastrus veatchi.
Banksia saffordi.	Euonymus splendens.
Palaeodendron americanum.	Cupanites eolignitieus.
Coccolobis uviferafolia.	Sapindus eolignitieus.
Pisonia eolignitica.	Sapindus formosus.

Sapindus linearifolius.
Sapindus mississippiensis.
Sapindus knowltoni.
Rhamnites knowltoni.
Rhamnus **cleburni.**
Rhamnus coushatta.
Rhamnus eoligniticus.
Rhamnus marginatus.
Rhamnus marginatus apiculatus.
Grewiopsis tennesseensis.
Sterculia puryearensis.
Sterculia wilcoxensis.
Bombacites formosus.
Bombacites wilcoxianus.
Dillenites ovatus.
Dillenites texensis.
Ternstroemites eoligniticus.
Ternstroemites ovatus.
Ternstroemites preclaibornensis.
Cinnamomum buchii.
Cinnamomum oblongatum.
Mespilodaphne coushatta.
Mespilodaphne eolignitica.
Mespilodaphne pseudoglauca.
Nectandra glenni.
Nectandra lancifolia.
Nectandra lowii.
Nectandra puryearensis.
Nectandra pseudocoriacea.
Nectandra sp.
Oreodaphne coushatta.
Oreodaphne mississippiensis.
Oreodaphne obtusifolius.
Oreodaphne puryearensis.
Oreodaphne pseudoguianensis.
Oreodaphne salinensis.
Persea longipetiolata.
Persea wilcoxiana.
Calyptranthes eocenica.
Eugenia grenadensis.
Myrcia bentonensis.
Myrcia vera.
Combretum obovale.
Combretum ovale.
Combretum wilcoxense.
Concocarpus eoligniticus.
Terminalia hilgardiana.
Terminalia lesleyana.
Melastomites americanus.
Melastomites verus.
Oreopanax oxfordensis.
Oreopanax wilcoxensis.
Nyssa wilcoxiana.
Icacorea prepaniculata.
Bumelia americana.
Bumelia pseudotenax.
Mimusops mississippiensis.
Diospyros brachysepala.
Diospyros eolignitica.
Diospyros wilcoxiana.
Fraxinus johnstrupi.
Apocynophyllum constrictum.
Apocynophyllum mississippiense.
Apocynophyllum sapindifolium.
Apocynophyllum tabellarum.
Apocynophyllum wilcoxense.
Cordia lowii.
Avicennia nitidaformis.

The total number of plants from the western area amounts to 181 species, and of this number 79.6 per cent are also found in the eastern area. This leaves 37 species distributed among 33 genera which are restricted to the western area. "Restricted" is here used as between the Wilcox floras of the eastern and western Gulf areas and is not intended to signify that some of the species may not have an outside range. These forms come from 38 different localities scattered from Arkansas to the Rio Grande.

Of these 33 genera the following are entirely unrepresented in the eastern area: *Acrostichum*, *Araceaeites*, *Calatoloides*, *Clusiaphyllum*, *Cupressinoxylon*, *Dryopteris*, *Helictoxylon*, *Marchantites*, *Pistia*, and *Pterobalanus.* It is interesting to note that the closest relative of *Calatoloides* is a living Central American genus, and that the *Dryopteris* is an immigrant into the Coastal Plain from the somewhat earlier Raton formation in southeastern Colorado. *Pterobalanus* is a unique type of unascertained botanic relationship, and the others are without significance except *Cupressinoxylon*, which shows seasonal growth rings. As this genus has not been found in the eastern Gulf area these specimens have no comparative climatic value, but they are of some interest in connection with the climate of the western area. (See p. 39.)

The list of species restricted to the western area is given below. The following forms are found at earlier horizons in the western United States and are undoubtedly immigrants in the southwestern Coastal Plain: *Aralia notata*, *Artocarpus lessigiana*, *Cinnamomum affine*, *Dryopteris cladophleboides*, *Hicoria antiquorum*, *Ilex affinis*, and *Leguminosites arachioides.* It is significant that approximately 19 per cent of the species restricted to this western Wilcox area are identical with Eocene forms of the western interior of the United States.

Marchantites stephensoni.
Lygodium hastataforme.
Acrostichum sp.
Dryopteris cladophleboides.
Cupressinoxylon calli.
Cupressinoxylon wilcoxense.
Cyperacites sp.
Araceaeites friteli.
Pistia wilcoxensis.
Hicoria antiquorum.
Dryophyllum amplum.
Ficus eolignitica.
Artocarpus dubia.
Artocarpus lessigiana.
Menispermites cebathoides.
Menispermites wilcoxensis.
Caesalpinites bentonensis.
Cassia bentonensis.
Leguminosites arachioides.
Ilex affinis.
Sapindus coushatta.
Calatoloides eocenicum.
Rhamnites berchemiaformis.
Helictoxylon wilcoxianum.
Sterculia zavalana.
Sterculiocarpus eocenicus.
Dillenites microdentatus.
Clusiaphyllum eocenicum.
Cinnamomum affine.
Cinnamomum postnewberryi.
Cryptocarya eolignitica.
Laurus verus.
Laurinoxylon branneri.
Aralia notata.
Calycites ostryaformis.
Pterobalanus texanus.
Phyllites suspectus.

There are 354 species and several uncertain forms in 148 genera restricted to the eastern area, or almost 71 per cent of the total flora of the area. The number is somewhat increased by the fact that 52 of the species represent fruits and flowers, which are always of sporadic occurrence. The corresponding proportion of restricted species in the flora of the western area is 20 per cent. Of the species found in the eastern area 29 per cent are common to the western area.

The following 10 species restricted to the eastern area are also known from the western interior of the United States (two—the *Planera* and the *Pterospermites*—doubtfully identified in the Wilcox): *Aralia acerifolia*, *Hicoria crescentia*, *Juglans occidentalis*, *Osmanthus pedatus*, *Planera crenata?*, *Platanus nobilis*, *Pterospermites* cf. *P. minor*, *Salvinia preauriculata*, and *Taxodium dubium.* This number is 2.82 per cent of the restricted species, as compared with 19 per cent for the western area. Thus the western area has proportionately nearly eight times as many species common to the western United States as the eastern area, although the total number of species in the eastern area is 2.73 times the number in the western area and the larger number of known species from the eastern area might be expected to show more in common with the western United States than the much smaller number known from the western area. If these figures have any significance they indicate that the western area was much more accessible to immigration from the western interior of the United States than the eastern area.

Several of the species restricted to the eastern area in the Wilcox are found in the western area in the later Eocene, two or possibly three are found in the Brandon lignite of Vermont, and two additional occur in the upper Eocene of western Greenland (*Aralia* and *Echitonium*). A third Wilcox species that occurs in Greenland, *Fraxinus johnstrupi*, found in both eastern and western Gulf areas, shows that a few of the members of the lower Eocene flora of southeastern North America extended their range far northeastward during Eocene time. This resemblance between southeastern North America and Greenland in the Eocene is, however, much less close than that between these two regions during Ripley or earlier Upper Cretaceous time, and this can mean only one thing—namely, that the Upper Cretaceous floras were a part of the holarctic flora, whereas the Wilcox is distinctly occidental and consists largely of autochthonous forms and immigrants from equatorial America.

The list of species restricted to the eastern shores of the embayment, from 92 localities, is as follows:

Caenomyces annulata.
Caenomyces cassiae.
Caenomyces laurinea.
Caenomyces myrtae.
Caenomyces pestalozzites.
Caenomyces sapotae.
Lycopodites? eolignitieus.
Lygodium binervatum.
Asplenium hurleyense.
Cheilanthes eocenica.
Meniphylloides tennesseensis.
Phanerophlebites knowltoni.
Salvinia preauriculata.
Zamia mississippiensis.
Zamia tennesseeana.
Taxites sp.
Arthrotaxis? eolignitica.
Taxodium dubium.
Taxodium wilcoxianum.
Cyperacites minutus.
Cyperacites wilcoxensis.
Potamogeton incertus.
Potamogeton glücki.
Potamogeton? fructus.
Acorus heeri.
Sparganium sp.
Nipadites burtini umbonatus.
Nipadites sp.
Palmocarpon syagrusioides.
Palmocarpon cf. P. sessile.
Smilax wilcoxensis.
Phyllites wilcoxensis.
Engelhardtia mississippiensis.
Engelhardtia puryearensis.
Hicoria crescentia.
Juglans occidentalis.
Juglans saffordiana.
Paraengelhardtia eocenica.
Myrica elaeanoides.
Myrica puryearensis.
Dryophyllum juvenale.
Dryophyllum puryearense.
Planera crenata?
Pseudolmedia eocenica.
Ficus cinnamomoides.
Ficus fructus pedicellata.
Ficus fructus rostrata.
Ficus mississippiensis cordata.
Ficus mississippiensis gigantea.
Ficus monodon.
Ficus myrtifolia.
Ficus myrtifolia ampla.
Ficus myrtifolia ovata.
Ficus pandurifolia.
Ficus tennesseensis.
Ficus wilcoxensis.
Ficus sp.
Artocarpus sp.
Platanus nobilis.
Banksia tenuifolia.
Knightiophyllum wilcoxianum.
Proteoides wilcoxensis.
Aristolochia wilcoxiana.
Coccolobis eolignitica.
Pisonia chlorophylloides.
Pisonia fructifera.
Pisonia praejacksoniana.
Pisonia puryearensis.
Magnolia leei angusta.
Anona robertsi.
Asimina leiocarpa.
Menispermites americanus.
Menispermites hardemanensis.
Ceratophyllum incertum.
Nelumbo protolutea.
Capparis eocenica.
Capparis eocenica ampla.
Liquidambar wilcoxianum.
Chrysobalanus eocenica.
Acacia wilcoxiana.
Inga mississippiensis.
Inga puryearensis.
Pithecolobium eocenicum.
Pithecolobium eocenicum anomalum.
Pithecolobium oxfordense.
Pithecolobium? tennesseense.
Mimosites acaciafolius.
Mimosites inaequilateralis.
Mimosites lanceolatus.
Mimosites wilcoxensis.
Caesalpinia wilcoxiana.
Caesalpinites mississippiensis.
Caesalpinites pinsonensis.
Caesalpinites wilcoxensis.
Cassia bolivarensis.
Cassia emarginata.
Cassia glenni.
Cassia glenni major.
Cassia lowii.
Cassia nictitanioides.
Cassia puryearensis.
Cassia robertsi.
Cassia wilcoxiana.
Cercis wilcoxiana.
Copaifera? wilcoxiana.
Gleditsia? mississippiensis.
Gleditsiophyllum constrictum.
Gleditsiophyllum ellipticum.
Gleditsiophyllum entadaforme.
Gleditsiophyllum hilgardianum.
Gleditsiophyllum ovatum.
Gleditsiophyllum minor.
Hymenaea eocenica.
Hymenaea wilcoxiana.
Parkinsonia eocenica.
Canavalia acuminata.
Cladrastis eocenica.
Dalbergia attenuata.
Dalbergia monospermoides.
Dalbergia puryearensis.
Dalbergia tennesseensis.
Dalbergia wilcoxiana.
Dalbergites ellipticifolius.
Dalbergites ovatus.
Sophora henryensis.
Sophora lesquereuxi.
Sophora mucronata.
Sophora palaeolobifolia.
Sophora puryearensis.
Leguminosites andiraformis.
Leguminosites arachioides minor.
Leguminosites astragaliformis.
Leguminosites chesterensis.
Leguminosites collinsi.
Leguminosites copaiferanus.
Leguminosites contortus.
Leguminosites drepanocarpoides.
Leguminosites emarginatus.
Leguminosites hardemanensis.
Leguminosites hoffmanseggiaformis.
Leguminosites ingafructoides.
Leguminosites monospermoides.
Leguminosites panduriformis.
Leguminosites phyllocarpoides.
Leguminosites pongamioides.
Leguminosites reniformis.
Leguminosites robertsi.
Leguminosites shandyensis.
Leguminosites subovatus.
Leguminosites wickliffensis.
Citrophyllum bifoliatum.
Citrophyllum wilcoxianum.
Fagara eocenica.
Fagara hurleyensis.
Fagara puryearensis.
Ptelea eocenica.
Rutaphyllum trifoliatum.
Zygophyllum? eocenicum.
Simarubites eocenicus.
Carapa eolignitica.
Cedrela mississippiensis.
Cedrela mississippiensis major.
Cedrela mississippiensis minor.
Cedrela odoratifolia.
Cedrela puryearensis.
Cedrela wilcoxiana.
Banisteria fructosa.
Banisteria repandifolia.
Crotonophyllum appendiculatum.
Crotonophyllum eocenicum.
Drypetes prekeyensis.
Drypetes prelateriflora.
Euphorbiophyllum fayettense.
Manihot eocenica.
Anacardites falcatus.
Anacardites inequilateralis.
Anacardites marshallensis.
Anacardites metopifolia.
Anacardites minor.
Anacardites serratus.
Heterocalyx saportana.
Ilex eolignitica.
Ilex vomitoriafolia.
Celastrus bolivarensis.
Celastrus bruckmannifolia.
Celastrus eolignitica.
Celastrus minor.
Celastrocarpus eocenicus.
Euonymus? fructescens.

Maytenus puryearensis.
Negundo knowltoni.
Cupanites amplus.
Cupanites formosus.
Cupanites loughridgi.
Dodonaea knowltoni.
Dodonaea parvula.
Dodonaea wilcoxiana.
Sapindus fructiferus.
Sapindus oxfordensis.
Berchemia eocenica.
Paliurus angustus.
Paliurus mississippiensis.
Paliurus pinsonensis.
Reynosia praenuntia.
Reynosia praenuntia longepetiolata.
Reynosia wilcoxiana.
Rhamnus puryearensis.
Zizyphus falcatus.
Zizyphus meigsii.
Cissites asymmetrica.
Cissites collinsi.
Grewiopsis elegans.
Grewiopsis wadii.
Monocarpellites perkinsi.
Buettneria eocenica.
Pterospermites cf. P. minor.
Sterculia knowltoni.
Sterculiocarpus sezannelloides.
Sterculiocarpus sphericus.
Bombacites eocenicus.
Dillenites serratus.
Dillenites tetracerafolia.
Ternstroemites crassus.
Ternstroemites lanceolatus.
Banara eocenica.
Ouratea eocenica.
Cinnamomum obovatum.
Cinnamomum ovoides.
Cryptocarya wilcoxiana.
Mespilodaphne puryearensis.
Nectandra parvula.
Nectandra wilcoxensis.
Oreodaphne intermedius.
Oreodaphne wilcoxensis.
Persea fructifera.
Laurus collinsi.
Laurus hardemanensis.
Laurophyllum florum.
Laurophyllum juvenale.
Laurophyllum preflorum.
Eugenia densinervia.
Eugenia hilgardiana.
Eugenia puryearensis.
Myrcia grenadensis.
Myrcia parvifolia.
Myrcia puryearensis.
Myrcia wortheni.
Combretum leve.
Combretanthites eocenicus.
Laguncularia preracemosa.
Terminalia vera.
Terminalia wilcoxiana.
Trapa wilcoxensis.
Melastomites ovatus.
Aralia dakotana.
Aralia jorgenseni.
Aralia? semina.
Oreopanax minor.
Oreopanax wilcoxensis crenulatus.
Schefflera elliptica.
Schefflera formosa.
Nyssa curta.
Nyssa eolignitica.
Nyssa tennesseensis.
Chrysophyllum ficifolium.
Bumelia grenadensis.
Bumelia hurleyensis.
Bumelia pseudohorrida.
Bumelia pseudolycioides.
Bumelia wilcoxiana.
Mimusops eolignitica.
Mimusops prenuntia.
Mimusops sieberifolia.
Sideroxylon ellipticum.
Sideroxylon premastichodendron.
Diospyros asper.
Diospyros madisonensis.
Diosypros sp.
Fraxinus wilcoxensis.
Osmanthus pedatus.
Apocynophyllum crassum.
Apocynophyllum linifolium.
Apocynophyllum mississippiense ovatum.
Apocynophyllum parvulum.
Apocynophyllum preplumiera.
Echitonium lanceolatum.
Acerates wilcoxiana.
Cordia eocenica.
Avicennia eocenica.
Citharexylon eolignitícum.
Solanites crassus.
Solanites pusillus.
Solanites saportanus.
Solanites sarrachaformis.
Bignonicapsula formosa.
Exostema pseudocaribaeum.
Guettarda ellipticifolia.
Psychotria grandifolia.
Rubiacites pellicieraformis.
Rubiacites sphericus.
Rubiacites wilcoxensis.
Antholithes (9 species).
Calycites (4 species).[a]
Carpolithus (39 species).
Phyllites grenadensis.

To a certain extent these species seem to indicate an Antillean avenue of invasion of the eastern Gulf area. I believe this invasion was due in part to ready access and relative nearness to the expanded Antillean region, but also in part to the milder climate of the eastern shores of the embayment. This relation can perhaps be indicated more clearly by a consideration of the genera rather than the multiferous species restricted to the eastern area.

Of the 180 genera recognized in the Wilcox flora 77, or 42.77 per cent, are restricted to the eastern shores of the embayment. A number of these I regard as of no significance, because they are based on single specimens, such as *Lycopodites*, *Acorus*, *Sparganium*, *Aristolochia*, *Asimina*, *Ceratophyllum*, *Cladrastis*, *Arthrotaxis*, *Potamogeton*, *Copaifera*, and *Manihot*, and hence may be suspected to be due to accidents of preservation or discovery; or they represent fruits, such as *Celastrocarpus*, *Bignonicapsula*, and *Rubiacites;* or flowers, such as *Laurophyllum* and *Solanites;* or are of no value, as the leafspot fungoid genus *Caenomyces*. The subtraction of these and doubtfully determined genera like *Planera*, *Gleditsia*, *Zygophyllum*, and *Pterospermites* leaves 55 genera, or 30 per cent of the known Wilcox genera, restricted to the eastern area.

Of these the genera *Paraengelhardtia*, *Knightiophyllum*, and *Combretanthites* have never been found outside this area and *Pseudolmedia* is known nowhere else in the fossil state. Some of these genera, such as *Cheilanthes*, *Trapa*, and *Nelumbo* are known from but a single locality, but others, such as *Capparis*, *Pithecolobium*, *Dalbergia*, *Dalbergites*, *Citrophyllum*, *Fagara*, *Cedrela*, *Drypetes*, *Paliurus*, *Reynosia*, *Zizyphus*, and *Cissites*, occur at many localities in the area and are represented by several species.

A number of these genera had colonized this region in Upper Cretaceous time—for example, *Capparis*, *Dalbergia*, *Citrophyllum*, *Cedrela*, *Zizyphus*, and *Cissites*. (See pp. 12–14.) In the category of genera confined to the eastern shores of the embayment during Wilcox time which may be considered to have entered the embayment by way of the Antilles I would place *Pseudolmedia*, *Pithecolobium*, *Copaifera*, *Hymenaea*, *Parkinsonia*, *Dalbergites*, *Fagara*, *Simarubites*, *Carapa*, *Cedrela*, *Drypetes*, *Maytenus*, *Reynosia*, *Banara*, *Ouratea*, *Laguncularia*, *Chrysophyllum*, *Sideroxylon*, *Citharexylon*, *Exostema*, and *Guettarda*. That the eastern shores of the embayment were more genial than the western is perhaps indicated by the fact that several of these genera, such as *Copaifera*, *Fagara*, *Carapa*, *Cedrela*, *Reynosia*, *Laguncularia*, *Chrysophyllum*, and *Citharexylon*, occur in the Claiborne or Jackson deposits of the western Gulf area, laid down when, as I believe, the climate was considerably milder than it was during Wilcox time.

The eastern area is especially contrasted with the western in its abundant Leguminosae, the following genera of that alliance being restricted to the eastern region: *Acacia*, *Pithecolobium*, *Cercis*, *Copaifera*, *Gleditsia?*, *Hymenaea*, *Parkinsonia*, *Dalbergia*, and *Dalbergites*, comprising 9 of the 19 known genera. No genera and but three species of this alliance are restricted to the western area.

The genera that are restricted to the eastern area are the following:

Caenomyces.	Zygophyllum?
Lycopodites.	Simarubites.
Cheilanthes.	Carapa.
Phanerophlebites.	Cedrela.
Salvinia.	Crotonophyllum.
Taxites.	Drypetes.
Arthrotaxis?	Euphorbiophyllum.
Taxodium.	Manihot.
Potamogeton.	Celastrocarpus.
Acorus.	Maytenus.
Sparganium.	Negundo.
Nipadites.	Berchemia.
Smilax.	Paliurus.
Paraengelhardtia.	Reynosia.
Planera?	Zizyphus.
Pseudolmedia.	Cissites.
Platanus.	Monocarpellites.
Knightiophyllum.	Buettneria.
Proteoides.	Pterospermites?
Aristolochia.	Banara.
Asimina.	Ouratea.
Ceratophyllum.	Laurophyllum.
Nelumbo.	Combretanthites.
Capparis.	Laguncularia.
Liquidambar.	Trapa.
Acacia.	Schefflera.
Pithecolobium.	Chrysophyllum.
Cercis.	Sideroxylon.
Copaifera.	Osmanthus.
Gleditsia?	Echitonium.
Hymenaea.	Acerates.
Parkinsonia.	Citharexylon.
Cladrastis.	Solanites.
Dalbergia.	Bignonicapsula.
Dalbergites.	Exostema.
Citrophyllum.	Guettarda.
Fagara.	Psychotria.
Ptelea.	Rubiacites.
Rutaphyllum.	

ENVIRONMENTAL CONDITIONS

The physical conditions indicated by the Wilcox flora were discussed in considerable detail in 1916.[19] The numerous species that have been added to this flora since that date necessarily modify some of the statements there made, although they do not affect the general conclusions to any considerable degree.

In that discussion I stated that the Wilcox flora probably seemed to be more tropical in character than it really was. This statement receives confirmation in the present study, which has served also to render more precise a picture of the environmental conditions in the Gulf embayment region during lower Eocene time. These conditions have been described in the present work with respect to certain selected localities; and the section on climate completes the environmental picture in so far as it is possible to do so with the present data, so that it seems unnecessary to devote a special section to ecology.

This statement is especially true because, for the present at least, the paleobotanist is less interested in the relations between structure and environment from the point of view of the physiologist and is much more interested in the relation between the plant associations found in the rocks and the grosser features of their physical environment from the point of view of the plant geographer. Where fossil floras are preserved as impressions and structural material is wanting, such questions as age, origin, and paths of dispersal will be those upon which information will be obtainable.

Consequently considerable space is here devoted to the time and place of origin of the several types, their probable paths of dispersal, and the relations to other fossil floras. The general conclusion seems to me to be warranted that aside from those resemblances which resulted from the interchange of a small number of species that were capable of being distributed by ocean currents without loss of vitality, the latitudinal, or east and west intercontinental similarities of floras and faunas, particularly as we find them at the present time, are not due to former oceanic land bridges, or to the drifting apart of continents à la Wegener, but are conditioned by the general zonal distribution of similar environments which these floras and faunas have come to occupy by invasions, equatorward or poleward, along more or less longitudinal paths.

CORRELATION

The surprisingly large number of additional forms that have been discovered in the Wilcox since their correlation was discussed in 1916 have not served to modify the general conclusions reached at that time. These conclusions were that in terms of the standard European section the Wilcox is decisively pre-Lutetian in age and finds its closest parallel in the Ypresian floras of southern England and the Paris Basin, though it also shows some but rather less close affinities with the flora found in the Sparnacian (plastic clay with lignite) of French geologists (Dollfus, 1880); the upper Landenian of Meyer Eymar (1857). If, as seems probable, the Sparnacian in France represents the littoral, estuarine, and continental sediments deposited during the withdrawal of the Thanetian sea from northern France, this means that the Wilcox

[19] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 133–140, 1916.

may, like the Sparnacian, be partly contemporaneous with the uppermost Thanetian marine beds.

This conclusion is of slight significance with respect to the Wilcox, for it is the identical position taken in 1916, but it is of considerable significance in connection with the question of the intercontinental correlation of those formations in the western United States in regard to which there are such great differences of opinion, and that is my chief reason for reaffirming it.

There is no warrant for introducing any extended comment on the correlation of such formations as the Raton, Denver, and related beds in a report devoted to the Wilcox. There are, however, considerable resemblances between the Wilcox flora and those of the western formations just mentioned, and several additional elements have come to light in recent years, as I will mention below, so that my own views may be restated with profit.

Nothing that has been discovered during the last 10 years has served to change my statement published in 1916 that the Wilcox is younger than the Raton, Denver, and related formations. The late F. H. Knowlton, who was an ardent advocate of the Eocene age of all the disputed horizons in the western United States, was inclined to see the proof of his position in the above-mentioned similarities between these floras and that of the Wilcox. Although I find serious difficulties in the way of admitting that such floras as those of the Raton or Denver formations can be of pre-Eocene age, science does not progress by special pleading, and the contrasts as well as the nature of the similarities should be precisely stated.

Of the approximately 543 species now recorded from the Wilcox, less than 75 have an outside distribution. This is an unusually small proportion, and serves to impart a striking individuality to the Wilcox flora. This individuality is partly due to the geographic position of the region where the flora is found, for it is predominantly a coastal flora at the gates of the American Tropics. It is also partly due to the fact that no other American floral unit has its precise chronologic limits.

I suppose that in a general way the Wilcox flora may be correlated with that known as the Fort Union, but until the Fort Union becomes tied to a more definite geologic unit and its flora is segregated among the component stratigraphic units, there can be no precision in such a statement, and in any event the composition and environment of the two are widely different and scarcely comparable.

In the table of distribution given below 74 Wilcox species are listed which appear to have an outside distribution. Of these species 23 occur in either the Claiborne or the Jackson Eocene of the Gulf embayment region, each of which has 15 species common to the Wilcox. It should be emphasized that the determination of these species is more precise than that of some of the Wilcox species recorded from western floras.

Two Wilcox species have been recognized in the small florule found in the rhyolitic tuffs of the Barrilla Mountains of western Texas,[20] midway geographically between the Wilcox and Raton areas.

Twenty-seven Wilcox species have been recorded by Knowlton in the Raton formation of southeastern Colorado and northeastern New Mexico, and there is a considerable additional community of generic representation in the two, commonly by rather closely related species. The two floras differ considerably by reason of the large number of Leguminosae and Lauraceae and the many representatives of genera now living in equatorial America that are found in the Wilcox. The Raton flora, on the other hand, has a somewhat more temperate facies, despite its abundant palms, and contains a large assemblage of species in the genera *Juglans*, *Magnolia*, *Platanus*, and *Viburnum*, which are sparingly or (*Viburnum*) not at all represented in the Wilcox. If the Raton formation is basal Eocene, as its considerable quota of Wilcox forms seems to indicate, it is probably of the age of the Midway of the Gulf embayment region. I can see no evidence for regarding the Wilcox and Raton as synchronous, and the rather strong evidence that the Wilcox is largely the equivalent of the Ypresian of Europe seems to me to be decisive on this point.

There are 17 species common to the Wilcox and Denver flora and its equivalents in Colorado (Arapahoe, Middle Park, and Dawson), 16 common to the so-called Fort Union flora, and 8 common to the Lance flora. The actual floral resemblance is greatest with the Denver, but there are the same objections to considering the Denver and Wilcox synchronous as in the case of the Raton. They have fewer common species, and a considerable number of these are not certainly identified, as is also true of several species that have been considered to be common to the Wilcox and to the Lance and Fort Union. Thus *Ficus puryearensis* Berry and *Sophora wilcoxiana* Berry have been recorded by Knowlton from the Denver, but I have recently examined this material and consider the identity to be extremely doubtful. *Planera crenata*, *Pterospermites minor*, and *Aralia dakotana*, which are tentatively identified by me in the Wilcox, are similarly doubtfully identical with these Lance and Fort Union species. That the Denver flora should show a degree of resemblance to that of the Wilcox is not surprising if the Denver and Raton formations are

[20] Berry, E. W., An Eocene flora from trans-Pecos Texas: U. S. Geol. Survey Prof. Paper 125, pp. 1–9, 1919.

synchronous, as Knowlton seems to have proved. The Denver flora differs decidedly from that of the Wilcox in the same particulars as the Raton, and in addition it contains a large number of contrasting elements identified as species of *Populus*, *Cissus*, *Ginkgo*, *Dombeyopsis*, *Viburnum*, *Platanus*, *Alnus*, *Betula*, *Crataegus*, and other genera, for the most part entirely unrepresented in the Wilcox.

A single Green River species is doubtfully recorded in the Wilcox, and a species of *Salvinia* is common to the Wilcox and the Bridger (?) formation of the Wind River Basin in Wyoming. Two species are common to the Wilcox and the Arctic Eocene. Of unusual interest is the presence in the Wilcox of several species based upon fruits that are closely related to or identical with forms described from the Brandon lignite of Vermont, which has often been considered to be of Miocene age. For this and many other reasons already set forth,[21] I think there is not the slightest doubt but that the Brandon lignite is of Eocene age. Since the paper just cited was written the finding of identical species of *Nyssa* and *Cinnamomum* in the lignite on the Taylor farm in Chester County, Tenn., adds materially to the evidence.

There is no need for repeating the evidence of relationship between the Wilcox flora and those of the Sparnacian and especially the Ypresian of Europe. This evidence was given at length in 1916, and additional studies all tend to confirm rather than to modify it in any way.

The list of Wilcox species that occur in other regions is given in the following table:

[21] Berry, E. W., The age of the Brandon lignite: Am. Jour. Sci., 4th ser., vol. 47, pp. 211-216, 1919.

Distribution of Wilcox species in other regions and formations

	Midway (?)	Claiborne	Jackson	Raton	Denver (Arapahoe, Dawson, etc.)	Lance	Fort Union	Bridger (?)	Green River	Arctic Eocene	Brandon, Vt.	Barrilla Mountains, Tex.	Chile, South America
Marchantites stephensoni			×										
Anemia eocenica		×											
Asplenium eoligniticum					×								
Pteris pseudopennaeformis					×								
Dryopteris cladophleboides				×									
Salvinia preauriculata								×					
Glyptostrobus europaeus		×	×			×	×						
Taxodium dubium			×			×	×						
Chamaedorea danai					(?)								
Nipadites burtini umbonatus			×										
Palmocarpon butlerense		×											
Palmocarpon cf. P. sessile			×										
Sabalites grayanus				×	×								×
Hicoria antiquorum						×							
Juglans berryi				×									
Juglans occidentalis				×	×		×						
Juglans schimperi				×	×		×						
Engelhardtia ettingshauseni				×									
Dryophyllum moori				×									
Planera crenata?							×						
Artocarpus lessigiana					×								
Artocarpus pungens					×								
Ficus artocarpoides?				×		×	×						
Ficus denveriana?	×			×	×	×							
Ficus mississippiensis			×	×	×								
Ficus monodon				×									
Ficus occidentalis	×			×	×								
Ficus puryearensis					(?)								
Ficus pseudolmediafolia				×									
Ficus schimperi				×									
Platanus nobilis						×	×						
Magnolia angustifolia				×									
Magnolia leei				×									
Magnolia leei angusta		×											
Anona eolignitica		×											
Parrotia cuneata							×						
Sophora wilcoxiana		×	×										
Leguminosites arachioides				×	×		×						
Gleditsiophyllum eocenicum		×	×										
Ilex affinis?									×				
Celastrus taurinensis						×	×						
Euonymus splendens				×									
Sapindus mississippiensis		×											
Zizyphus meigsii				×									
Rhamnus cleburni				×	×								
Rhamnus emarginatus apiculatus	×												
Rhamnites knowltoni				×	×								
Grewiopsis wadii			×										
Pterospermites cf. P. minor						×	×						
Cinnamomum affine	×				×								
Cinnamomum buchii			(?)										
Cinnamomum ovoides											×		
Oreodaphne obtusifolia		×	×										
Oreodaphne pseudoguianensis												×	
Nectandra lancifolia				×									
Laurinoxylon branneri		×	×										
Myrcia bentonensis		×	×										
Combretum ovale				×									
Terminalia hilgardiana	×			×			×						
Terminalia lesleyana	×			×									
Aralia dakotana							×						
Aralia jorgenseni?										×			
Aralia notata					×	×	×						
Nyssa curta											×		
Nyssa wilcoxiana		×	×										
Bumelia wilcoxiana		×											
Diospyros brachysepala		×	×		×		×						
Diospyros madisonensis		×											
Fraxinus johnstrupi										×			
Osmanthus pedatus				×									
Apocynophyllum linifolium				×									
Apocynophyllum wilcoxense				×									
Psychotria grandifolia													×

THE PROBLEM OF THE EOCENE CLIMATES

It is perhaps fatuous to point out that climate, either present or past, depends upon many factors, both cosmic and terrestrial. Of the former the only one that is of practical importance is solar—that is, radiant energy from the sun, for it is inconceivable that other heavenly bodies or the introduction of kinetic energy by meteorites could exert any appreciable effect.

The amount of solar energy reaching the earth depends upon the sun's activity, which is variable; on the distance of the earth from the sun, which is also variable; and more practically, in so far as terrestrial climates are concerned, on the condition of the earth's atmosphere, especially with respect to the amount of ozone, water vapor, carbon dioxide, and dust present, all of which again are variable. The latitude, which determines the angle of incidence of the sun's rays, is an obvious factor, as is also the geographic pattern and the topography, including altitude. The geography determines whether the sun's energy falls on the land or the water, it determines the temperature gradient between the Equator and the poles and the consequent force of the planetary winds and ocean currents, and in less obvious ways it is of the greatest significance, as the following illustration will make clear.

The equatorial currents in the Atlantic are so situated that the south equatorial—the stronger and the larger of the two—is divided by Cape San Roque into a larger, northern or Guiana current and a smaller, southern or Brazil current. Some authors, like Guppy, are inclined to consider the south equatorial as bipartite throughout and call the Guiana current the main equatorial current. The point is immaterial in the present connection, as all I desire to show is that the shape of eastern South America and the latitude of Cape San Roque are purely fortuitous in so far as their relation to climate is concerned, and yet if Cape San Roque had happened to lie a few degrees north of its present position much of the water that ultimately contributes to the Gulf Stream would have turned southward to augment the Brazilian current, and the climate—especially of Europe and the Arctic—would be profoundly modified.

Scant attention will be devoted to the various theories that have been advanced to explain geologic climates. These theories range from that of Croll, in its original or modified form, based upon the eccentricity of the earth's orbit and the obliquity of the ecliptic, which was doubtless a factor at all times but hardly a controlling one, through those theories that rely on changes in the atmosphere, such as alterations in the amount of carbon dioxide (Tyndall, Arrhenius, Chamberlin), or amounts of volcanic dust (Humphreys), to the extreme form of the hypothesis advanced by Manson and elaborately defended by Knowlton, that a combination of cloudiness progressively diminishing during earth history and a terrestrial control due to a cooling earth, instead of a solar control as at present, are the primary factors which explain past climates. Finally there are those highly speculative hypotheses, such as Chamberlin's reversal of the oceanic circulation, and a group which predicate a wandering of the poles in various ways, now fashionable in the revived form put forward by Wegener.

I have quite possibly omitted other proposals that might be mentioned, and I have now to mention the theory, if it can be called a theory, which is the main thesis of the present chapter—namely, that it seems to me possible to interpret geologic climates in the light of demonstrated changes in topography and geography, including under geography differences in the distribution of land and water and the transfer of energy by currents.

This idea, as applied to the Pleistocene glaciation, was first advanced, I believe, by Lyell, and in its more general application has been recently put upon a scientific basis by Brooks, with whom I am in perfect agreement—not only in the evaluation of these as major factors but also in my firm conviction that armchair philosophy, with its fondness for highly speculative and catastrophic hypotheses, has no place in a uniformitarian world or in twentieth century science but belongs in the medieval age of human thought. Not only have most writers on geologic climates been as ardent as they were uncritical, but many have been equally uninformed.

Climate, in a uniformitarian geology, occupies the somewhat anomalous position, which the scientific world has been slow to recognize, that the history of the human race has been made under climatic conditions which, from the point of view of the student of earth history, are exceptional. Man was evolved subsequent to the relative elevation and the great extension of the continents which ushered in the Pleistocene glaciation, and therefore what is normal in human experience is abnormal for the bulk of geologic climate.

Therefore, although we recognize that the climatic factors and the meteorologic elements are the same now as always, their combination to form actual climates has depended upon a great many other factors, among the chief of which were the size, shape, position, and relative altitude of the land masses. It may be remarked parenthetically that the numerous theories of the causes or descriptions of geologic climates have been advanced by students ignorant of meteorology and also usually ignorant of the relationship of organisms to their environments, and the last statement is strikingly true of Köppen and Wegener's recent treatise.[22]

In attempting a few years ago to explain the extension of floras nearly to the poles during late Eocene time, I relied chiefly on the submergence of continental areas in the middle Eocene and the resulting free oceanic connections at that time between equatorial and arctic waters, pointing out that these arctic floras were coastal floras and therefore under the régime of an oceanic climate.[23] An additional and important factor has since been brought forward by Brooks,[24] who points out that the temperature gradient is a simple function, whereas the influence of ice increases as the square of the radius. Hence a coincidence of minor factors sufficient to effect an overturn in the one or the other direction—that is, toward ice formation or melting—would suffice to induce a wide extension of polar ice or to prevent the polar regions from maintaining a permanent ice cap. If this is true then it seems quite probable that there was little polar ice during late Eocene time. This would mean profound changes in the distribution of barometric pressures and consequent wind circulation, and, in fact, in all the elements that constitute climate. It would mean that in western Greenland, for example, where the most extensive late Eocene arctic flora has been found, the present-day glacial anticyclonic winds would be replaced by westerly or southwesterly winds blowing from the relatively warmed waters of Baffin Bay, and this would satisfactorily explain the details of the floral facies.

Regarding the general history of discussions of geologic climates, I believe that most paleontologists who have written on this topic, especially those dealing with the pre-Cenozoic periods, have had little basis in fact for their speculations. They seem to me to be utterly oblivious of the great amount of modern work on the distribution of marine organisms, and their ideas of the climatic significance of a trilobite, eurypterid, or ammonite are purely traditions inherited from the distant past, when all strange organisms were associated with torrid climates.

In stating my belief in a greater uniformity of climate during the past than exists at the present time I do not wish to be understood as advocating such fallacies as the entire absence of zonation, which many paleobotanists have defended (Jeffrey, Knowlton, Hollick), or a similar uniformity throughout all time. Both ideas are equally absurd and are disproved both by geologic observation and by meteorologic principles. Jeffrey,[25] for example, holds that the more ancient the epoch the warmer the climate, and that there has been a gradual and progressive refrigeration during geologic time; that the organization of secondary wood in extinct plants furnishes the most reliable evidence of climatic conditions; that toward the end of Paleozoic time growth rings appeared in woods in high latitudes; that in Triassic time growth rings were developed 10° nearer the Equator than they were during the Paleozoic time; and that in Jurassic time the tracheids first developed tangential pitting, which was at the end of the annual ring and was accompanied by storage elements (wood parenchyma).

There is scarcely a statement in the chapter from which the above assertions are culled that is true. There are no geologic or paleontologic facts that indicate a progressive climatic cooling during geologic time, and the "Permo-Carboniferous" glaciation was admittedly more extensive than that of the Pleistocene. The presence or absence of growth rings exhibits what might be called constitutional variations quite independent of climate, not that they really are independent, but two associated species under an identical climate will behave differently with respect to this feature of their anatomy. Growth rings appear in some Paleozoic woods many degrees nearer the Equator than Jeffrey admits,[26] and in marine formations deposited off low coasts, so that the plants can not be considered to have been upland types. The Paleozoic genus *Mesoxylon* shows tangential pitting, which, according to Jeffrey, first appeared in the Jurassic; and the citation of a wood from the Triassic of Arizona as an argument for the advance equatorward of cooler climates during early Mesozoic time is particularly weak, as it is perfectly clear that the growth rings in this wood have nothing to do with temperature but are due to periodic lack of moisture in that region, as exemplified by the contemporaneous deposits of gypsum.

I have perhaps devoted more space to Jeffrey's arguments than their importance warrants, but I do this because they furnish part of the basis for his well-known views on the evolution of anatomical elements in the higher plants, and, as has been shown above, the actual climatic history affords no support to these views.

Similarly, in the recent elaborate work on geologic climates already cited, Köppen and Wegener offer explanations to account for climates which they assume

[22] Köppen, W., and Wegener, A., Die Klimate der geologischen Vorzeit. 255 pp., 1924.

[23] Berry, E. W., A possible explanation of upper Eocene climates: Am. Philos. Soc. Proc., vol. 61, pp. 1–14, 1922.

[24] Brooks, C. E. P., The problem of warm polar climates: Roy. Meteorol. Soc. Quart. Jour., vol. 51, pp. 83–94, 1925.

[25] Jeffrey, E. C., Anatomy of woody plants, chap. 30, 1917.

[26] These occurrences are summarized by Goldring, W., Annual rings of growth in Carboniferous wood: Bot. Gaz., vol. 72, pp. 326–330, pl. 14, 1921.

to have prevailed during the successive geologic periods but which in reality never existed.

As I have pointed out on previous occasions, paleobotanists in general have entirely lacked objective experience outside the Temperate Zone and have invariably overestimated temperatures. They have been prone to use the present distribution of the fancied or real relatives of their fossil forms as if temperature were the sole factor in the environment, and they have stopped with the geographic occurrence in the apparently simple trust that all lands in the equatorial zone were at sea level and wet tropical. A sojourn in the arctic climate beneath the Equator on the backbone of South America would do much to correct this misapprehension, as would also some experience in the temperate rain forests of different regions.

Climatologists, agriculturists, and biogeographers have long recognized that in nonarid environments the temperature affords a direct if not wholly exact correlation with organic activity. In reference to plants the length of the available growing season, as determined by the interval either between the last frost in the spring and the first frost in the fall or between the last and first killing frosts, has long been used satisfactorily throughout the Temperate Zone, although it has been recognized that temperature stands in a casual relation to other vital environmental factors, and that the length of the dormant period due to cold, or the intensity of the cold or heat to which the plants are subjected, are important factors in distribution. These factors, however, have never been evaluated, so that for the present we have to rely on the approximation furnished by the length of the growing season. Of course, in frostless regions this would be determined by other climatic factors than temperature—chiefly factors affecting their water relations.

The following brief discussion of certain of the climatic elements in the Southeastern States during early Eocene time includes some comments upon the present conditions in this region, on which such a discussion must be based, the data being those of the United States Weather Bureau, and more especially upon the elaborate study of these records as bearing on the distribution of vegetation in the United States, by Livingston and Shreve.[27]

The average length of the frostless season in the Atlantic Coastal Plain at the present time is 200 days or more, reaching 300 days in coastal Texas, the Mississippi Delta, and peninsular Florida. It is 280 days along the whole Gulf coast, except for a small area in Louisiana, and reaches 340 days in southern Florida. It would undoubtedly be relatively somewhat longer with the distribution of land and water that existed at the time of the maximum submergence of the Wilcox. It is not possible to determine this length quantitatively, but that the frostless season was longer than it is now is shown by the presence as far north as latitude 37° in western Kentucky of fossil plants whose existing relatives reach only about latitude 28° in peninsular Florida.

By plotting the equiseasonal lines of the present time on a map it is apparent that they follow rather closely the isothermal lines, so that a determination of the isothermal lines for Wilcox time would afford a fairly reliable method of estimating the length of the Wilcox growing season in different parts of the region. In default of this determination, which it seems to me would require more information than is available, certain minimum temperatures for Wilcox time can be arrived at, and these indicate that the growing season was longer than it is at present for the same latitudes.

Meteorology has not yet reached that stage where it becomes possible to make precise estimates of what climatic features would result if, for example, the present continents were widely submerged or if the polar ice caps were greatly reduced or perhaps absent altogether, as Brooks believes they may have been during the Eocene. Brooks[28] has discussed these features at considerable length, and it would be pure pedantry for me to attempt any such discussion.

The epicontinental seas in the latitude of the Wilcox embayment showed the same contrasts between their eastern and western shores as are shown by the present eastern and western oceanic coasts, of which the two coasts of the Atlantic are familiar to all students and probably most typical. During the winter lower pressures over the embayment than over the adjacent land would result in southerly and westerly moist winds on the east coast and northerly offshore winds on the west coast. Consequently, the winters would be more severe along the west coast. During the summer the barometric conditions of the winter would be more or less reversed—to a less degree, however, and with less definite effects.

Figure 4 shows the present normal annual precipitation in inches, plotted on a map showing the maximum transgression of the Wilcox shore line. I think that without assuming that the distribution of the precipitation during Wilcox time was greatly dissimilar to that of the present, there is justification for believing that the boundary between areas with a precipitation of 40 to 50 inches and those with 50 to 60 inches would be smoothed out and would retreat

[27] Livingston, B. E., and Shreve, Forrest, The distribution of vegetation in the United States, as related to climatic conditions: Carnegie Inst. Washington Pub. 284, 590 pp., 1921.

[28] Brooks, C. E. P., Climate through the ages, London, 1927.

northward from the Coastal Plain of South Carolina, Georgia, Alabama, and Mississippi.

The belts of rainfall of the present would move northward with the transgression of the Wilcox coast, and the heaviest precipitation would occur along the eastern shore of the embayment from southern Illinois through Kentucky, Tennessee, and Mississippi to southern Alabama, where it was probably greatest. The rainfall would also be heavy on the west side of the head of the embayment from Illinois through Arkansas and would probably decrease toward the southwest. However, the Wilcox coastal region in Texas must have received more rain than that region does at the present time, and the north and south belts of light rains of the present could not have existed in the Eocene. This inference follows from the Eocene distribution of land and water and is fully corroborated by the Eocene plants of the Barrilla Mountains, in trans-Pecos Texas, by the number of forms common to the Wilcox and the Raton and

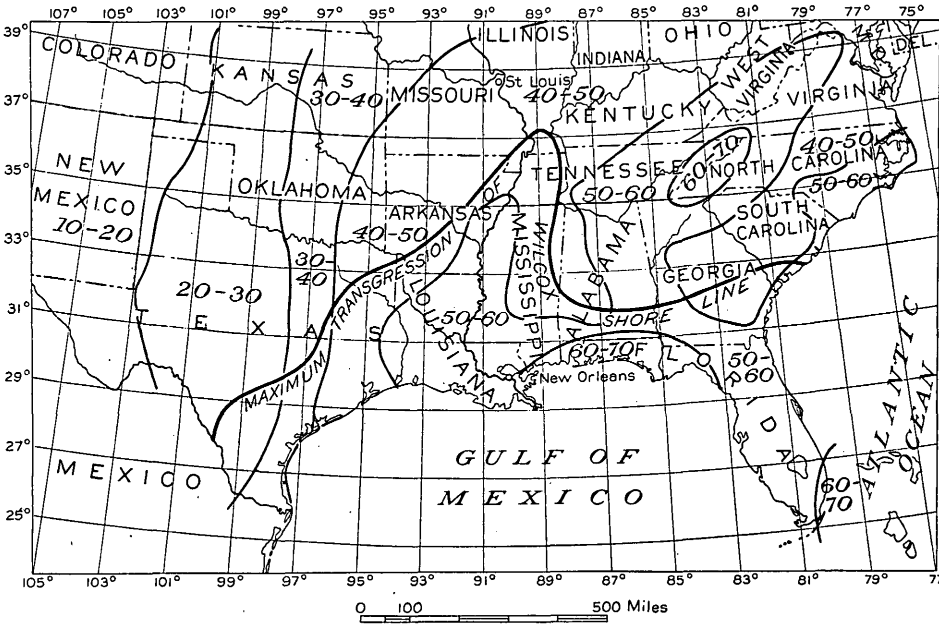


FIGURE 4.—Map of Southeastern States showing normal annual precipitation, in inches

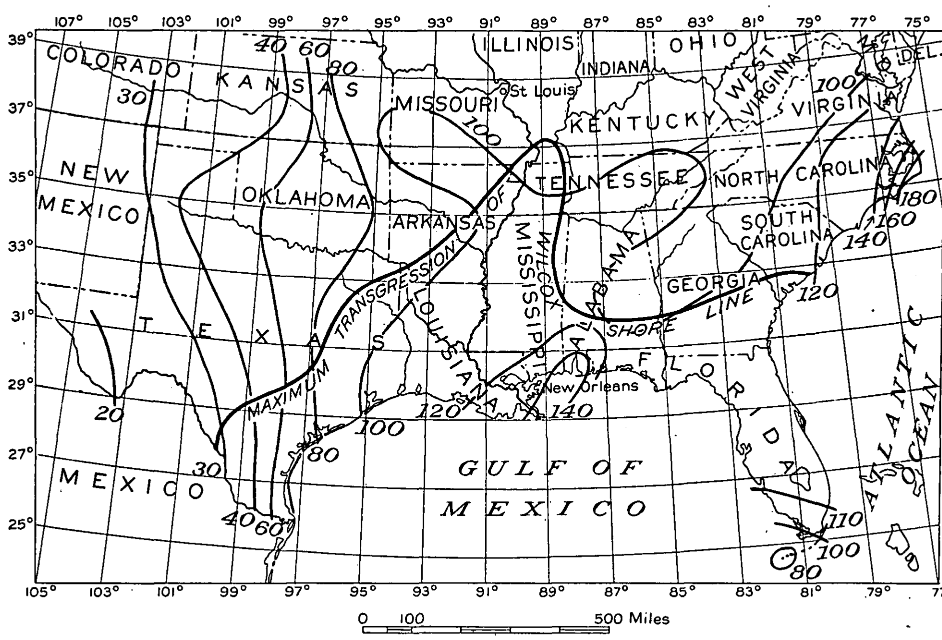


FIGURE 5.—Map of the Southeastern States showing relation of precipitation to evaporation. Figures on curves indicate normal precipitation divided by normal evaporation, expressed as percentages. After Livingston and Shreve

Denver floras of the Rocky Mountain region, and by the evidence of the northward spread of southern types by way of the Mexican coastal region.

As is well known but frequently disregarded, the effective value of precipitation for plant activity depends upon its distribution during the year and at all times upon the evaporation capacity of the air—that is, on the humidity. The humidity is, of course, influenced by several factors that are difficult to determine, such as the amount of sunshine and character of wind, and it is equally obvious that precipitation and humidity can not be divorced from temperature.

The curves in Figure 5 show the relation of the present normal annual precipitation to the evaporation in this region. Curves showing such a relation for the growing season would perhaps be more enlightening, but I give the annual relation for several considerations, chief of which is that it is less favorable to plant growth than the corresponding relation for the summer, although the latter would be closer to what I regard the conditions to have been throughout most of the year during Wilcox time.

That the effective value of the precipitation as measured in this way followed the coasts of the Wilcox exactly as temperature, precipitation, and evaporation did is, I think, unquestionable; the facies of the fossil flora seems to me to prove this as well as the length of the growing season. The great accumulation of lignite near the head of the embayment in western Kentucky and on its western coast in Texas as far as the southern part of that State, as, for example, along the Rio Nueces, demands a degree of humidity quite different from that prevailing at the present time in that region, where now the effective rainfall is deficient and diminishes rapidly toward the west.

In considering the present distribution of humidity in the Southeastern States by itself (fig. 6) two features stand out conspicuously: First, the areas of greatest humidity, even in the far Southwest, follow the present coasts and must have done so during early Eocene time. This distribution would mean that a belt of country of considerable width along the Wilcox coast, throughout its extent, had a mean annual humidity between 75 and 80 per cent. The second feature of the present distribution of humidity is the rapid decrease westward. For example, it is 75 per cent at Corpus Christi, less than 70 at San Antonio, only 60 at Eagle Pass, and below 50 per cent west of the Rio Pecos. Like the belts of rainfall these pronounced belts of low humidity could not have been developed during Wilcox time, and for the same reasons.

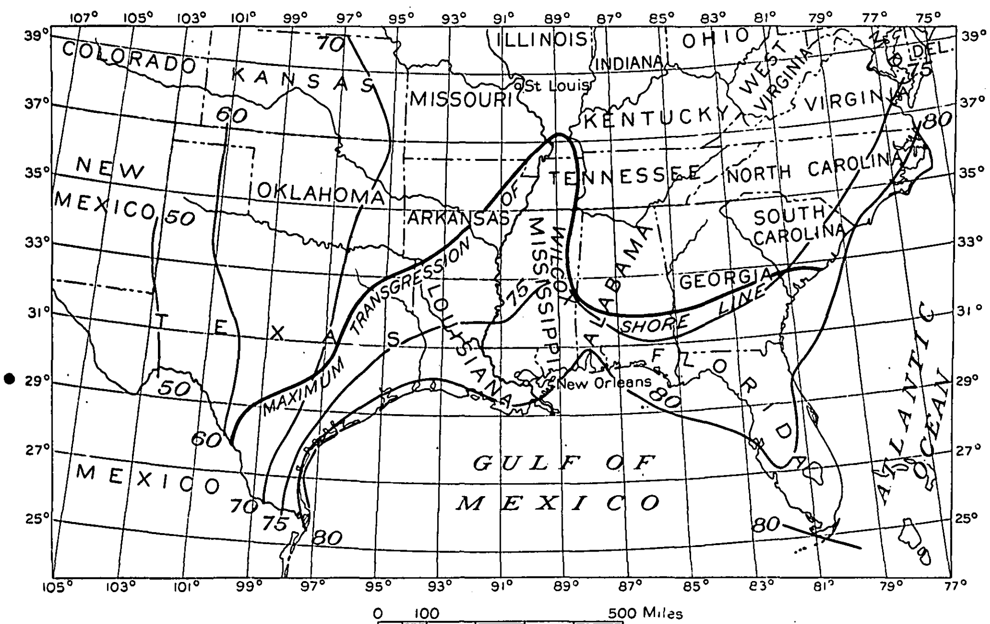


FIGURE 6.—Map of the Southeastern States showing normal mean annual humidity. After Livingston and Shreve

Figure 7 is introduced because it shows graphically the present conditions better than a long explanation could possibly elucidate them, and also because it gives a concrete basis for conceptions regarding the modification which would be brought about by such a flooding of the lower Mississippi Valley as that which took place during early Eocene time. The line A–A records the southernmost observed and altogether exceptional zero temperatures that have been recorded since the founding of the United States Weather Bureau. The line B–B marks the southern limit of normal daily mean temperatures of 32° or lower; hence south of this line the daily means are normally above freezing. Both of these lines would necessarily have been embayed northward during Wilcox time in curves more or less parallel to the shore of the marine embayment.

Brooks [29] has developed a mathematical formula for the determination of past mean temperatures which was based upon the distribution of land, water, and ice in circles with an angular radius of 5° and 10°. The method need not be quoted here, as it is given in full in an appendix of the work cited. Mr. Brooks has been good enough to calculate for me the January and July temperatures for two localities on the Wilcox coast for a time near the maximum transgression.

One of these localities is on the eastern shore of the Wilcox embayment in latitude 32°, longitude 87°. Here, because of the ameliorating influence of the embayment waters to the west, the January temperature would be approximately 5° F. above the present January temperature and the July temperature would be 4° F. below the present July temperature.

The other locality is about midway on the western shore of the embayment in latitude 32°, longitude 97°. Here, because of the mass of land to the west, the departures from present temperatures would be smaller. The January mean would be but 0.4° F. warmer than the present January mean, and the July mean would be 1.3° F. below the present July temperature. But as Brooks points out, his formula was developed primarily for the study of glacial and postglacial climates and rests on the assumption that the general meteorologic system of the earth was similar to that of the present time. That is, of course, a doubtful assumption for Wilcox time, for we have every reason to believe that there was a diminution of the polar ice caps in the Eocene.

This diminution of the polar ice caps would greatly modify the general meteorologic system and would result in much higher temperatures along the Wilcox coasts than those given above, because of the fact that the subtropical anticyclonic belts would extend poleward into temperate latitudes. This thesis is developed by Brooks,[30] and although the changes involved can not be stated quantitatively, their general tenor agrees admirably with the qualitative ideas regarding Wilcox climate derived from an analysis of the extensive Wilcox flora.

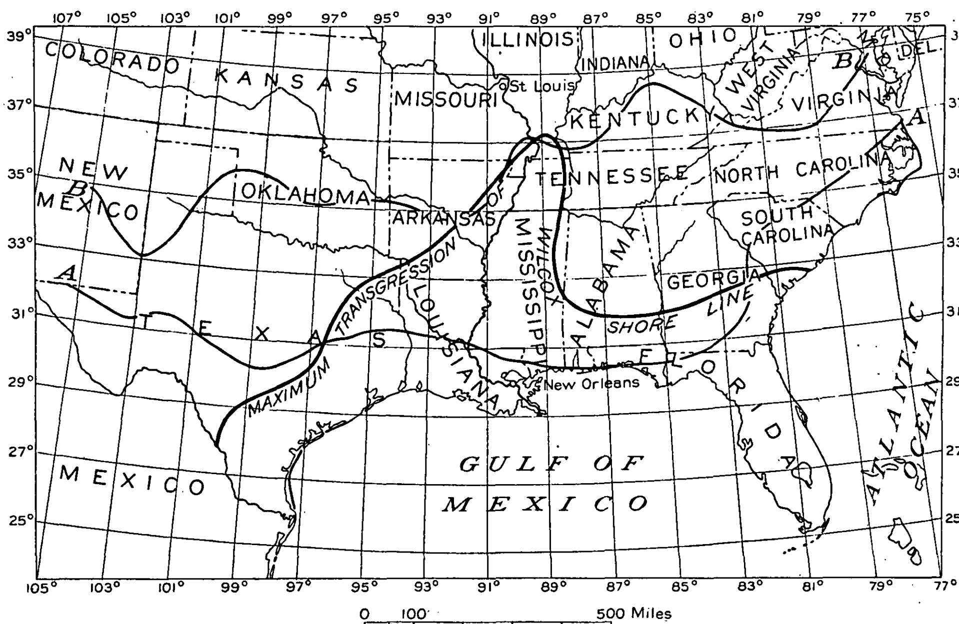


FIGURE 7.—Map of the Southeastern States showing southern limits of freezing (B) and zero (A) temperatures

The nearest Weather Bureau station to the point mentioned on the eastern shore of the Wilcox embayment is at Selma, Ala., which is about 30 miles north of it and at an altitude of 147 feet. The factor of altitude may be ignored here, although it is a modifying factor. The average length of the growing season at Selma for 34 years of records is 240 days. The average January mean for a period of 27 years is 48.58° F., and the average July mean for a period of 30 years is 80.15° F. Brooks's calculations for the Wilcox, when applied to these figures, give a January mean of about 53° F. and a July mean of about 76° F.

[29] Brooks, C. E. P., Evolution of climate, London, 1922.

[30] Brooks, C. E. P., Climate through the ages, London, 1926.

There are two Weather Bureau stations in the vicinity of the point mentioned on the western shore of the Wilcox embayment. These stations are Corsicana, Tex., about 35 miles slightly north of east, and Waco, Tex., about 32 miles directly south. Corsicana has an altitude of 445 feet; records for 19 years give an average growing season of 244 days, and the average January and July means for 36 years of records are, respectively, 45° F. and 84.3° F. Waco has an altitude of 424 feet; the average growing season, based on 19 years of records, is 250 days, and the average January and July means of 37 years of records are, respectively, 48.5° F. and 83.3° F. By using these figures without reducing them to sea level we obtain for the Wilcox, at the time of its maximum extent, at the point on its western shore, a January mean somewhere between 45.5° and 49° F. and a July mean of 82° or 83° F.

As I have pointed out, these figures may be regarded as correctly derived and hence of a different order of value from all previous estimates of paleobotanic students, which have been inferences from the character of the plants represented as compared with the distribution of their existing relatives. My figures are then quantitative and not qualitative. Moreover, as I have noted above, they are based on the assumption that the present meteorologic conditions prevailed during Wilcox time and are hence minimum figures, because either a decrease of land in latitude 32° N. or a shrinkage of polar ice, such as seems probable, would tend to increase and not decrease these determinations.

In another section of this work I have given an analysis of the similarities and differences in the known floras of the two shores of the embayment. Obviously the factors governing the distribution of plants are highly complex, so that only rarely is it possible to analyze satisfactorily even existing floras, for which many of the factors can be observed. Changes are somewhat crudely assigned to changes in latitude or altitude, wetness or dryness, edaphic conditions, and other factors. Usually what might be called the historical factors—that is, the ancestry of any particular plant population and the means of access to the region—can not be evaluated.

In contrasting the floras of the two shores of the embayment it seemed possible to discern some of the historical factors, and certain other observed differences between the floras appeared to be climatic. These data will not be repeated in this section, but the reader is referred to the discussion cited. (See pp. 25–29.) It was hoped that a study of the secondary woods of silicified members of the Wilcox flora would throw some light on this problem, but as yet almost the only well-preserved petrified woods have come from the western shores of the embayment, so that whatever these have to disclose awaits future discoveries.

The species *Laurinoxylon wilcoxianum*, which has been found in Tennessee and Mississippi on the eastern shore and Louisiana on the western shore, is alike throughout and shows no evidence of seasonal changes. *Helictoxylon wilcoxianum*, known only from the western shore in Louisiana, likewise shows no evidence of seasonal changes. A considerable number of specimens of *Cupressinoxylon wilcoxense* have been examined, but unfortunately these also all came from the western shore in Louisiana. These specimens show a great deal of variation in the extent and distinctness of seasonal activities. In some specimens the growth rings are sharp; in others the so-called spring wood consisted of 45 to 70 radial elements and the so-called summer wood of but two radial elements in which reduction is scarcely perceptible. It is of interest in this connection to note that Seward [31] has described a species of *Cupressinoxylon* from the contemporaneous London clay of southeastern England, which shows well-defined seasonal rings.

Another significant feature of this Wilcox *Cupressinoxylon* is that the tangential walls of the tracheids are pitted. This pitting is not confined to the terminal tracheids of the so-called ring, as it should be according to Jeffrey's hypothesis, mentioned earlier in this paper. If Strassburger's explanation, that tangential pitting was evolved to facilitate a rapid water supply to the cambium when its activity becomes renewed in the spring, has any validity, the pitting throughout the ring might be construed as an argument in favor of a continuously active cambium throughout the whole or most of the year.

I have said nothing thus far about the possible effect of ocean currents on the Wilcox climate. The occurrence of other than tidal currents in the Gulf embayment is problematic, and I believe extremely doubtful. The general shallowness of the embayment waters would seem to indicate that any well-marked currents were absent, although tidal action and alongshore drift seem to be indicated by the distribution of many plants which are normally distributed by currents, such as *Avicennia*, *Caesalpinia*, *Canavalia*, *Carapa*, *Conocarpus*, *Dalbergia*, *Laguncularia*, *Nipadites*, *Sapindus*, and *Sophora*.

The land barriers of Yucatan and peninsular Florida were submerged in early Eocene time but on the other hand there was an undetermined amount of uplift in the Antilles, so that it is by no means clear what the course of the Eocene Gulf Stream was—that is, whether the bulk of the Atlantic equatorial current turned northward east of the Antilles or entered the

[31] Seward, A. C., Fossil plants, vol. 4, p. 194, fig. 718C. 1919.

Caribbean, sweeping across Yucatan and making the circuit of the deeper offshore waters of the Gulf embayment. If it followed the latter course, this Eocene Gulf Stream would have been several hundred miles offshore and would have approached only that part of the Wilcox coast in southeastern Alabama and southern Georgia. In this event doubtless small offsets might have eddied along the eastern shore of the Wilcox Gulf, carrying their burden of drift fruits and seeds.

Another feature of the Wilcox environment, sufficient to account for the absence of all traces of marine faunas in the Wilcox sediments north of latitude 32° 30′, was the tremendous influx of fresh water. The Wilcox embayment received all the drainage of North America between the incipient Rocky Mountains and the Appalachians, at least south of the present Canadian border. From the evidence of the Wilcox flora, as well as that of scattered floras along the Rocky Mountain front, the rainfall was greater than it is at present, so that the shallow Wilcox waters would be very considerably subsaline. This condition ought to have resulted in the development of a characteristic brackish-water fauna, but no traces of such a fauna, beyond the rare occurrence of a *Corbula*-like pelecypod, have been discovered. This absence would be more significant were it not for the fact that similarly no traces of fresh-water shells, other than the equally rare occurrence of a *Unio*-like form in obviously delta deposits, have been discovered.

LOCALITIES

The numbers assigned in the following list of plant localities are used for reference in the systematic list of the Wilcox flora that follows this list.

ALABAMA

1, Claybank Creek, Dale County; 2, Kinterbish Creek, Choctaw County.

MISSISSIPPI

3, 11 miles east of Coffeeville, Yalobusha County; 4, Colemans Mill, Choctaw County; 5, DeKalb-Herbert road, Kemper County; 6, Hurleys, Benton County; 7, Oxford, Lafayette County; 8, Early Grove; 9, Lamar, and 10, Holly Springs, all Marshall County; 11, Lockhart, Lauderdale County; 12, Grenada, Grenada County; 13, Meridian, Lauderdale County; 14, Dabney, Montgomery County; 15, 1 mile east of Water Valley, Yalobusha County.

TENNESSEE

Chester County: 16, Taylor farm, Silerton road.

Hardeman County: 17, Big Cut at Pine Top; 18, Rogers Spring; 19, gully north of old State Line road; 20, three-fourths mile west of Rogers Spring road; 21, 3 miles south of Saulsbury; 22, Saulsbury; 23, Center Church; 24, 2½ miles northwest of Burnetts Store; 25, 2 miles southeast of Bolivar (Murrell place); 26, half a mile southeast of Walnut Grove Church; 27, Bolivar, west of hospital; 28, Young farm, northwest of Shandy; 29, 2¼ miles north of Shandy; 30, Mill Creek; 31, Gin Creek; 32, Teague; 33, north of Clover Creek; 34, 1 mile northeast of Cloverport; 35, Whiteville; 36, Shepherd Price farm; 37, 5¼ miles south of Whiteville; 38, Piney Creek, 10 miles east of Bolivar; 39, 1¼ miles east of Grand Junction.

Fayette County: 40, 1½ miles west of Grand Junction; 41, Baughs Bridge; 42, one-fourth mile northwest of Smyrna Church; 43, Brinkley Place, Fayette Corners; 44, 1 mile west of Laconia; 45, 3¼ miles northeast of Somerville; 46, half a mile south of Henley's store; 47, north of Loosahatchie River, 1 mile north of Somerville; 48, Safford-Lesquereux locality; 49, float in Grenada ironstone; 50, 1⅕ miles south of Somerville; 51, 1½ miles south of Somerville-Whiteville road; 52, 2$\frac{9}{10}$ miles southwest of Somerville; 53, 1½ miles northeast of Williston; 54, three-fourths mile northwest of Pattersonville; 55, road west of La Grange; 56, La Grange; 57, gully west of State road, La Grange; 58, Davenport property, La Grange; 59, 1 mile south of Grand Junction; 60, 4¾ miles southwest of Williston; 61, 5 miles southwest of Williston.

Madison County: 62, Pinson; 63, cut, Gulf, Mobile & Northern Railroad, one-fourth mile south of Mandy; 64, Will Brooks farm, northwest of Mercer; 65, Jim Tomphson farm, northeast of Jackson; 66, 2 miles southeast of Spring Creek; 67, Pope farm, north of Mercer; 68, one-fourth mile east of Denmark; 69, Jackson-Bolivar road, 5½ miles south of Jackson; 70, Mobile & Ohio Railroad, 4 miles north of Jackson.

Gibson County: 71, 4 miles southwest of Trenton; 72, 1 mile west of Milan.

Haywood County: 73, Somerville-Brownsville road, 1 mile north of Dancyville.

Carroll County: 74, Thompson-Barksdale prospect, 2 miles south of McKenzie; 75, Huckleberry Schoolhouse.

Henry County: 76, Foundry Church pit; 77, Whitlock pit; 78, Breedlove pit; 79, Bradley pit; 86, Grable pit; 81, Puryear; 82, Cottage Grove; 83, Atkins pit; 84, Spink pit; 85, Holcomb property, 2 miles south of Paris; 86, 1 mile southeast of New Boston; 87, Grove pit; 88, Cole pit; 89, pits southwest of Crossland.

KENTUCKY

90, Boaz, Graves County; 91, Wickliffe, Ballard County; 92, Bell City pottery pit; 93, east of pottery pit, Calloway County.

ILLINOIS

94, Mound City, Pulaski County.

ARKANSAS

95, Boydsville, Clay County; 96, Gainesville, and 97, Hardys Mills, both Greene County; 98, Bolivar Creek, Poinsett County; 99, Benton, Saline County; 100, Malvern, Hot Spring County; 101, Jacksonville, Pulaski County; 102, Texarkana, Miller County; 103, Nevada County; 104, 5 miles north of Texarkana, Miller County.

LOUISIANA

105, Friersons Mill, 106, Mansfield, 107, Naborton, and 109, McLees, all De Soto Parish; 108, Negreet, Sabine Parish; 110, Coushatta, Red River Parish; 111, 1½ miles east of Bienville, Bienville Parish; 112, Cross Bayou, 113, Vineyard Bluff, 114, Slaughter Pen Bluff, and 115, Spanish Lake, all Caddo Parish.

TEXAS

116, Old Port Caddo Landing, and 117, 6 miles north of Scottsville, both Harrison County; 118, 1½ miles west of Queen City, Cass County; 119, Sabine River, Sabine County;

120, 10 miles southwest of Palestine, Anderson County; 121, Butler Dome, Freestone County; 122, Colorado River, Bastrop County; 123, Calaveras Creek, Wilson County; 124, Elmendorf pit, Bexar County; 125, Elm Creek, Uvalde County; 126, 2 miles east of Tyler, Smith County; 127, 1 mile below Pullian ranch house, 128, 1½ miles south of La Pryor crossing, 129, Jug Slough, and 130, 5 miles northeast of La Pryor, all Zavala County; 131, Carrizo Springs, Dimmit County; 132, Concillas Creek, Webb County.

THE COMPLETE WILCOX FLORA

In the following systematic list the numbers refer to the preceding list of localities:

Phylum THALLOPHYTA
Class FUNGI
Order PYRENOMYCETES?

Caenomyces laurinea. 7.
Caenomyces sápotae. 7.
Caenomyces pestalozzites. 7, 12.
Caenomyces annulata. 40.
Caenomyces cassiae. 40.
Caenomyces myrtae. 7.

Phylum BRYOPHYTA
Class HEPATICAE
Order MARCHANTIALES

Marchantites stephensoni. 101.

Phylum LEPIDOPHYTA
Order LYCOPODIALES
Family LYCOPODIACEAE

Lycopodites? eolignіticus. 8.

Phylum ARTHROPHYTA
Class CALAMARIEAE
Order EQUISETALES
Family EQUISETACEAE

Equisetum sp. 30, 44, 63.

Phylum PTERIDOPHYTA
Class LEPTOSPORANGIATEAE
Order POLYPODIALES
Family SCHIZAEACEAE

Anemia eocenica. 18, 65, 74, 80, 81, 95, 106.
Lygodium binervatum. 2, 6.
Lygodium hastataforme. 130.
Lygodium trilobatum. 13, 25, 26, 29, 33, 107, 120.

Family POLYPODIACEAE

Acrostichum sp. 130.
Asplenium eolignіticum. 5, 97, 116.
Asplenium hurleyense. 6.
Cheilanthes eocenica. 81.
Dryopteris cladophleboides. 106.
Meniphylloides ettingshauseni. 107, 116.
Meniphylloides tennesseensis. 82.
Phanerophlebites knowltoni. 44, 52, 58.
Pteris pseudopennaeformis. 13, 19(?), 107, 108, 113.

Class HYDROPTERIDAE
Order HYDROPTERALES
Family SALVINIACEAE

Salvinia preauriculata. 25(?), 33, 63.

Phylum CYCADOPHYTA
Order CYCADALES
Family CYCADACEAE

Zamia mississippiensis. 13.
Zamia tennesseeana. 27.
Zamia wilcoxensis. 22, 107.

Phylum CONIFEROPHYTA
Class CONIFERAE
Order CONIFERALES
Family TAXINACEAE(?)

Taxites? sp. 85, 92.

Family CUPRESSINACEAE

Athrotaxis? eolignitica. 81.
Cupressinoxylon calli. 96.
Cupressinoxylon wilcoxense. 106, 107, 112, 114.
Glyptostrobus europaeus. 7, 8, 16, 17, 26, 52, 55, 93, 115.
Taxodium dubium. 18, 26, 62, 79.
Taxodium wilcoxianum. 16, 40.

Phylum ANGIOSPERMOPHYTA
Class MONOCOTYLEDONAE
Order GRAMINALES
Family POACEAE

Poacites sp. 44, 114.

Family CYPERACEAE

Cyperacites minutus. 16.
Cyperacites wilcoxensis. 16.
Cyperacites sp. 95, 114, 127, 132.

Order NAIADALES
Family NAIADACEAE

Potamogeton glücki. 63.
Potamogeton? fructus. 16.
Potamogeton incertus. 29.

Order ARALES
Family ARACEAE

Araceaeites friteli. 107.
Acorus heeri. 55.
Pistia wilcoxensis. 107.

Order PANDALES
Family SPARGANIACEAE

Sparganium sp. 81.

Order ARECALES
Family ARECACEAE

Chamaedorea danai. 4, 99.
Nipadites burtini umbonatus. 12, 82.
Nipadites sp. Unknown.
Palmocarpon butlerense. 17, 95, 121, 131.
Palmocarpon syagrusioides. 33, 65.
Palmocarpon cf. P. sessile. 81.
Sabalites grayanus. 7, 10, 12, 13, 17, 22, 25, 27, 30, 34, 36, 37, 41, 43, 52, 56, 57, 59, 62, 65, 69, 74, 76, 77, 80, 81, 93, 95, 99, 103, 104(?), 107, 113, 116, 123, 127, 128, 130, 131, 132.

Order LILIALES
Family SMILACACEAE

Smilax wilcoxensis. 55, 81.

Order SCITAMINALES
Family CANNACEAE

Canna eocenica. 7, 12, 25, 30, 116, 132.

POSITION UNCERTAIN

Phyllites wilcoxensis. 12.

Class DICOTYLEDONAE

Superorder CHORIPETALAE

Order JUGLANDALES

Family JUGLANDACEAE

Hicoria antiquorum, 112.
Hicoria crescentia. 45, 47, 49, 50, 52, 54, 61, 75.
Juglans berryi. 91, 110.
Juglans occidentalis. 17, 25, 43, 49, 60(?), 61.
Juglans saffordiana. 56.
Juglans schimperi. 30, 37, 42, 45, 48, 54, 55, 56, 64, 74, 80, 93, 95, 106, 132.
Paraengelhardtia eocenica. 35(?), 64, 80, 81, 82.
Engelhardtia ettingshauseni. 8, 10, 12, 27, 30, 49, 53, 56, 61, 65, 74, 80, 81, 91, 95, 99, 111, 130.
Engelhardtia mississippiensis. 8.
Engelhardtia puryearensis. 65, 80, 81.

Order MYRICALES

Family MYRICACEAE

Myrica elaeanoides. 6, 15, 40, 49, 61, 82, 90.
Myrica puryearensis. 74, 81.
Myrica wilcoxensis. 12, 42, 82, 132.

Order FAGALES

Family FAGACEAE

Dryophyllum amplum. 107.
Dryophyllum anomalum. 81, 104.
Dryophyllum juvenale. 81.
Dryophyllum moorii. 6, 91, 116.
Dryophyllum puryearense. 12, 16, 49, 50, 54, 61, 70, 80, 81, 91.
Dryophyllum tennesseense. 7, 10, 12, 16, 17, 18, 22, 23, 27, 29, 30, 31, 33, 37, 42, 48, 52, 53, 54, 59, 61, 64, 65, 74, 76, 77, 78, 80, 81, 83, 90, 91, 92, 93, 95, 104, 107, 131(?).

Order URTICALES

Family ULMACEAE

Planera crenata? 12.

Family MORACEAE

Pseudolmedia eocenica. 56, 74, 81.
Ficus artocarpoides? 30(?), 34, 43(?), 106, 110, 130.
Ficus cinnamomoides. 5(?), 7(?).
Ficus denveriana? 91, 106, 110, 112.
Ficus eolignitica. 97.
Ficus fructus pedicellata. 81.
Ficus fructus rostrata. 81.
Ficus harrisiana. 74, 101, 107, 112, 113.
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Guettarda ellipticifolia. 10, 52, 81, 82, 83.
Rubiacites pellicieraformis. 17.
Rubiacites sphericus. 75, 79, 81, 92.
Rubiacites wilcoxensis. 30, 93.

POSITION UNCERTAIN

Antholithes amentiferus. 82.
Antholithes arundites. 81.
Antholithes grablensis. 80.
Antholithes iliciformis. 82.
Antholithes marshallensis. 8.
Antholithes mimosaformis. 30.
Antholithes pruniformis. 79.
Antholithes ternstroemioides. 81.
Antholithes wilcoxensis. 82.
Calycites davallaformis. 81.
Calycites milanensis. 72.
Calycites ostryaformis. 123.
Calycites puryearensis. 81.
Calycites rhizophoroides. 80.
Carpolithus aggregatus. 30.
Carpolithus ailanthioides. 27.
Carpolithus alatus. 23.
Carpolithus banisteroides. 56.
Carpolithus bicapsulis. 56.
Carpolithus biseminatus. 79.
Carpolithus bolivarensis. 27, 81.
Carpolithus burseraformis. 81.
Carpolithus callowayensis. 92.
Carpolithus chesterensis. 16.
Carpolithus collinsi. 16.

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPHYTA

Class CALAMARIAE

Order EQUISETALES

Family EQUISETACEAE

Genus EQUISETUM Linné

Equisetum sp.

Plate 7, figure 1; Plate 50, figure 5

The clays near Laconia, Tenn., are full of what appear to be tubers of some species of *Equisetum*, and more rarely they contain fragments of what appear to be rhizomes of the same species. One specimen, that figured, shows nearly 5 centimeters of stem with one node, and at the node one of the tubers is attached and two detached ones are lying near at hand. Fragments of stems as much as 1.5 centimeters in diameter and poorly preserved occur in the Wilcox of eastern Texas, and may be referred to this same form. A fragment of a slender stem about 4 millimeters in diameter shows an internode 3.3 centimeters long and two nodes with slender, acute teeth about 7 millimeters in length. Comparisons with previously described species are obviously of slight value, but the presence of this long-ranging genus in the Wilcox is of interest. A larger species is present in the later Eocene of this region.

Occurrence: Holly Springs sand, gully 1 mile west of Laconia, Fayette County, Tenn.; Mandy, Madison County, Tenn.; Wilcox formation, Queen City, Cass County, Tex.

Phylum PTERIDOPHYTA

Class HYDROPTERIDAE

Order HYDROPTERALES

Family SALVINIACEAE

Genus SALVINIA Adanson

Salvinia preauriculata Berry

Plate 7, figures 2, 3; Plate 50, figure 1

Salvinia preauriculata Berry, Torreya, vol. 25, p. 116, figs. 1–4, 1925 (1926).

Dorsal or floating leaves relatively thick, elliptical, with a rounded apex and a rounded or slightly cordate base; of different sizes; the maximum dimensions observed are 16 millimeters in length and 10 millimeters in width. The midvein is well defined. The laterals are thin, nearly straight, diverging at regular intervals, very ascending in the tip of the leaf, the angle of divergence decreasing regularly proximad, the basal laterals being in places even slightly descending; they are connected by numerous thin and for the most part poorly seen oblique veinlets. The tubercles or pits lie in rows between the laterals and are usually well marked but somewhat irregularly developed. No ventral (submerged) leaves or sporocarps have been observed in the Wyoming material from the Bridger (?) formation, although spherical bodies about 2 millimeters in diameter are closely associated with the leaves, and these might possibly represent sporocarps. The specimen from the Holly Springs sand at Mandy, Tenn., shown in Plate 50, Figure 1, is unique in showing a complete and what appears to be a fruiting plant. Four floating leaves, three of which are nearly perfect, are clearly made out, as well as 14 threadlike divisions of the submerged leaves, with their appendages. Several of these dissected submerged leaves appear to be complete and are 2.5 centimeters in length. Immediately beneath the lowermost and incomplete floating leaf are two small subspherical bodies about 1.25 millimeters in diameter, and these appear to be in organic union with the submerged leaves at their base and to represent sporocarps. These bodies are brownish carbonaceous and of considerable consistency, so that when the plant was buried and flattened in the mud the floating leaf was pressed over them, and when the clay was split the leaf film over them flaked off. Immediately beside these objects that are interpreted as sporocarps is a similar impression in the clay without any carbonaceous residue, which might represent a third sporocarp.

There can not be the slightest doubt regarding the botanic affinity of this species, and, although it is not possible to verify the interpretation of the sporocarps, they appear very convincing. In the Wind River Basin this species is found in Bridger(?) deposits on the same slabs with the fruits of *Sparganium* and other representatives of a lakeside or slack-stream vegetation. In Tennessee it is associated with a large and varied coastal and lagoon-border flora.

Salvinia preauriculata is so named because of its great similarity to the existing *Salvinia auriculata* Aublet, which ranges from Cuba and Central America to Paraguay. Among the described fossil species it is closest to *Salvinia zeilleri* Fritel. The Wilcox beds in which it is found are correlated with the Ypresian stage of the Eocene. The Wyoming occurrence, less certainly correlated, is somewhat younger and may belong in the Lutetian stage of the middle Eocene. If this correlation is correct, it would tend to indicate that this species had spread northward to Wyoming from equatorial America during Eocene time.

The nominal fossil species of *Salvinia* number about a dozen. The oldest of these are the present species and *Salvinia zeilleri* Fritel,[32] from the Sparnacian stage of the Eocene of the Paris Basin. *Salvinia zeilleri* is one of the most completely preserved fossil species and is also more like the Wilcox species than any of the later Tertiary forms. There is a rather well-marked species from the Puget group (upper Eocene) in the State of Washington.[33]

The later forms, which are all from the Old World, except some species in the Miocene of Colombia [34] and Virginia,[35] comprise Oligocene species in France, Saxony, and Bohemia and Miocene species in Germany, Bohemia, Switzerland, Transylvania, Tonkin, China, and Japan. These have been reviewed recently in an important paper by Florin.[36]

All the fossil species are based primarily upon the dorsal leaves, but the dissected ventral or submerged leaves and sporocarps are present in some specimens, so that there is little doubt regarding the identification of the majority of the fossil forms referred to *Salvinia*. Brabenec [37] some years ago described specimens of the Miocene species *Salvinia formosa* Heer from the Saaz Basin in Bohemia that were said to show recognizable microspores and megaspores.

The existing species of *Salvinia* number 12 or 13 and are found chiefly in the equatorial regions of the world, especially in South America, where with *Azolla*, they are often present in myriads of individuals. One species, *Salvinia natans* Hoffmann, is found from southern France to India and northern China and has been reported from several localities in the United States.

Occurrence: Holly Springs sand, Bolivar-Jackson road north of Clover Creek and about 2 miles southeast of Bolivar, on Murrell property (?), Hardeman County, Tenn.; Mandy, Madison County, Tenn.

Class **LEPTOSPORANGIATAE**

Order **POLYPODIALES**

Family **POLYPODIACEAE**

Genus **PHANEROPHLEBITES** Knowlton

Phanerophlebites knowltoni Berry, n. sp.

Plate 7, figure 6

Frond habit unknown. Pinnae large, simple, elongate, with entire margins. Apex and base missing. Texture apparently not coriaceous to judge from the very fragmentary nature of the specimens and the extent to which the lamina is pushed apart between the veins during fossilization. The midvein is very broad but was apparently somewhat flat rather than stout and prominent in life. The lateral veins are thin, diverging at an acute angle, curving rapidly outward, dichotomous and anastomosing.

The material is insufficient for a proper diagnosis, but as it represents a unique type, new to the Wilcox flora, it was deemed important enough to record with as much detail as could be made out.

The genus was proposed by Knowlton [38] for a single species from the Laramie formation of Colorado, the name resting on the resemblance shown to the recent ferns of the genus *Phanerophlebia*. The present species differs from the type, *Phanerophlebites pealei* Knowlton, in its more delicate texture, less prominent midvein, and more ascending lateral veins. It appears to have been not uncommon in the Wilcox, but all of the specimens are small fragments. Its presence in the Wilcox is of especial interest, because a problematic type, described by the writer in 1919 as *Phyllites asplenioides* [39] and rather common in the Coffee sand member of the Eutaw formation of Tennessee, appears to be a representative of this same genus. The specimen from the Eutaw was a very large form, unfortunately in a fragmentary condition. It showed

[32] Fritel, P. H., Jour. botanique, 2d ser., vol. 1, p. 190, 1908.

[33] Hollick, Arthur, Torrey Bot. Club Bull., vol. 21, p. 255, 1894.

[34] Engelhardt, Hermann, Senckenberg. naturf. Gesell. Abh., Band 19, p. 39, pl. 3, figs. 18, 19, 1895.

[35] Berry, E. W., Jour. Geology, vol. 17, p. 21, 1909.

[36] Florin, Rudolf, Eine Übersicht der fossilen *Salvinia*-Arten mit besonderer Berücksichtigung eines Fundes von *Salvinia formosa* Heer im Tertiär Japans: Geol. Inst. Upsala Bull., vol. 16, pp. 243–260, pl. 11, 1919.

[37] Brabenec, Bedřich, O novém nalezišti třetihorních rostlin ve spodním pásmu vrstev žateckých: Rozpr. České Akad., Tř. II, vol. 13, No. 18, 25 pp., 1 pl., 1904.

[38] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, p. 110, 1922.

[39] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 140, pl. 33, 1919.

the same widened midvein and somewhat flabellate dichotomous anastomosing venation.

The living genus *Phanerophlebia*, to which these fossil species appear to be related, contains about a dozen closely related species that range from Mexico to Brazil.

Occurrence: Holly Springs sand, gully 1 mile west of Laconia, Fayette County, Tenn.; gully west of La Grange, on Davenport property, Fayette County, Tenn. Grenada formation, 2.9 miles southwest of Somerville, just below Moses Hall, Fayette County, Tenn.

Genus MENIPHYLLOIDES Berry

Meniphylloides tennesseensis Berry, n. sp.

Plate 49, figures 1–5

Fronds simple or once pinnate. All the numerous specimens are detached and have a considerable rachis, which rather favors the opinion that they are fronds rather than pinnae, but no conclusions can be reached on this point. They are lanceolate to linear-lanceolate. Texture coriaceous. Margins entire, inclined to be slightly revolute. Base rather uniformly acuminate. Apex varying from abruptly pointed to acuminate. Length ranging from 4 to 12 centimeters. Maximum width ranging from about 1 to 2.25 centimeters. Rachis stout, curved, maximum length 1.5 centimeters. Midvein stout prominent on the under side, tending to be sulcate on the upper side. Laterals diverging at angles of 60° to 80°, fairly stout but not prominent, spaced at intervals of about 2 millimeters, their tips connected by somewhat irregular arches in the marginal region. The space between is netted veined, with mostly quadrangular but somewhat variable meshes. The ultimate vein endings appear to be free inside the meshes, but this feature is generally obscure because of the faintness of the venation on the upper surface and because of the fact that nearly every areole on the lower surface is occupied by a fusiform brownish object which I first thought represented sori but which I conclude is of a ramental nature or a glandular secretion. Undoubted free endings are clear in some places, but in most places obscure as indicated above. The so-called laterals are not differentiated in some specimens, and all of the laterals, both primary and intermediary, are of approximately the same size.

It is not at all certain that the foregoing seemingly characteristic features are correctly interpreted, and it is possible that these interesting specimens may not even be those of a fern but that they represent some glandular dicotyledonous leaf.

After mature consideration I have decided to include this species in the genus *Meniphylloides*, established in 1916 for a species from the Grenada formation of Mississippi. This decision will modify the generic diagnosis, which was based on the type in which free veinlets were lacking.[40]

When collected I supposed that the fusiform spots within the areolae represented sori, but they show no traces of spores in microscopic preparations, and are homogeneous and structureless. Professor Bower, who, during his recent visit to America, examined the specimens with me, regarded these sorilike objects as glands at the blind endings of the veins within the areolae, and this seems to be the most likely explanation, as they are variable in size, are found within both large and small areolae anywhere on the lamina, and are homogeneous and not structurally differentiated.

Bower agreed with me in considering that the venation suggested the *Drynaria* type, although it is not a typical expression of that type. This conclusion does not greatly help in attempting to fix the existing

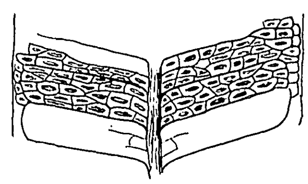

FIGURE 8.—Fragment of *Meniphylloides tennesseensis* Berry, showing venation and glandular secretion. × 4

relatives of the fossil. Ettingshausen, in his artificial classification of filicalean foliar types, instituted two groups which included forms similar to this and which he termed *Drynaria regularis* and *D. irregularis*, but there is considerable intergradation and much variability in details, and this type of venation is now known to characterize a variety of not closely related Polypodiaceae and to be approached by some others that have what has usually been termed the *Meniscium* type of venation.

I thought of using *Drynaria* as a generic term for the present fossil, but that would suggest relationships that are not warranted and is at variance with the usually accepted rules of nomenclature. I have not been able to find any existing form which actually matched the fossil, but it is approached by a variety of existing species, especially in the large and varied genus *Dryopteris*.

The present species resembles *Meniphylloides ettingshauseni* Berry in general form but tends to be more elongated and less acuminate at both ends. It differs in having an entire margin and a glandular surface, in the more rectangular areolation, the free

[40] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 166, 1916.

veinules, and more prominent midvein, and in the absence of a marginal vein. The two nevertheless appear to me to be rather closely related, and in the absence of more conclusive data to be properly within the limits of a single genus.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn. (abundant).

Genus CHEILANTHES Swartz

Cheilanthes eocenica Berry, n. sp.

Plate 48, figure 35.

Fronds at least bipinnate. Stipe narrowly winged. Pinnae elongate triangular, finely divided. Pinnules small, alternate, somewhat irregularly scalloped or lobed with rounded scallops and tip. Substance thick. Venation obscured. This species is based upon a considerable amount of fragmentary material, the specimen figured being the largest one discovered.

One of the reasons for regarding this form as a species of *Cheilanthes* is the manner of dissection of the fronds, which are superficially very similar to those of existing species of this genus. A more convincing reason is that the pinnule margins are clearly much involute, and in the clearer specimens this region is marked by relatively large circular swellings about 0.5 millimeter in diameter, which may well be considered sori. No other details can, of course, be made out in the carbonized remains, but their general organization, as I believe I have correctly interpreted it, seems to me conclusive evidence of relationship.

The genus *Cheilanthes* has been variously segregated by students of recent ferns, and some of its subgenera are commonly given generic rank, but for paleobotanic work it seems best to use the name in a broad sense. So far as I know no fossil species of *Cheilanthes* have been described. Goeppert proposed the term *Cheilanthites* for certain Paleozoic plants that are certainly unrelated to *Cheilanthes*. The only American fossil form that at all resembles the present species, and I believe this resemblance to be purely superficial, is a form represented by some thin sterile fragments from the so-called Laramie of Yellowstone Park described by Knowlton [41] as *Asplenium haguei*.

The present species appears to me to differ from *Dicksonia*, *Cyathea*, *Alsophila*, and other modern genera with which it has been compared. In the genus *Cheilanthes* a large number of existing forms from various continental areas might be mentioned as closely resembling the fossil form. In America two similar existing species are *Cheilanthes moritziana* Kunze of Mexico and northern South America and *Cheilanthes lendigera* Swartz of northern South America. Other forms might perhaps as justly deserve mention, and I attach no particular significance to those mentioned.

The genus has between 50 and 100 species in the temperate and tropical parts of all the continents, and a considerable number are characteristic of such rocky and semiarid regions as those of our trans-Mississippian southwestern country, but several still exist around the perimeters of the Eocene Mississippi embayment.

The present species is known only from the single locality cited below and may have been derived from the Paleozoic limestone country which lay in the eastern hinterland of the upper embayment.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Family SCHIZAEACEAE

Genus LYGODIUM Swartz

Lygodium hastataforme Berry, n. sp.

Plate 7, figure 4

Pinnules entire, simple, ligulate, and generally more or less falcate, widest at or above the middle, with a rounded tip and a cuneate sessile base. Length about 7 centimeters; maximum width about 2 centimeters. Margins entire, distinctly undulate or broadly and flatly crenate. Texture subcoriaceous. Midrib stout, prominent, and generally curved; laterals diverge from it at very acute angles, curving somewhat outward, and are regularly twice or thrice dichotomous. This material obviously does not represent *Pteris*, *Blechnum*, *Asplenium*, or *Anemia*. It is somewhat suggestive of *Gymnogramme trifoliata* Desvaux of Peru, but, on the other hand, it is practically identical with the existing *Lygodium hastatum* Desvaux of northern South America (Brazil, Guiana, and other countries), which resemblance has suggested the specific name of the fossil.

The genus is represented in the earlier Wilcox by the conspicuously different *Lygodium binervatum* Berry [42] and reappears in the Claiborne in *Lygodium kaulfussi* Heer. The two last belong to the palmate section of the genus, and the present species is obviously simple. It is represented by several specimens.

Occurrence: Carrizo sandstone, east bank of the Nueces, 5 miles N. 30° E. of La Pryor, Zavala County, Tex.

Lygodium trilobatum Berry, n. sp.

Plate 7, figure 5

Pinnules small, trilobate. Lobes narrow, linear, diverging at angles of about 45°, separated by deep, narrow sinuses. Base rounded. Venation characteristic of the genus, three stout primaries made up of

[41] Knowlton, F. H., U. S. Geol. Survey Mon. 32, pt. 2, p. 655, pl. 77, figs. 1, 2, 1899.

[42] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 165, pl. 10, figs. 3–8, 1916.

coalescent secondaries diverging from the base. Secondaries thin, ascending, dichotomously branched but slightly curving, terminating in the entire margins.

Length about 7 centimeters; maximum width about 8 centimeters; width of lobes 11 to 12 millimeters.

This species is very similar to previously described species, of which three are now known from the Wilcox and a fourth from the Claiborne. The present species differs from *Lygodium binervatum* (Lesquereux) Berry, the common lower Wilcox species, in its trilobate habit, smaller size, narrower and more elongated lobes, finer and more ascending venation. The differences between it and the simple-pinnuled *Lygodium hastataeformis* of the upper Wilcox of Texas are too obvious to require comment.

Lygodium kaulfussi Heer of the Claiborne and western Tertiary is a larger, more coriaceous form, usually quadrilobate, with long slender lobes.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, road half a mile southeast of Walnut Grove Church, Hardeman County, Tenn., Grenada formation, near Meridian, Miss. Wilcox formation, near Naborton, La.

Genus ANEMIA Swartz

Anemia eocenica Berry

Plate 47, figure 1

Aneimia eocenica Berry, U. S. Geol. Survey Prof. Paper 91, p. 164; pl. 9, fig. 7; pl. 10, fig. 2; pl. 11, figs. 1, 2, 1916.

The fine specimen from Puryear figured herewith is a larger portion of frond than any found previously. It is similar to the Raton species, *Anemia occidentalis* Knowlton, and comparable forms occur in the Denver formation. A similar form, possibly specifically distinct and possibly only a variety of *Anemia eocenica* is present in undescribed material from the Fayette sandstone of Trinity County, Tex.

The present species has been found at seven localities, widely distributed along both shores of the Wilcox embayment. So far as known, it is confined to the horizon of the Holly Springs sand.

Occurrence: Holly Springs sand, Rogers Spring, Hardeman County, Tenn.; Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Grable pit and Puryear, Henry County, Tenn. Wilcox formation, Boydsville, Ark., and Mansfield, La.

Phylum CYCADOPHYTA

Order CYCADALES

Family CYCADACEAE

Genus ZAMIA Linné

Zamia tennesseeana Berry, n. sp.

Plate 32, figure 8

The only two alternatives regarding the botanic affinity of this fossil appear to me to be the Cycadaceae and the *Nageia* section of the genus *Podocarpus*. The genus *Nageiopsis* of Fontaine, which is supposed to be related to the modern *Nageia*, is a common type throughout the Lower Cretaceous in eastern North America, and if the present detached specimen had come from Lower Cretaceous strata I would be inclined to identify it as *Nageiopsis angustifolia* Fontaine. The genus *Nageiopsis* is definitely excluded from the Cycadaceae by the character of the branched twigs, but in the absence of any evidence of this sort in the Wilcox specimen, and in the absence of definite proof of an actual botanical relationship between *Nageiopsis* and *Nageia*, the probability is all in the direction of the present specimen representing a cycad pinnule. If it had a midrib it would very likely represent some member of the tribe Bambusae, or other grass. As there is no midrib and the veins are stouter and closer and the texture is also more coriaceous than normally obtains among the grasses, the choice of identity seems narrowed to the Cycadaceae, and in this restricted family, at least as developed in southeastern North America in the Tertiary and recent floras, the choice would seem to be further restricted to the genus *Zamia*. It may be described as follows:

Pinnule lanceolate, widest below the middle, tapering upward to an obtuse point; not bilaterally symmetrical, one margin being nearly straight and the other curved. Texture subcoriaceous. A distinct basal callosity or area of attachment present. Length about 6.5 centimeters; maximum width about 6 millimeters. Veins stout, parallel in the median part of the pinnule, where they number 19 or 20; they converge slightly distad and more noticeably proximad, coalescing into about half the normal number in the extreme base.

Of the existing genera of cycads in the Western Hemisphere—*Zamia*, *Ceratozamia*, *Dion*, and *Microcycas*—all except the first have foliage unlike the fossil. *Zamia* is the only one of these genera not exceedingly restricted in both distribution and differentiation, and it contains over one-third of the existing species of the whole cycad family. Its 35 or more living species are scattered from southern Florida and Mexico through the Antilles to about latitude 24° S. in South America east of the Andes. Among these species there is considerable variation in the size and proportions of the pinnules. During the Tertiary the range was considerably greater, for well-marked *Zamia* remains have been found as far south as latitude 38° S.,[43] and in our American Eocene they reach northward to western Tennessee in the east and to Alaska in the west.

The habitat of the modern species ranges from humid to nearly arid not only in *Zamia* but through-

[43] Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 4, p. 120, pl. 1, fig. 4; pl. 2, figs. 1–3, 1922.

out the whole family, so that in the Tertiary, at any rate, they can not be considered as throwing any precise light on environmental conditions, which must be derived from associated forms.

Two other supposed species of *Zamia* have been recorded from the Wilcox—the somewhat doubtful *Zamia* (?) *wilcoxensis* Berry,[44] a much larger form, very imperfectly known, and *Zamia mississippiensis* Berry,[45] an indubitable *Zamia* with small, slender fronds with few veined blunt pinnules like those of the existing *Zamia floridana* De Candolle.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Phylum CONIFEROPHYTA

Order CONIFERALES

Family PINACEAE

Genus GLYPTOSTROBUS Endlicher

Glyptostrobus europaeus (Brongniart) Heer [46]

Plate 7, figures 7–9

This widespread species was recorded from two localities in the Holly Springs sand of northern Mississippi in 1916, one occurrence being based upon a small fragment of a twig and the other on somewhat problematic seeds, both preserved in the clays. A second small fragment of a twig was collected from a third locality in the Wilcox in 1923. The total record from the clays has thus been two small specimens, although the clays have been very thoroughly explored and there are many openings. The astonishing abundance of *Glyptostrobus* twigs in the lignite band at the outcrop on the Taylor farm in Chester County, Tenn., is all the more remarkable. This 12-inch lignite bed consists almost entirely of these twigs. They show considerable differences in appearance, according as the leaf bases are short or elongated. Several of these are figured. No traces of *Glyptostrobus* cones have been detected in the lignite, although seeds and fruits of various other kinds of plants are not uncommon.

Occurrence: Holly Springs sand, road west of La Grange, Fayette County, Tenn.; Silerton road, Taylor farm, Chester County, Tenn.

Genus TAXITES Brongniart

Taxites (?) sp., Berry

Plate 36, figures 1, 2

Based upon rather stout leafy twigs. Leaves flat, coriaceous, linear-lanceolate, with acuminate tips, abruptly narrowed to a decurrent base, 2 centimeters or less in length and 2 millimeters in maximum width. The midvein is broad but not prominent; on either side of it parallel with and close to the margin a line of contact is impressed on the clay matrix, indicating that the stomata were in broad bands on either side of the midrib. The material is in the form of ferric oxide replacement, and no structural details can be made out. There is little doubt, however, that the interpretation just given is the correct one. The phyllotaxy is spiral and the habit of the more mature specimens is more or less bifacial, less so in the smaller and presumably younger specimens.

There is a considerable uncertainty regarding the best method of treating these fossils. The leaves are exactly like those of the existing *Sequoia sempervirens* (Lambert) Endlicher and should possibly be referred to the ubiquitous and probably composite *Sequoia langsdorfii* (Brongniart) Heer, the wood of which was recorded by Penhallow [47] from the Claiborne Eocene of Texas. No trace of the cones or foliage of *Sequoia* has been discovered in the Eocene of southeastern North America, and Penhallow's determination of the wood may be erroneous. It seems strange if *Sequoia* was a member of the Wilcox flora that no traces of cones should have been discovered in these prolific and widely explored deposits. Other extremely similar existing types are those of the genera *Taxus* and *Tumion* (or *Torreya*), species of which still exist in the Florida region. The difficulty is increased by the presence of stomatiferous bands, such as might serve to indicate a relationship to *Taxus* or *Torreya*, in *Sequoia sempervirens*. Despite this resemblance to the modern redwood, I am referring the fossils to the form genus *Taxites* of Brongniart, thus signifying my belief that they are related to *Taxus* or *Torreya*. I am influenced in this course by the nondiscovery of *Sequoia* cones in the Wilcox and by the practical identity between the present remains and those from the Eocene that have been referred to *Taxites*, fruits of which would be less likely of preservation or recognition than those of *Sequoia*, as, for example, the Fort Union forms referred to *Taxites olriki* Heer.[48] It is true that these are all from much more northern localities, as remote as those furnishing *Sequoia*, but the survival to modern times near the Gulf coast of both *Taxus* and *Torreya* has considerable weight.

Occurrence: Holly Springs sand, Holcomb property, Henry County, Tenn.

[44] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 169, pl. 114, fig. 2, 1916.

[45] Berry, E. W., U. S. Geol. Survey Prof. Paper 108, p. 63, fig. 17, 1917.

[46] The extensive synonymy of this probably composite species is given in Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 171–172, 1916.

[47] Penhallow, D. P., Roy. Soc. Canada Trans., 3d ser., vol. 1, sec. 4, pp. 94, 95, 1917.

[48] See Knowlton, F. H., U. S. Geol. Survey Mon. 32, p. 680, pl. 82, figs. 1, 3, 4, 1899.

Genus TAXODIUM L. C. Richard

Taxodium wilcoxianum Berry, n. sp.

Plate 7, figures 10–12

Taxodium sp., Berry, U. S. Geol. Survey Prof. Paper 91, p. 173, pl. 15, fig. 9, 1916.

Heretofore the single seed figured in 1916 was the only trace of *Taxodium* seeds found in the Wilcox. In the lignite band at the outcrop in Chester County, Tenn., cypress seeds are common and characteristic. They probably represent the widespread Tertiary species *Taxodium dubium* (Sternberg) Heer, or, as it is more commonly called, *Taxodium distichum miocenum* Heer. As this probable relationship between foliage and seeds can not be demonstrated, it has seemed proper to definitely name the seeds.

They are absolutely typical of *Taxodium* and differ from the seeds of the existing bald cypress, *Taxodium distichum* Richard, merely in being slightly below the average of this species in size and in being somewhat more slender.

Occurrence: Holly Springs sand, Silerton road, Taylor farm, Chester County, Tenn.

Phylum ANGIOSPERMOPHYTA

Class MONOCOTYLEDONAE

Order GRAMINALES

Genus POACITES of authors

Poacites sp. Hollick

Plate 7, figure 13

In the original account of the Wilcox flora [40] *Poacites* sp. and *Cyperites* sp. were listed as indefinite monocotyledonous foliage because they were already in the literature, although no attention was paid to similar remains of grass or sedge foliage which are present in the Wilcox at many outcrops. They are all too indefinite for either generic or specific characterization and are without either biologic or geologic significance beyond demonstrating the presence of this type of plants, which conclusion might have been considered established a priori.

Some of the older as well as modern authors list a long array of species of grass and sedge which are of little or no value. In the present work I have illustrated a specimen to show the abundance of this class of remains in the Wilcox at some localities. Although slightly narrower it may be referred to *Poacites* sp. Hollick, which was based upon material from the later Wilcox of Louisiana.

Occurrence: Holly Springs sand, gully 1 mile west of Laconia, Fayette County, Tenn.

[40] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 174, 1916.

Order CYPERALES

Family CYPERACEAE

Genus CYPERACITES Schimper

Cyperacites wilcoxensis Berry, n. sp.

Plate 35, figure 7

I have never endeavored to differentiate or describe the numerous traces of grass and sedgelike foliage that are common at various horizons in the Wilcox. Among the numerous remains of fruits and seeds present in the loosely consolidated lignite from Chester County, Tenn., there are two varieties of fruits that almost certainly represent lower Eocene species of sedges and are therefore worthy of formal description. The first and more certainly identified of the two is represented by two specimens.

The achene is compressed, ovate-acuminate in profile, distinctly and stoutly pedunculate. It is widest proximad and tapers upward to a pronounced and slightly curved beak. Length about 3.5 millimeters. Maximum width about 2 millimeters. Except for the lack of bristles, which might be expected to become lost during fossilization and which are indeed absent in many Pleistocene forms referred to *Scirpus*, these lower Eocene achenes are very similar to those of that genus. I know of no other existing group other than the Cyperaceae whose fruits would be at all likely to be confused with those of sedges, and although it is impossible to conclude that the fossil represents *Scirpus* rather than some other existing genus, its reference to the family under the form genus *Cyperacites* appears to be warranted.

The modern species of *Scirpus* are widely distributed in ponds and both fresh and brackish marshes.

Occurrence: Holly springs sand, Silerton road, Taylor farm, Chester County, Tenn.

Cyperacites minutus Berry, n. sp.

Plate 35, figure 6

Ovate acuminate, small, compressed achenes(?), unstalked and unarmed, widest proximad, recurved slightly distad. About 2 millimeters in length and 1.25 millimeters in maximum width.

This species is much less clear in its botanical affinity than the associated *Cyperacites wilcoxensis* Berry. It appears to be strictly comparable with various existing sedges with small beaked biconvex achenes, such as certain species of *Scirpus* and *Cyperus*, but it might, on the other hand, represent the seed of some higher plant. Two specimens have been collected, and as the deposit is palustrine and the form is that of numerous sedges, it is not unlikely that such is its relationship.

Occurrence: Holly Springs sand, Silerton road, Taylor farm, Chester County, Tenn.

Order PANDANALES

Family SPARGANIACEAE

Genus SPARGANIUM Linné

Sparganium? sp.

Plate 8, figure 1

The single specimen upon which this determination rests is shown in the accompanying illustration. The details are not well preserved, and therefore possibly it has been misinterpreted. The specimen shows a stout stalk or branch slightly over a centimeter in length, which gives off a more slender branch about halfway above its base. Both are terminated by capitate clusters of what appear to be pistillate flowers. These are now partly crushed, but the whole was probably globular in life and from 5 to 6 millimeters in diameter.

This form bears a very great similarity to the pistillate flower heads of the recent species of *Sparganium*, although there are members of the families Pontederiaceae and Alismaceae that are not conspicuously different in appearance. The genus *Sparganium* has about a dozen existing species, widely distributed for the most part in temperate and cool regions, in wet or even submerged environments. Fossil remains are fairly numerous, comprising, in addition to the recent species, which have been found fossil in the Pleistocene, about 15 species ranging from the Upper Cretaceous through the Pliocene. Several of these species, notably those recorded from the Upper Cretaceous, are not especially convincing, but there is an unmistakable species in the middle Eocene of the western United States,[50] and undoubted species occur in the Oligocene and later Tertiary of Europe.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Order NAIADALES

Family NAIADACEAE

Genus POTAMOGETON Linné

Potamogeton incertus Berry, n. sp.

Plate 29, figure 5

Leaf small, orbicular in general outline, broadly rounded distad, somewhat decurrent proximad to the broad sessile line of attachment. Margins full and evenly rounded. Texture thin and lax. Length about 3.25 centimeters; maximum width, midway between the apex and the base, about 2.3 centimeters. Midvein thin. Balance of the lamina with very fine closely spaced longitudinal parallel veins.

This single specimen by its thin membranous texture and delicate venation is obviously the submerged leaf of some aquatic plant. Some modern Pontederiaceae, Hydrocharitaceae, and Naiadaceae have submerged leaves more or less similar to the fossil, and probably it represents such a leaf of *Potamogeton*, which genus is represented by very decisive material in the Upper Cretaceous of this same area.

The genus *Potamogeton* has a large number of fossil species and many widely distributed existing species in ponds and streams. It has not heretofore been recognized in the Wilcox flora, although, as previously stated, it occurs in the Ripley flora of west Tennessee and there are two species in the upper Eocene (Jackson) flora of this region.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

Potamogeton glücki Berry, n. sp.

Plate 44, figures 13, 14

Leaf small, lanceolate, widest medianly, about equally tapering and acute at the apex and base, the latter decurring to a short, broad petiole. Margins entire. Texture delicate. Length about 2.25 centimeters; maximum width about 5 millimeters. The primary venation comprises a slender midvein and two slender acrodrome primaries on either side, about equidistantly spaced and descending into the base. Thin, closely spaced transverse veinlets connect the primaries. The species is named in honor of Professor Glück, of Heidelberg, the well-known student of recent aquatic plants.

This species, which is unfortunately based upon the single specimen figured, obviously represents the submerged leaf of some species of *Potamogeton* and is much more certainly identified than the Wilcox form which I have called *Potamogeton incertus*. It is very similar to the submerged leaves of a number of existing species of *Potamogeton* as, for example, the widespread *Potamogeton heterophyllus* Schreber. Obviously a single leaf fails to reveal the limits of variation in this Wilcox species and makes comparisons with existing species rather futile.

Occurrence: Holly Springs sand, cut on the Gulf Mobile & Northern Railroad, one-fourth mile south of Mandy, Madison County, Tenn.

Potamogeton? fructus Berry, n. sp.

Plate 49, figures 11–15

The material washed from the lignite at the Taylor place contains six specimens of a fruit which I have referred with some hesitation to the genus *Potamogeton*. It seems clearly to belong to the family Naiadaceae, but whether it represents *Potamogeton*, the leaves of which occur in the Wilcox, or whether it is closer

[50] Berry, E. W., Bot. Gazette, vol. 78, p. 346, figs. 1–7, 1924.

to the genus *Ruppia*, or represents an extinct genus of this family can not be satisfactorily determined.

These fruits are much compressed, a natural bifacialism being much accentuated by pressure during or subsequent to burial. They are eccentrically ovate, rounded proximad, abruptly narrowed distad to form a recurved styliferous beak. In the two smallest specimens there is a peduncle not over 0.5 millimeter in length. The surface is smooth, except that in both small and large specimens there are patches of material that are interpreted as residual parts of a thin and partly destroyed pericarp. Dimensions range from 4 to 7 millimeters in length, of which about one-fourth is beak, and from 2.75 to 4.25 millimeters in maximum width. The supposed seed is coriaceous and smooth.

The exact position of these fruits is uncertain. I have seen no recent *Potamogeton* fruits that are closely similar. In some respects the fossils suggest the allied genus *Ruppia*, but the latter forms are considerably smaller and long pedicellate. It is possible that these lower Eocene forms represent a proto-*Ruppia* in the process of adaptation to the specialized habit of the modern species of *Ruppia*, but such a possibility is of course pure speculation. Clement Reid has already recognized an extinct genus of this family in the English Eocene which he calls *Limnocarpus*—a type, however, readily distinguishable from this Wilcox form.

Occurrence: Holly Springs sand, Taylor farm, on Silerton road, Chester County, Tenn.

Family ARACEAE

Genus ACORUS Linné

Acorus heeri Berry, n. sp.

Plate 8, figure 7

Scape slender, slightly over 1 millimeter in width; apparently angled, but this feature is somewhat problematic. Inflorescence distinctly pedunculate, about 1.4 centimeters in length and 3 millimeters in maximum diameter, bluntly rounded distad and somewhat tapering proximad. The specimen is unfortunately broken away about 2 millimeters above the attachment of the spadix, so that it can not be determined whether the spathe was a narrow continuation of the scape and not obviously differentiated, as in the existing species of *Acorus*, or whether it expanded, as in most modern Araceae. Scape preserved for a distance of 2.2 centimeters.

This unique specimen obviously represents some member of the family Araceae, and on the whole it appears to agree rather closely with the genus *Acorus*. It is most unfortunate that the distal part, which would definitely settle this question, is broken away. I was at first disposed to compare the fossil with the modern genus *Spathiphyllum* Schott, which appears to be represented in the Sparnacian of France by *Araceaeites parisiensis* Fritel [51] and in the Wilcox by *Araceaeites friteli* Berry,[52] both of which are more robust forms than the present species. The resemblance to *Acorus* is closer, however.

Only two existing species of *Acorus* are known. They are small plants of swamps and wet stream banks, one confined to Japan and the other, the familiar *Acorus calamus* Linné, a widespread holarctic form, found also in the warmer parts of eastern Asia, the East Indies, and Atlantic North America. Its wide distribution would tend to indicate that it was a type of considerable antiquity. The fossil records of the genus are very incomplete and unsatisfactory and comprise a late Eocene or Oligocene form from Svalbard (Spitsbergen) described by Heer, rather doubtful records from the Eocene Denver formation of Colorado and Hanna formation of Wyoming, the early Oligocene *Acoropsis minor* Conwenz of the Baltic amber, and a later Oligocene species in Italy.

Occurrence: Holly Springs sand, road west of La Grange, Fayette County, Tenn.

Order ARECALES

Family ARECACEAE

Genus PALMOCARPON Lesquereux

Palmocarpon cf. P. sessile Barry

Palmocarpon sessile Berry, U. S. Geol. Survey Prof. Paper 92, p. 152, pl. 61, fig. 5, 1924.

Two specimens from beds near the top of the Holly Springs sand at Puryear, Henry County, Tenn., show no appreciable differences in size or habit from the type of this species, which came from the Fayette sandstone of central Texas and is Jackson in age.

The nuts in the Wilcox material are slightly more crowded, and it is improbable that the two occurrences represent the same botanical species, for several genera of existing palms have this same fruiting habit. The Fayette material was compared with the genus *Geonoma*, which appears to be represented in the Ripley formation, the latest Upper Cretaceous formation in Tennessee, and in the Mount Selman formation, the earliest formation of the Claiborne group in Texas, by forms referred to *Geonomites*. This foliar type has not yet been discovered in the Wilcox, however. Another significant modern type with fruits like these is the genus *Thrinax*, represented by foliage in the Claiborne and Jackson. The species from the Bahamas and the Florida Keys, *T. keyensis* Sargent and *T. microcarpa* Sargent, both have similar fruits quite as small and commonly smaller than the

[51] Fritel, P. H., Soc. Géol. France Mém. 40, p. 29, pl. 3, fig. 1, 1910.

[52] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 175, pl. 114, figs. 3, 4, 1916.

fossil. They are also much like the existing *Chamaedorea elegans* and *Chamaedorea schiedeana*, which belong to a genus represented by foliage in the Wilcox.

Palmocarpon syagrusioides Berry, n. sp.

Plate 8, figures 5, 6

Small, essentially symmetrical, fusiform or turbinate, monospermic fruits with a fibrous exocarp, somewhat rounded proximad and extended and acutely pointed distad, about 2.5 centimeters in length and about 1 centimeter in diameter.

These fruits appear to be of some species of palm and are much like diminutive fruits of *Nipadites* but are more pointed.

Among previously described fossil forms they are very close to *Carpolithes provincialis* Saporta [53] from the lignites of Fuveau (Aturian) in southern France. Among recent forms they are much like the fruits of the tropical American palms referred by Martius to the genus *Syagrus*, now usually considered a subgenus of *Cocos* Linné.

Occurrence: Holly Springs sand, Bolivar-Jackson road just north of Clover Creek, Hardeman County, Tenn.

Genus NIPADITES Bowerbank

Nipadites sp.

Plate 50, figures 11–13

The specimen figured was collected many years ago by J. M. Safford when State geologist of Tennessee. No record of the horizon or locality is available. The specimen was preserved in the collections of Vanderbilt University, and I am indebted to Prof. L. C. Glenn, of that institution, for presenting it to the United States National Museum.

The specimen is a ferruginous replacement, presumably limonite, and is 6.5 centimeters in length and about 4.3 centimeters in maximum diameter. It is approximately circular in cross section but shows five equatorial planes of external compression, so that it is faintly pentagonal. The boundaries of these planes become pronounced ridges distad and are especially prominent toward the somewhat truncated, rounded apex. The actual tip of the fruit is a somewhat projecting rounded umbilicus. The whole fruit is somewhat unsymmetrical, as shown in the lateral view. The base is truncate and slightly excavated and shows a thick rounded peduncular scar, about 5 millimeters in diameter. The surface is longitudinally and irregularly ribbed.

A polished median transverse section fails to show structural details. No cell outlines can be made out, and it appears that the specimen shows the external form with great fidelity but was built up from without inward by laminar layers of limonite. If it presents a true pattern of internal arrangement it indicates a moderately thick wall, averaging about 6 millimeters in thickness, and a single-seeded central cavity between 2.5 and 3 centimeters in diameter. The limonite of this central region is vesicular and labyrinthine and might be assumed to represent a replacement of a shriveled and more or less rotted seed. On the other hand these features may be illusory and purely fortuitous.

The question of the identity and horizon is one which can not be definitely settled. Externally the specimen agrees closely with specimens of *Nipadites*, and with the nuts of the existing *Nipa*, except that the latter are usually more compressed, but this is an exceedingly variable feature. I feel reasonably sure that it represents *Nipadites*, but hesitate to give it a specific name, although there is little reason to doubt but that it represents the same species that I have called *Nipadites burtini umbonatus* Bowerbank.[54] Bowerbank and others set up many species based upon size and form, but most students of the European Eocene specimens conclude that this is unwarranted in view of the great variation in the modern species due to the position of the nuts in the head, their degree of development or abortion, and their mutual compression.[55]

If my identification is correct, the chances are strongly in favor of Safford having obtained this specimen from the Grenada formation of west Tennessee, possibly in Fayette County, for this is the one place where preserved collections show that he did considerable field work. Moreover, the Grenada is rather characterized by ferruginized plant remains, and similarly preserved fruits have been found at this horizon in adjoining States.

By approaching the question from the angle of eliminating horizons from which the specimen could not have come, it is possible to discard all the Upper Cretaceous and Tertiary horizons except the Grenada formation of the Wilcox group and the Jackson; the latter in some places in Obion County and adjacent parts of western Kentucky contains ferruginized fruits.

The question of the relationship of *Nipadites* to the existing monotypic genus *Nipa* has never been conclusively settled, although a close filiation has been commonly assumed to be indicated by the resemblances between the two and the comparable habitat indicated

[53] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 47, pl. 1, fig. 6, 1863.

[54] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 176, pl. 112, figs. 13, 14, 1916.

[55] Seward, A. C., and Arber, E. A. N., Mus. roy. hist. nat. Belgique Mém., vol. 2, 1903.

by the fossils. Quite recently Chandler[56] has redescribed fragmentary specimens of pinnate palm leaves from the upper Eocene of Hordle, England. These specimens she finds agree in every detail with those of the existing *Nipa* and differ in various details from all other existing palm leaves examined. She consequently refers the English specimen directly to *Nipa*, and for this there is abundant precedent in the backward extension to the Eocene of many existing genera of angiosperms.

Genus SABALITES Saporta

Sabalites grayanus (Lesquereux) Berry

Sabal grayana Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 412, pl. 14, figs. 4–6, 1869 (not Lesquereux, 1871, 1874, 1876, 1878, or Knowlton, 1900).

Berry, U. S. Geol. Survey Prof. Paper 91, p. 177, pl. 2, figs. 1–3; pl. 14, fig. 1, 1916; U. S. Geol. Survey Prof. Paper 125, p. 4, pl. 1; pl. 3, fig. 5, 1919.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 288, 1918.

Flabellaria eocenica Lesquereux, The Tertiary flora, p. 111, pl. 13, figs. 1–3, 1878.

As has often been remarked, there are almost insuperable difficulties in determining the isolated foliage of palms, either feather or fan palms, especially when, as usual, they are fragmentary. Some genera have quite characteristic leaves, but the majority do not. This early described species has been recorded from various western localities where its presence may be considered as extremely unlikely, and of late years it has been customary to give different names to somewhat similar leaves from different regions and horizons. Thus I have described nominal species of *Sabalites* in the Gulf embayment region from the Ripley, Claiborne, Catahoula, Alum Bluff, and Hattiesburg formations.

Similar forms from the western United States are usually referred directly to the genus *Sabal*, although it is by no means certain that they are congeneric with the recent species of this genus. Supposed species of *Sabal* have been recorded from the Laramie, Vermejo, Fruitland, Montana, Denver, Lance, Animas, Fort Union, Raton, Green River, and Bridger formations.

Sabalites grayanus is exceedingly common in the Wilcox and has been recorded from 40 localities along both the eastern and western shores of the Gulf embayment of Wilcox time. Good specimens are not common and are hard to quarry, but the frayed and tangled rays are widely distributed. Many large and perfect leaves were present in the exposure in the ravine at Oxford, Miss., and at a few other outcrops. This species is probably related to our existing *Sabal palmetto* and like that species was essentially a coastal form. A restoration, based largely on this modern species, is shown in Figure 9.

One can readily visualize these old Wilcox coasts and almost hear the rustling of the stiff leaves of the fan palms in the diurnal land and sea breezes and picture the masses of frayed rays, dicotyledonous leaves, and other vegetable débris that covered the face of the waters after storms.

Occurrence: See table of distribution.

Order LILIALES

Family SMILACACEAE

Genus SMILAX Linné

Smilax wilcoxensis Berry, n. sp.

Plate 10, figure 3

Leaves oblong ovate, widest in the lower half, inequilateral throughout, especially at the acuminate tip. Base slightly sagittate, broadly rounded, probably slightly cordate. Margins undulate. Leaf substance very thin but apparently stiff. Midrib stout, slightly flexuous. Lateral primaries thin, somewhat flexuous, strictly acrodrome; the main pair diverge from the midrib at or near its base at wide angles and pursue their course one-third of the distance inside the margins, with which they are subparallel; the outer pair are thinner and close to the margins; certain of the cross veins between the midrib and the main lateral primaries are slightly more prominent than others, but they scarcely merit the term "secondaries" and are merely the slightly enlarged members of the well-marked open inosculating mesh characteristically shown in the illustration.

This species adds a striking new element to the Wilcox flora. Its resemblances to modern forms are shared by the families Smilacaceae and Dioscoreaceae, and a decision is difficult. I have referred it to the former because the leaves in the latter are usually more regular, with more numerous primaries and well-marked secondaries; the areolation is nearly alike in both.

The genus *Smilax* is the principal genus and comprises most of the family Smilacaceae, which is sometimes made a subfamily of the Liliaceae, as by Engler. It consists of herbaceous or woody climbers with alternate leaves. There are about 200 existing species, chiefly in the American and Asiatic Tropics but extending well into the Temperate Zone in North America, eastern Asia, and the Mediterranean region. There are 17 existing species in the United States, and several of these range northward as far as southern Canada.

The known fossil species of *Smilax* number about 60, most of them conclusively determined. They appear in the early Upper Cretaceous in New Jersey and

[56] Chandler, M. E. J., The upper Eocene flora of Hordle, Hants, pt. 1; Palaeont. Soc., vol. 77 (issued for 1923), p. 15, pl. 2, figs. 1, 2, 1925.

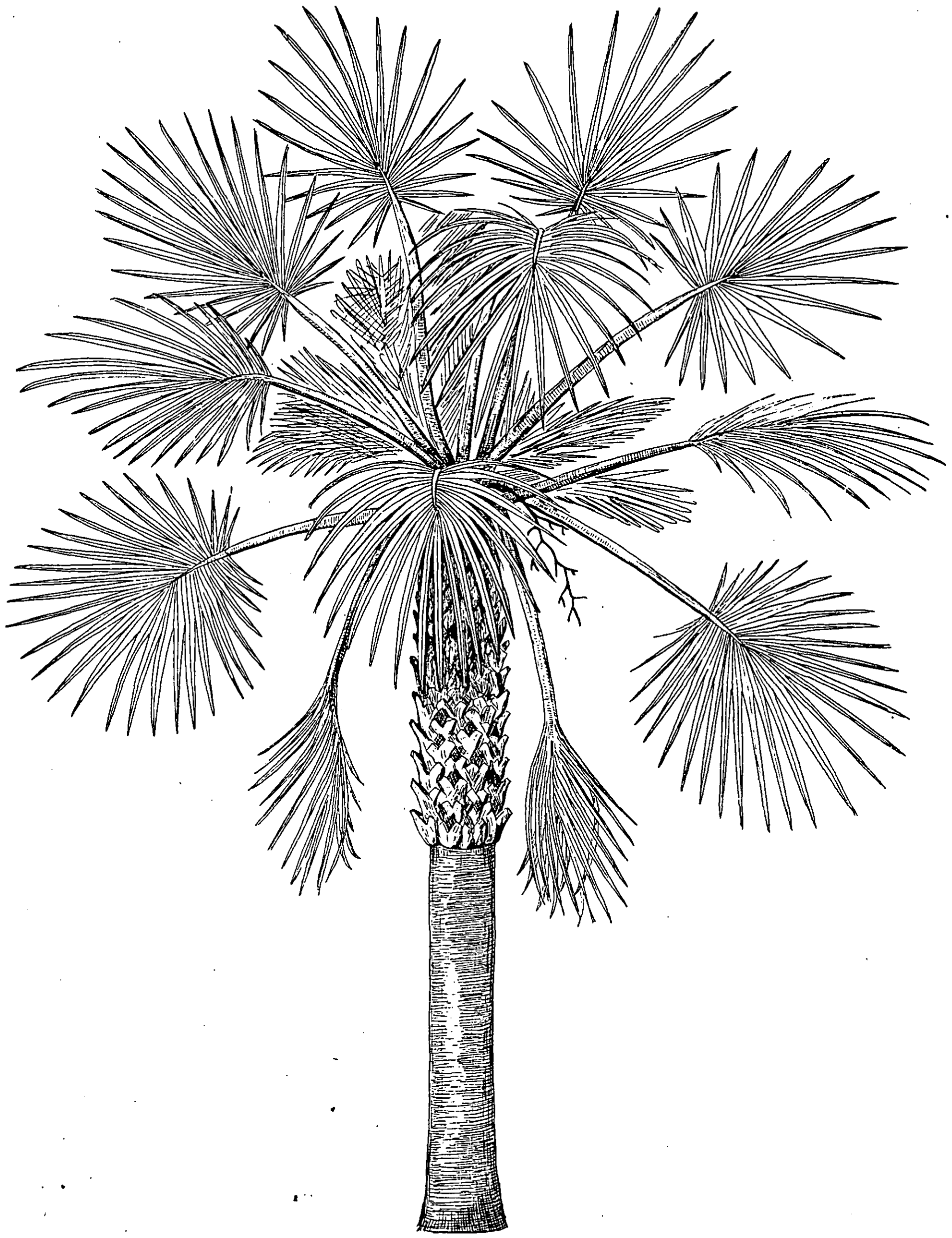

FIGURE 9.—Restoration of fan palm to show appearance of *Sabalites grayanus* (Lesquereux) Berry

Kansas and slightly later in Poland. During the Eocene they are recorded from the early Eocene of Wyoming and France and from the later Eocene of Greenland, Sakhalin Island, and the Mackenzie River country. The Oligocene has yielded a dozen species in Germany, Tyrol, France, and Italy and includes flowers in the Baltic amber. The Miocene species number over 30, found chiefly in central and southern Europe but present in the Rocky Mountain region and on the northern Pacific coast in this country.

The Pliocene species are few in number and are known from only France and Italy, and there are Pleistocene species in Tuscany and on the Lipari Islands.

Occurrence: Holly Springs sand, roadside at La Grange, Fayette County, Tenn.

Class DICOTYLEDONAE

Superorder CHORIPETALAE

Order JUGLANDALES

Family JUGLANDACEAE

Genus JUGLANS Linné

Juglans occidentalis Newberry

Plate 9, figure 4

Juglans occidentalis Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 507, 1882 (1883); U. S. Geol. Survey Mon. 35, p. 34, pl. 65, fig. 1; pl. 66, figs. 2–4 (not pl. 66, fig. 1), 1898.
Knowlton, U. S. Geol. Survey Prof. Paper 131, p. 158, 1923.

Juglans schimperi Lesquereux, The Tertiary flora, pl. 56, figs. 7, 8, 10 (not figs. 5, 6, 9), 1878.
Hollick, Louisiana Geol. Survey Special Rept. 5, p. 280, pl. 33, fig. 1; pl. 25, fig. 3 (not pl. 32, fig. 5?; pl. 33, fig. 2), 1899.
Berry, U. S. Geol. Survey Prof. Paper 91, p. 182, pl. 18, figs. 3, 5 (not fig. 4), 1916.
Knowlton, U. S. Geol. Survey Prof. Paper 101, pl. 64, fig. 1, 1918.

Knowlton[57] in his recent revision of the flora of the Green River formation with the type material of Newberry and Lesquereux in front of him has made the distinctions set forth in the synonymy of this species and that of *Juglans schimperi* Lesquereux. There can be no doubt of the distinctions pointed out by Knowlton.

Both were originally from the same locality and horizon and both are associated in the Wilcox, so that, as Knowlton states, one is led to suspect that both represent the leaflets of a single botanical species of the Eocene, the one perhaps representing terminal, the other lateral leaflets. It might be added that the natural variations in leaves might account for the observed differences.

As at present understood the leaflets of *Juglans occidentalis* are wider, less acuminate, with less ascending secondaries, and with an inequilateral base. The Wilcox leaflet figured in the present paper is large, acuminate, and very inequilateral, especially at the base. It is very similar to the form from the Wilcox of Louisiana that I figured in 1916,[58] but larger, wider, and more equilateral. The venation shows it to represent the same species. I am strongly of the opinion that these two supposed species represent a single botanic species but keep them distinct pending the definite settlement of the question. *Juglans occidentalis* came originally from the Green River formation, which is younger than the Wilcox, but it is also reported from the Raton formation, which is older than the Wilcox.

Occurrence: Wilcox formation, Coushatta and Naborton, La.; Bolivar Creek, Ark. Grenada formation, of Wilcox group, Grenada, Miss.; Brinkley property, Fayette Corners, Fayette County, Tenn.; 4¾ miles southwest of Williston, Fayette County, Tenn.; 5 miles southwest of Williston (float), Fayette County, Tenn. Holly Springs sand of Wilcox group, Puryear, Henry County, Tenn. The specimen figured is from the Holly Springs sand on the old Murrill property, about 2 miles southeast of Bolivar, Hardeman County, Tenn.

[57] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 131, p. 158, 1923.
[58] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pl. 18, fig. 5, 1916.

Juglans schimperi Lesquereux

Juglans schimperi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 8, 1872; The Tertiary flora, p. 87, pl. 56, figs. 5, 6, 9 (not figs. 7, 8, 10), 1878.
Hollick, Louisiana Geol. Survey Special Rept. 5, p. 280, pl. 32, fig. 5(?); pl. 33, fig. 2 (not pl. 33, fig. 1; pl. 35, fig. 3), 1899.
Berry, U. S. Geol. Survey Prof. Paper 91, p. 182, pl. 18, fig. 4; pl. 19, fig. 4 (not pl. 18, figs. 3, 5), 1916.
Knowlton, U. S. Geol. Survey Prof. Paper 131, p. 159, 1923; U. S. Geol. Survey Prof. Paper 134, p. 80, pl. 7, fig. 1, 1924.

As explained in the discussion of the preceding species, this species is associated with that one at the type locality and at several localities in the Wilcox group. In general *Juglans schimperi* has narrower, more elongated, and more equilateral leaflets, with slightly more ascending secondaries. The details of venation are identical in the two species, and the more ascending secondaries would naturally result from the narrower leaflets if both belonged to the same species, which I regard as highly probable but as yet unproved.

Juglans schimperi, as here delimited, came originally from the Green River formation of Wyoming. It has been recorded from the Denver and Animas formations of Colorado, from the upper part of the Clarno formation of Oregon, and from the upper Eocene beds on Bridge Creek, Wheeler County, Oreg. It occurs at the following Wilcox localities:

Occurrence: Wilcox formation, Coushatta, La.; Grenada formation, of Wilcox group, 1 mile south of Somerville, Fayette County, Tenn.; Holly Springs sand, of Wilcox group, Puryear, Henry County, Tenn.; 5¼ miles south of Whiteville, Hardeman County, Tenn.; a quarter of a mile northwest of Smyrna Church, 3¼ miles northeast of Somerville, Fayette County, Tenn.; three-quarters of a mile northwest of Pattersonville, road west of La Grange, Fayette County, Tenn.; and Wickliffe, Ky.

Genus HICORIA Rafinesque

Hicoria crescentia Knowlton

Plate 34, figures 1–5

Hicoria crescentia Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 690, pl. 84, fig. 7, 1899.

This species, which was described by Knowlton from rocks of Fort Union age in the Yellowstone National Park, was based on the single specimen figured, which lacked both apex and base. What appears to be this same species is abundantly represented in the upper Wilcox, from which over fifty specimens have been collected. These specimens show considerable variability, but some are identical with the type of this species. Specimens have been submitted to Knowlton, who agrees with me that these Wilcox specimens probably represent the same species as the western form.

In view of the incompleteness of the western material adequate comparisons are impossible and there may be some question as to absolute identity. However, as the horizon is about the same, and as the type is really insufficient in itself, little harm can result in the course followed. As represented in the Wilcox, where several specimens show attached terminal and lateral leaflets, the diagnosis may be considerably amplified.

Leaves of variable size, odd pinnate in habit. Rachis stout. Leaflets variable in size and form. Apex acuminate, either short or produced. Base narrowly to broadly cuneate, nearly or quite equilateral in the terminal leaflet, more or less inequilateral in the lateral leaflets. Texture subcoriaceous. Margins with mostly small serrate teeth, some of which vary toward crenate. The teeth are somewhat feebly developed and spaced in the tip, becoming closely spaced in the median region and becoming obsolete a short distance above the base. The leaflets are all petiolulate, the petiolules being from 5 to 12 millimeters in length. In outline they vary from ovate lanceolate to elliptical lanceolate. In size they range from 5 to 15 centimeters in length by 1.2 to 6 centimeters in maximum width. The midveins are stout and prominent. The secondaries are stout and camptodrome, varying somewhat in spacing and in angle of divergence with the relative proportions of the leaflets, in general at wide angles and rather straight in their courses until they reach the marginal region. In no specimen have they been observed to be craspedodrome, although some seem to be in the type. The latter arrangement is not the usual one in *Hicoria*, and the tertiary branches entering the teeth have probably been mistaken for the secondary endings, which are really camptodrome. Tertiaries mostly percurrent, frequently inosculating midway between the secondaries.

According to Knowlton, *Hicoria crescentia* is related to *Hicoria antiquorum* (Newberry) Knowlton, a Lance and Fort Union form, which has been recorded from the upper Wilcox in Louisiana. It is quite possible that the two names represent a single botanical species, in which case Newberry's name has priority. I have seen no good material from the Wilcox that could be referred to *Hicoria antiquorum*, unless the abundant remains here referred to *Hicoria crescentia* represent the former species. There is also considerable resemblance to *Juglans nigella* Heer, an Alaskan Kenai species, which has been recorded from the Raton, Paskapoo, and Fort Union formations in western North America. In the absence of fruiting material it is generally impossible to differentiate between *Hicoria* and *Juglans*.

Occurrence: Grenada formation, 3¼ miles northeast of Somerville; north of Loosahatchie River on road to Yum Yum (very common); 1.2 miles southwest of Somerville; 2.9 miles southwest of Somerville; 5 miles southwest of Williston; all in Fayette County, Tenn.

Genus PARAENGELHARDTIA Berry

Paraengelhardtia eocenica Berry

Plate 46, figures 11, 12

Paraengelhardtia eocenica Berry, U. S. Geol. Survey Prof. Paper 91, p. 186, pl. 17, figs. 2–5, 1916.

This primitive member of the Juglandaceae, which is believed to represent an intermediate stage ancestral to the prominently winged fruits of the genera *Engelhardtia* and *Oreomunnea*, has been found in considerable abundance. The fine specimen shown in Plate 46, Figure 11, brings out the characteristic venation much more clearly than any specimens previously figured. The somewhat distorted specimen shown in Plate 46, Figure 12, shows a crushed nut, which, in its present condition, is 1.75 centimeters in diameter.

I can see no reason for doubting the botanical relationship of this form. It is confined to the eastern shore of the Wilcox Gulf embayment.

Occurrence: Holly Springs sand, Whiteville (?), Hardeman County, Tenn.; Will Brooks farm, 2.1 miles northwest of Mercer, Madison County, Tenn.; Grable pit and Puryear, Henry County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn.

Genus ENGELHARDTIA Leschen

Engelhardtia puryearensis Berry

Engelhardtia puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 185, pl. 17, figs. 6, 7, 1916.

The winged fruits of this species have been found at other than the type locality and have been utilized in making a restoration of the probable habit of this Eocene species.

The restoration shown in Figure 10 is a combination of the trialate fruits of the foregoing species with the leaflets associated with it and described as *Engelhardtia ettingshauseni* Berry. A somewhat different species of *Engelhardtia* fruit with which these leaflets are also associated is *E. mississippiensis* Berry. Whether all three represent a single variable botanical species, or whether, if two species are represented, which one is to be associated with the leaflets, can not be determined. This does not affect the restoration essentially, for the two sorts of fruits are not particularly dissimilar.

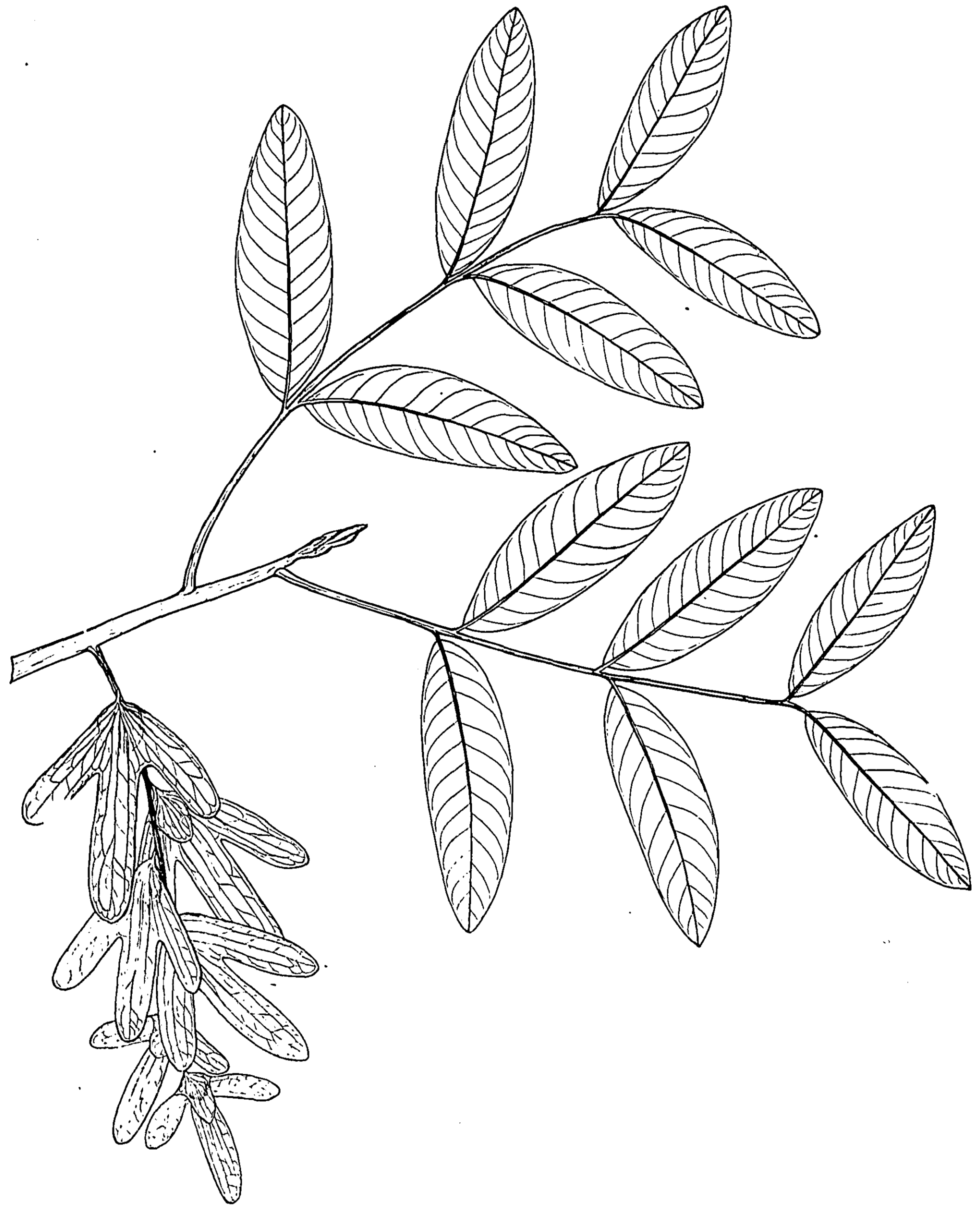

FIGURE 10.—Restoration of *Engelhardtia*

This interesting genus is confined to the oriental region, except for a single Central American species quite generally made the type of a separate genus—*Oreomunnea*. The two are not greatly different, but *Oreomunnea* has fewer and larger and coarser fruits of the same general type. In making the restoration the existing species of both *Engelhardtia* and *Oreomunnea* have been studied, and the fruit spike has been made shorter than in *Engelhardtia* and with the number of fruits intermediate between it and *Oreomunnea*. The leaves have been depicted as even pinnate, as is the rule in these forms, although the prevailing habit in the Juglandaceae is for them to be odd pinnate. The number of leaflets has been arbitrarily made six. It varies in the recent forms, but is usually 6 to 8 in *Oreomunnea*.

Whether these American Eocene forms are closer to the surviving Central American species or to the surviving species of southeastern Asia is somewhat uncertain, although one would expect the former alternative to be the most likely. The fact that the fossil leaflets are entire (some of the existing Engelhardtias have toothed leaflets) and that the fruits are larger and more robust than those of the existing Engelhardtias rather points to the correctness of this supposition.

Another point which can not be settled is the exact relationship between these forms and the genus *Para-*

engelhardtia Berry. That genus is now represented by numerous fine specimens from the Wilcox Eocene and is, with its large spherical nut and broad, incipiently lobed and reticulated bract, clearly related to *Engelhardtia* and *Oreomunnea.* The less degree of lobation has suggested that *Paraengelhardtia* is the more primitive, but this may not have been the case.

Order MYRICALES

Family MYRICACEAE

Genus MYRICA Linné

Myrica puryearensis Berry, n. sp.

Plate 48, figures 36–38

Leaves of small to medium size, lanceolate, some of them inequilateral proximad, although the majority of the specimens are symmetrical. Widest at or below the middle. Some specimens taper equally in both directions, but the majority are somewhat more narrowly extended distad than proximad. Apex acute. Base narrowly to broadly cuneate. Texture subcoriaceous. Margins entire for a greater or less distance above the base, in some specimens to the middle, above with irregularly spaced serrate teeth, which are usually small but may be as much as a millimeter in length. Length ranging from 4.25 to 6.5 centimeters. Maximum width ranging from 1 to 2 centimeters. Petiole stout, about 1 centimeter in length. Midvein stout, prominent on the under side of the leaf. Secondaries stout, not especially prominent, irregularly spaced, diverging from the midvein at wide angles, indifferently camptodrome or craspedodrome according to the arrangement and spacing of the marginal teeth. Tertiaries thin, a combination of transverse veins and those subparallel with the secondaries. Areolation of fine myricaform meshes.

This species is represented by a considerable number of various sized specimens which differ within narrow limits in outline and development of the marginal teeth. Some of the broader of these are exceedingly like the leaves of such existing species as *Myrica cerifera* or *M. gale.*

Two other species of *Myrica* have been recorded from the Wilcox—*Myrica elaeanoides* Lesquereux of the Ackerman formation and the Holly Springs sand and *Myrica wilcoxensis* Berry of the Grenada formation. This new species is closer to *M. wilcoxensis* than to *M. elaeanoides,* differing in its average larger size, broader base, longer petiole, and usually more numerous teeth.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.

Order FAGALES

Family FAGACEAE

Genus DRYOPHYLLUM Debey

Dryophyllum juvenale Berry, n. sp.

Plate 48, figure 18

Leaf small, ovate, inequilateral, with inordinately stout midvein and secondaries and a serrate margin. Length about 4 centimeters. Maximum width, in the lower half, about 1.3 centimeters. Leaf substance thin. Midvein very wide and flat, curved. Secondaries wide and flat, diverging from the midvein at wide angles, nearly straight and subparallel, craspedodrome.

This form does not, in my opinion, represent a botanic species, but a juvenile leaf of *Dryophyllum tennesseense* Berry, which is so common at this outcrop. Its juvenile character is indicated by its delicate texture, soft, wide, and immature venation, and form. Its rarity also points in the same direction, for the juvenile leaves would not ordinarily become detached or preserved, and this form is one of the very few from this prolific locality which is represented by only a single specimen.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Order PLATANALES

Family PLATANACEAE

Genus PLATANUS Linné

Platanus nobilis Newberry

Plate 8, figure 4; Plate 10, figure 1; Plate 11, figure 7

Platanus nobilis Newberry, New York Lyc. Nat. Hist. Annals, vol. 9, p. 67, 1868.

[Lesquereux], U. S. Geol. and Geog. Survey Terr., Illustrations of Cretaceous and Tertiary plants, pl. 17; pl. 20, fig. 1, under *Platanus haydenii,* 1878.

Dawson, Roy. Soc. Canada Trans., vol. 4, sec. 4, p. 24, pl. 1, fig. 7, 1886 [1887].

Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 552, pl. 41, fig. 1, 1886; U. S. Geol. Survey Bull. 37, p. 35, pl. 16, fig. 1, 1887.

Knowlton, U. S. Geol. Survey Bull. 204, p. 65, 1902; Washington Acad. Sci. Proc., vol. 11, pp. 192, 195, 211, 212, 213, 214, 1909.

The type of the species came from the Fort Union formation of North Dakota, and the species is abundant and widely distributed in that formation. It is also not uncommon in the underlying Lance formation and has been recorded from several localities in the Eocene of western Canada.

Abundant but somewhat fragmentary remains of this species were discovered in west Tennessee in the summer of 1923. The species may be redescribed in the light of all of the material as follows: Leaves very large, prevalingly trilobate, although leaves with incipient additional lobes have been referred to it. Lobes wide and abruptly acuminate, separated by open sinuses that do not extend more than halfway to the base. Ward records a Fort Union leaf that was 35 centimeters in maximum width and 30 centimeters along the midrib. Some of the Wilcox specimens from Tennessee indicate as large if not larger specimens. The margins are somewhat irregularly excavated by very shallow sinuses between the termini of the secondary and in places the tertiary veins, resulting in slight marginal teeth which are not at all produced, so that the margins might almost be called repand; basally they are entire and slightly and irregularly undulate. The petiole is very stout and of unknown length. Primaries are three in number from the top of the petiole, diverging from one another at angles of about 50° to 55°, rather straight in their courses, and exceedingly stout, the midvein being stouter than the laterals; they terminate in the tips of the lobes, of which they form the midveins. Secondaries stout and relatively straight; rather regularly spaced and subparallel, craspedodrome. Tertiary venation very characteristic, distinctly platanoid, a combination of percurrent and inosculating cross veins; the marginal ones in places run to a marginal point and elsewhere loop along the margin, filling a considerable area in the angles between the primaries where normal secondaries are not developed; a characteristic feature of the tertiary venation is the rapid diminution in caliber of the veins in the mid areas between the secondaries, which enables small fragments of these large leaves to be recognizable.

The discovery of this species in western Tennessee adds a striking new element to the Wilcox flora and another like element correlating the Wilcox with the Fort Union of the western United States. It also adds another temperate element to this flora. Ettingshausen suggested that this species was more likely an *Aralia* than a *Platanus*, but it seems to me to be unquestionably platanoid in all of its characters.

Occurrence: Holly Springs sand, big cut at Pine Top, Hardeman County, Tenn. (common); Murrell place, 2 miles southeast of Bolivar, Hardeman County, Tenn.; 5¼ miles south of Whiteville, Hardeman County, Tenn.; 4¾ miles southwest of Williston (?), Fayette County, Tenn.; and gully 1 mile west of Laconia, Fayette County, Tenn.

Order URTICALES

Family MORACEAE

Genus ARTOCARPUS Forster

Artocarpus pungens (Lesquereux) Hollick

Plate 9, figures 1–3

The specimens figured are more like the original *Aralia pungens* of Lesquereux from Golden, Colo., than they are like the other and larger Wilcox leaves referred to this species.

They undoubtedly represent the same botanical species as is shown by the identity in characters of the venation.

Typical specimens have recently been recorded [59] from the Animas formation of southwestern Colorado.

Occurrence: Holly Springs sand, Silerton road about 4 miles northwest of Silerton, Taylor farm, Chester County, Tenn.

Artocarpus sp.

At the locality west of the hospital near Bolivar there are two scraps with a pustulose surface that agree with similar surface impressions of staminate flowers of *Artocarpus* from the Upper Cretaceous of Greenland described by Nathorst.[60] Except for their smaller size they are also similar to the surface configuration of the fruit in this genus. As *Artocarpus* leaves of several kinds are not uncommon in the Wilcox, these scraps may be referred to that genus with considerable probability as representing one of these foliar species.

Occurrence: Holly Springs sand, west of the hospital at Bolivar, Hardeman County, Tenn.

Genus FICUS Linné

Ficus tennesseensis Berry, n. sp.

Plate 33, figures 18, 19

This form represents one of the broader, coarse-leafed species of *Ficus*, variable in both size and outline but preserving throughout the same characteristic features of the stout venation. It may be described as follows: Leaves of varying size, ovate to ovate-cordate in outline, widest at or slightly below the middle, tapering gradually or abruptly to the acuminate tip. The basal margins show varying degrees of fullness, commonly slightly different in the two halves of the lamina, resulting in a base that may be simply rounded in the smaller leaves or moderately cordate in the larger. The margins are entire but tend to be somewhat irregular. The texture is coriaceous.

[59] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 134, p. 85, pl. 12, 1924.

[60] Nathorst, A. G., K. svenska Vet.-Akad. Handl., Band 24, No. 1, pp. 1–10, pl. 1, 1890.

Length ranging from 6.5 to 9 centimeters. Maximum width ranging from 3.4 to 6.5 centimeters. Petiole of moderate length, relatively very stout. Midvein stout and prominent, generally curved in the slightly unsymmetric leaves. Secondaries stout and prominent, about 5 pairs, irregularly spaced and varying from opposite to alternate, the basal pair opposite and diverging from the top of the petiole. In the smaller leaf figured there are two basal secondaries on one side, giving the leaf an appearance like that of the leaflets of several species of Leguminosae, but the venation is otherwise identical with that of the larger leaves, and the tertiary venation is distinctly not leguminous in character. The secondaries diverge from the midvein at varying angles, ranging from acute to obtuse, and are camptodrome close to the margins. The tertiaries are stout and prominent, the internal ones being prevailingly slightly curved, percurrent but occasionally forked, especially in the larger leaves, the external ones being camptodrome. The areolation is well marked in some specimens and is distinctly ficoid in character.

This well-marked species is, as far as known, confined to beds of late Wilcox age. The genus is unusually well represented in the Wilcox flora, but only two of the previously described Wilcox species are at all similar to the present. These species are *Ficus occidentalis* Lesquereux [61] and *Ficus schimperi* Lesquereux,[62] both from the lower Wilcox Ackerman formation, the former occurring also in the Denver formation of Colorado. Both are much less coarse than the present species; the former is distinctly broader and shorter and triveined, and the latter is a relatively more elongated, very much more delicate leaf with thin veins throughout. I do not regard either of these species as closely related to *Ficus tennesseensis*.

In such a large genus as *Ficus* it is naturally not difficult to find recent species with leaves that closely resemble this Eocene species, but such resemblances can not be regarded as possessing any particular significance.

Occurrence: Grenada formation, northwest of Somerville and about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

Ficus pandurifolia Berry, n. sp.

Plate 21, figures 5, 6; Plate 42, figure 4

Leaves usually small, panduriform, with a bluntly pointed tip and a rounded base. Slightly above the middle on each side there is a greater or less developed indentation with an angular sinus. This sinus may extend from three-sevenths to seven-ninths of the distance inward toward the midvein. Margins otherwise entire but in places slightly undulate in the upper half. Texture subcoriaceous. Length ranging from 4.5 to 9.5 centimeters; maximum width, in the lower half of the leaf, 2.25 to 5.6 centimeters. Petiole of medium length and relatively very stout, about 6 millimeters in length in the smaller leaves, as much as 1.4 centimeters in the largest. Midvein relatively stout and prominent on the under side of the leaf. Secondaries numerous, thin, diverging from the midvein at angles of about 45°, camptodrome. Tertiaries typical of *Ficus*.

These somewhat variable and usually small leaves are clearly those of a lower Eocene *Ficus* and are very distinct from previously described forms.

Occurrence: Holly Springs sand, west of Bolivar, Bolivar-Jackson road, just north of Clover Creek, Hardeman County, Tenn.; La Grange, Fayette County, Tenn.

Ficus mississippiensis gigantea Berry, n. var.

Plate 23

A rather complete discussion of the forms considered by me to represent *Ficus mississippiensis* and its variants was given in 1922 [63] and need not be repeated.

To summarize for the sake of understanding what by me to represent *Ficus mississippiensis* and its was conceived it embraced a series of forms from ovate lanceolate to almost orbicular acuminate, showing every variation in the relation of length to width and the consequent modifications in venation, apex, and base. All these were considered to represent the variable foliage of a single botanical species.

The form described in the following paragraphs is clearly related to this series but differs sufficiently to merit being described as a new variety. At least that is my conclusion. Other students might consider what I have included under *Ficus mississippiensis* as representing five botanical varieties, and others might include var. *gigantea* as the extreme variant in one direction of a single botanical species. The actual relationships are, I believe, unquestionable, and the only issue is one of taxonomic judgment. The present variety may be thus described: Leaves of large size, at least 23 centimeters in length by 16.5 centimeters in maximum width. Triangular in general outline, widest proximad, with an acute, nonextended apex, and a deeply cordate base. Petiole stout, of unknown length. Venation coarse and prominent. Practically five primaries from the extreme base, the outside ones being practically the lower secondaries of the lateral primaries of what is really a triveined leaf.

[61] Lesquereux, Leo, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.

[62] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, p. 417, pl. 18, figs. 1–3, 1869.

[63] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, pp. 9–12, pls. 6–8, 1922.

Secondaries all stout; those from the midvein five or six subopposite to alternate pairs, diverging at acute angles, curved ascending, subparallel, and camptodrome. The secondaries from the lateral primaries are all on the outside, regularly spaced, subparallel, stout, and camptodrome. Tertiaries comprise regular camptodrome branches from one or two of the secondaries on each side and a regular series of basally directed camptodrome branches from the basal secondary (pseudoprimary) of the lateral primaries. The cross veins are mostly stout and approximately percurrent throughout. The areolation is fine meshed and distinctly ficoid.

Among the unnamed variants of *Ficus mississippiensis* the present form is most like the wider, as for example, that shown on Plate 8 in the publication cited. Such a form has merely to become about 50 per cent larger, straighten out the upper margins until the apex becomes cuneate rather than rounded acute or acuminate, develop the prominently cordate base and the consequent accommodation of the venation to these changes to result in the variety *gigantea*. It is possible that the *Ficus* sp.[64] described from the Holly Springs sand in Mississippi may represent this variety. Except for its equilateral form it is very similar to the much smaller and wide-ranging European *Ficus tiliaefolia* (Alexander Braun) Heer.[65] There are several existing species that approach it very closely.

Occurrence: Grenada formation, 1.2 miles south of Southern Railway station at Somerville; about 1 mile north of Somerville, north of Loosahatchie River; 1 mile west of Laconia; all in Fayette County, Tenn.

Ficus mississippiensis cordata Berry, n. var.

Plate 39, figure 11

In accordance with the discussion of *Ficus mississippiensis* and its mutants as given in 1922[66] I regard a series of leaves, of which one is figured, as representing the extreme of variation of this protean species. These leaves are much like the widest forms of that species previously figured but differ in the development of a deeply cordate base and corresponding with this the outer secondaries of the lateral primaries sometimes become enlarged, which results in a somewhat different appearance. The result is a leaf much like the Jackson species that I have described[67] as *Buettneria jacksoniana*.

I am frank to confess that if I had been the original describer of these mutants of *Ficus mississippiensis* I would not refer them to the genus *Ficus*. It is quite true that various authors have referred similar forms to this genus, but they do not have the foliar characters of recent members of the genus, and I do not believe they are related to the Moraceae. In the absence of conclusive proof I prefer to leave them where they are. The resemblance to *Buettneria* is, I believe, significant, and from their association and identity of venation with what has been described as *Sterculia wilcoxensis* Berry I have long been of the opinion that the forms called *Ficus mississippiensis* and the large trilobate *Sassafras*-like leaves of *Sterculia wilcoxensis* represent the same botanical species, and that this should be referred to the Sterculiaceae and not to the Moraceae.

As previously stated, it is undesirable to give this matter of opinion formal expression in the nomenclature until more definite proof is forthcoming.

Occurrence: Holly Springs sand, Huckleberry schoolhouse, 2½ miles south of McLemoresville, Carroll County, Tenn.; Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.

Ficus myrtifolia ampla Berry, n. var.

Plate 32, figure 13

This form has all the venation characters of *Ficus myrtifolia* Berry, but as it is not narrowly elongate elliptical and as *myrtifolia* is represented by many specimens and none of these diverge from the type or approach the present form, it is certainly to be regarded as distinct. It may be described as follows:

Leaves more or less elongate elliptical, widest medianly, abruptly angled or rounded distad, broadly incurved-cuneate and slightly decurrent at the base. Margins entire, full, and in places slightly undulate. Texture coriaceous. Petiole very stout, about 2 centimeters in length. Midrib straight, very stout, prominent on the underside of the leaf. Secondaries relatively (not actually) thin, numerous, closely spaced, subparallel; diverging from the midrib at angles of about 70° to 75°, rather straight, their tips connected by a slightly arched marginal vein. Tertiary venation typical of this type of *Ficus* leaf. Dimensions range from the more elongate forms, which are 13 centimeters long and 4.5 centimeters in maximum width, to the more elliptical forms, which are about the same length and 6 centimeters in maximum width.

The proportions of this form cause it to depart from the *myrtifolia* type and to closely resemble the leaves of those recent species of *Ficus* which are of the *Ficus elastica* type (the plants commonly cultivated under the term rubber plants). It is clearly a true species of *Ficus* and finds its prototype in the

[64] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 206, pl. 24, fig. 1, 1916.
[65] Heer, Oswald, Flora tertiaria Helvetiae, Band 2, p. 68, pl. 83, figs. 3–12; pl. 84, figs. 1–6; pl. 85, fig. 14, 1856.
[66] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, pp. 9–12, pls. 6–8, 1922.
[67] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 182, pls. 56, 57, and 58, fig. 1, 1924.

Southeastern States in *Ficus stephensoni* Berry [68] of the Black Creek formation (Upper Cretaceous) in North and South Carolina. Nothing like it is known from the Ripley, the latest Upper Cretaceous flora known from this general region. It is from a somewhat higher horizon in the Wilcox than *Ficus myrtifolia.*

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn., and Smiths Church, northwest of Pattersonville. Fayette County, Tenn.

Ficus myrtifolia ovata Berry, n. var.

Plate 38, figures 4, 5

This form has the exact venation of the species and its other varieties and may simply be a mutant. It differs from the type, which is consistently elongate and almost linear lanceolate, in being markedly ovate lanceolate. Leaves ovate lanceolate, more or less undulate margined, with an extended acuminate tip and a cuneate ultimately decurrent base. Petiole and venation exactly like the type and the variety *amplus.* Dimensions, 12 to 16 centimeters in length by 3.25 to 4.3 centimeters in maximum width.

There can be little doubt of the relationship of this and the other forms of this species to one another and to antecedent and later species of *Ficus.* It is quite possible that the forms differentiated, even though they show constant features, represent a single botanical species, but until this can be confirmed by at least finding them abundantly associated, it is best to recognize the differences observed.

Occurrence: Holly Springs sand, Jim Tomphson farm and near Mandy, Madison County, Tenn.

Ficus myrtifolia ovata Berry, n. var.

Plate 48, figure 8

The condition of preservation does not permit a positive identification of these remains, but they agree exceedingly well with certain existing pedicellate figs, such as *Ficus populnea* Willdenow of peninsular Florida and the Antilles, and I have no doubt that they represent a Wilcox species of that genus, the leaves of which are common fossils at this outcrop and throughout the Wilcox. It may be partly described as follows: Fruit fleshy, subglobular, slightly reniform in outline as preserved in a flattened condition in the clay, about 8 millimeters long and 10 millimeters in maximum width. There are parts of two bracts at the base, and the whole is borne on a slender curved pedicle that is 1.5 centimeters long. I can not be certain that the true surface is preserved in the specimens, but either it is or because of slacking the surface is minutely tuberculated. The collection contains three good specimens from Puryear and a rather obscure specimen from Moses Hall.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.; Grenada formation, 2.9 miles southwest of Somerville, just below Moses Hall, Fayette County, Tenn.

[68] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 38, pl. 12, figs. 1–3, 1914.

Ficus fructus rostrata Berry, n. sp.

Plate 48, figure 5

Fruit fleshy, subglobular, produced distad into a distinct conical apex. Peduncle stout, tapering downward, about 5 millimeters in length. Length 1.6 centimeters. Maximum width 1 centimeter, as preserved. Decisive details of organization obscured.

This is a larger form than the associated *Ficus fructus pedicellata* and differently shaped and clearly represents a second species of fruit. Although its botanical position can not be proved, I am reasonably satisfied that it represents another Wilcox fig. It is perhaps not surprising that more *Ficus* fruits have not been found in the Wilcox when their edible nature and the ease with which they decay is recalled to mind.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Order PROTEALES

Family PROTEACEAE

Genus BANKSIA Linné son

Banksia tenuifolia Berry

Plate 31, figure 3

Banksia tenuifolia Berry, U. S. Geol. Survey Prof. Paper 91, p. 210, pl. 36, figs. 1–3, 1916.

The leaves of this species are not at all uncommon. They vary considerably in size and in the development and prominence of the marginal teeth, some of which are exceedingly prominent. The accompanying restoration represents foliage alone and shows the range of variation in marginal toothing. Except for the arrangement of the leaves on the branch it is based on actual material. The more coarsely toothed leaves are not greatly different from those often referred to the genus *Myrica* and raise the old question whether these fossil leaves so like various genera of the existing Proteaceae actually represent that family or the Myricaceae. The majority of existing species of *Banksia* have leaves more abruptly pointed than *Banksia tenuifolia*, but some existing species match it exactly, and the areolation of the associated *Banksia saffordi* (Lesquereux) Berry is distinctly proteaceous and not myricaceous, so that the extant evidence, although not conclusive, points to the original botanical determination as being the most probable.

Occurrence: Holly Springs sand, $5\frac{1}{4}$ miles south of Whiteville; Gin Creek; west of Bolivar; Mill Creek; $2\frac{1}{4}$ miles north of Shandy (all in Hardeman County, Tenn.); Grable and Atkins pits, Henry County, Tenn.; Jim Tomphson farm and 4 miles north of Jackson, Madison County, Tenn.; La Grange, Fayette County, Tenn.; Bell City Pottery pit and 100 yards east of Bell City Pottery pit, Calloway County, Ky. Grenada formation, float in orange sand south of Somerville, Fayette County, Tenn. (doubtful determination, may represent *Banksia saffordi*).

The question of the proteaceous affinity of this and similar fossil forms of the Northern Hemisphere has been widely discussed by Unger, Heer, Ettingshausen, Schimper, Schenk, Saporta, and later writers and has been the occasion of wide differences of opinion. The opinions that foliage is undeterminable or that all the records of Proteaceae represent *Comptonia*, *Myrica*, or other nonproteaceous genera are untenable, as Alfred Russel Wallace pointed out years ago. I have discussed this question, together with the existing and geologic distribution of the various genera, in my first paper on the Wilcox flora,[69] and the conclusions there expressed need not be repeated.

[69] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 83–87, 1916.

No fruits have been found in the Wilcox to certainly corroborate the evidence of the foliage, although a probable *Banksia* fruit is described as *Carpolithus proteoides*. On the other hand, neither have fruits, real or supposed, of *Myrica* been detected. *Banksia tenuifolia* is exceedingly abundant in the Wilcox in many places and is a very characteristic form of leaf. In Figure 11 I have attempted the restoration of a branch of this species, based upon actual specimens and hypothetical only in respect to the grouping of the leaves on the branch.

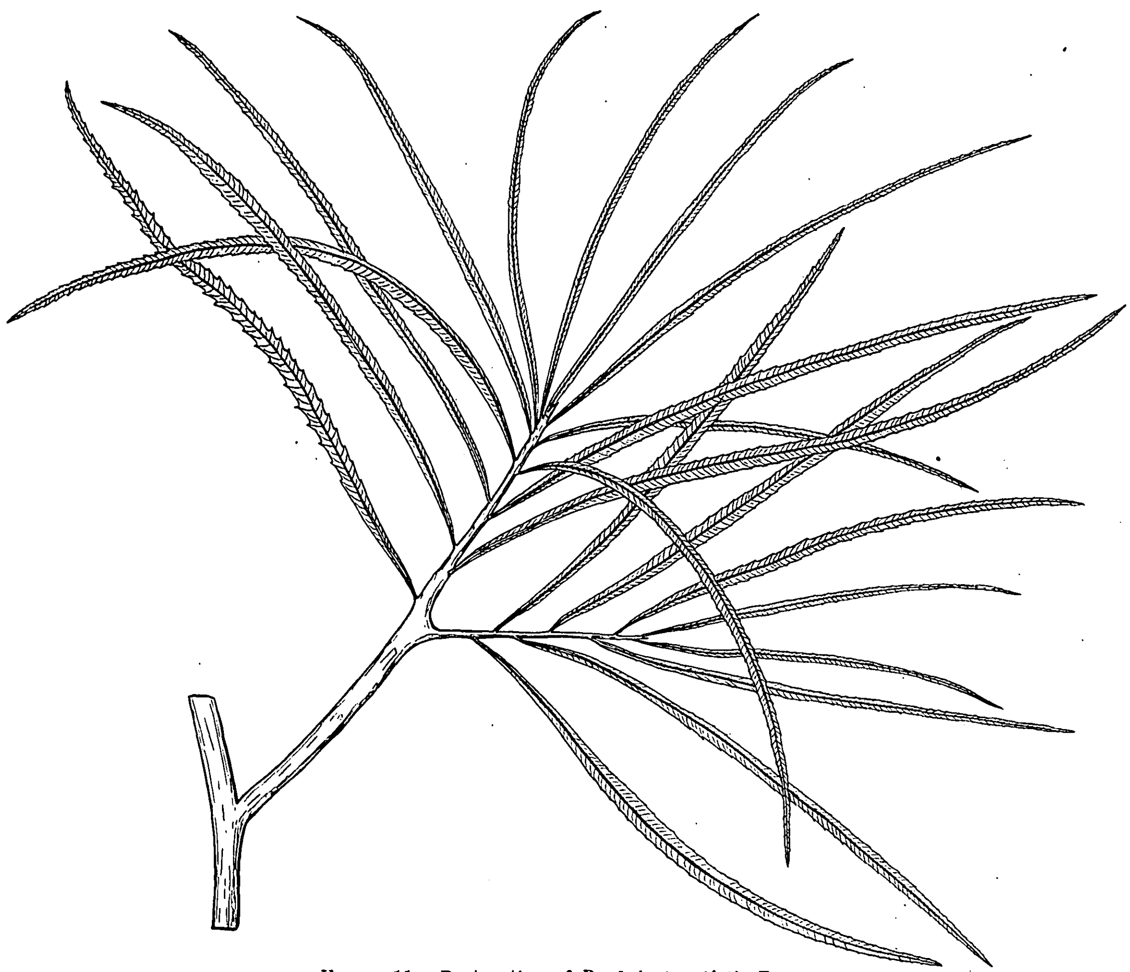

FIGURE 11.—Restoration of *Banksia tenuifolia* Berry

Order POLYGONALES

Family POLYGONACEAE

Genus COCCOLOBIS P. Browne

Coccolobis uviferafolia Berry

Plate 22, figure 9

Coccolobis uviferafolia Berry, U. S. Geol. Survey Prof. Paper 91, p. 212, pl. 87, fig. 5, 1916.

When it was described in 1917 this species was known only from a single locality in western Tennessee. It has since been recognized at a number of localities in both the eastern and the western Gulf areas. The specimen figured herewith, from Harrison County, Tex., adds considerably to our knowledge of its features.

Occurrence: Holly Springs sand, of Wilcox group, three-fourths mile northeast of Pattersonville, Fayette County, Tenn.; and Foundry Church pit and Puryear, Henry County, Tenn. Wilcox formation, Boydsville, Ark.; and 6 miles north of Scottsville, Harrison County, Tex. Carrizo sandstone, 5 miles northeast of La Pryor, Zavala County, Tex.

Order CHENOPODIALES

Family NYCTAGINACEAE

Genus PISONIA Plumier

Pisonia fructifera Berry, n. sp.

Plate 11, figures 5, 6

A nutletlike fruit or achene, with a peduncle about the same length as the fruit and crowned with the persistent calyx teeth, so similar to the existing fruits of *Pisonia* that it has seemed proper to refer them to that genus. Peduncle stout, about 8 millimeters in length. Fruit elliptical in side view. The two specimens are more or less flattened in the clays, and the presumption that they were approximately circular in cross section can not be verified. The surface is clearly costate, but the number of ribs can not be determined. The somewhat truncated apex is crowned by slight central projections whose exact outlines are not clear, which are considered to represent the persistent calyx teeth.

This fruit is most similar to those of *Pisonia* among the fruits that I am familiar with, and as foliage that appears to represent this genus is not uncommon in Wilcox deposits, I feel justified in referring these fruits to that genus, the occurrence of which in the Wilcox has already been discussed at some length.[70]

Several fossil fruits have been referred to this genus, including *Pisonia racemosa* Lesquereux,[71] from the Black Buttes coal group of Black Buttes, Wyo., which are much smaller, perfectly distinct from the present species, and somewhat doubtful in character, as are *Pisonia eocenica* Ettingshausen,[72] from the Oligocene of the Tyrol, and *Pisonia radobojana* (Unger) Ettingshausen,[73] from the Miocene of Croatia.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

[70] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 213–214, 1916.
[71] Lesquereux, Leo, The Tertiary flora, p. 209, pl. 35, fig. 4, 1878.
[72] Ettingshausen, Constantin von, Die tertiäre Flora von Haering in Tirol, p. 43, pl. 11, fig. 21, 1855.
[73] Unger, Franz, Sylloge plantarum fossilium, pt. 3, pl. 11, fig. 7, 1865.

Pisonia praejacksoniana Berry, n. sp.

Plate 46, figure 2

Leaves of relatively small size, oval and inequilateral in outline, widest above the middle, the full lateral margins incurved somewhat abruptly to the slightly extended and round pointed tip and less abruptly to the cuneate and slightly decurrent base. Texture coriaceous but not thickened. Margins entire. Length about 3.5 centimeters. Maximum width about 1.5 centimeters. No specimens with a petiole preserved have been found. Midvein stout, curved, partly immersed. Secondaries stout, immersed; three or four pairs diverge from the midvein at angles of about 45° and are camptodrome. The tertiaries are immersed.

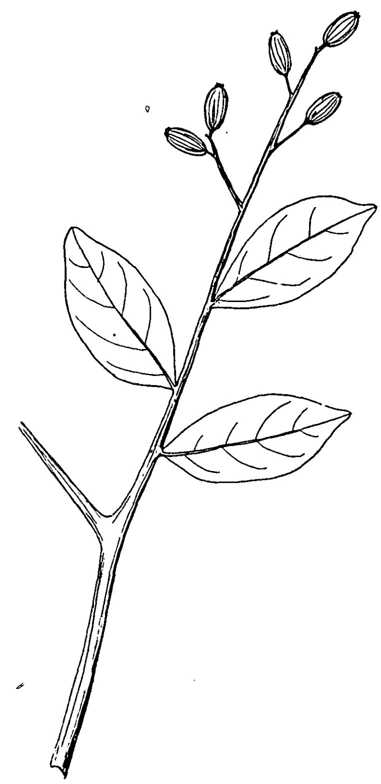

FIGURE 12.—Restoration of *Pisonia*

The outlines of the epidermal cells in cuticular preparations show the cells to have been exceedingly small and approximately isodiametric; the stomata on the other hand appear to have been relatively large unless corrosion has increased the size of the holes marking their position.

The genus *Pisonia* is represented in the Wilcox by three other species based upon leaves and another based upon characteristic fruits. The present species differs from those previously described sufficiently to be easily recognized and does not require an extended discussion of its differences. It is larger and differs in form from *Pisonia eolignitica* Berry and *Pisonia* *puryearensis* Berry; it is intermediate between the extremes of sizes of the lower Wilcox *Pisonia chlorophylloides* Berry, from which it differs slightly in outline and more conspicuously in secondary venation. Species of *Pisonia* have also been described from the Claiborne and Jackson, and the present species is named from its apparently praenuntial relationship to *Pisonia jacksoniana* Berry[74] of the Jackson, from which it differs in being slightly smaller and thinner textured.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

The restoration shown in Figure 12 is based upon the fruits described as *Pisonia fructifera* Berry, from the upper part of the Holly Springs sand at Mill Creek, Hardeman County, Tenn. There are several species of *Pisonia* based on foliage in the Wilcox, and the leaves which I have depicted in association with the fruits are those of *Pisonia praejacksoniana* Berry, which are found at a nearly equivalent horizon in the Holly Springs sand of Henry County, Tenn. The habit is that of *Pisonia longifolia* Sargent and other existing species of the genus.

Order RANALES

Family MENISPERMACEAE

Genus MENISPERMITES Lesquereux

Menispermites hardemanensis Berry, n. sp.

Plate 10, figure 2

Leaves of medium size, reniform or cordate, with entire margins and a thin or fleshy texture. Apex probably pointed but possibly rounded. Base broadly truncated or slightly cordate. Length about 7.5 centimeters; maximum width, in the basal half of the leaf, about 9.25 centimeters. Petiole stout, of undetermined length. Midvein stout, curved. Lateral primaries, one on each side, subparallel with the margins, diverging from the midvein at the top of the petiole, at angles of more than 45°, curving upward, and camptodrome in the apical part of the leaf. Secondaries, two or three alternate, much-curved, camptodrome pairs from the midrib and numerous regularly spaced camptodrome pairs from outer sides of the lateral primaries, the basal pair of which from the extreme base of the primaries is somewhat enlarged. Tertiary venation comprising small arches about the margins and internally rather straight nervilles inosculating midway between primaries and secondaries or subsecondaries, forming large and prevailingly transverse meshes.

This species is readily distinguished from the other three members of this genus found in the Wilcox. It is much smaller and less elongated than *Menispermites wilcoxensis* Berry[75] and also differs conspicuously in its venation. Its distinctness from *Menispermites cebathoides* Berry[76] is marked. That form is a coarser leaf with stouter veins, which are straighter and more ascending, and with seven primaries and pseudoprimaries diverging from the base.

Menispermites hardemanensis differs from the associated *Menispermites americanus* in its larger size, less stout petiole, and palmate instead of pinnate venation.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Menispermites americanus Berry, n. sp.

Plate 11, figures 1–4

Leaves of relatively small size, short and wide and slightly cordate in form, with a bluntly pointed apex, full-rounded lower lateral margins, and a broad truncated or slightly cordate base. Length ranging from 3.5 to 6 centimeters; maximum width, in basal half of the leaf, ranging from 4.5 to 7 centimeters. Margins entire. Texture thin. Petiole very stout and apparently fleshy, usually not preserved. Midrib stout and prominent. Secondaries subopposite, all except the basal pair thin, four or five pairs, diverging from the midrib at wide angles, at first rather straight in their courses, curving rapidly upward as they approach the margins, and camptodrome. Tertiaries for the most part obsolete, a few transverse nervilles seen internally, and arches along the margins.

This species, which is not uncommon, is readily distinguished from the other three Wilcox species referred to this genus, being smaller than the others, and differing from all of them in its pinnate venation.

It suggests comparisons with a variety of leaves of existing species, as, for example, various genera of the Euphorbiaceae, such as *Omalanthus*, *Stillingia*, and *Dalechampia*, especially certain species of the first like the East Indian *Omalanthus populifolia* Jussieu, and some of the nonlobate Dalechampias of tropical America, but these lack the fleshy petiole and subcordate base of the fossil, and are also more acuminate and show differences in venation.

Some South American species of the genus *Onestis* (Connaraceae) are also superficially like the fossil but are larger and coriaceous, tend to an ovate outline, and show differences in venation. Some species of *Begonia* (Begoniaceae) show some resemblances to the fossil, but they are not close and there are conspicuous differences.

[74] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 162, pl. 32, figs. 6, 7, 1924.

[75] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 21, pl. 115, figs. 1, 2; pl. 116, figs. 2, 3, 1916.

[76] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, p. 12, pl. 11, fig. 1, 1922.

Some students might be disposed to compare *Menispermites americanus* with the genus *Populus*, but that genus, aside from its commonly toothed margins, differs in petiole, venation, and relative proportions.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy and 2¼ miles north of Shandy, Hardeman County, Tenn.

Family MAGNOLIACEAE

Genus MAGNOLIA Linné

Magnolia leei angusta Berry, n. var.

Plate 37, figure 2

Enormously elongated and narrowly lanceolate leaves, widest medianly and tapering gradually to the narrowly and equally acuminate apex and base. Margins entire, undulate. Leaf substance thin but stiff. Length about 32 centimeters; maximum width between 4 and 4.5 centimeters. Petiole not preserved. Midvein extremely stout and prominent. Secondaries numerous, stout, diverging from the midvein at wide angles at fairly regular intervals, rather straight in their courses until they approach the margins, where they are somewhat abruptly camptodrome. Tertiary venation as in the type.

This leaf is obviously a narrow form of *Magnolia leei* Knowlton of the Wilcox and Raton, with which it agrees in all its features except its proportions, and as it preserves these at several scattered outcrops where the type is not represented it is believed to represent a definite botanical variety.

The propriety of referring it to the genus *Magnolia* may well be questioned. It bears some resemblance to what has been called *Magnolia angustifolia* Newberry but differs decidedly in the spacing and curvature of the secondaries. It is also much like a leaf from the Raton formation which Knowlton [77] refers to *Magnolia laurifolia* Lesquereux but is not especially like the type of that species. It is also much like a form from the Oligocene of Italy described by Principi [78] as *Ficus grandifolia* (not of Unger, 1869).

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.; Thompson & Barksdale prospect, Carroll County, Tenn.; and Grable pit, Henry County, Tenn.

Magnolia angustifolia Newberry

Plate 38, figure 2

Magnolia angustifolia Berry, U. S. Geol. Survey Prof. Paper 91, p. 214, 1916.

This species, which is common in the Raton formation of New Mexico, is found to be not uncommon in the Wilcox, and a nearly complete specimen is figured in the present report.

Occurrence: Holly Springs sand, Taylor farm, Chester County, Tenn.; west of Bolivar, Hardeman County, Tenn.; 1 mile west of Laconia, Fayette County, Tenn.; 1 mile southwest of Grand Junction, Fayette County, Tenn., just west of Hardeman County line; Breedlove pit, Grable pit, Atkins pit, and Puryear, Henry County, Tenn. Wilcox formation, Mansfield, Naborton, and Coushatta, La.

Family ANONACEAE

Genus ANONA Linné

Anona robertsi Berry, n. sp.

Plate 41, figures 14–18

A variable elliptical seed of which I have 21 specimens from six localities appears to be that of some species of *Anona*, the leaves of three different species of which are rather common at certain horizons in the Wilcox. Very probably these seeds represent one or more of these foliar species, but no course is available except to describe the seeds as a new species, and I am referring all these seeds to a single species, although they are sufficiently variable to suggest that more than one is represented. *Anona* seeds in the recent species are variable in both size and outline, but these fossil seeds show slight differences in textural features as well as the two extremes of form that are illustrated by the photographed specimens from Bell City, Ky., and Milan, Tenn.

Similar variations are seen in the seeds of the existing Anonas, where the testa is usually thin and discloses the markings of the ruminate or wrinkled endosperm, although in some species the testa is thick, hard, and smooth. The fossils all belong to the former type, and the peculiar transverse or oblique markings are believed to represent the wrinkled endosperm. That the seeds were of considerable consistency is shown by the specimens in the more carbonaceous beds like those at Cottage Grove, which specimens in drying have more or less slacked and destroyed their characteristic appearance.

Seeds variable in size and outline, roughly elliptical, compressed, rounded throughout, about twice as long as wide, and about three times as wide as thick, many of them excentric in outline. In general wider above the middle and slightly truncated along the apical and basal margins. Surface wrinkled, either at right angles or obliquely to the axis. Some of the specimens have the appearance of a veined pod, but they contain no cavity or definite seeds and appear to be solid, so that the conclusion that they are seeds seems well founded. They are very similar in appearance to the seeds of several existing species of *Anona*, and

[77] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, pl. 106, fig. 2, 1918.

[78] Principi, Paolo, Mem. serv. desc. Carta Geol. Italia, vol. 6, p. 83, pls. 32–33, fig. 2, 1916.

I believe represent that genus. I have also compared them with the seeds of the related genus *Asimina*, to which Lesquereux referred a specimen, since lost, from the lower Wilcox of Mississippi. The fossils appear to me to be more definitely related to *Anona* than to *Asimina*.

Occurrence: Holly Springs sand, Holcomb property, Grable pit, Henry County, Tenn.; Jim Tomphson farm, Madison County, Tenn.; Bell City Pottery pit, Calloway County, Ky. Grenada formation, Cottage Grove, Henry County, Tenn.; Milan, Gibson County, Tenn.

Family CERATOPHYLLACEAE

Genus CERATOPHYLLUM Linné

Ceratophyllum incertum Berry, n. sp.

Plate 33, figures 7, 8

An elliptical somewhat compressed nutlike fruit of considerable consistency about 3 millimeters in length and 2 millimeters in maximum width narrowly margined around the border and this margin produced outward to form delicate spines of varying length, the apical one slightly more prominent than the others, which are about 10 in number and are somewhat less regularly developed than the enlarged drawing shown in Plate 33, Figure 8, indicates. After a rather complete canvass of the vegetable kingdom for analogous fruits this strikingly characteristic small form is referred, with some hesitation, to the genus *Ceratophyllum*.

The modern species of this genus are differently evaluated by systematists and may be but three or four very wide-ranging forms of ponds and slow streams or may be ten or a dozen in number. There is considerable unevaluated variation in the character of the fruits. Usually the persistent style forms the beak, and this is indicated in the fossil material by the greater development of the apical spine. Otherwise the recent fruits may be profusely spined like the fossil or nearly or quite spineless.

The geologic history of the genus is very imperfectly known, and if the present species is correctly determined it represents the oldest well-authenticated form. Fruits of the recent species are not at all uncommon in the Pleistocene of both North America and Europe, but older records are less conclusive. Ettingshausen recorded very unconvincing fragments of stems and leaves from the Cretaceous of Australia and the Miocene of Styria as species of *Ceratophyllum*, and Saporta [79] recorded more satisfactory specimens of stems with verticillate leaves from the lower Miocene of France. Characteristic fruits from the Miocene Esmeralda formation of Nevada have recently been described.[80]

Order PAPAVERALES

Family CAPPARIDACEAE

Genus CAPPARIS Linné

Capparis eocenica ampla Berry, n. var.

Plate 36, figures 4, 5

Leaves of characteristic aspect obviously related to *Capparis eocenica* Berry and possibly representing variants of that species but showing constant differences. Elongate and narrowly elliptical in outline, widest medianly, with entire but slightly wavy margins and coriaceous in texture. Apex and base about equally abruptly pointed; apex in some specimens slightly emarginate. Length 7.5 to 10.75 centimeters, maximum width 2 to 2.5 centimeters. Petiole stout, expanded proximad, 1 centimeter in length. Midvein stout throughout, prominent on the underside of the leaf. Secondaries numerous, stout, and prominent, diverging from the midvein at wide angles, camptodrome. Tertiaries well marked, closely spaced, percurrent, and anastomosing, prominent on the underside of the leaf.

This form is common at the localities cited. It differs from *Capparis eocenica* in its larger and relatively broader form and in its somewhat stouter venation and longer and stouter petiole. The largest leaf that I have seen of *Capparis eocenica*, and I have handled abundant material, is 8 centimeters long and 1.7 centimeters in maximum width and has a petiole 3 millimeters in length. The variety *ampla* averages about the same length as this specimen but is never under 2 centimeters in maximum width and has a petiole much stouter and over three times as long.

Occurrence: Holly Springs sand, Jim Tomphson farm and Will Brooks farm, Madison County, Tenn.

Order ROSALES

Family HAMAMELIDACEAE

Genus PARROTIA C. A. Meyer

Parrotia cuneata (Newberry) Berry

Plate 12, figure 10

Viburnum cuneatum Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 511, 1882 [1883]; U. S. Geol. Survey Mon. 35, p. 130, pl. 57, fig. 2, 1898.

Parrotia cuneata Berry, U. S. Geol. Survey Prof. Paper 91, p. 219, 1916.

In 1916 I referred this species, described by Newberry from the Fort Union formation of Montana as a *Viburnum*, to the genus *Parrotia*, basing my de-

[79] Saporta, Gaston de, Recherches sur la végétation du niveau Aquitanien de Manosque, p. 19, pl. 2, figs. 8–10, 1891.

[80] Berry, E. W., U. S. Nat. Mus. Proc., vol. 72, art. 23, p. 10, pl. 1, figs. 2–4, 1927.

scription on specimens found near the base of the Holly Springs sand in Tennessee but not figuring any of these, as all were incomplete. What appears to be the same species, despite certain differences, occurs in large, nearly complete specimens in Nevada County, Ark., and one of these is figured in the present report. This specimen differs from the type in its larger size and fewer and more curved secondaries but preserves the same general facies. It is a form that students have frequently referred to the genus *Quercus*, although in my opinion it is not related to that genus. It is not unlike a leaf in the Clarno formation of Oregon that Newberry [81] described as *Quercus paucidentata*. It is also similar to a form from the travertine of Sézanne in France (Thanetian) described by Saporta [82] as *Hamamelites fothergilloides* and referred by him to the same family to which I have referred the Wilcox fossils. Ward [83] identified a Fort Union species with that of Saporta, but I much doubt their identity, nor is Ward's species like the present one that I have referred to *Parrotia*.

Occurrence: Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark. Holly Springs sand, Silerton road, Chester County, Tenn.

Genus LIQUIDAMBAR Linné

Liquidambar wilcoxianum Berry, n. sp.

Plate 21, figure 8

Leaves of medium size, palmately five-lobed. Median lobe largest, basal lobes smallest and recurved. Lobes conical acuminate, separated by open, somewhat angular sinuses that extend more than halfway to the base. Margin with small serrate teeth, which become close spaced toward the tips and are absent in the sinuses. Petiole stout, curved, of undetermined length. Primaries five, from the top of the petiole, stout and prominent, becoming thin distad. Secondaries numerous, thin, regularly curved, and camptodrome. Fruits are mud casts, fragmentary but characteristic.

Only a single specimen of the leaf of this species has been found, and as the leaves of this genus are remarkably variable it may have had leaves with 3 to 7 lobes. The leaves of the existing sweet gum (*Liquidambar styraciflua*) rot very rapidly, and this perishability was probably shared by the ancestral forms of the genus, to judge by their relative scarcity in the rocks.

It has been customary to refer the majority of fossil forms of *Liquidambar* to the protean species *Liquidambar europaeum* Alexander Braun, which in consequence has an extended geographic and geologic range. In fact, all the fossil forms thus far known might be matched by the variants of one or another of the existing species. The Wilcox form, so far as it is known, could readily be referred either to *L. europaeum* or to *L. styraciflua*. It is, however, highly improbable that a single botanic species ranged all over the Northern Hemisphere without modification or maintained its specific identity from Eocene to Miocene, much less to Recent time. For these reasons the Wilcox species is described as a new species.

The present is one of the oldest authentic records of *Liquidambar* and tends to disprove a previously entertained hypothesis that the genus may have originated in northern latitudes, a view which was suggested by the fact that the hitherto oldest known forms were found in the upper Eocene of Alaska, Greenland, and Oregon.[84]

Occurrence: Holly Springs sand, near State hospital west of Bolivar (leaf); big cut at Pine Top (fruits); Murrell property, southeast of Bolivar (fruits); all in Hardeman County, Tenn.

Family DRUPACEAE

Genus AMYGDALUS Linné

Amygdalus wilcoxiana Berry, n. sp.

Plate 12, figure 1

Elliptical, almost circular, compressed ligneous stones, abruptly pointed distad, rounded proximad, somewhat inequilateral in outline, compressed. Surface markedly rugose, the longitudinal ribs more persistent than those that run in other directions, the latter becoming more prominent toward the base. Length, about 2 centimeters; maximum width, about 1.6 centimeters.

These characteristic objects are known from several different localities in the Wilcox and appear to be referable to the genus *Amygdalus*, which is represented in the Tertiary of Europe by leaves and stones, the latter of which are commonly very similar to the Wilcox specimens. Among these foreign occurrences the most similar are *Amygdalus prisca* Watelet,[85] from the Sparnacian of the Paris Basin, and *Amygdalus pereger* Unger,[86] which has been recorded from horizons ranging from the uppermost Oligocene (Chattian) to the Pliocene.

The existing species of *Amygdalus* number about five. They are shrubs or small trees of Asia. De

[81] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 76, pl. 43, fig. 1, 1898.

[82] Saporta, Gaston de, Prodrome d'une flore fossile des travertins anciens de Sézanne: Soc. géol. France Mém., 2d ser., vol. 8, Mém. 3, p. 393 (105), pl. 32 (11), fig. 3, 1868.

[83] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 64, pl. 29, fig. 1, 1887.

[84] *Liquidambar integrifolium* Lesquereux of the Upper Cretaceous is not a gum but a species of *Sterculia*, as is also in all probability a so-called gum from the Eocene of France described by Watelet.

[85] Watelet, Adolphe, Description des plantes fossiles du bassin de Paris, p. 237, pl. 58, fig. 11, 1866.

[86] Unger, Franz, Die fossile Flora von Sotzka, p. 54, pl. 34, figs. 10–14, 1850.

Candolle considers the cultivated peach to be a native of China and the almond of western Asia (Syria and Anatolia), although it is possible that the almond is also a native of other Mediterranean countries, as, for example, Greece and Algeria. Some botanists refer the genus *Emplectocladus* Torrey with two or three shrubby species in California, Mexico, and Asia to *Amygdalus*.

At any rate, there is no reason why the ancestral stock should not have existed in North America during the early Tertiary.[86a]

It is quite natural that this earlier stock should have had smaller stones than the later forms, and this appears to have been true of all the fossil species. The greater compression of the stone in the Wilcox form may be compared with the condition in the existing *Amygdalus platycarpa* (Decaisne) of China.

The known fossil species, most of them based upon fruits as well as leaves, number 10, all of which except *Amygdalus gracilis* Lesquereux,[87] which is based upon leaves and rather unconvincing stones, are from the Old World. The oldest of these is *Amygdalus prisca* Watelet,[88] from the lower Eocene of the Paris Basin. There are two species in the Oligocene of Europe, eight in the Miocene and one in the Pliocene of Italy, and one in the Pliocene of Asia Minor.

[86a] Since this paragraph was written a characteristic *Amygdalus* stone has been recorded from the Miocene of the State of Washington.

[87] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 199, pl. 40, figs. 12–15; pl. 44, fig. 6, 1883.

[88] Watelet, Adolphe, op. cit., p. 237.

Occurrence: Grenada formation, 2.9 miles southwest of Somerville, near Moses Hill; Somerville, north of Loosahatchie River, on road to Yum Yum; all in Fayette County, Tenn. Holly Springs sand, Whiteville gully, Hardeman County, Tenn.

Family ROSACEAE

Genus CHRYSOBALANUS Linné

Chrysobalanus eocenica Berry

Plate 12, figures 2–4

Chrysobalanus eocenica Berry, U. S. Geol. Survey Prof. Paper 91, p. 220, pl. 44, figs. 4, 5; pl. 112, figs. 8–10, 1916.

These fruits were described from Grenada, Miss., and Puryear, Tenn., in the report cited above. They were all preserved in clays, and their condition was not nearly so good as those collected in 1923 from a but slightly compressed lignite band at the outcrop in Chester County, Tenn. At the latter locality they may be washed out of the lignite in perfect condition. I have been fortunate in having a representative series of the fruits of the modern *Chrysobalanus icaco* Linné from southern Florida through the Antilles to Colombia for comparison with the fossils. Except for the average smaller size of the fossil form, it is identical in outline, thin flesh, and rugosities with the fruits of this modern species, and there can not be the slightest doubt but that the fossil represents a lower Eocene species of *Chrysobalanus*, which is also represented by characteristic leaves at numerous localities in the Wilcox.

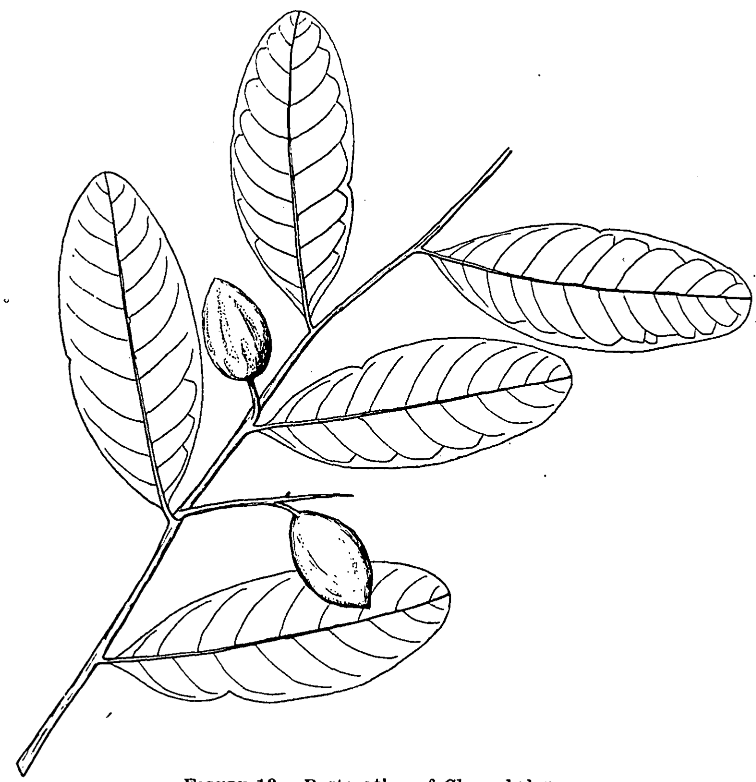

FIGURE 13.—Restoration of *Chrysobalanus*

Only new localities are listed below.

Occurrence: Grenada formation, on road to Macon, 1½ miles south of Somerville, Fayette County, Tenn.; Holly Springs sand, Silerton road, Taylor farm, Chester County, Tenn.

The restoration shown in Figure 13 is a combination of the leaves described as *Chrysobalanus inaequalis* (Lesquereux) Berry, of the upper part of the Holly Springs sand and the Grenada formation, and the characteristic ridged stones of a drupe described as *Chrysobalanus eocenica* Berry and found at several localities in the Holly Springs sand and Grenada formation and beautifully preserved in the lignite seam on the Taylor farm in Chester County, Tenn. The habit is that of the existing *Chrysobalanus icaco* Linné. The fruits are depicted somewhat larger in size than is indicated by the fossil stones.

Family MIMOSACEAE

Genus MIMOSITES Bowerbank

Mimosites variabilis Berry

Plate 12, figure 6; Plate 32, figure 7

Mimosites variabilis Berry, U. S. Geol. Survey Prof. Paper 91, p. 227, pl. 45, figs. 6–11, 1916.

A specimen of this common species from a place near Rogers Spring, Tenn., unlike all the numerous specimens hitherto collected, adds to our knowledge of the leaf in that it shows six leaflets of the maximum size of this species, closely spaced on the rachis. They are slightly ascending in attitude, at intervals of about 5 millimeters, so that they overlap slightly in the median region of the leaflet.

A second specimen showing the three terminal leaflets and coming from Mill Creek is referred to this species with a good deal of confidence. If normal for the species it shows that the leaves were odd pinnate in habit, and in conjunction with the specimen mentioned above it allows the complete leaf to be pictured.

The specimen figured shows considerable resemblance to the tripartite calices of certain species of the genus *Macreightia* A. de Candolle, a member of the family Ebenaceae found at the present time in the African and American Tropics and occurring fossil in the European Miocene. This resemblance is believed to be illusory, however, and the specimen is believed to represent *Mimosites variabilis.*

Occurrence: Holly Springs sand, Early Grove, Holly Springs, Miss.; Wickliffe, Ky.; west of La Grange and 1½ miles west of Grand Junction, Fayette County, Tenn.; Puryear, Henry County, Tenn.; Rogers Spring, half a mile southwest of Walnut Grove, west of Bolivar, Bolivar-Somerville road, Mill Creek, Bolivar-Jackson road, near Clover Creek, half a mile southeast of Walnut Grove (very common); and 3 miles south of Saulsbury, all in Hardeman County, Tenn. Grenada formation, Grenada, Miss. Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark.

Mimosites acaciafolius Berry

Plate 30, figures 5–8

Mimosites acaciafolius Berry, U. S. Geol. Survey Prof. Paper 91, p. 226, pl. 45, fig. 14, 1924.

The accompanying figures of this species from a new locality add somewhat to our knowledge of its characteristics, known hitherto from a single locality. The character of the base and venation, not shown in the figure of the type, will serve for its recognition in the future.

Occurrence: Holly Springs sand, Bolivar-Jackson road, just south of Madison-Hardeman County line and north of Clover Creek, Hardeman County, Tenn.

Mimosites wilcoxensis Berry, n. sp.

Plate 38, figures 6–8

Four Wilcox species based upon leaflets have been referred to the genus *Mimosites*, and the various pods found have been referred to *Leguminosites*, *Cassia*, *Parkinsonia*, and other genera. Recent collections contain numerous fragments of linear, many seeded, compressed pods that appear definitely to belong in the family Mimosaceae, and these are accordingly referred to the form genus *Mimosites* and may well represent the fruits of one of the four species based upon leaflets.

These pods are stipitate, compressed, linear in outline, with a bluntly pointed apex and a gradually narrowed and curved base. Their substance appears to have been stiff and rather brittle, to judge by the way in which they are broken. They are about 9 centimeters long and 8 millimeters in maximum width. They contain about 15 compressed seeds which are orbicular in outline. The margins are well marked, and a few transverse veins are visible.

The only Wilcox pod at all similar to these is one described as *Cassia bentonensis* Berry.[89] This form is sparsely represented, is somewhat larger, less strictly linear, with more prominent venation and thinner texture, the contained seeds not sufficiently thick to influence the contour of the surface and to give the compartment appearance so obvious in the present species.

Several existing species of *Mimosa* have pods like *Mimosites wilcoxensis*, as has also *Acacia filiculoides* (Cavanilles) Trelease, a prairie plant ranging from

[89] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 229, pl. 50, fig. 1, 1916.

Missouri and Kansas southward into Mexico. Authors have described similar fossil pods from the European Tertiary as *Acacia* or *Mimosa*, but in the present state of our knowledge positive discrimination is impossible.

Occurrence: Holly Springs sand, Mill Creek and Clover Creek, Hardeman County, Tenn.

Genus PITHECOLOBIUM Martius

Pithecolobium? tennesseense Berry, n. sp.

Plate 22, figure 6; Plate 39, figure 7

Leaflets relatively small, elongate, markedly inequilateral below, and roughly ovate. Apex narrowly rounded. Base acuminate on one side and full and rounded on the other. Margins entire. Apparently thin and stiff in texture. Length about 3.5 centimeters; maximum width, at or slightly above the middle, about 1.4 centimeters. Leaflets apparently sessile. Midvein stout, prominent on the under side of the leaflet, conspicuously curved. Secondaries thin but prominent, numerous, camptodrome.

This species is sparingly represented in the collections but is markedly distinct from previously described forms. It is not unlike the leaflets of several unrelated existing genera of the Leguminosae, as, for example, *Cassia bifoliolata*, and some species of *Bauhinia*. The venation, however, appears to me to be more like that of *Pithecolobium*, and as the form is rather characteristic of that genus, it is tentatively referred to it.

Two well-marked species of *Pithecolobium* are already known from the middle and upper Wilcox,[90] and several Tertiary species have been described since the Wilcox report was published—from the Oligocene of Louisiana,[91] from the Miocene of the Dominican Republic[92] and Porto Rico,[93] and from the Pliocene of Bolivia.[94]

Occurrence: Holly Springs sand, northwest of Pattersonville, Fayette County, Tenn.

Pithecolobium eocenicum Berry

Plate 32, figure 10

Pithecolobium eocenicum Berry, U. S. Geol. Survey Prof. Paper 91, p. 225, pl. 45, fig. 2, 1916.

One of the interesting features of the recent collections from the Wilcox is the extended distribution of many species known only from the single locality at Puryear at the time that the first report was written. Such a great variety of forms were recorded from Puryear that the author could not help but suspect that chance variation in form may have led to an unnecessary duplication of species. When these forms are found at scattered localities, however, the presumption that they are normal is greatly increased. The specimen of the present species figured herewith is relatively slightly wider than the type, with somewhat less curvature of the midvein; it has a slightly mucronate tip and a short and not especially conspicuous petiolule.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy and Mill Creek, Hardeman County, Tenn.; Puryear, Henry County, Tenn.

Pithecolobium eocenicum anomalum Berry, n. var.

Plate 44, figures 1, 2

Two specimens of very inequilateral leaves or leaflets from different localities are believed to be abnormal forms of the well-known Wilcox species *Pithecolobium eocenicum* Berry. The smaller of these specimens represents a supposed leaflet less than 1.5 centimeters in length and about 8 millimeters in maximum width, of a coriaceous texture and relatively very prominent and coarse venation. The exceedingly stout midvein is considerably curved, and four-fifths of the lamina is on the convex side of the midvein. The stalk is very stout and curved and about 1.4 centimeters in length. The secondaries in the wider side are relatively stout, four or five in number, diverging from a midvein at a relatively wide angle and curving upward subparallel with the margins, camptodrome. The tertiaries are well marked and irregularly percurrent.

The larger specimen is even more inequilateral than the smaller, with which it agrees in venation. Only between 1 and 2 millimeters of petiolule is preserved, so that it is not known if it was extended as in the smaller form. I imagine that it was not. This larger leaflet is about 2 centimeters in length and 13.5 millimeters in maximum width, and I regard it as more typical of this variety than the smaller leaf.

The stout elongated petiolule, if it is a petiolule, of the smaller specimen is an objection to considering it to represent a *Pithecolobium*, but the similarity of form and the identity of the venation in the two suggests the following explanation: In the smaller specimen we have an abnormal leaflet representing all that was developed there of a leaf, and the stout petiolule is not a true petiolule but the stipe of a small leaf, of which only this single leaflet was formed.

If my interpretation is correct, then this variety normally differed from *Pithecolobium eocenicum* in being relatively shorter and wider, with a coarser

[90] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 225, pl. 45, figs. 2, 3, 1916.

[91] Berry, E. W., U. S. Geol. Survey Prof. Paper 98, p. 239, pl. 55, fig. 10, 1916.

[92] Berry, E. W., U. S. Nat. Mus. Proc., vol. 59, p. 120, pl. 21, fig. 2, 1921.

[93] Hollick, Arthur, New York Bot. Garden Bull., vol. 12, pp. 302, 303, pl. 10, fig. 8; pl. 11, fig. 4, 1924.

[94] Berry, E. W., U. S. Nat. Mus. Proc., vol. 54, p. 131, pl. 15, fig. 20, 1917; Johns Hopkins Univ. Studies in Geology, No. 4, p. 173, pl. 6, figs. 7, 8, 1922.

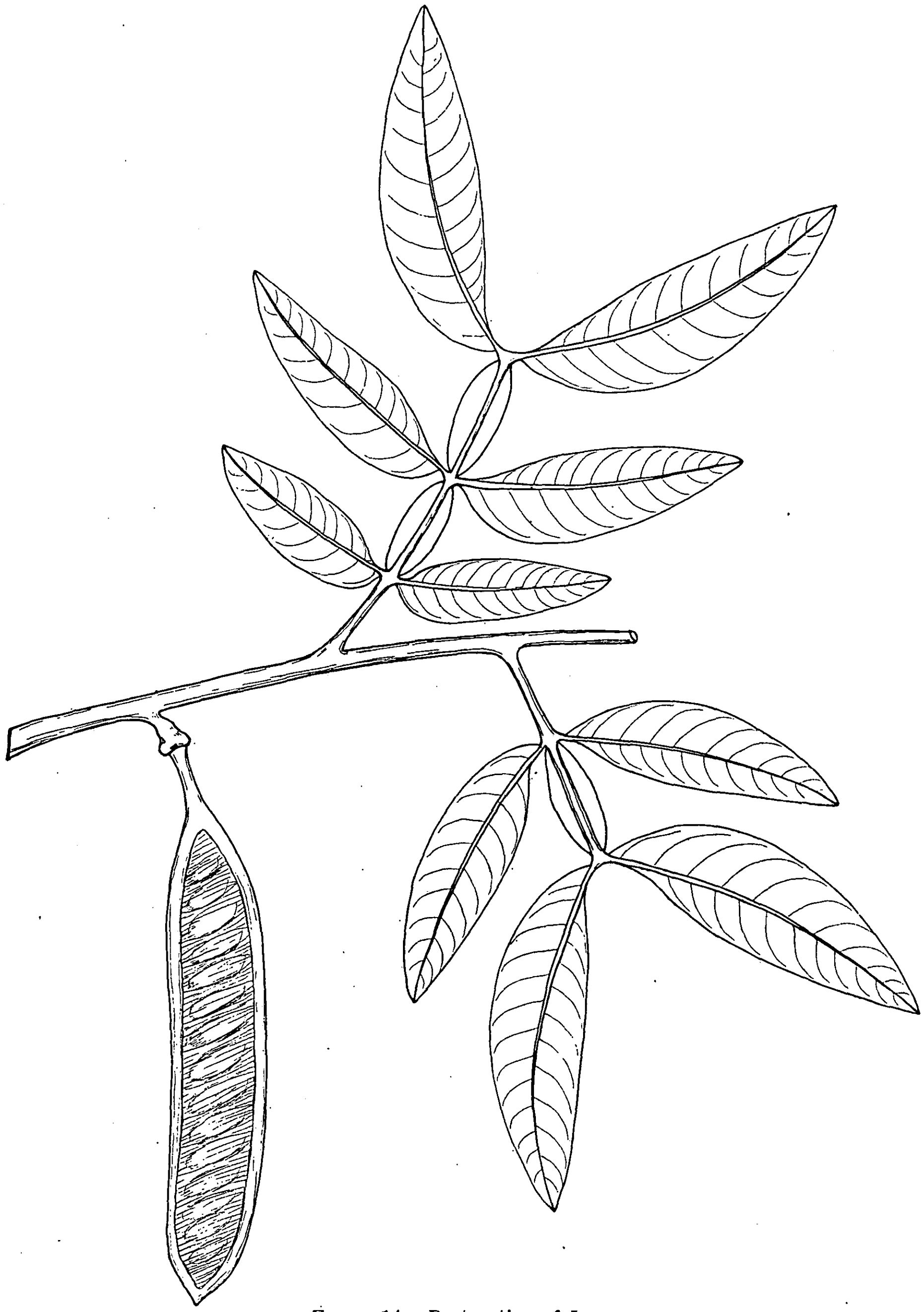

FIGURE 14.—Restoration of *Inga*

venation, fewer and more ascending secondaries, a greater expansion on one side and a diminution on the other of the lamina, and a slipping downward, as it were, of the midvein, so that the tip of the leaflet was very obliquely truncated, the lamina on the small side forming an acute angle with the tip of the midvein, and the lamina on the other side extending upward to form a broadly rounded earlike expanse.

Modern leaves of *Pithecolobium* show a very considerable variation in size, form, and texture, and it is possible that the variety described above should be regarded as merely the variants of *Pithecolobium eocenicum*.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.

Genus INGA Willdenow

Inga laurinafolia Berry

Plate 22, figures 1–4

Inga laurinafolia Berry, U. S. Geol. Survey Prof. Paper 91, p. 224, pl. 48, fig. 8, 1916.

This very characteristic form was described originally from a single locality in Louisiana and is but sparingly represented in the eastern embayment. In view of the great abundance of fossil plants in this region this fact can only mean that it was not common there. The specimens figured from Harrison County, Tex., where this form is very abundant, show well its limits of size and form.

Occurrence: Grenada formation, 2.9 miles southwest of Somerville, near Moses Hall, Fayette County, Tenn.; Holly Springs sand, Grove pit, Henry County, Tenn. Wilcox formation, Mansfield and Coushatta, La.; 6 miles north of Scottsville, Harrison County, Tex.

The leaflets described as *Inga laurinafolia* Berry are not uncommon in the upper half of the Wilcox in Louisiana and Texas. They are rather similar to several existing species of *Inga* and are especially like *Inga laurina* Willdenow of the Antillean region, which resemblance suggested the specific name of the fossil species. Only the detached leaflets have been found, and therefore their synthesis into even-pinnate leaves rests on the habit of various existing species, as does the winged rachis.

The pods are those from the upper part of the Holly Springs sand in western Tennessee described as *Leguminosites ingafructoides* Berry, which are also like the pods of numerous existing species, especially the Mexican species *Inga leptoloba* Schlechtendahl. Of course we have no means of knowing that these particular pods and leaflets represent a single Eocene species of *Inga*, for the leaflets of three other species have been described from the Wilcox, and the present association rests on the equally robust character of both the pods and leaflets.

Family CAESALPINIACEAE

Genus PARKINSONIA Linné

Parkinsonia eocenica Berry, n. sp.

Plate 12, figure 9; Plate 41, figure 11

In 1916 I described certain small, obovate-lanceolate leaflets from the Wilcox of western Tennessee as *Caesalpinites* (*Parkinsonia?*) *aculeatafolia*,[95] the specific name being suggested by their resemblance to the leaflets of the existing *Parkinsonia aculeata* Linné. In the collections of 1923 there are fragmentary specimens of pods, which are likewise absolutely indistinguishable from the pods of this existing species. I realize that other Leguminosae have similar torulose pods, but the circumstantial evidence seems to me convincing enough to warrant the reference of these fossils to the genus *Parkinsonia*. I have accordingly described these pods as a species of that genus and would transfer the leaflets mentioned above to the same genus.

The pods may be described as follows: Pods rounded in cross section, lanceolate falcate in form, with a stout curved peduncle about 1.5 centimeters in length, with three or four elliptical seeds elongated in the axis of the pod, conspicuously constricted between the seeds, apparently with a smooth surface and indehiscent, and of a coriaceous consistency. Length about 9 centimeters (estimated); maximum diameter about 8 millimeters.

[95] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 237, pl. 50, fig. 15, 1916.

As previously mentioned, many leguminous species have more or less torulose or moniliform pods. Among these there are several still existing in the Texas part of the Atlantic Coastal Plain or in the region west and south of Texas, comprising *Acacia tortuosa* Willdenow of the Rio Grande Valley and regions to the south; *Prosopis juliflora* De Candolle,

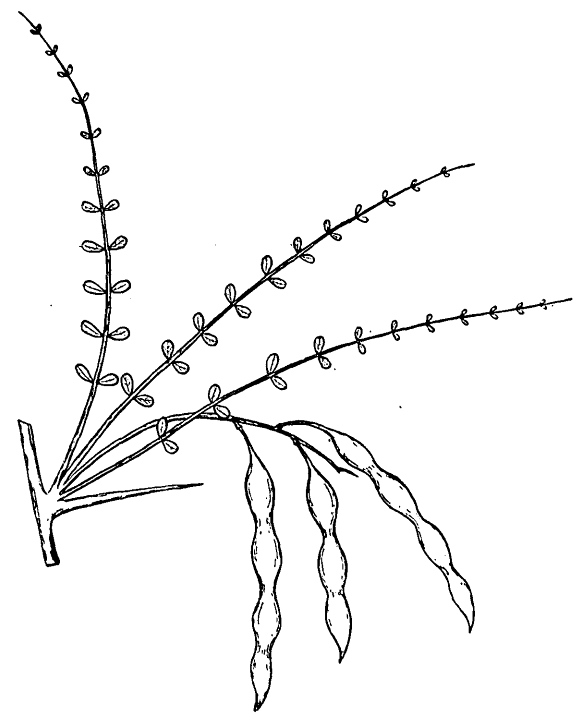

FIGURE 15.—Restoration of *Parkinsonia*

the mesquite, which ranges from Texas to Lower California; *Sophora secundiflora* De Candolle and *Sophora affinis* Torrey and Gray, which range, respectively, from Texas to Mexico and from Arkansas to Texas; and *Olneya tesota* Gray of southern California, Arizona, and Mexico. The last is a desert type, but the others, although living in an arid climate, require more or less moisture.

I have compared the fossil pods with these, and they show more or less conspicuous differences.

These fossil pods are somewhat more slender than those of the existing *Parkinsonia microphylla* Torrey and are of the same size, form, and relative proportions as the pods of the existing *Parkinsonia aculeata* Linné. The accompanying restoration (fig. 15) consists of the pods of *Parkinsonia eocenica* Berry and the leaflets of *Caesalpinites aculeatafolia* Berry and is closely patterned after the existing *Parkinsonia aculeata* Linné, except that as there is no evidence from the fossils of a stipe, which was probably present, the pods are depicted as attached directly upon the axis of the inflorescence.

Parkinsonia aculeata is a relatively small tree, not over 30 feet tall, commonly with a stout trunk and slender spreading branches, indigenous in the moister soils of depressions or stream valleys in arid or semiarid regions, ranging from the basin of the Rio Grande and its tributaries in southern Texas and northern Mexico, the Rio Colorado Valley in Arizona, and in Lower California to northwestern Peru. It has been rather extensively planted as an ornamental plant in the warmer countries of the world and has become naturalized in Florida, the Bahamas, the West Indies, and in many tropical countries.

The genus contains but three or four existing species found in the warmer parts of North America near the Mexican border and southward and in South Africa. Unless its modern environment represents a change in its requirements since Wilcox time, its presence in the Wilcox might be taken to indicate a certain amount of aridity, probably entirely local and due to its having inhabited sandy coastal regions where the water table was near the surface but where the insolation was especially pronounced and the growth open and without much shade from other trees—that is, a sort of beach chaparral.

Of the two species of *Parkinsonia* that occur in the United States, the one is a desert plant and the other, *P. aculeata*, is found in low moist situations in regions where the general climate is more or less arid.

The only other fossil species of the genus known is *Parkinsonia recta* Laurent,[96] a typical species, represented by both leaflets and pods and found in the Tongrian of southern France (Célas). This form is exceedingly close to the Wilcox form but has somewhat larger and more elongated leaflets.

Among similar fossil forms may be mentioned the pods described by Saporta[97] from the lower Miocene of southern France (Armissan) as *Acacia bousqueti*.

Occurrence: Holly Springs sand, La Grange, west of road and south of railway at western edge of the town, Fayette County, Tenn.

Genus COPAIFERA Linné

Copaifera? wilcoxiana Berry, n. sp.

Plate 46, figures 5, 6

These forms are referred tentatively to the genus *Copaifera*, with the leaflets of the existing species of which they agree in their form and venation, although it is recognized that other Leguminosae, as, for example, certain species of *Cassia* and *Caesalpinia obliqua* Vogel, also have similar leaflets. I am largely influenced in this identification by the presence of characteristic fruits of *Copaifera* in the Claiborne Eocene of the embayment region[98] combined with the previously mentioned agreement in the foliage preserved in the Wilcox with that of various species of *Copaifera*, as, for example, *Copaifera langsdorfii* Desfontaines and other species of the genus existing in northern South America.

The present form, if correctly determined, adds a new and interesting generic type to the already largely represented Leguminosae of the Wilcox. It may be described as follows:

Leaflets very unsymmetrical, with approximately symmetrical acute tips and obliquely truncated, very inequilateral bases. Margins entire. Texture coriaceous. Length from 2.25 to 3 centimeters along the midvein; maximum width from 7.5 to 13 millimeters. In the wider forms the lamina a short distance above the base is 7 millimeters wide on one side and 4 millimeters wide on the other. The leaflets are sessile and attached at the expanded base of the midvein. The midvein is relatively stout and nearly straight. The secondaries are medium stout but immersed in the leaf substance, so that they are not prominent; a greater or lesser number of pairs diverge from the midvein at wide angles, pursue rather straight courses outward, and are abruptly camptodrome well within the margins. The tertiary venation and areolation are immersed, except for the arched tertiaries outside the secondary camptodrome loops.

This type is a well-marked one and readily distinguished from previously described Wilcox Leguminosae. As stated above, it is believed to represent the genus *Copaifera*, which has about a score of existing species in the American and African Tropics and a number of Tertiary species in Europe and America. If authentic, the present is the oldest-known species.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

Genus CAESALPINIA Linné

Caesalpinia wilcoxiana Berry

Plate 40, figure 1

Caesalpinia wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 235, pl. 50, figs. 9–12, 1916.

This species was described in 1916 from the detached leaflets, which are common at a considerable number of localities throughout the Holly Springs

[96] Laurent, Louis, Flore des calcaires de Célas, p. 140, pl. 14, figs. 18–21, 1899.

[97] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 378, pl. 13, fig. 12, 1865.

[98] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 63, pl. 10, fig. 4, 1924.

sand. In 1925 a complete leaf was collected. This specimen shows it to have been even pinnate, as in existing species of *Caesalpinia*, with but two pairs of leaflets, which were widest on their distal sides, and to have had a relatively long and very stout petiole. From this specimen the accompanying restoration has been prepared. (See fig. 16.) No part of this figure is hypothetical, and the restoration consists merely in completing the outlines of the leaflets and the venation of this unique specimen from entire leaflets in the collection.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

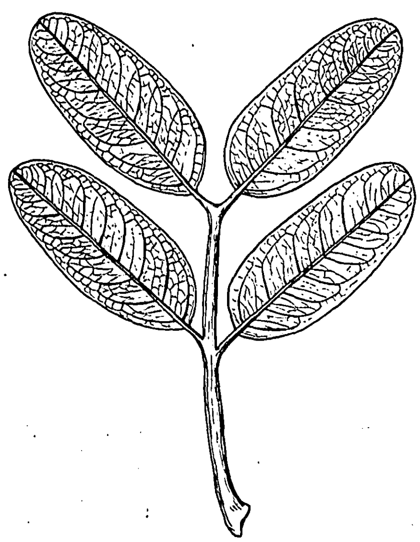

FIGURE 16.—Restoration of a complete leaf of *Caesalpinia wilcoxiana* Berry

Genus CAESALPINITES Saporta

Caesalpinites wilcoxensis Berry, n. sp.

Plate 44, figures 21, 22

Leaflets small, oval, and very inequilateral, especially in the lower half of the leaflet. Tip rounded, nearly equilateral. Base narrowly descending on one side, flaring and full on the other. Texture relatively coriaceous. Petiolule barely more than an expanded proximal end of the midvein, not quite a millimeter long in the largest leaflets, the base of the broader side of the lamina commonly inserted above that of the narrower side. Midvein thin except at its base, not prominent. Secondaries thin, numerous, immersed in the leaf substance, regularly spaced and subparallel. Length from 1 to 2 centimeters; maximum width from 5 to 8 millimeters.

These small leaflets resemble two previously described Wilcox species of Leguminosae—*Mimosites inaequilateralis* Berry and *Caesalpinia wilcoxiana* Berry. They differ from the first of these species in their proportions, being relatively twice as wide, and they also show constant differences in outline. They differ from the second in their shorter petiolule and more inequilateral base and in their venation.

The uncertainty attending the generic identification of the leaflets of a larger number of species in this vast alliance precludes dogmatism, but as the present fossils are believed to represent a Wilcox species belonging to the family Caesalpiniaceae, they are referred to the form genus *Caesalpinites*.

Occurrence: Holly Springs sand, Bradley pit and Grable pit, Henry County, Tenn.

Caesalpinites mississippiensis Berry

Plate 39, figure 5

Caesalpinites mississippiensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 237, pl. 50, fig. 16, 1916.

This characteristic small leaflet is confined to the eastern shore of the Wilcox embayment, where it is never abundant, although it occurs at several widely separated localities.

Occurrence: Holly Springs sand, Holly Springs, Marshall County, Miss.; Mill Creek, Hardeman County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.

Genus CASSIA Linné

Cassia wilcoxiana Berry

Plate 12, figure 7

Cassia wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 230, pl. 50, figs. 2–5, 1916.

Although the pod figured in this paper is considerably smaller than those that have been referred to this species, it probably does not represent a different species, for in general outline, character of the margins, and venation it is practically identical with that species, as may be seen by comparing it with the restoration of that species published in another paper,[99] where it is shown one-half natural size. It should be noted that the foliage of *Cassia wilcoxiana* has not been found at Mill Creek, where the foliage of four other species of *Cassia* is preserved in the clays, and it is therefore quite possible that this pod may represent the fruit of one of these species.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.; La Grange, three-fourths mile northwest of Pattersonville, Fayette County, Tenn.

Cassia fayettensis Berry

Plate 12, figure 8; Plate 25, figure 22; Plate 39, figure 4; Plate 46, figures 7, 8; Plate 48, figure 33

Cassia fayettensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 232, pl. 49, figs. 5–8, 1916.

The leaflets of this species are widely distributed at numerous localities, especially in beds deposited

[99] U. S. Geol. Survey Prof. Paper 91, p. 231, 1916.

near the end of the time represented by the Holly Springs sand in northern Mississippi and western Tennessee. Heretofore these leaflets were always found in a detached condition. During the field season of 1925 two specimens with attached leaflets were found at different localities, which add materially to

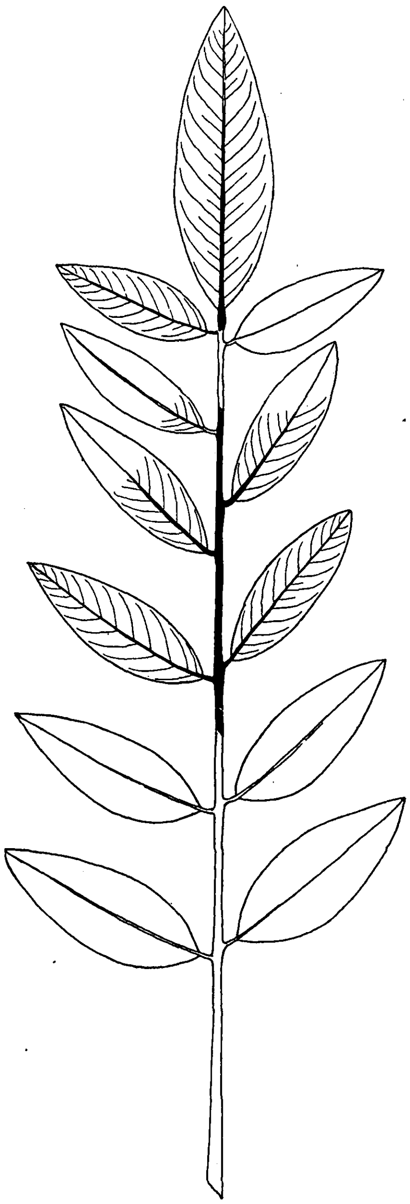

FIGURE 17.—Restoration of a complete leaf of *Cassia fayettensis* Berry

our knowledge of this species. The first specimen, from Mill Creek, shows a terminal and the subjacent lateral leaflet. The terminal leaflet is much larger than the lateral and is in fact larger than any known leaflets of this species, having a length of 6 centimeters and a maximum width of 1.9 centimeters. Whether this leaflet was abnormally large or whether the terminal leaflet was normally larger than the laterals can not, of course, be determined from a single specimen. Evidently the leaf habit was odd pinnate.

The second specimen, from Puryear, shows parts of five attached leaflets, two of which are complete. These leaflets are nearly equilateral, ascending, and petiolulate on a stout stipe at intervals of 2.25 to 3 centimeters. None of them are opposite, and the members of some of the pairs are at least a centimeter from opposite points.

From these two specimens and the numerous detached leaflets that have been discovered, the accompanying restoration of a complete leaf has been made. (See fig. 17.) The venation has been omitted from the parts restored, and the number of lateral leaflets is of course conjectural. They were possibly fewer than has been indicated, but be this as it may, the restoration probably gives a more complete idea of the features of this form than can be obtained in any other way.

No traces of petiolar glands have been detected, and the habit also differs from most existing species of *Cassia*, which are even pinnate.

Occurrence: Holly Springs sand, of Wilcox group, Lamar and Holly Springs, Miss.; west of Bolivar, 2¼ miles north of Shandy, Mill Creek, Bolivar-Jackson road north of Clover Creek, 1 mile northeast of Cloverport, all in Hardeman County, Tenn.; La Grange, Fayette County, Tenn.; Mobile & Ohio Railroad 4 miles north of Jackson, Madison County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Grable pit, Puryear, and Cottage Grove, Henry County, Tenn. Grenada formation, of Wilcox group, 2.9 miles southwest of Somerville, 1½ miles northeast of Williston, 5 miles southwest of Williston, all in Fayette County, Tenn. Wilcox formation, Benton, Saline County, Ark.; sec. 10, T. 14 S., R. 21 W., Nevada County, Ark.; 5 miles northeast of Texarkana, Miller County, Ark.

Cassia robertsi Berry, n. sp.

Plate 41, figure 7

Leaflets small, linear, markedly inequilateral, especially at the tip, which is evenly rounded, the termination of the midvein being one-third of the total width from one side and two-thirds of the distance from the other. The base is rounded, but the two sides of the lamina come to a point at the extreme base, that of the narrower side being about 0.5 millimeter below that of the broader side. Margins entire. Texture subcoriaceous. Petiolule hardly more than the expanded base of the midvein and about as long as wide. Midvein relatively stout, nearly straight, projecting as a slight point beyond the tip and abruptly expanding at the base, relatively prominent on the under side of the leaflet. Secondaries relatively stout and prominent on the under side, numerous, closely spaced, and subparallel; they diverge from the midvein at angles between 60° and 65° and are for the most part indistinctly camptodrome, forking and merging in the camptodrome loops immediately within the margins.

This is clearly a new type among the numerous leguminous leaflets that have been described from the Wilcox. In outline it is much like various forms that have been referred to *Cassia*, *Mimosites*, *Caesalpinia*, and *Gleditsiophyllum* but differs in size or relative proportions and particularly in venation from all of these. There is some question of the propriety of its reference to *Cassia*, most of the Wilcox species of which are larger, but it appears to me to differ from what I have, perhaps somewhat arbitrarily, considered as typical in *Mimosites*, *Caesalpinia*, and *Gleditsiophyllum* and to be more like certain existing and fossil species in the very large genus *Cassia*. The differentiation of the leaflets of the Leguminosae is perhaps an insoluble problem, but there is a certain advantage in making consistent use of the available criteria, especially when all of the vast amount of material passes through the hands of a single student, as it has in the Wilcox flora, which I believe outweighs whatever botanic inconsistency may be present. The species is named for the collector.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Cassia nictitanioides Berry, n. sp.

Plate 41, figure 8

Pods of relatively small size, linear lanceolate, compressed, slightly curved parallel margins, acute apex and base, the former with a trace of the style and the latter decurring on the stout curved peduncle, which is about 4 millimeters in length. The pod itself is about 3 centimeters in length and 6 millimeters in maximum width, faintly transversely veined, slightly thickened margins, apparently not coriaceous and showing no contours to indicate the number of contained seeds.

This pod greatly resembles that of *Acuan illinoiensis* (Michaux) Kuntze, a modern prairie and river bank form found from Indiana and Minnesota to Florida and Texas. It is perhaps more similar to that of *Cassia nictitans* Linné, a dry-soil herb of the eastern United States. Both the genera mentioned have other forms of pods, so that but little reliance can be placed upon the indicated relationships.

However, the present pod is much like other Wilcox pods referred to *Cassia* with which abundant leaflets are associated, and as both recent and fossil species of this large genus have similar pods, it seems more desirable to use the generic term *Cassia* rather than the vaguer term *Leguminosites*.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

Cassia bolivarensis Berry, n. sp.

Plate 32, figures 4, 5

Leaflets small, markedly inequilateral, oblanceolate, widest at or above the middle, tapering gradually proximad to the markedly inequilateral, broadly or narrowly acute base and more abruptly upward to the less inequilateral, slightly mucronate tip. Margins entire, generally evenly rounded. Texture subcoriaceous. The narrower leaflets are generally falcate, the wider ones are less commonly so. Length about 2.5 centimeters; maximum width from 6 to 9 millimeters. Petiolule short and stout, about 1 millimeter long and nearly as thick. Midvein stout and prominent, commonly curved. Secondaries thin and largely immersed; they are numerous and subparallel, diverging from the midvein at angles of 70° to 80°, pursuing relatively straight outward courses until the marginal region is reached, where they are camptodrome.

This species is clearly unlike previously described Wilcox leguminous leaflets, especially as exemplified in the narrower leaflets, such as that shown in Plate 32, Figure 4. The broader leaflets are less sharply distinct in outline but share with the narrower leaflets the numerous relatively straight, wide-angled secondaries that form one of the characteristic features of this species. One may naturally hesitate in accepting *Cassia* as the true repository of these leaflets, as the genus is such a large one, with considerable foliar variation, and as so many other genera of the leguminous alliance have similar leaflets.

Twelve different species from the Wilcox, in addition to the present one, have been referred to *Cassia*. The only one of these that approaches at all closely to *Cassia bolivarensis* is *Cassia marshallensis* Berry[1] of the middle and possibly also of the upper Wilcox, which is uniformly wider, lanceolate rather than oblanceolate, with fewer and slightly more ascending secondaries.

Occurrence: Holly Springs sand, west of Bolivar Hardeman County, Tenn.

Cassia puryearensis Berry

Plate 12, figure 13

Cassia puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 230, pl. 51, figs. 13, 14, 1916.

The specimen from Mill Creek here figured, although it preserves the general form and venation

[1] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 232, pl. 50, figs. 6, 7, 1916.

characteristic of this rather large species, is relatively considerably wider. The species is confined to the eastern shores of the Mississippi Gulf at several localities near the top of the Holly Springs sand and in the Grenada formation.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.; road west of La Grange and La Grange, Fayette County, Tenn.; Will Brooks farm, 2.1 miles northeast of Mercer, Madison County, Tenn.; Grable pit, Puryear, and Holcomb property, 2 miles south of Paris, Henry County, Tenn.; Bell City Pottery pit, Calloway County, Ky. Grenada formation, 2.9 miles southwest of Somerville, near Moses Hall, Fayette County, Tenn.; Cottage Grove, Henry County, Tenn.

Cassia glenni Berry

Plate 41, figure 13

Cassia glenni Berry, U. S. Geol. Survey Prof. Paper 91, p. 233, pl. 45, figs. 15, 16, 17a, 18; pl. 52, fig. 6, 1916.

The leaflet of this species from the Atkins pit here figured shows the observed extreme of variation in ovate form, although preserving the characteristic venation and emarginate tip. The species ranges from the Holly Springs sand into the Grenada formation and as far as known is confined to the eastern shores of the Mississippi Gulf, where it is not uncommon, although showing considerable variation in form.

Occurrence: Holly Springs sand, Early Grove and Holly Springs, Miss.; Mill Creek and Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn.; 1½ miles west of Grand Junction, half a mile south of Henley's store, La Grange, Fayette County, Tenn.; Will Brooks farm, 2.1 miles northwest of Mercer, and Pope farm, 1½ miles north of Mercer, Madison County, Tenn.; Atkins pit, Henry County, Tenn.; Wickliffe, Ballard County, Ky. Grenada formation, Cottage Grove, Henry County, Tenn.; Brinkley place, Fayette Corners, Fayette County, Tenn.

Genus GLEDITSIA Linné

Gleditsia? mississippiensis (Berry) Berry

Plate 50, figures 2–4

Cassia mississippiensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 235, pl. 51, figs. 10, 11, 1916.

Specimens of pods present in the Holly Springs sand and Grenada formations of Tennessee and Mississippi were referred to the genus *Cassia* in the preliminary account of the Wilcox flora, largely because of the abundance of *Cassia*-like leaflets in these deposits and also because similar compressed pods had been described as belonging to that genus.

Additional material and more extended study leads to the suggestion that these pods may represent an Eocene prototype of the existing *Gleditsia aquatica* Marsh of the stream bottoms of the lower Mississippi Valley. (See pl. 50, figs. 8–10.)

The pods of *Gleditsia aquatica* are compressed, a somewhat variable oval in outline, with a greater or less developed mucronate tip and an abruptly narrowed constricted stalklike base of variable length, generally long but commonly no longer than in the fossil, with the peduncle below the old flower receptacle correspondingly short or long. Usually but a single seed matures and the pod does not dehisce. If the fossil pods be compared with the modern the same compression and variation in form may be noted; the mucronate tip is short or long and similarly situated; the marginal sutures are the same; there is the same constricted basal stalk, shorter it is true than the average length in the modern pods but exactly similar to the one shown in Plate 50, Figure 8; the venation and apparently the consistency are the same. Moreover, the Wilcox flora contains a variety of leaflets described under the generic term *Gleditsiophyllum*, several of which are very similar to those of *Gleditsia* and might well represent this species. Flat orbicular seeds agreeing in size and shape with those of *Gleditsia aquatica* have been described, and one of the beetle wings from the Wilcox belongs to the same genus as one which I developed from the pods of *Gleditsia aquatica.*

It therefore seems to me desirable to remove this form from the overlarge genus *Cassia* and to refer it tentatively to the genus *Gleditsia.*

Occurrence: The new material is from the Holly Springs sand at the Grable pit, Henry County, Tenn.

Genus GLEDITSIOPHYLLUM Berry

Gleditsiophyllum eocenicum Berry

Gleditsiophyllum eocenicum Berry, U. S. Geol. Survey Prof. Paper 91, p. 238, pl. 46, figs. 1–7, 1916.

In order to give this handsome species more objectivity I have prepared the accompanying illustration of the terminal part of a branch.

The species appears in the record near the end of the deposition of the Holly Springs sand and continues throughout the Grenada formation and its equivalents in the western part of the embayment. The restoration is based on a considerable number of complete leaves which are of rather common occurrence in the clays of the Holly Springs sand at Puryear, Henry County, Tenn. (See fig. 18.)

Genus HYMENAEA Linné

Hymenaea eocenica Berry, n. sp.

Plate 13, figure 1

Leaves of relatively small or medium size; bifoliate, consisting of two ovate entire-margined leaflets, sessile at the end of a stout petiole about 2 centimeters long. Leaflets diverging at angles of about 80°, slightly falcate but nearly equilateral except basally, the acute base being markedly inequilateral; the lamina on the outside decurrent to the top of the petiole, that on the inside terminating 2 or 3 millimeters above the base and being narrower and more ascending than on the outer side. The leaflets are widest in the median region, narrowing almost equally in both directions, with narrowly rounded or slightly emarginate tips. The texture is subcoriaceous, obscuring the areolation. The midribs are stout, prominent on the under side and curve slightly upward. The secondaries are thin, numerous, subopposite to alternate, rather evenly spaced, subparallel, and camptodrome; those on the outer sides are more ascending than those on the inner sides.

The present species adds an important element to the Wilcox flora and one that I expected to find in it and have long looked for, because of the presence of the genus in the Upper Cretaceous of North America.

The bifoliate habit characteristic of *Hymenaea* is shared by certain species in other genera of the leguminous alliance, such as *Bauhinia*, *Leucaena*, *Cassia*, *Acacia*, and *Cynometra*, but certainly, in typical specimens at least, they are readily distinguished by the ensemble of habit, form, and venation.

The present form I regard as an undoubted Eocene representative of *Hymenaea*, which in modern floras comprises about a dozen species of trees confined to the American equatorial region. They are popularly known as locust or copal trees and yield an oleoresin known as animé or copal, much used in the manufacture of varnish and to some extent in perfumery. The pods are buoyant and constitute a considerable element in the Antillean drift, and it is conceivable that the present species reached the Mississippi embayment through the agency of ocean currents, although the presence of the genus in our Upper Cretaceous may mean that this Eocene species was a descendant of some Cretaceous form that dwelt in the same general region.

Except for very doubtfully determined forms from the European Miocene, the Tennessee species represents the first Tertiary record of the genus.[2]

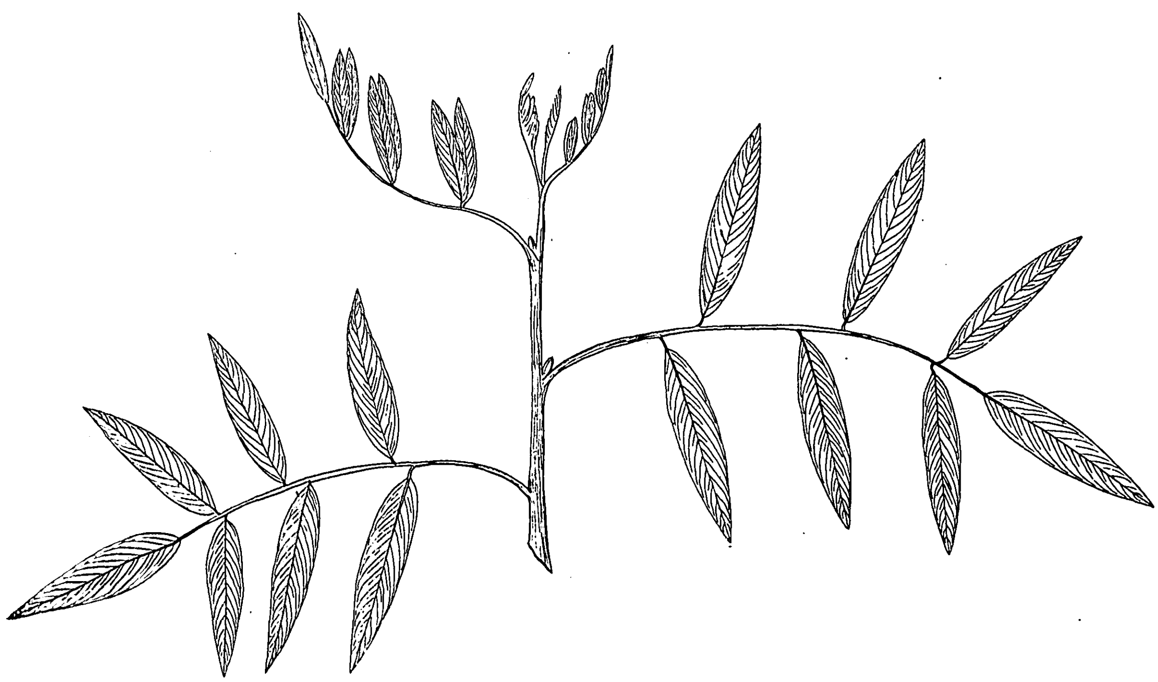

FIGURE 18.—Restoration of *Gleditsiophyllum eocenicum* Berry

Five species of *Hymenaea* have been recorded from the Upper Cretaceous—three from Europe and two from the United States. Some of these are of doubtful identity, but the form from the Tuscaloosa formation of western Alabama appears to be above suspicion.

As the genus never appears to have reached northern latitudes it would appear to have originated in the American Tropics during Cretaceous time. To what extent it colonized the Old World is problematic, and possibly the European forms referred to it should be referred to other genera—for example, to *Bauhinia*, to which Heer referred the Swiss form.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

[2] For a sketch of the genus see Berry, E. W., Am. Jour. Sci., 4th ser., vol. 47, pp. 65–68, 1919.

Hymenaea wilcoxiana Berry, n. sp.

Plate 41, figure 5

Leaves small, bifoliate, the two inequilateral leaflets diverging at angles of about 25° from the stout petiole, which is about 1 centimeter in length. Leaflets ovate lanceolate, inequilateral, and slightly falcate, widest below the middle, overlapping for about half their length on the inside. Tips acute. Margins entire. Texture coriaceous. Midvein stout, prominent on the under side. Secondaries numerous, thin, diverging from the midvein at wide angles, camptodrome, mostly immersed in the leaf substance.

This form adds a second Wilcox species in this interesting genus. It is, of course, within the range of possibility that the present form represents a small and variant leaf of the same botanic species as *Hymenaea eocenica* Berry, but the two are not at all similar except in their bifoliate habit. *Hymenaea wilcoxiana* is only half as large and its leaflets are acute and overlapping, with faint and wide-angled instead of prominent ascending secondaries.

Occurrence: Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn.

Genus CERCIS Linné

Cercis wilcoxiana Berry

Cercis wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 228, pl. 49, fig. 1, 1916.

The restoration shown in Figure 19 is based on the foliage of *Cercis wilcoxiana* Berry, a rather rare type in the Holly Springs sand, combined with the pods described as *Leguminosites collinsi* Berry, which are like those of the existing species of *Cercis* and which are found at a considerable number of localities in the Holly Springs sand. The habit is that of the existing redbud, *Cercis canadensis* Linné.

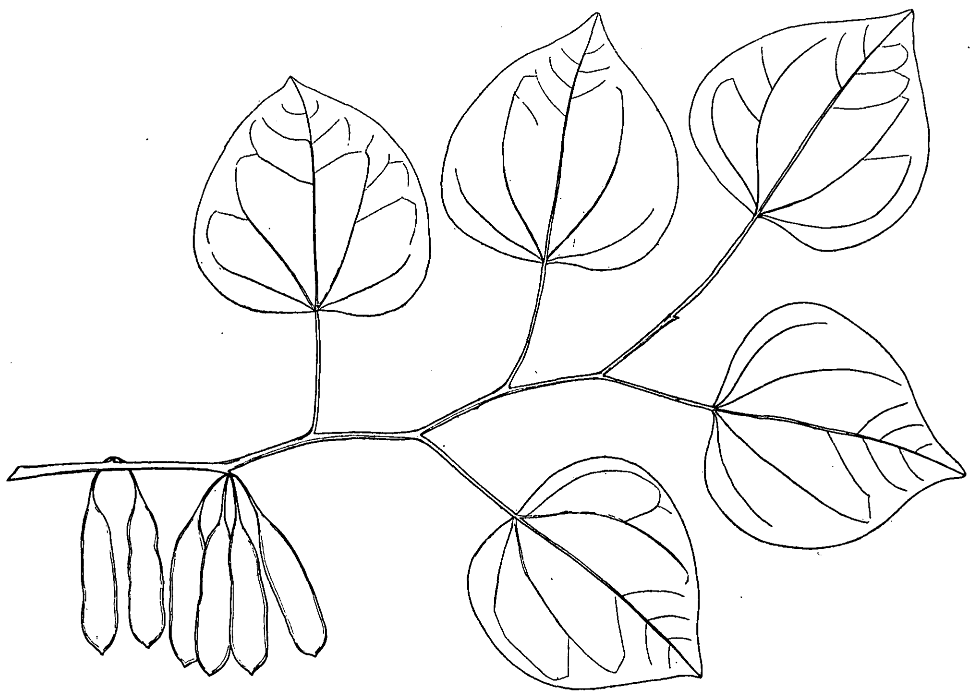

FIGURE 19.—Restoration of *Cercis wilcoxiana* Berry

Family PAPILIONACEAE

Genus CLADRASTIS Rafinesque

Cladrastis eocenica Berry, n. sp.

Plate 41, figure 12

Pods oblong, indehiscent or tardily dehiscent, compressed, slightly constricted between the two or three elliptical compressed seeds, abruptly pointed, narrowing to the stout curved peduncle, which is 1.5 centimeters in length. Pod 4 centimeters long and 1.25 centimeters in maximum width, rather delicate texture, and reticulate venation. This venation is entirely obscured in the illustration by the longitudinal folds of compression.

There is a superficial resemblance between these pods and those few seeded ones of *Parkinsonia eocenica* Berry, such as are figured in this paper. The *Parkinsonia* pods are more slender, conspicuously constricted between the seeds, with prominent margins, coarser venation, acuminate tip, broader base, and shorter and more slender peduncle.

So far as I know, this is the first recognition of *Cladrastis* in the fossil record. Menzel[8] described a

[8] Menzel, Paul, K. preuss. geol. Landesanstalt Abh., neue Folge, Heft 46. p. 86, pl. 6, fig. 14, 1906.

twig from the Miocene of Germany which he compared with those of *Cladrastis amurensis* Bentham of Manchuria, but this was not especially conclusive.

The genus *Cladrastis* is a most interesting one. At the present time it contains but two species of trees, one in Japan and Manchuria and the other a somewhat rare form found in the vicinity of upland streams in the region between western North Carolina and Tennessee River in Kentucky and Tennessee. Although so restricted in its natural range, its beauty has caused it to be planted both in this country and Europe, and under these conditions it is hardy as far north as New England and Ontario. The leaves are odd pinnate with rather characteristic leaflets, but no leaves of this type have as yet been recognized as fossils.

If the existing Asiatic and American forms are really related, this in itself indicates a considerable unknown Tertiary history.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

clusion—but until such time as intermediate forms are discovered good practice demands that they be kept separate.

There is some resemblance to the pods of certain oriental species of the genus *Mezoneuron*, as, for example, *Mezoneuron cummingianum* Fenzler, of the Philippines, but as the only American representative of this genus is a much larger form from the late Tertiary of New Jersey, and as most of the existing species have larger and stouter, more inflated pods, I place little weight on this similarity.

Occurrence: Holly Springs sand, Grove pit, three-fourths mile south of Paris, Henry County, Tenn.

Dalbergia wilcoxiana Berry

Plate 48, figure 34

Dalbergia wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 246, pl. 53, fig. 7; pl. 54, figs. 1, 2, 1916.

The chief interest in the specimen figured herewith is that it shows the complete stipe of the leaf, which is stout and about 2.5 centimeters long. The typical leaflet preserved is terminal, showing that the leaf habit was odd pinnate, as in the existing species of the genus, a fact not previously known for this fossil species. *Dalbergia* is a common type from the Upper Cretaceous onward and is widely distributed. It is represented in the Wilcox by five nominal species based upon both leaflets and characteristic single-seeded pods. The present species is not abundant and has been detected at only the following localities, all near the top of the Holly Springs sand.

Occurrence: Holly Springs sand, Puryear and Atkins pit, Henry County, Tenn.; and Mill Creek, Hardeman County, Tenn.

I have combined in the restoration shown in Figure 20 a characteristic pod and two types of *Dalbergia* leaflets which are associated toward the top of the Holly Springs sand at Puryear, Henry County, Tenn. The leaf habit is partly conjectural, as all of the leaflets of both foliar species have been found detached except a single specimen of *Dalbergia wilcoxiana* Berry.

FIGURE 20.—Restoration of *Dalbergia*

Genus DALBERGIA Linné son

Dalbergia attenuata Berry, n. sp.

Plate 38, figure 1

Pods relatively long and narrow for this genus, lanceolate falcate, with thickened margins, acute apex and base, coriaceous, indehiscent, with a single compressed elliptical or reniform seed, finely transverse, netted veined. Length 3.5 centimeters; maximum width about 1 centimeter. Peduncle short and stout, 3 to 4 millimeters in length.

This pod shows considerable resemblance to that described[4] as *Dalbergia monospermoides* but is less thick, narrower, and more elongated and with a correspondingly slender and slightly shorter peduncle. It is, of course, possible that the two may represent the extremes of variation of a single botanical species—in fact, I regard this as a not improbable conclusion—but until such time as intermediate forms are discovered good practice demands that they be kept separate.

[4] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 246, pl. 54, fig. 3, 1916.

which shows that in this species at least the leaves were odd pinnate.

The pods are those described as *Dalbergia monospermoides* Berry, the leaf on the left is that of *Dalbergia wilcoxiana* Berry, and that on the right is *Dalbergia eocenica* Berry. Another species of *Dalbergia* pod is present in the Wilcox, but the association of the three nominal species mentioned at a single outcrop is the warrant for considering them to be related.

Genus SOPHORA Linné

Sophora mucronata Berry

Plate 32, figures 1–3; Plate 44, figure 24

Sophora mucronata Berry, U. S. Geol. Survey Prof. Paper 91, p. 244, pl. 52, fig. 4, 1916.

This species, known only from the Puryear locality in 1916, has now been found at several additional localities, and several leaflets are figured in the present report to illustrate its variations. These leaflets show considerable variation in both size and form. The tip may be evenly rounded or more or less narrowed, and the same variations are seen in the base. The leaflet may be widest medianly or below the middle; the petiolule varies considerably in length, and the only constant feature is the conspicuously mucronate apex. Dimensions range from 4 to 6.5 centimeters in length and from 1.4 to 2.5 centimeters in maximum width. As far as known this species is confined to the upper part of the Holly Springs sand of the eastern shore of the Wilcox embayment.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.; Grable pit and Puryear, Henry County, Tenn.

Genus CANAVALIA Adanson

Canavalia eocenica Berry

Plate 32, figure 12

Canavalia eocenica Berry, U. S. Geol. Survey Prof. Paper 91, p. 248, pl. 53, figs. 3–6, 1916.

This characteristic form has been rather completely described and illustrated. Leaflets are not uncommon in the Wilcox, but no complete trifoliate leaves, such as were formerly collected at the Puryear locality, have been encountered. The leaflet here figured, from the Holly Springs sand at La Grange, Tenn., is relatively narrower and longer than the average but shows the same short expanded petiolule and characteristic venation.

Occurrence: Grenada formation, Grenada, Miss. Holly Springs sand, Holly Springs, Miss.; west of Bolivar and Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn.; three-quarters of a mile northwest of Pattersonville and at La Grange, both in Fayette County, Tenn.; Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.; 1 mile west of Milan, Gibson County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Puryear and Atkins pits, Henry County, Tenn. Wilcox formation, T. 14 S., R. 21 W., Nevada County, Ark.; 10 miles southwest of Palestine, Anderson County, Tex. Carrizo sandstone, 5 miles west of La Pryor, Zavala County, Tex.; Carrizo Springs, Dimmit County, Tex.

Canavalia acuminata Berry

Plate 12, figure 5; Plate 27, figure 1; Plate 32, figure 11

Canavalia acuminata Berry, U. S. Geol. Survey Prof. Paper 91, p. 249, pl. 110, figs. 4, 5, 1916.

This species is known from only detached leaflets and is less certainly identified than *Canavalia eocenica* Berry. It has not been found along the western shores of the Mississippi embayment nor at a horizon younger than the Holly Springs sand. It has been detected at a considerable number of localities along the eastern shore of the embayment, and the specimens figured herewith add considerably to our knowledge of its limits of variation and show the expanded petiolules which ally it to *Canavalia eocenica*.

Occurrence: Holly Springs sand, Early Grove, Miss., west of Bolivar and Mill Creek, Hardeman County, Tenn.; one-fourth mile northwest of Smyrna Church, three-fourths mile northwest of Pattersonville, and road west of La Grange, Fayette County, Tenn.; Will Brooks farm, 2.1 miles northwest of Mercer, Madison County, Tenn.; and Puryear, Henry County, Tenn.

LEGUMINOSAE OF UNCERTAIN POSITION

Genus LEGUMINOSITES Bowerbank

Leguminosites drepanocarpoides Berry, n. sp.

Plate 12, figures 11, 12

Leaflets small, triangular in general outline, sessile, with an acute, rather straight-sided tip, rounded lower lateral margins, and broadly truncated base. Margins entire. Texture thin, apparently stiff. Length about 2 centimeters. Maximum width about 1.5 centimeters. Approximately equilateral throughout. Midvein inordinately stout and prominent to the extreme tip. Secondaries not especially thin but not at all prominent, five or six pairs diverging from the midvein at wide angles, the basal ones thicker, more widely spaced and more curved; all camptodrome. External tertiaries forming intramarginal arches. Internal tertiaries as shown in the enlarged figure. Areolation of thin veinlets forming isodiametric polygonal meshes.

This form is a unique and characteristic leaflet, entirely distinct from any hitherto described from this or any other geologic horizon so far as known. It appears to represent a leguminous leaflet, but its generic affinity is uncertain, and it is therefore referred to the form genus *Leguminosites* and named from its resemblance to the leaflets of the existing South American species *Drepanocarpus ferox* Martius.

The genus *Drepanocarpus* Meyer, with which the fossil is compared, comprises about a dozen existing species of trees or high-climbing shrubs found from southern Mexico to the Amazon basin and a single species in tropical West Africa. Fossil species have been recorded from France[5] and Italy[6] and a third from the Pliocene of Bolivia.[7] The Italian material represents both pods and leaflets and comes from the upper part of the middle Eocene.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Leguminosites hoffmanseggiaformis Berry, n. sp.

Plate 41, figure 9

Pods small, stipitate, ovate, compressed, widest medianly, about equally pointed at the apex and base. Length about 1 centimeter; maximum width about 4.25 millimeters. Peduncle with persistent calyx 3 millimeters in length. Surface finely cross veined.

These small pods are identical with those of some species of the genus *Hoffmanseggia* Cavanilles, but as these vary considerably throughout the genus, not much reliance can be placed upon this resemblance.

The genus contains about 20 existing species of herbs and low shrubs, of which all but two African forms are western American, from Kansas to Patagonia, and largely in arid or semiarid situations.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Leguminosites astragaliformis Berry, n. sp.

Plate 39, figure 6

Pods inflated, tardily or not at all dehiscent, prolate spheroidal in shape, rounded at both ends, diameter slightly greater below the middle, approximately circular in cross section, about 3 centimeters in length and 1.5 centimeters in diameter. Margins thickened. Substance of considerable consistency, intricately reticulate veined.

There is no certainty regarding the true generic affinity of these pods. They are named from their resemblance to the pods of the large modern herbaceous genus *Astragalus*, but of course they may not represent that genus.

[5] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, pt. 1, p. 130, pl. 8, fig. 4.

[6] Unger, Franz, K. Akad. Wiss. [Wien] Sitzungsber., Band 18, p. 31, pl. 1, fig. 2 (1855), 1856.

[7] Berry, E. W., U. S. Nat. Mus. Proc., vol. 54, p. 149, pl. 17, figs 10, 11, 1917.

Occurrence: Holly Springs sand, 1 mile west of Milan, Gibson County, Tenn.

Leguminosites ingafructoides Berry, n. sp.

Plate 13, figure 8; Plate 29, figure 1

Pods relatively large, compressed, linear, somewhat falcate, abruptly and somewhat inequilaterally pointed at both ends, of a coriaceous or woody consistency. The complete length is not preserved but appears to have been about 20 centimeters; the maximum width is about 3 centimeters. The margins are prominent, 4 or 5 millimeters wide, and longitudinally wrinkled or striate. The pods are slightly arched over the cavity and contained about 22 seeds, which were apparently transversely elongate elliptical in outline. The walls are transversely depressed between the seeds, forming shallow slightly oblique transverse furrows, and the surface is slightly and obliquely wrinkled. The pods were tardily or not at all dehiscent.

These pods, of which the most complete is figured, are characteristic objects, quite unlike any previously known from the Wilcox. It is of course generally impossible to correctly allocate the detached pods of the Leguminosae, and the present species is therefore referred to the form genus *Leguminosites*.

In looking over the leguminous genera that are represented by foliage in the Wilcox it appears that these pods may be, at least tentatively, correlated with the genus *Inga*, foliage of four species of which has been recognized in the Wilcox. There are, of course, many other leguminous genera with comparable pods—for example, I have pods of a recent species of the genus *Delonix* that are very similar to these fossil pods—and there are many other genera that might be mentioned.

I have indicated my belief as to the relationship of these fossil pods in the specific name proposed for them.

Among the pods of recent species of *Inga* with which they have been compared the fossils are identical with those of *Inga leptoloba* Schlechtendahl, in size, form, margins, consistency, seed, and surface markings, and I am strongly of the opinion that the fossil species represents the fruit of an Eocene species of the genus *Inga*.

Inga leptoloba belongs to the series Gymnopodae of the genus *Inga* and is an inhabitant of Mexico.

Occurrence: Holly Springs sand, Mill Creek and Bolivar, west of Hospital, Hardeman County, Tenn.

Leguminosites andiraformis Berry, n. sp.

Plate 13, figures 4, 5; Plate 22, figure 8

Supposed leaflets elliptical or elliptical ovate, relatively large, widest at or below the middle, about equally rounded at the apex and base; approximately equilateral but invariably with stronger venation in one-half of the lamina, and as far as the small amount of material shows it is always the same half that has the fainter venation. Margins entire, slightly undulate in some specimens. Length uniformly slightly under 7 centimeters in the material collected; maximum width from 3.75 to 4.25 centimeters. Petiolule short and stout, absent in some specimens. Midvein stout and prominent, in some specimens slightly curved. Secondaries medium stout on one side, thin on the other; seven or eight opposite to alternate pairs, at irregular intervals, diverging from the midvein at angles of about 45° or slightly more, usually regularly curved upward and subparallel, camptodrome. External tertiaries forming faint intramarginal arches. Internal tertiaries thin and prevailingly percurrent. Areolation obscure.

This well-marked form is perfectly distinct from previously described species. Its leaflet character is somewhat in doubt, and it is referred to the Leguminosae with some hesitation and for the reason that it resembles the leaflets of various existing species of that alliance more closely than it does any other forms with which it has been compared. Its botanical position in that alliance is uncertain, and it is therefore referred to the form genus *Leguminosites* and named from its resemblance to several existing South American species of the genus *Andira.*

Andira Lamarck is a genus of the Dalbergieae comprising more than a score of existing species of trees, all of which are confined to tropical America except two African species. A doubtfully determined fossil species has been recorded from the Oligocene of France.

Occurrence: Holly Springs sand, road west of La Grange, three-quarters of a mile northwest of Pattersonville, Fayette County, Tenn.

Leguminosites robertsi Berry, n. sp.

Plate 27, figure 2

Leaflets ovate, markedly inequilateral throughout, widest medianly and about equally pointed at the apex and base, sessile. Margins entire. Texture coriaceous. Length about 2 centimeters or slightly more; maximum width about 1 centimeter, the lamina on one side three times wider than on the other. Midvein stout, curved. Secondaries in the wider side diverging from the midvein at acute angles, their courses parallel with the lower lateral margin, camptodrome or forking to form camptodrome loops; in the narrower side the veins are thin and no secondaries are differentiated. The areolation is mostly obsolete in the substance of the relatively thick lamina.

This small form is strikingly different from the previously known and rather numerous leaflets of the Leguminosae known from the Wilcox and shows a resemblance to the leaflets of several unrelated genera of this alliance. It suggests comparisons with certain species of the very large genus *Cassia*, as well as certain small forms of *Bauhinia*, as well as other genera that it does not seem worth while to mention. As a decision with regard to its relationship is impossible it is referred to the form genus *Leguminosites* and named for one of the collectors—Prof. J. K. Roberts, of the University of Virginia.

Occurrence: Holly Springs sand, in Fayette County, 1 mile southwest of Grand Junction, Hardeman County, Tenn.

Leguminosites pongamioides Berry, n. sp.

Plate 32, figure 6

Legume small, compressed, lanceolate, long pedunculate, inequilateral, mucronate pointed, about 1.8 centimeters in length and 6 millimeters in maximum width, wide margined and faintly reticulate veined. Peduncle stout, curved, about 6 millimeters in length. The number of seeds is problematic.

The botanic affinities of this small pod other than that it represents some Wilcox member of the Leguminosae, are entirely problematic. Its specific name indicates a resemblance to the oriental genus *Pongamia* Ventenat, but this is without significance, as similar pods occur in a great variety of genera. It shows considerable resemblance to the extinct genus *Micropodium* of the French Oligocene, referred by Saporta to the Caesalpiniaceae.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Leguminosites shandyensis Berry, n. sp.

Plate 13, figure 3

Small compressed subelliptical pods, about 10 or 11 millimeters in length and 5 or 6 millimeters in width, of thin texture and with slight traces of transverse inosculating veins. No trace of a peduncle. Certain markings indicate that these pods contained two thin circular seeds. The affinity of these pods is conjectural. If the seeds were single and more inflated the form might be compared with the Tertiary genus *Podogonium* of Heer, but such a relationship is decidedly not indicated by the characters that are available. Pending further evidence it is referred to the form genus *Leguminosites.*

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

Leguminosites collinsi Berry, n. sp.

Plate 13, figures 6, 7; Plate 22, figure 5; Plate 41, figure 20

Flattened pods of medium size, indehiscent or tardily dehiscent, rather abruptly pointed at both ends, almost linear in form or more or less torulose and constricted between the flat elliptical seeds. The margins are narrow, the surface is transversely netted veined, and the consistency was not at all woody, the but slightly arched lateral walls appearing to have been thin. All the specimens are fragmentary but indicate that these pods were three or four seeded. In some of the specimens there appears to have been a partition between the seeds, but this may be due to ferruginous infiltration. I believe that I am correct in associating the two types figured in a single botanic species. Those that are nearly linear in form have slight sinuses between the seeds, and the two extremes are alike in texture, venation, size, and character of the margin.

The systematic position among the leguminous families is conjectural, but they are markedly distinct from the rather numerous leguminous pods that have been discovered in the Wilcox. They are named for the collector. Among the pods of existing species their resemblance to those of *Mimosa sepiaria* Bentham, a Brazilian species, is noteworthy.

Occurrence: Holly Springs sand, Mill Creek, west of Bolivar, Hardeman County, Tenn.; three-fourths mile northwest of Pattersonville, Fayette County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn.; 4¾ miles southwest of Williston, Fayette County, Tenn.

Leguminosites hardemanensis Berry, n. sp.

Plate 14, figure 1

This well-marked seed of some leguminous plant is perfectly characteristic and entirely unlike anything previously described from the Wilcox group. It is at the same time impossible to arrive at a correct botanic determination, for very many members of this large alliance have seeds similar to the fossil. It is moderately compressed, elliptical in outline, evenly rounded, with a smooth surface, slightly mucronate at the chalazal end, the point being slightly inequilateral, and with a narrow shelf-like margin around the border. Length 12.5 millimeters; maximum width 8 millimeters; thickness 2.5 millimeters. It might readily appertain to several of the leguminous species from the Wilcox that are based on foliar remains.

Occurrence: Holly Springs sand, Young farm, northwest of Shandy, Hardeman County, Tenn.

Leguminosites arachioides minor Berry, n. var.

Plate 14, figures 2–6

This variety, which is very abundant at certain horizons in the Eastern Gulf region, is more slender, consistently smaller, and never more than half the diameter of the type. The longitudinal ornamentation is also more pronounced.

Attention should perhaps be called to the resemblance between these objects and what Heer[8] called *Nyssa arctica*, although I doubt if there is any botanic relationship between the two. The modern species *Nyssa sylvatica* and *N. biflora* sometimes have the fruit in pairs, but most members of the genus do not, and it is very doubtful if the stones would be fossilized in pairs even when they developed that way. The present species occurs in the Denver formation of Colorado.

Occurrence: Holly Springs sand, big cut at Pine Top, gully along Old State Line road, and Young farm northwest of Shandy, all in Hardeman County, Tenn.

Leguminosites chesterensis Berry, n. sp.

Plate 14, figures 7–10

These very characteristic fruits are entirely new and readily recognizable. They are exceedingly common in the lignite band at the outcrop on the Taylor farm. Their botanic affinity is uncertain, but their solid condition in section indicates that they represent seeds, rather than stones, nutlets, or capsules, and the most logical comparison seems to be with seeds of the leguminous alliance. They are therefore referred to the form genus *Leguminosites*.

They may be described as follows: Seeds of relatively large size, nearly circular in outline, somewhat variable in size, not greatly flattened during fossilization (carbonization)—that is, lenticular in life. Hilum marginal. The largest are 1.5 centimeters, and the smallest 8 millimeters in diameter; a large number of specimens average about 1 centimeter in diameter. They are thickest in the center and thin toward the periphery, measuring about 3 millimeters in maximum thickness, and were obviously but slightly compressed during carbonization.

It appears profitless to attempt comparisons between these fossils and existing leguminous lenticular seeds in which there is a large amount of parallelism. They are about the same size and form as the fruits of *Paliurus* found in the Wilcox but differ in the marginal instead of central hilum and in ornamentation.

Occurrence: Holly Springs sand, Silerton road, Taylor farm, Chester County, Tenn.

Leguminosites emarginatus Berry, n. sp.

Plate 44, figure 3

This small unique form appears to be a leguminous leaflet, but in the absence of any certain relationship to existing genera with comparable leaflets it is re-

[8] Heer, Oswald, Flora fossilis arctica, Band 4, pl. 19, figs. 1–10, 1877.

ferred to the form genus *Leguminosites*. There is the further possibility that it may represent a bract of some kind, or the united stipules of a leaf in which the lamina had disappeared, or a phyllode, but the first is regarded as the more probable. It may be characterized as follows:

Leaflets small, obcordate, widest across the rounded ears, narrowing rapidly to the cuneate base, the lateral margins being nearly straight. Texture delicate. Length about 1.4 centimeters; maximum width 1.2 centimeters. Apparently sessile. Midvein relatively very stout. Laterals diverging at acute angles; the outermost parallel with the margin, which forms an angle of less than 30° with the midvein; the inner parallel with the midvein; the intermediates forking; their tips connected by loops along the rounded margins of the ears; they are also connected by thin transverse tertiaries.

This leaflet is a characteristic form, readily recognizable. Similar leaflets have been referred to a variety of genera of the leguminous alliance, but I can see no basis for arriving at any definite conclusions.

Occurrence: Holly Springs sand, Will Brooks farm, 2.1 miles northwest of Mercer, Madison County, Tenn.

Leguminosites monospermoides Berry, n. sp.

Plate 25, figure 15; Plate 49, figure 18

Pods small and delicate, much compressed, falcate, with a single flat obovate seed. The pods, of which three specimens were collected, are about 1.25 centimeters long, widest medianly, where they reach a width of 3 to 4 millimeters, tapering about equally to the acute tip and base, the base decurring to a slender curved peduncle about 2.5 millimeters in length. The walls are delicately reticulate veined. The margins are slightly thickened.

As three identical specimens were collected, the forms figured may be considered to be normal for the species. One of the specimens lies partly across a leaflet of *Mimosites variabilis* Berry, but this may be entirely a chance association, and the precise botanic affinity of these pods remains uncertain. That they represent some leguminous form can scarcely be doubted, and their characteristic form makes them readily recognizable.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Leguminosites contortus Berry, n. sp.

Plate 48, figure 32

Pod linear, compressed, contorted, small, incompletely preserved, with stout ventral margin. Length and outline unknown; width about 4 millimeters. The seeds are widely spaced, small and round, about 2 millimeters in diameter, with conspicuous stalks. Venation inconspicuous, transverse.

There are a large number of Leguminosae, particularly among the herbaceous forms, which have pods similar to this fossil pod. Other than its reference to this alliance its botanic affinity is not determinable.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Leguminosites panduriformis Berry, n. sp.

Plate 48, figure 7

The occasional assumption of an emarginate and laterally constricted form by leaves which are normally more or less elliptical, as, for example, in *Robinia* and *Gleditsia*, leads me to assume that this unique specimen is an abnormal leaflet of one of the species whose normal leaflets are more abundantly represented at this outcrop. In its size, texture, and venation it is so like the smaller leaflets of the very abundant *Sophora wilcoxiana* Berry that I believe it to represent an abnormal leaflet of that species. However, as it is so different from the normal outline of that species and the two can not be positively connected, I am forced to give it a distinctive name.

It may be characterized as follows: Leaflet slightly inequilateral, elliptical, with a rounded base, prominently emarginate at the tip. A constriction of each side of the lamina one-third to one-fourth of the distance from the apex to the base forms a shorter distal and a larger proximal rounded lobe. It is practically sessile, but as the insertion of the lamina on one side is about a millimeter higher than on the other, it may be said to have a very short petiolule, especially as the proximal end of the midvein is expanded. The midvein is stout and prominent. The secondaries are thin, diverging from the midvein at angles of about 45°, and camptodrome. The texture agrees with that of *Sophora wilcoxiana*, and the tertiary venation is characteristic of this alliance and largely obsolete by immersion in the leaf substance. Only the single specimen figured is known.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Leguminosites phyllocarpoides Berry, n. sp.

Plate 43, figures 4–6

Pods large, compressed, tardily dehiscent, elongate elliptical, narrowing proximad to a stout peduncle. A small recurved mucronate point distad toward the ventral side. Texture subcoriaceous. A stout marginal hem present. Length about 12 centimeters; width about 4 to 4.75 centimeters. Margins subparallel, in one specimen (pl. 43, fig. 5) with a slight constriction in the upper part. Seeds large, transversely elliptical, compressed seven or eight in number.

Venation of an irregular, transverse, reticulate character.

It would seem that such characteristic-looking pods as these could be readily allocated among the recent Leguminosæ, but such has not proved to be the case. I have examined much recent material without conclusive results and have therefore referred the fossils to the form genus *Leguminosites.* The specific name is given in allusion to their resemblance to what I take to be the pods of *Phyllocarpus*, although I am not certain of this determination.

Phyllocarpus is a recently described monotypic genus of the Caesalphiniaceae from Guatemala,[9] and the comparison may be illusory. The general shape is the same and the peculiar venation net of thin and thick veinlets is also similar.

Whatever the botanic affinity of the fossil pods they constitute a striking and readily recognizable element in the flora of the Holly Springs sand.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.; Jim Tomphson farm 3¼ miles northeast of Jackson, Madison County, Tenn.

Leguminosites copaiferanus Berry, n. sp.

Plate 45, figure 16

Pods indehiscent or tardily dehiscent, relatively small, unsymmetrically ovate, much compressed, recurved, acute at the apex, stoutly pedunculate at the base, with a single large seed. Length about 2 centimeters, of which about 3 millimeters is stalk; maximum width about 8 millimeters. Surface finely reticulate veined. The ventral margin is less inflated than the dorsal and bears a mucronate point about a millimeter below the larger apical point of the pod. The seed is anatropous, 13.5 millimeters long and about 6.5 millimeters in maximum width, oval and compressed, thickest in the lower or chalazal end.

This characteristic pod is of uncertain relationship. I was at first inclined to compare it with the capsules of *Connarus*, to which there is a striking similarity in outline. In *Connarus*, however, the capsules are much inflated and ligneous and lack the netted venation of the fossil. After an extended search among recent carpologic material I have come back to the Leguminosae as the more probable group to which the fossil should be referred. In this alliance the family Papilionaceae must be excluded from comparisons because of the amphitropous character of the ovules. I have by no means seen the fruit of all the existing forms of Mimosaceae or Caesalpiniaceae, and I have therefore referred the fossil to the form genus *Leguminosites*, giving it the specific name of *copaiferanus* in allusion to its possible relationship to the genus *Copaifera* of the Caesalpiniaceae. Undoubted fruits of *Copaifera* are present as early as the middle Eocene (Claiborne) of Texas, and several have been recorded from both America and Europe at later horizons.

The fossil is more delicate than any *Copaifera* pods that I have seen, nor have I observed the double point in any recent material. Leaflets doubtfully referred to *Copaifera* are recorded from the Wilcox in the present report, and these may be related to the pods in question, but as both are inconclusive, neither can be said to strengthen the determination of the other. Two specimens of the pods have been collected. These are beautifully preserved in a fine-grained clay and show the details enumerated above with great fidelity.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

Leguminosites sp.

Plate 48, figures 1, 2

This small leguminous leaflet is sessile, inequilateral, emarginate, with a few wide-angled camptodrome secondaries. It is only 1.3 centimeters in length and 7 millimeters in maximum width. An attempt to describe it in greater detail does not seem worth while.

The affinities seem conclusively leguminous, but as this alliance is so prolific in the Wilcox, and as there are several described species of *Sophora*, *Pithecolobium*, *Cassia*, and other genera which might well have had occasional anomalous leaflets of this character, it is by no means certain that this form represents a distinct species, although from the present material it is not possible to definitely correlate it with any of the previously described forms.

Occurrence: Near the top of the Holly Springs sand at Puryear, Henry County, Tenn.

Order GERANIALES

Family RUTACEAE

Genus CITROPHYLLUM Berry

Citrophyllum bifoliolatum Berry, n. sp.

Plate 33, figure 15

Leaves palmately compound of two or more somewhat falcate, markedly inequilateral leaflets. Leaflets small, unequal in size in the single specimen seen, which is also bifoliate but may be unique in this respect. Ovate-lanceolate, widest below the middle, acute at both ends but more narrowed distad. Margins finely but conspicuously denticulate, becoming entire proximad. Texture relatively coriaceous, obviously punctate. Length from 2.25 to 3.25 centimeters; maximum width from 6 to 10 millimeters.

[9] Smith, J. D., Bot. Gazette, vol. 55, p. 433, 1913.

Midvein stout, prominent, curved. Secondaries few, widely spaced, immersed. Four or five pairs broadly and evenly curved in the wider side of the lamina, which is the distal portion with respect to the whole leaf, more ascending in the narrower side of the lamina, camptodrome. Tertiaries obsolete. The two leaflets preserved in union are without petiolules and diverge from one another at a wide angle. Possibly the normal leaf of this species may have been trifoliate like the leaves of numerous existing Rutaceae.

This genus is an interesting one. The species previously referred to it have been characteristic simple leaves of larger size with alate petioles, but both simple and compound leaves occur in the existing Citrinae; in fact the alate petioles of the simple forms are supposed to be vestiges of a compound ancestral type, so that I can see no objection to referring the present species to the form genus *Citrophyllum*, which evidently represents ancestral forms of the Citrinae.

The punctate character of the present species is a further corroboration of such a relationship. The genus appears in the Upper Cretaceous of southeastern and western North America, contains a second Wilcox species and a fourth well-marked species in the middle Eocene (Claiborne) of this region. A fifth fossil species from the Pliocene of Brazil has also been referred to this genus.

Occurrence: Holly Springs sand, about 1 mile north of Somerville, and north of Loosahatchie River, Fayette County, Tenn.

Genus **RUTAPHYLLUM** Berry, n. gen.

This generic term is proposed for leaves belonging to the family Rutaceae but of uncertain generic affinity. The type and only known species, described below, will give the generic characters in so far as they are known at present.

Rutaphyllum trifoliatum Berry, n. sp.

Plate 42, figure 3

Leaves trifoliate, relatively small, long petioled. Petiole stout, expanded at the base, about 2.5 centimeters long. Terminal leaflet lanceolate, somewhat larger than the lateral leaflets, about 5 centimeters in length, and about 1.25 centimeters in maximum width, which is midway between the apex and the base; shortly petiolulate, approximately equilateral. Lateral leaflets lanceolate, practically sessile but slightly or considerably inequilateral at the base, about 3.75 centimeters in length by 1 centimeter or slightly less in maximum width. Midveins all stout and relatively prominent. Secondaries thin and widely spaced, ascending, and somewhat variably camptodrome. It is difficult to be certain about the texture, but it seems to have been subcoriaceous. The surface of the fossil is covered with regularly spaced tiny papillae of the clay matrix, which is interpreted as meaning that the leaves in life were punctate, the matrix being adherent and possibly slightly different in juxtaposition with each glandular punctation. The margins are entire in the specimen, but the variability in the endings of the secondaries suggests that it may have been feebly toothed in some specimens, just as so many of the existing Rutaceae are individually variable with respect to this feature.

It is most unfortunate that the single incomplete specimen figured is the only one that has been discovered. With more abundant and complete material it might be possible to correlate it with an existing genus.

The presence of characteristic fruits of *Ptelea* in the Wilcox at once suggested that genus. Although the leaf may represent the same botanic species as the fruit, it was deemed that such robust fruits should exhibit some correlation with the leaves, because there seems to be a direct relationship between fruits, leaves, and habitat among the existing species of *Ptelea*. Of course with but a single specimen known, one can not say whether the leaf represents the norm of the fossil species or a reduced variable, so that possibly the present form should be referred to *Ptelea*. On the other hand, the fossil is actually much more similar to the leaves of *Helietta* Tulasne, especially *Helietta parvifolia* Bentham, a slender tree of the lower Rio Grande Valley and southward on the calcareous ridges of the Sierra Madre. The genus, with four or five existing species, ranges from Texas to Brazil and Paraguay. I was at first disposed to refer the fossil directly to *Helietta*, but in view of the considerations mentioned it seems better to adopt a more conservative course, at least until more and better material becomes available.

Occurrence: Grenada formation, about 1 mile north of Somerville and north of Loosahatchie River, Fayette County, Tenn.

Genus **PTELEA** Linné

Ptelea eocenica Berry, n. sp.

Plate 41, figure 4

Fruit rather large, compressed, indehiscent, with a broad circumferential reticulated wing. Outline suborbicular, slightly emarginate distad, otherwise entire margined. Length 2.25 centimeters; maximum width 2 centimeters. Peduncle stout, tapering downward 5 millimeters in length. The samara is fusiform in outline but greatly compressed, about midway between the apex and base of the winged border, about 1.5 centimeters long and 6 millimeters wide. The number of cells can not be made out. The winged border is thin and scarious, with rather intricately reticulate veins, and these pass over the surface of the samara without thickening. These veins are thinner and less regular in pattern than in the fruits of the existing *Ptelea trifoliata* Linné.

There can be no doubt regarding the identity of these fruits, which in all their features are identical with the fruits of the existing species, especially with those of our familiar arborescent form, from which they differ merely in a slightly larger size and somewhat finer venation.

The presence of this genus in the Wilcox is of great interest, as the only other fossil species known from North America, which is based upon leaves, is from the Miocene of Florissant, Colo. The Wilcox form is also the oldest authentic occurrence of the genus.

The genus is confined to North America at the present time and, I am inclined to think, had an exclusively American history. In the modern flora they are shrubs or small trees which, with the exception of *Ptelea trifoliata*, whose range is from New York to Minnesota and southward to Florida, Texas, and New Mexico, are found in the broken country of the southwestern United States to southern Mexico (Oaxaca). The last are exceedingly variable, mostly shrubby forms whose systematic limits are very differently conceived. As conceived by Bentham, Gray, Sargent, and Wilson (North American flora) the existing species are 3 to 5 in number. Greene,[9a] on the other hand, has described 59 species.

Regarding the geologic history of the genus, 8 or 9 nominal species have been described. These species merit a critical enumeration, for they are, in my judgment, exceedingly misleading. Heer[9b] in 1883 described *Ptelea arctica* from the early Tertiary of western Greenland. This species was based on a single isolated leaflet, not especially like the modern leaflets and absolutely worthless as evidence of the presence of the genus *Ptelea* in the Arctic. This same author also described two species from the Miocene of Switzerland,[9c] one of which was recorded from the Oligocene and the other from the Pliocene of northern Italy by Peola. These were also both based upon single detached and not convincing leaflets and are without any scientific value as evidence of the presence of the genus in the Tertiary of Europe.

Three species have been recorded from the European Tertiary and are based upon fossil fruits. These are *Ptelea intermedia* and *Ptelea microcarpa*, described by Ettingshausen[10] from the lower Miocene (Aquatanian) of Sagor in Carniola, and *Ptelea macroptera* Kovats[11] from the late Miocene of Hungary. Although the last species has also been mentioned by Stur and Unger, all three, so far as can be judged by their illustrations, are not conclusive; Ettingshausen's forms in particular look more like *Dodonaea* than they do like *Ptelea*. Finally Marty[12] has described both leaves and fruits of what he calls *Ptelea pagesi* from the late Miocene (Pontian) of the Cantal in central France. This species is the most convincing of the European records, but the illustrations are not conclusively convincing.

Although I would hesitate to repudiate all these European records without an opportunity to see the specimens upon which the determinations rest, I think that until more conclusive evidence is brought forward botanists are justified in retaining great doubt regarding *Ptelea* ever having been a member of the European Tertiary flora. So many existing North American plants are conclusively known to be present in the European Tertiary that it would not be at all unusual for *Ptelea* to have been one of that large number, but the extant evidence that such was the case is not conclusive.

Occurrence: Holly Springs sand, in Fayette County, 1¼ miles southwest of Grand Junction, Hardeman County, Tenn.

Family SIMARUBACEAE

Simaruba eocenica Berry

Plate 22, figure 7; Plate 29, figure 6

Simaruba eocenica Berry, U. S. Geol. Survey Prof. Paper 91, p. 252, pl. 54, fig. 7, 1916.

This species, sparingly represented by leaflets, is known only from the middle and upper parts of the Holly Springs sand in Tennessee. The occasion for attempting a restoration of the complete leaf was the finding of the specimen figured on Plate 22, showing the three terminal leaflets of an odd-pinnate leaf. The habit is that of *Simaruba glauca* De Candolle and other existing species of *Simaruba*. (See fig. 21.)

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Genus SIMARUBITES Berry, n. gen.

This genus is proposed for winged fruits which appear to me to be referable to the family Simarubaceae but which are of uncertain or at least undetermined generic affinities, possibly representing an

[9a] Greene, E. L., Contr. U. S. Nat. Herbarium, vol. 10, pt. 2, 1906.
[9b] Heer, Oswald, Flora fossilis arctica, Band 7, p. 135, pl. 91, fig. 8, 1883.
[9c] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, p. 86, pl. 127, figs. 37, 38, 1859.

[10] Ettingshausen, Constantin von, Ueber die fossile Flora von Sagor in Krain, Teil 2, p. 42, pl. 16, figs. 2, 3, 1877.
[11] Kovats, Julius, Fossile Flora von Tállya, p. 15, pl. 1, fig. 2, 1856.
[12] Marty, Pierre, Flore miocène de Joursac, p. 62, pl. 12, figs. 1, 2, 1903.

extinct genus. For the present its characters are those of the following and only known species.

Simarubites eocenicus Berry, n. sp.

Plate 44, figures 15, 16

The pedunculate character of this material proves it to have been a fruit and not a winged seed. It shows the following features: Fruit a samara, compressed, slightly unsymmetrically elliptical lanceolate

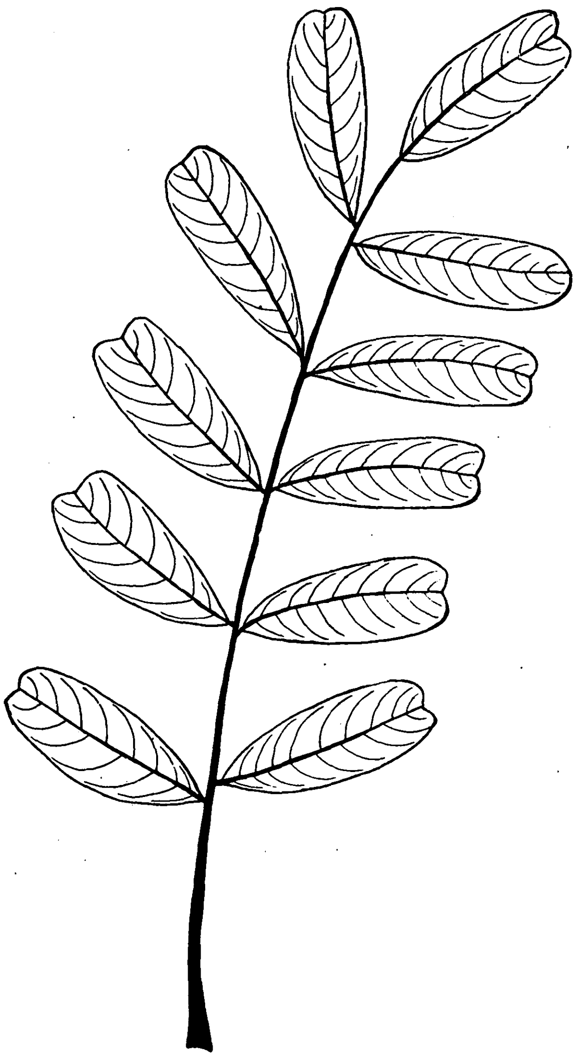

FIGURE 21.—Restoration of a complete leaf of *Simaruba eocenica* Berry

in outline, with a stout curved peduncle about 4 millimeters long, bluntly pointed at the apex, with a centrally located compressed fusiform seed cavity occupying about seven-elevenths of the length and about one-half the maximum width, surrounded by an entire scarious wing, in which the venation is transverse, in contrast to the longitudinally reticulate veining of the central area. Length about 1.5 centimeters; maximum width, midway between the apex and the base, about 6 millimeters.

Among the existing species of families with samaroid or winged fruits with which comparisons might profitably be made—the Ulmaceae, Simarubaceae, Aceraceae, Sapindaceae, Oleaceae, and Rutaceae—I find nothing that is strictly comparable. There have been fossils referred to the genus *Ulmus* which are not greatly unlike the present fossil, but *Ulmus* usually has a distinctly bifid tip and a persistent calyx, which seems to effectually rule out such a relationship. The genus *Fraxinus* invariably has a terminal wing and a somewhat different organization and is usually more coriaceous and differently veined. The fossil impresses me as differing decidedly from the fruits of the genus *Ailanthus* but is nearer to it than to the other possible groups mentioned above. After considering all the evidence, inconclusive as it is admitted to be, I believe that the affinities are with the family Simarubaceae, in which a very considerable carpologic variety is displayed.

I have accordingly proposed the form genus *Simarubites* as indicative of such a relationship. Possibly with more completely representative carpologic material of existing species this conclusion might be improved upon, but, tentatively at least, this genus may be regarded as an extinct genus of the Simarubaceae.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

Family ZYGOPHYLLACEAE

Genus ZYGOPHYLLUM Linné

Zygophyllum? eocenicum Berry, n. sp.

Plate 31, figure 1

The present specimen might represent a leaflet of some unknown leguminous form, but its great resemblance in outline and especially in venation to certain existing forms of *Zygophyllum* has led me to refer it tentatively to that genus. More abundant material and specimens showing the habit are much to be desired. It may be described as follows:

Leaflets rhomboidal elliptical, widest medianly, very slightly inequilateral, with a broadly rounded, sightly emarginate apex and a cuneate or slightly decurrent, apparently sessile base. Margins entire. Texture coriaceous. Length about 4 centimeters; maximum width about 3.7 centimeters. Venation largely immersed. Midvein stout but not prominent. Secondaries similar, diverging from the midvein at acute angles at irregular intervals, relatively straight in their course, forming simple camptodrome loops well within the margins, and upon these are imposed similar secondary and tertiary loops.

This form is almost exactly like the leaflets of several existing species of *Zygophyllum*. It also resembles a leaflet of an undetermined species of *Guajacum* from Venezuela, which was figured by me in connection with a Pliocene species from Brazil [13] and is considerably different from the leaflets of the existing *Guajacum sanctum* Linné, which reaches southern Florida from the Antilles.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Family MELIACEAE

Genus CEDRELA Linné

Cedrela mississippiensis major Berry, n. var.

Plate 41, figure 3

Leaflets ovate, abruptly pointed, rounded and markedly inequilateral at the base, with a coriaceous texture and prominent primary, secondary, and tertiary venation, which is in exact agreement with that of the type.

This form is relatively shorter and wider and more inequilateral than the type, with which it is associated. It has seemed best to distinguish it by a trinomial, although it is believed to be simply a variant of *Cedrela mississippiensis*. A specimen from a locality near Bolivar shows two leaflets side by side as if they had been attached to a common stipe.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn., west of Bolivar, Hardeman County, Tenn.

Cedrela mississippiensis minor Berry, n. var.

Plate 41, figures 1, 2

Leaflets small, slender, lanceolate, falcate, widest near the base, narrowed distad to the abruptly acuminate tip. Primary, secondary, and tertiary venation identical with that of the type. Length 2.5 centimeters; maximum width 5.5 millimeters.

I believe that this form represents the small distal leaflets of *Cedrela mississippiensis*. They differ from the normal leaflets of this species in their smaller size, more slender form, and shorter petiolule. The venation is identical, and they are found associated, so that perhaps the proposed trinomial is unnecessary. The forms *major* and *minor* probably represent the extremes of individual variation of the type, but rather than recharacterize the species it has seemed better to give these variants a varietal name until such time as the complete foliar characters become known. This course can do no harm, for their probable relationship is clearly recognized. As yet both of the varieties have been found associated with the type at the single locality mentioned below.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

[13] Hollick, Arthur, and Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 5, pl. 4, fig. 13, 1924.

Genus CARAPA Aublet

Carapa eolignitica Berry

Plate 39, figure 10

Carapa eolignitica Berry, U. S. Geol. Survey Prof. Paper 91, p. 253, pl. 55, fig. 4; pl. 60, fig. 4, 1916.

The complete leaf of this form from La Grange figured herewith is entirely typical of the smaller leaves of this characteristic species. It is not uncommon in the Holly Springs sand, well above the middle, and is known from only the eastern shore of the Wilcox Mississippi Gulf.

Occurrence: Holly Springs sand, Center Church, Hardeman County, Tenn.; three-fourths of a mile northwest of Pattersonville and La Grange, Fayette County, Tenn.; Will Brooks farm, 2.1 miles northwest of Mercer, Madison County, Tenn.; Puryear, Henry County, Tenn.; and Wickliffe, Ballard County, Ky.

Family MALPIGHIACEAE

Genus HIRAEA Jacquin

Hiraea wilcoxiana Berry

Plate 27, figure 6

Hiraea wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 257, pl. 57, fig. 8; pl. 109, fig. 6, 1916.

Additional specimens by the character of the tertiary venation confirm the relationship of these leaves. The specimen figured is characteristically like certain existing species of the genus. The type came from the later Wilcox outcrops at Puryear, Tenn.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Order EUPHORBIALES

Family EUPHORBIACEAE

Genus MANIHOT Adanson

Manihot eocenica Berry, n. sp.

Plate 14, figures 11, 12

Long-petioled, digitately lobate leaves of small size and somewhat delicate texture. Orbicular in general outline, with a rounded base, divided by conical angular sinuses extending more than halfway to the base into four unequal, fingerlike, straight-sided, and obtusely pointed lobes. Margins entire. Length about 3 centimeters; maximum width, from tip to tip of the lateral lobes, about 3.7 centimeters. Petiole long, slender, and curved, about 1.5 centimeters in length. The subequal primaries diverge at acute angles and run in relatively straight courses to the tips of the lobes, of which they constitute the midveins. The secondaries are thin and few, irregularly spaced, diverging from the primaries at acute angles, much ascending, becoming parallel with the margins in their upper courses, eventually camptodrome except for one in each lobe, which runs to the angle of the sinus. Tertiaries and areolation obsolete.

The only recent forms that suggested comparisons with this fossil form were the genus *Passiflora* and several genera of the Araliaceae and Euphorbiaceae. I have satisfied myself that it is not a *Passiflora.* It may be some araliaceous form, of which a great variety have been described from the beds, but many of these are rather poorly authenticated. After comparisons with recent forms I have concluded that it represented a Wilcox species of the genus *Manihot.* This genus, not otherwise known in the fossil state, comprises between 80 and 100 existing species, ranging from Mexico through Central America to Brazil, where the majority are found at present.

According to Tracy,[14] the various cultivated varieties of *Manihot* can be grown successfully where the growing season is sufficiently long, as in some of our Gulf States. In their native home the tropical species are said to find their optimum conditions in coastal regions.

The only fossil form deserving of mention in this connection is *Manihotites georgiana* Berry,[15] a large and rather convincing form from the Upper Cretaceous Eutaw formation in Georgia. This species is quite different from the Wilcox plant, but *Manihot* shows very great individual and specific variation in its foliar characters.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Order SAPINDALES

Family ANACARDIACEAE

Genus HETEROCALYX Saporta

Heterocalyx saportana Berry

Plate 14, figures 13–16

Heterocalyx saportana Berry, U. S. Geol. Survey Prof. Paper 91, p. 260, pl. 59, fig. 1, 1916.

This species was described in 1916 from the Holly Springs sand at Early Grove, in Marshall County, Miss. Several specimens in more recent collections from Tennessee appear to represent this species, although I was at first disposed to consider them as representing some possibly rosaceous flower. They are the same size as the type, and the supposed sepals are of the same form but appear to be of greater consistency. The lack of any essential flower parts, which should leave some traces in such a fine-grained clay, where stamens and anthers are preserved in other specimens, suggests rather strongly that these objects represent *Heterocalyx* rather than a flower.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Genus ANACARDITES Saporta

Anacardites eocenicus Berry, n. sp.

Plate 14, figure 18

These fossils from the character of the base are obviously leaflets of some compound leaf, and the preponderance of their features points to their being referable to the family Anacardiaceae; they are therefore referred to the form genus *Anacardites.* Leaflets of medium size, markedly inequilateral in form, with a shortly acuminate tip and a roundedly acute base that is markedly inequilateral, one side being fuller than the other and terminating about 4 millimeters below that of the narrower side. Margins entire, rather full and evenly rounded. Texture subcoriaceous. Length about 7 centimeters; maximum width, midway between the apex and base, about 2.5 centimeters, of which one side of the lamina is about 1 centimeter and the other about 1.5 centimeters wide, the wider side having a somewhat less evenly rounded margin than the narrower side. Petiolule short, stout, and curved, about 3 millimeters in length. Midvein stout, prominent, straight above the slightly curved proximal part. Secondaries medium stout, 8 or 9 irregularly spaced pairs, diverging from the midvein at wide angles, curving principally as they approach the margins, and camptodrome. Tertiaries mostly obsolete.

This species is obviously unlike any previously known member of the Wilcox flora. It resembles a number of recent, chiefly South American, genera of the Anacardiaceae, and is referred to the convenient form genus *Anacardites*, proposed by Saporta for uncertainly determined fossil forms belonging to this family. Seven species of *Anacardites* have already been recognized in the Wilcox, but none of these are at all close to the present species, which probably represents a different botanical genus.

Occurrence: Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark. Holly Springs sand, of Wilcox group, Mill Creek, Hardeman County, Tenn.

Anacardites inequilateralis Berry, n. sp.

Plate 29, figure 7

Leaflets small, markedly inequilateral, oval and somewhat falcate, widest below the middle, narrowing distad to the blunt tip. Base full and rounded on one side, narrowly cuneate on the other. Margins entire but somewhat irregular. Texture coriaceous. Length about 4.25 centimeters; maximum width about 1.5

[14] Tracy, F. M., U. S. Dept. Agr. Farmers' Bull. 167, 1903.

[15] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 114, 1914.

centimeters. Petiolule short, stout, and curved, about 1.5 millimeters in length. Midvein relatively very stout and prominent to the extreme tip, conspicuously curved, the concavity toward the narrower side of the lamina. Secondaries stout and prominent, 6 to 9 pairs, diverging from the midvein at wide angles, relatively straight proximad, curving as they approach the margins, and camptodrome, usually by a single loop; those in the narrower side of the lamina fewer in number and the lower ones more ascending. Tertiary venation obsolete.

Eight species of *Anacardites* were previously known from the Wilcox, representing both leaves and leaflets, with various affinities among existing genera of the family Anacardiaceae. The only one of these Wilcox species at all like the present one is *Anacardites metopifolia* Berry [16] of the later Wilcox, which is of about the same size and proportions and has a similar petiolule. *Anacardites metopifolia* is, however, much more symmetrical, with very much thinner and more numerous secondaries. These two species appear to be related, however, and may have belonged to the same botanical genus.

Occurrence: Holly Springs sand, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

Family CELASTRACEAE

Genus CELASTRUS Linné

Celastrus veatchi Hollick

Plate 14, figures 20, 21

Celastrus veatchi Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 285, pl. 43, figs. 4, 5, 1899; Berry, U. S. Geol. Survey Prof. Paper 91, p. 267, pl. 61, fig. 2, 1916.

This middle and upper Wilcox species is rather rare at all its occurrences. Two incomplete leaves of it are figured from Hardeman County in this paper. A small leaf of this species from La Grange measures but 3 centimeters in length and 1.25 centimeters in maximum width.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.; 2 miles southeast of Bolivar, on old Murrell place, Hardeman County, Tenn.

Celastrus bolivarensis Berry, n. sp.

Plate 29, figure 2

Leaves small, widest medianly and narrowly elliptical in general outline, bluntly pointed distad and acute proximad. Margins entire. Texture coriaceous. Length about 1.5 centimeters; maximum width about 6.5 millimeters. Petiole relatively long and stout, about 5 millimeters in length. Midvein stout and prominent. Secondaries relatively stout and prominent; about five alternate pairs diverge from the midvein at angles of about 45°, curve regularly and subparallelly upward, and are camptodrome. The tertiary venation is obsolete.

Among previously described forms the present species approaches closest to *Celastrus minor* Berry [17] of the Holly Springs sand in Mississippi. It is slightly wider, less pointed at the ends, with a longer petiole and much coarser and more prominent midvein and secondaries.

There are at least half a dozen species of *Celastrus* in the Wilcox, but the others are all markedly distinct from *Celastrus bolivarensis*.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Celastrus minor Berry

Plate 14, figure 17

Celastrus minor Berry, U. S. Geol. Survey Prof. Paper 91, p. 266, pl. 61, figs. 3, 4, 1916.

The leaf of this small species that has been figured from Mill Creek is relatively wider than the leaves of this size usually are. The species was described from the type locality of the Holly Springs sand but has also been found in the overlying Grenada formation in Fayette and Henry Counties, Tenn. It has not been observed in the western Gulf area.

Occurrences: Holly Springs sand, Holly Springs, Miss.; Mill Creek and 5¼ miles south of Whiteville, Hardeman County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Grable pit and Holcomb property, Henry County, Tenn., Grenada formation, Cottage Grove, Henry County, Tenn.; 2.9 miles southwest of Somerville, near Moses Hall, and 5 miles southwest of Williston, Fayette County, Tenn.

Genus CELASTROCARPUS Berry, n. gen.

Celastrocarpus eocenicus Berry, n. sp.

Plate 25, figures 26–29

Capsule stalked, loculicidal, three-valved. Valves ovate, margined, transversely rugose. Peduncle stout, about 1 centimeter in length. Valves about 1.25 centimeters in length and from 4 to 6 millimeters in maximum width.

This characteristic fruit is represented by a single complete specimen and several detached valves. Their peculiar ornamentation makes them readily recognizable. Its features are those of several genera of the family Celastraceae and the form genus *Celastrocarpus* is therefore proposed for it. Among previously described fossil forms the only one that I have seen

[16] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 262, pl. 58, fig. 7, 1916.

[17] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 266, pl. 61, figs. 3, 4, 1916.

which approaches it at all closely is an unnamed specimen from the Miocene of Switzerland that Heer[18] refers to *Celastrus*. There is considerable resemblance to the capsules of the strictly American genus *Agave*, in which, however, the capsules are usually much larger.

Leaves representing the genera *Maytenus*, *Celastrus*, and *Euonymus* of the family Celastraceae have been described from the Wilcox, and it is possible that the present fruiting specimen may belong to one of these species described from the foliage.

Occurrence: Holly Springs sand, about 500 yards south of Saulsbury station, Hardeman County, Tenn.; 1 mile west of Laconia, Fayette County, Tenn.

Genus EUONYMUS Linné

Euonymus? fructescens Berry, n. sp.

Plate 25, figure 13

A single specimen that appears to be related to the fruits of *Euonymus* is tentatively referred to that genus. It shows the following features: Capsule somewhat ligneous, apparently tardily dehiscent, four-lobed; the lobes rounded and separated by sulcate sinuses. Surface smooth. General form spheroidal. Length about 6 millimeters; maximum diameter about the same. Peduncle stout, about 7 millimeters in length, sharply flexed just below the capsule.

This fruit, unfortunately represented only by the single specimen figured, is apparently that of *Euonymus* and greatly resembles the fruits of various existing species. As the leaves of this genus are so very abundant at this horizon in the Wilcox, this determination appears to be all the more probable.

The only previously described fossil form that shows a resemblance is *Euonymus moskenbergensis*, described by Ettingshausen[19] from the Miocene of Styria.

Occurrence: Holly Springs sand, 2 miles southeast of Bolivar, on old Murrell property, Hardeman County, Tenn.

Family ACERACEAE

Genus NEGUNDO Moench

Negundo knowltoni Berry, n. sp.

Plate 21, figure 7; Plate 42, figure 7

The present species is based on the single specimens figured and counterparts. They are interpreted as representing lateral leaflets of a trifoliate species of *Negundo*, although there is the alternative that they represent an abnormal leaf of some otherwise unknown Wilcox species of *Acer*. The species is decisively referable to the Aceraceae, both by its form and venation, and in my opinion the first alternative is much the more probable.

Leaflet of medium size, inequilaterally rhomboidal, widest in the lower half, with an inequilateral cordate base and an acuminate tip. Margin with irregular serrate teeth, separated by rounded sinuses, the lowermost on the wider side of the lamina extending inward one-third the distance to the midvein and cutting off a well-defined basal lobe. Length about 7.5 centimeters; maximum width about 5.1 centimeters. Petiolule stout, preserved for a length of 5 millimeters. Midvein stout, curved. Secondaries stout, five to seven opposite to alternate, regularly curved, craspedodrome pairs; the basal pair diverging from the top of the petiolule and constituting subprimaries. Lateral tertiaries craspedodrome, or camptodrome where they reach a toothless part of the border. Internal tertiaries mostly subpercurrent, partly anastomosing. Areolation obsolete.

This form adds an interesting element to the Wilcox flora and represents a genus whose geologic history is very incompletely known. Two species have been recorded from the Upper Cretaceous and two from the Eocene of the western United States, and there is a well-marked species in the middle Eocene of Wyoming. The present species is decidedly different from all of these. The later history of the genus is entirely unknown.

The existing species of *Negundo* are three in number and are usually small trees of mesophytic environments, such as stream or swamp borders, or at least where the water table reaches close to the surface. Our eastern species ranges from western Vermont and central New York to Florida and extends westward to Utah, Arizona, and New Mexico, where a suitable environment is found. Our western species grows in a restricted area in the lower Sacramento Valley and along streams on the western slopes of the San Bernardino Mountains. The third species occurs in Central America. The presence of the genus in the moist warm climates of the early Eocene and a surviving form in Central America suggests that the genus diverged from the ancestral *Acer* stock in low latitudes and probably during Upper Cretaceous time.

Occurrence: Grenada formation, northwest of Somerville, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

Family SAPINDACEAE

Genus CUPANITES Schimper

Cupanites formosus Berry, n. sp.

Plate 30, figures 1–4

Leaves of medium size, quinquefoliate, odd pinnate, consisting of a larger equilateral petiolulate terminal

[18] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, pl. 154, figs. 28 29, 1859.

[19] Ettingshausen, Constantin von, Beiträge zur Kenntniss der Tertiärflora Steiermarks: K. Akad. Wiss. Wien Sitzungsber., Band 60, p. 83, pl. 6, fig. 4, 1869.

leaflet and two pairs of sessile inequilateral lateral leaflets. Petiole about 1.25 centimeters long below the point of attachment of the basal laterals. Length, including petiole, about 11.5 centimeters; maximum width, from tip to tip of the superior lateral leaflets, about 9.5 centimeters.

Fortunately, one specimen shows a complete leaf of this species, otherwise it would have been impossible to reach a decision regarding its affinity, as the leaflets are variable and show resemblances to a number of unrelated genera. In the type the terminal leaflet is separated from the point of attachment of the superior lateral leaflets by an interval of stipe or petiolule of 1.5 centimeters. It is broadly lanceolate and strictly equilateral in form, with an acuminate tip and a cuneate base. The margin is coarsely dentate. Length about 7.5 centimeters; maximum width about 3 centimeters, or a millimeter or two less. The secondaries are numerous, thin, relatively straight, diverging from the midvein at angles generally in excess of 45°, and craspedodrome; they are somewhat irregularly spaced, and when farther apart they fork distally, sending a branch to the subadjacent marginal tooth. The superior pair of laterals are smaller and narrower than the terminal leaflet, subopposite in position and sessile or with a very short petiolule; their midveins are usually slightly recurved; tips acuminate and practically equilateral; bases rounded, or pointed on the distal side and markedly inequilateral. Secondaries numerous and subparallel, more curved than in the terminal leaflet, craspedodrome, simple or branching near the margins to send a vein to each marginal tooth. Marginal teeth finer than in the terminal leaflet, serrate or crenate in form. The basal laterals are only about half the size of the superior laterals, from which they are separated by slightly more than 1 centimeter of stipe; they are usually sessile and have the same form and other features of the superior laterals in the type. In some specimens they are relatively narrower and longer. I am fortunate in being able to figure a complete leaf of this interesting species. The detached leaflets because of their varying proportions might well be confused with a variety of genera, the narrower ones suggesting *Rhus* among compound leaves or *Myrica* among simple leaves, and the broader specimens might even be confused with *Ulmus*, *Planera*, or *Carpinus*. The narrower leaflets suggest *Cupanites parvulis* Berry [20] of the upper Claiborne or more particularly *Cupanites nigricans* (Lesquereux) Berry [21] of the lower Jackson, the latter considered a Myrica by Lesquereux, and the present species seems to justify the reference of these two later Eocene species to the genus *Cupanites*.

The genus *Cupanites* was proposed by Schimper for forms that suggested a relationship with the existing genus *Cupania* Linné and may well serve for this new Wilcox species without attempting to stress the resemblance to any existing genus of the tribe Cupanieae.

The existing species of *Cupania* number about 30 and are confined to the American tropical and subtropical region. They are not uncommon in the Antilles but do not naturally reach the Florida peninsula. Several fossil species of *Cupanites* have been described from American and European rocks, and there are two additional species known from the Wilcox, both of which are so distinct from the present species that comparisons would be superfluous.

Occurrence: Holly Springs sand, northwest of Pattersonville, Fayette County, Tenn.; Grenada formation, 2.9 miles southwest of Somerville; road from Jones Chapel to Good Spring School, 5 miles southwest of Williston; ironstone float near last locality; about 1 mile north of Somerville, north of Loosatchie River; all in Fayette County, Tenn.

Cupanites amplus Berry, n. sp.

Plate 43, figures 1, 2

These specimens in their equilateral falcate form and very unsymmetrical base furnish evidence that they are not simple but represent the leaflets of a compound leaf. The toothed margin and craspedodrome venation exclude them from *Juglans*, *Hicoria*, *Fraxinus*, the Ternstroemiaceae, the Rhamnaceae, or any of the temperate forms with toothed margins that one ordinarily expects to find in such an association as the Wilcox flora indicates. The only family to which I can refer them is the Sapindaceae, and in this family they show so many resemblances to existing species of the tribe Cupanieae that they are referred to the form genus *Cupanites*, and they appear to be strictly congeneric with *Cupanites formosus* Berry of the Grenada formation. They may be incompletely characterized as follows:

Leaves compound, of large size. Leaflets large, ovate lanceolate, falcate, apparently sessile, widest at or slightly below the middle, with acute tips and a strikingly inequilateral base, which is truncate on the full side and acuminate on the other, narrowed side. Margins with regularly spaced, somewhat remote, prominent, serrate teeth. Texture subcoriaceous. Length about 12 to 18 centimeters; maximum width 4 to 5.5 centimeters. Midvein stout, prominent, curved, especially proximad. Secondaries relatively thin but prominent, numerous, subparallel, fairly reg-

[20] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 70, pl. 12, fig. 5, 1924.

[21] Idem, p. 176, pl. 34, fig. 7.

ularly spaced; they diverge from the midvein at wide angles, averaging about 70°, at intervals of 5 to 10 millimeters, curving as they approach the margins and terminating in the marginal teeth. Occasionally a marginal tooth will not be represented by a secondary, in which case a craspedodrome branch from the superadjacent secondary will take its place. More rarely an intercalated secondary will be unrepresented by a marginal tooth and will be camptodrome. The tertiaries are thin but well marked, being percurrent or inosculating midway between the secondaries, and forming well-marked marginal arches between the teeth.

This species is readily distinguishable from the other three species of *Cupanites* that have been discovered in the Wilcox. Among these it most resembles *Cupanites formosus* Berry, which is a very much smaller quinquelobate, odd-pinnate form, with correspondingly smaller teeth, more ascending and commonly forked secondaries.

Occurrence: Holly Springs sand, Thompson & Barksdale prospect, 2 miles south of McKenzie; Huckleberry Schoolhouse, 2½ miles south of McLemoresville; all in Carroll County, Tenn.

Genus DODONAEA Linné

Dodonaea parvula Berry, n. sp.

Plate 33, figures 1–4

Fruit relatively small, compressed, orbicular or elliptical, with a stout central axis, umbonate distad, two-celled. Walls thin, conspicuously reticulate-veined, passing at the margin of the capsule into a relatively narrow marginal wing which is reticulately veined. Peduncle relatively long, conspicuously thickened distad. In one of the perfect specimens there are no traces of seeds; in the other specimen one cell is empty and the other contains a single flattened, elliptical seed attached to the upper part of the axis. Peduncle 8 to 9 millimeters long. Capsular part of the fruit 6 or 7 millimeters long and 3.5 to 5 millimeters in maximum diameter. Marginal wing only about a millimeter in maximum width.

These characteristic small fruits are distinctly those of Sapindaceae, less certainly those of *Dodonaea*, in which the wings are usually more largely developed. The existing species, which are fairly numerous and occur in both the oriental and the occidental Tropics, have similar netted-veined capsules, which are from two to six celled and range in consistency from membranous to leathery. The majority are three-celled and generally carry two seeds in each cell. There are, however, several two-celled species, and some of the normally three-celled forms commonly show a reduction to two cells, and in many of these fruits none or but a single seed may mature in each cell.

Two species from the Wilcox have been already described, and the genus was rather fully discussed in 1916 in connection with their characterization.[22]

A number of very definite fossil species are known, those of the earlier Tertiary being confined to the Western Hemisphere, with both leaves and fruit in the Wilcox and leaves in both the middle (Claiborne) and upper (Jackson) Eocene. The European records of the genus appear to start with the Oligocene.

The fruits of *Dodonaea parvula* are too delicate to retain their vitality for any length of time in sea water, although they would float readily enough, nor would their feeble development of wings enable them to fly any great distance, especially in a humid forested country, although they might be blown considerable distances over a dry, sparingly covered land surface, such as a beach. The consistency of the seed is unknown, but any adaptation for dissemination by birds is very doubtful.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Dodonaea wilcoxiana Berry

Dodonaea wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 270, pl. 38, fig. 2, 1916.

Specimens from the Holly Springs sand at the Grable pit in Henry County, Tenn., are identical with the type but somewhat larger and relatively wider. Their dimensions are 4 centimeters in length, and 12 millimeters in maximum width.

Dodonaea knowltoni Berry

Dodonaea knowltoni Berry, U. S. Geol. Survey Prof. Paper 91, p. 271, pl. 64, fig. 3, 1916.

New material from the Holly Springs sand at Puryear, Henry County, Tenn., includes one characteristic specimen which is 2.75 centimeters in diameter and is thus considerably larger than the type, which came from this same locality.

The restoration of a Wilcox *Dodonaea* shown in Figure 22 has been made on the assumption that the fruits described as *Dodonaea knowltoni* Berry appertain to the same botanic species as the leaves described as *Dodonaea wilcoxiana* Berry. The two occur at the same horizon in western Tennessee but have not been discovered in the same outcrop. There is a possibility that the leaves might have belonged with the fruits described on a preceding page as *Dodonaea parvula* Berry, but the former supposition seemed the more probable.

[22] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 270–272, 1916.

The variations in the form and size of the leaves are based on actual specimens; their persistence on the distal part of the twigs is consistent with fruit-bearing twigs and is based on the habit of the existing *Dodonaea viscosa* Linné. The fruits illustrate the extremes of size as represented at the Puryear locality, and their arrangement conforms to that in the existing species.

Sapindus formosus Berry

Plate 36, figure 7

Sapindus formosus Berry, U. S. Geol. Survey Prof. Paper 91, p. 276, pl. 66, figs. 3–7, 1916.

This common and widespread species of the middle and upper Wilcox was fully described in Professional Paper 91. Prior to 1925 all the occurrences were of detached leaflets, and the botanic determination rested on the form and venation.

This specimen figured in this paper adds considerably to our knowledge of the species and confirms its identification. It shows the terminal part of a leaf with nine attached leaflets. The stipe is stout, with leaflets at intervals of about 2 centimeters. The leaflets are subopposite and their laminae are widest on the distal side. The habit is even pinnate, which is the prevailing but not the universal habit of the leaves of the existing species.

FIGURE 22.—Restoration of *Dodonaea*

Genus SAPINDUS Linné

Sapindus linearifolius Berry

Plate 14, figure 19

Sapindus linearifolius Berry, U. S. Geol. Survey Prof. Paper 91, p. 275, pl. 63, figs. 2–5; pl. 109, fig. 4, 1916.

This common middle and upper Wilcox species shows a single leaf from the Holly Springs sand at its type locality, Holly Springs, Marshall County, Miss., in which the leaf is bilaminate like that of certain recent species of Euphorbiaceae and Apocynaceae.

This specimen is made the basis for the restoration of the complete leaf of this species shown in Figure 23.

Occurrence: Holly Springs sand, one-fourth mile south of Mandy, Madison County, Tenn.

Sapindus fructiferus Berry, n. sp.

Plate 33, figure 16

Fruit relatively small, more or less globose, coriaceous, about 7 millimeters in diameter, with a prominent funicle. It is possible that this fruit, repre-

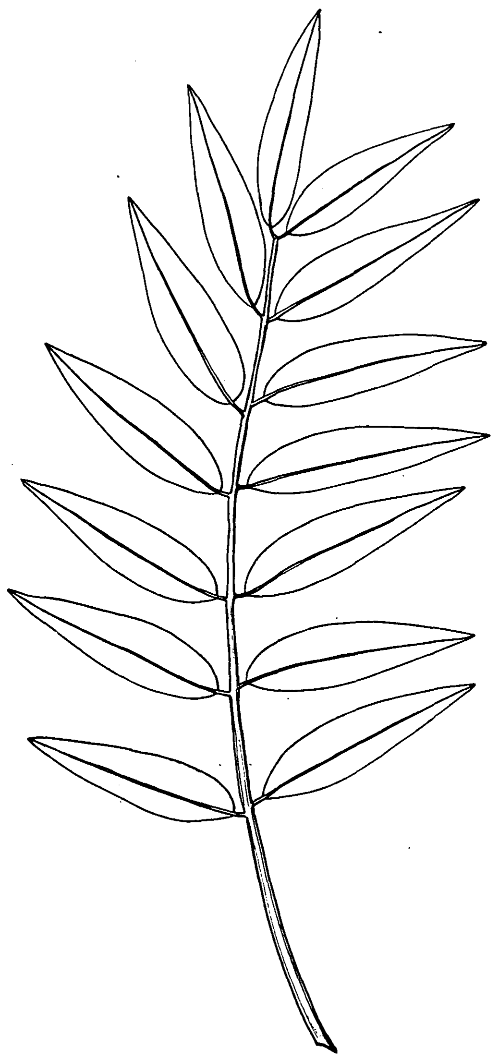

FIGURE 23.—Restoration of a complete leaf of *Sapindus formosus* Berry

sented by a single specimen, may represent some leguminous seed, but it bears a striking resemblance to the modern fruits of *Sapindus* and to those figured by Heer [23] from the Miocene of Switzerland, and among such a display of *Sapindus* leaflets as that contained in the Wilcox at numerous localities it would indeed be surprising if occasional fruits were not found.

[23] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, pl. 121, figs. 2b–2d, 1859.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Order RHAMNALES

Family VITACEAE

Genus CISSITES Heer

Cissites collinsi Berry, n. sp.

Plate 17, figures 1–6

Leaves trifoliate. Leaflets of medium size, from rhomboidal to trilobate, with an acute tip and a rounded to slightly cordate base. Margins entire. Texture not coriaceous. Length between 8 and 9 centimeters; maximum width, about midway between the apex and the base, from 5.5 to 7 centimeters. One fragment, which may represent a simple trilobate instead of a compound leaf, indicates a length of 13 centimeters and a maximum width of 12 centimeters. Petiole stout, about 2.75 centimeters in length. Mid-

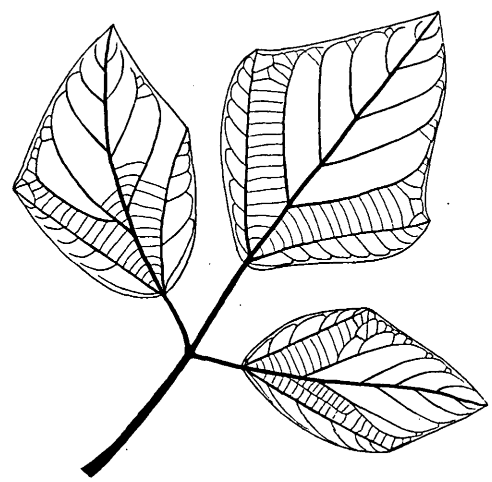

FIGURE 24.—Restoration of a complete leaf of *Cissites collinsi* Berry

rib stout below, becoming attenuated distad. Secondaries six to eight pairs, thin, diverging from the midrib at angles of about 45° at regular intervals and suboppositely; the basal pair are enlarged to form pseudoprimaries; they diverge from the top of the petiole, pursue relatively straight courses, and are craspedodrome, running to the tips of the incipient or more or less developed lateral lobes; the balance of the secondaries are subparallel and camptodrome, curving upward rather abruptly close to the margins, especially in those leaves in which the lateral lobes are undeveloped. In the trilobate forms the secondaries are more curved and more ascending and the suprabasilar pair fork opposite the sinuses. The tertiaries are camptodrome from the outside of the basal secondaries and mostly thin and percurrent between the secondaries.

The extremes of variation of this interesting species are shown in Figures 24 and 25. In the entire form the lower half of the leaflet is full to the rounded lateral angles, above which the margins are slightly excavated to form the broadly conical upper half of the leaf. In the trilobate form this tendency toward the development of sinuses above the middle is emphasized, and the leaflet is distinctly trilobate, with short rounded lateral lobes, separated from the conical median lobe by open, rounded sinuses. These extremes are identical in texture and venation and unquestionably represent variants of a single botanical species.

When first collected this species was thought to represent a variable but simple leaf. The clays at Mill Creek, however, contain many specimens which are commonly markedly inequilateral. Their absolute identity in features of texture and venation proves that they belong to a single botanical species, and the

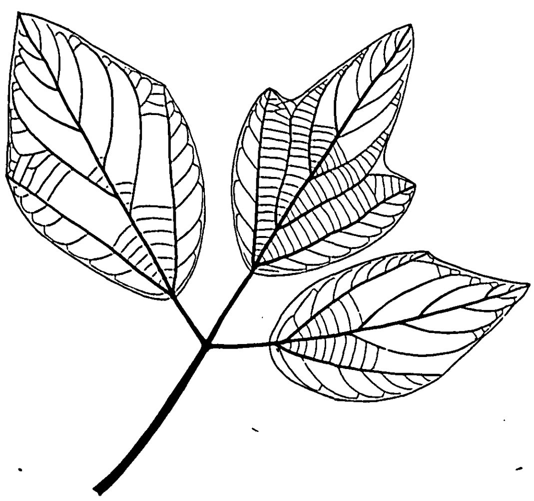

FIGURE 25.—Restoration of a complete leaf of *Cissites collinsi* Berry

conclusion has been reached that the leaves were trifoliate, a not uncommon habit in this family. The leaf is believed to be shown accurately in the accompanying restorations. Each leaflet pictured represents an actual specimen, which accounts for a slight discordance in size, and the restoration consists entirely in grouping them in threes, as none were found in actual connection.

Among previously described species the present species, which is named for the collector, is suggestive of the Denver species which Lesquereux [24] referred to *Sterculia modesta* Saporta and which Knowlton [25] renamed *Sterculia saportanea.* The entire form of the Wilcox species is, however, almost identical with one of the figured forms referred by Lesquereux [26] to his species *Cissites acuminatus* and ascribed to the Dakota sandstone.

[24] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 125, pl. 20, fig. 5, 1883.
[25] Knowlton, F. H., U. S. Geol. Survey Bull. 152, p. 224, 1898.
[26] Idem, p. 67, pl. 5, figs. 3, 4.

Cissites acuminatus shows a tendency to trilobation, with, however, a shorter median lobe and with more than one pair of secondaries craspedodrome. *Sterculia saportanea* Knowlton, which in my opinion is a *Cissites*, differs from the Wilcox species in having more ascending and true lateral primaries, a less extended median lobe, and pointed (acute and acuminate) lateral lobes. Neither of the western forms develops the cordate base of some of the Wilcox specimens.

The genus *Cissites* was proposed by Heer [27] for leaves of the family Vitaceae supposed to be related to the Linnean genus *Cissus.* To it have been referred a variety of forms, some of which are unquestionably allied to the Menispermaceae.

There are over 250 existing species in the genus *Cissus*, mostly climbers, found in all tropical countries.

Occurrence: Holly Springs sand, Mill Creek (type locality of species, where it is very abundant); 2½ miles northwest of Burnett's store; 2 miles southeast of Bolivar, on old Murrell place; Bolivar-Jackson road north of Clover Creek; all in Hardeman County, Tenn.

Cissites asymmetricus Berry, n. sp.

Plate 35, figures 1–5

Leaves probably trifoliate, certainly compound, and with at least three leaflets. Leaflets variable in size and form, rhomboidal to elliptical and markedly unsymmetrical, more or less trilobate or quadrilobate, with acuminate tip and asymmetric base, which is sharply ascending on one side and full and rounded on the other. Margins entire but generally faintly undulate to conform to the camptodrome endings of the secondary veins. Texture subcoriaceous. Dimensions ranging from lengths of 2.5 centimeters and maximum widths of 1.5 centimeters to lengths of 12 centimeters and maximum widths of 7 centimeters.

None of the specimens collected are complete, and most of them are considerably broken, but enough is available with the counterparts for determining most of their features. The smallest specimen figured clearly shows that at least three leaflets were present in the leaf. This specimen was probably trifoliate, but it might be a terminal portion of a pinnate leaf like those of some existing cissoid species. The medium-sized specimen shows a trilobate leaflet with rounded sinuses and acuminate lateral lobes. The largest specimen, as reconstructed, shows an acuminate tip and three irregularly placed acuminate lateral lobes. All the leaflets have stout petiolules; their

[27] Heer, Oswald, Soc. helvétique sci. nat. Mém., vol. 22, No. 1, p. 19, 1866.

length is intact in only the minimum-sized leaflets, where it is about 4 millimeters. The primaries diverge at acute angles from the top of the petiolule and are from 3 to 6 in number; they are medium stout, curved in their courses, and terminate in the acuminate lobes. The secondaries are medium stout, numerous, mostly long ascending, and camptodrome close to the margins. The tertiaries are thin but well marked and characteristic for the species in all the various-sized specimens; they are closely spaced and straight or flexed percurrent at approximately right angles to the adjacent primaries or secondaries; a minority fork or anastomose in the mid region. The areolation is obscurely quadrangular or polygonal.

This rather striking species shows many general resemblances to *Cissites collinsi* Berry, which is so common at certain horizons in the Tennessee Wilcox not appreciably different in age from the type locality of this species. It is indeed possible that the two may represent the extremes of variation of a single and highly variable botanic species, as both of these recognized specific entities are extremely variable. However, according to any logical method of handling foliar remains, the two must be recognized as distinct.

The resemblance between the two forms is based on what might be called facies—that is, it is confined to the ascending secondaries and numerous percurrent tertiaries and is generic. When detailed comparisons of individual features are made, specific unlikeness is satisfactorily emphasized. Thus the leaflets of *Cissites collinsi* are more uniform in size, more nearly symmetrical in outline, with rounded and scarcely perceptible inequilaterality at the base. The lobation, which only reaches perfection in occasional terminal leaflets, is rounded and not acuminate. The primaries are stouter and more prominent, as well as only three in number, and consequently more divergent, and although the features considered generic are similar in the two I have experienced no difficulty in correctly recognizing fragments of either.

Occurrence: Grenada formation, 2.9 miles southwest of Somerville, Fayette County, Tenn.

Family RHAMNACEAE

Genus BERCHEMIA Necker

Berchemia eocenica Berry, n. sp.

Plate 33, figures 12–14

Leaves small, oblong oval, with a bluntly pointed tip and an acute base. Margins entire. Texture relatively coriaceous. Length from 2 to 5 centimeters; maximum width from 7 to 16 millimeters. Petiole stout and curved, about 3 millimeters in length. Midvein relatively stout and prominent, generally somewhat curved. Secondaries numerous, subparallel, ascending, camptodrome. About 13 regularly spaced pairs diverge from the midvein at acute angles at regular intervals which increase somewhat proximad. Tertiaries thin, closely spaced, percurrent.

A characteristic leaf of this species from Cottage Grove reaches the maximum known size. It is 6 centimeters long and 2.25 centimeters in maximum width.

These characteristic small leaves have all the features of the leaves of the existing species of *Berchemia;* in fact, they are exceedingly like those of *Berchemia scandens* (Hill) Trelease, a high climbing shrub found at the present time in low woods from Virginia to Florida and from Missouri to Texas.

The genus contains about a dozen existing species, the others being natives of Asia and Africa. About seven nominal fossil species have been recorded, the majority of the fossil occurrences being attributed to *Berchemia multinervis* (Alexander Braun) Heer,[28] an obviously composite species. With the exception of certain Eocene records from North America the genus is more common in the later Tertiary, being known from the Oligocene to the Pliocene in Europe and in the Miocene of both Atlantic and Pacific North America. Lesquereux,[29] Ward,[30] and Knowlton[31] have identified leaves from the Denver, Raton, and Fort Union formations as identical with the European *Berchemia multinervis*, the type material of which came from the Miocene of Switzerland. These western Eocene leaves so designated are relatively shorter and wider than the Wilcox material, with fewer secondaries. In other respects the resemblance is very great. The present species is identical in appearance with *Berchemia prisca* Saporta[32] from the lower Miocene of France.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn.

Genus REYNOSIA Grisebach

Reynosia praenuntia Berry

Plate 41, figure 19

Reynosia praenuntia Berry, U. S. Geol. Survey Prof. Paper 91, p. 281, pl. 68, fig. 4; pl. 69, figs. 2, 3, 1916.

The specimen figured somewhat widens the limits of the species and serves to complete its characterization. In the description of the type the tip is described as broadly rounded. This feature is now seen

[28] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, p. 77, pl. 123, figs. 9–18, 1859.

[29] Lesquereux, Leo, The Tertiary flora, p. 277, pl. 52, figs. 9, 10 1878.

[30] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 73, pl. 33, fig. 1, 1887.

[31] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 333, pl. 101, fig. 5, 1918.

[32] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 338, pl. 11, fig. 1, 1865.

to range from truncate to faintly retuse, the present figure illustrating the extreme of variation of this feature. Another feature, now well known, appears to be the distal continuation of the midvein as a small mucronate point. The new material is from the Holly Springs sand at Puryear, Henry County, Tenn., where the type material was collected.

Reynosia praenuntia longepetiolata Berry, n. var.

Plate 46, figure 1

This variety occurs with the type and may be simply a variant of that species. It differs, however, in its more regularly obovate outline, being widest above the middle, in its slightly more pointed apex with a mucronate tip, and in its stouter midvein and more regularly curved secondaries. The petiole is also much stouter and longer. In the largest leaf of *Reynosia praenuntia* the dimensions are: Length, 6.25 centimeters; maximum width, 2.5 centimeters; and the petiole is about 8 millimeters long. In the new variety the dimensions are about 5 centimeters in length, 2 centimeters in maximum width, and the exceedingly stout petiole is 1.5 centimeters long.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Order MALVALES

Family TILIACEAE

Genus GREWIOPSIS Saporta

Grewiopsis elegans Berry, n. sp.

Plate 18, figure 5

Leaves of medium size, ovate, widest at or below the middle, narrowing upward to the acute tip and to a slight extent downward to the broadly rounded and cordate base. These leaves are short petiolate, the stout enlarged petiole being 4 millimeters in length. The form is somewhat inequilateral, the lamina being about one-sixth wider on one side than on the other. The margin is somewhat irregularly and coarsely dentate. Texture subcoriaceous. Length about 10 centimeters; maximum width about 5.5 centimeters. Midrib stout, prominent. Secondaries thin, pinnately arranged, prominent; about eight pairs diverge from the midrib at somewhat irregular intervals at angles of more than 45°; curving but slightly in their outer courses, camptodrome well within the margins, and sending off well-marked tertiary branches to the tips of the marginal teeth. The internal tertiaries consist of thin veins at approximately right angles to the secondaries, which either inosculate midway between the secondaries or are separated by a tertiary that extends outward from the midrib, resulting in an open, roughly rectangular areolation.

This species adds a well-marked type of this genus to the Wilcox flora, in the original account of which a single *Populus*-like species was recognized.

The present species approaches the Fort Union species described by Ward[33] as *Grewia pealei*, differing principally in the much shortened petiole, in the less ascending secondaries, and in the form, direction, and size of the marginal teeth. It is also much like a group of species from the Fort Union formation of the western United States, which Ward referred to the genus *Celastrus*.

The present species is clearly related to existing species of *Grewia*, and it would do little violence to the evidence to have referred it directly to that genus.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Grewiopsis wadii Berry

Plate 40, figure 2

Grewiopsis wadii Berry, U. S. Geol. Survey Prof. Paper 92, p. 179, pl. 52, fig. 1, 1924.

This species was described as follows:

> A leaf which when mature was about 8 centimeters in length by about the same in maximum width, distinctly trilobate in aspect, although there are no pronounced sinuses between the lobes terminated by the lateral primaries and the lobe terminated by the midrib. Texture subcoriaceous. Margin has shallow, broad dentate teeth, each with a craspedodrome vein. Venation stout and prominent on the under side of the leaf. Primaries three, subbasal. The lateral primaries give off several secondaries on the outside and at least one about halfway above the base on the inside. The tertiaries are prominent and prevailingly percurrent. The young leaves are elliptical or cordate in outline, relatively more elongate, and with smaller or obsolete teeth.

I can not discern any reliable features by which the material collected from the Wilcox of western Tennessee can be distinguished from the type which came from the Jackson of western Kentucky. There is great uncertainty as to the real botanic affinity of the various forms that have been referred to *Grewiopsis*, and I am not at all sure that they are interrelated. The most that can be said is that the present species and *Grewiopsis claiborniana* Berry of the Claiborne Eocene are congeneric. They show a certain resemblance to various forms from the Fort Union formation of the western United States that Ward referred to *Grewiopsis*, the specific names of which—*platanifolia*, *viburnifolia*, and *populifolia*—are a sufficient index of the uncertainty in the mind of their describer regarding their botanic affinity.

Occurrence: Holly Springs sand, Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.

[33] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 555, pl. 55, figs. 1–3, 1886.

Grewiopsis tennesseensis Berry

Plates 15 and 16

Grewiopsis tennesseensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 285, pl. 64, figs. 4, 5, 1916.

A large amount of material representing this species has been collected since it was described in 1916. These specimens illustrate a considerable variability in form and marginal character and especially in size.

Complete petioles are missing, but lengths as much as 3 centimeters are preserved. The outline varies in general proportions and in the nature of the apex and base. The apex is invariably acuminate but is commonly prolonged as a long, slender, entire-margined acumen like that shown in Plate 15, Figure 1. The base may be cuneate, truncate, rounded, or slightly cordate. The margin varies from nearly entire through crenate to serrate, with all large or all small teeth, or with alternations of large and small teeth, and appears to bear no relation to the size of the leaves.

The greatest variation is shown in the size of these leaves. Some are as small as 3.5 centimeters long by 3.1 centimeters in maximum width. The largest observed was 15 centimeters long and 12.5 centimeters in maximum width.

The venation appears to be rather constant in its major features, as shown by the more adequate illustrations given in the present publication.

Occurrence: Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River (very common), and 1.2 miles south of Somerville, Fayette County, Tenn. Holly Springs sand, Bolivar, west of hospital, Hardeman County, Tenn.; Somerville-Jackson road, 3¼ miles northeast of Somerville, Fayette County, Tenn.; also common in Fayette County 1 mile southwest of Grand Junction, Hardeman County, Tenn.

Family BOMBACACEAE

Genus BOMBACITES Berry

Bombacites eocenicus Berry, n. sp.

Plate 36, figure 8

Leaflets relatively large, slightly inequilateral and falcate, obovate, with an acuminate tip and a narrowly cuneate extended, slightly decurrent base. Rather thin but stiff in texture. Margins entire proximad, with small straight-serrate or dentate teeth distad. Length from 7 to 12 centimeters; maximum width, slightly above the middle, from 2.8 to 4.25 centimeters. Petiolule short and very stout, about 0.75 centimeter long in the largest leaflets. Midvein stout, curved, prominent on the under side of the leaflet. Secondaries of medium caliber and prominence, numerous, somewhat irregularly spaced, camptodrome, varying considerably in their angles of divergence. Tertiaries relatively prominent, forming large curved-sided blocks internally and camptodrome arches marginally. Short branches from the camptodrome arches enter the marginal teeth. Areolation fine, isodiametric.

This species has the generic characters of the two previously known Wilcox species which have been referred to *Bombacites*. It differs from *Bombacites formosus* Berry [34] in its prevailingly larger size, greater width, more numerous and prevailingly more ascending secondaries, and more numerous marginal teeth. It differs from *Bombacites wilcoxianus* Berry [35] in being broader, with a shorter and stouter petiolule. The secondaries are camptodrome farther from the margins and the margin is more prominently and regularly toothed, as it is only at the extreme tip in *Bombacites wilcoxianus*.

It is assumed from the form and from the characters of the existing species of *Bombax* and its allies that the present material represents the leaflets of a digitately compound leaf, although only these detached leaflets have been found. It agrees closely with the leaflets of certain existing species, which may be entire or toothed, as, for example, *Bombax glaucescens*. Fossil species that are very similar have been recorded from both the European and American Tertiary. The genus *Bombax*, which in this hemisphere has been recorded from the Miocene of Chile and Ecuador and the Pliocene of Brazil, is found in the warmer regions of all the continents except Europe, although the majority of the 50 or more existing species are American.

Occurrence: Holly Springs sand, Bell City Pottery pit and 100 yards east of it, Calloway County, Ky.

Bombacites formosus Berry

Plate 47, figure 2

Bombacites formosus Berry, U. S. Geol. Survey Prof. Paper 91, p. 289, pl. 75, fig. 1, text fig. 15, 1916.

The specimen from Puryear here figured is somewhat larger than the type, with which it agrees perfectly in its other features. The present figure shows the peculiar margin and the character of the venation much more clearly than the former figure.

The species is sparingly represented in the Wilcox, being known from only the two localities cited below, but these are widely separated geographically, so that its distribution must have extended at least around the head of the embayment between Tennessee and Louisiana.

Occurrence: Holly Springs sand, of Wilcox group, Puryear, Henry County, Tenn. Wilcox formation, Mansfield, La.

[34] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 289, pl. 75, fig. 1, 1916.

[35] Idem, p. 291, pl. 75, fig. 2.

Family STERCULIACEAE

Genus BUETTNERIA Löfling

Buettneria eocenica Berry, n. sp.

Plate 18, figure 4

Relatively small leaves, broadly ovate, with an acute tip and a broadly rounded base. Margins entire, somewhat irregular in that they are constricted in two or three places. Leaf substance thin. Length about 4.25 centimeters; maximum width, in the lower half of the leaf, about 3.75 centimeters. Petiole missing. Midrib extraordinarily stout throughout its length, prominent on the lower surface. Secondaries medium stout, prominent; about six opposite to alternate pairs diverge from the midrib at somewhat irregular intervals at angles of about 55° to 60°; these, except the basal pair, are comparatively straight and subparallel and are camptodrome close to the margins. The basal pair are opposite, diverging near the base of the midrib; they curve parallel with the lower leaf margins but are in no sense lateral primaries or pseudoprimaries; they give off four or five mostly regularly curved, camptodrome tertiaries on the outside. The internal tertiaries are thin but well marked, percurrent in some interspaces; in others they may anastomose midway between the secondaries; and in other areas they may be divided by a branch from the midrib or from a superadjacent secondary.

The characters of this small leaf are somewhat contradictory. At first sight it suggests a species of *Ficus*, which relationship, it seems to me, is negatived by the venation. It has also suggested comparisons with various Leguminosae, particularly trifoliate forms of Papilionaceae, and here again the venation is not characteristic of such a relationship. The sum of its features appears to indicate a relationship with the genus *Buettneria*, which comprises about 50 existing species, mostly confined to the warmer parts of the Western Hemisphere, although there are a few in the Old World Tropics. In America the genus *Buettneria* ranges from the Antilles southward to Argentina and consists, for the most part, of climbing herbs and shrubs, although there are a few arborescent species.

The fossil record of the genus is very imperfectly known. There is a large species in the Jackson formation of central Texas and an unquestionable species in the Miocene of Costa Rica and Colombia, a very doubtfully determined form in the Miocene of Florissant, Colo., and a third in the Miocene of Europe. It seems very probable that other fossil representatives of this genus have been collected but have remained unrecognized, the tendency of workers to consult pictures of fossils rather than the leaves of existing species resulting in the perpetuation of most original errors of identification.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Genus STERCULIA Linné

Sterculia zavalana Berry, n. sp.

Plate 18, figure 3

Leaves small, trilobate, with linear acuminate lobes, narrow ultimately rounded sinuses, and cuneate base. Margins entire. Texture coriaceous. Length about 4.5 centimeters; maximum width 2.75 centimeters. The lobes are somewhat unequally developed, the median being twice as wide and considerably longer than the lateral lobes. The sinus on one side reaches two-thirds of the distance to the base and that on the other side only a trifle over one-half the distance to the base. Petiole is stout, about 1 centimeter in length. The three primaries diverge at acute angles from the base and are stout and prominent, the median being stouter than the laterals. No trace of secondary or tertiary venation can be observed, owing probably to immersion in the coriaceous leaf substance.

As most lobed Sterculias are variable in form and number of lobes this species may have had 4-lobed or 5-lobed leaves, but only trilobate forms have been collected. It is smaller and markedly distinct from the other two Wilcox species of *Sterculia*. On the other hand, its characters suggest that it may have descended from the Upper Cretaceous species *Sterculia minima* Berry [36] of the Atlantic Coastal Plain, which is the smallest of American Cretaceous species. It also resembles *Sterculia mucronata* Lesquereux [37] of the Dakota sandstone.

Occurrence: Carrizo sandstone, east bank of Nueces, 5 miles N. 30° E. of La Pryor, Zavala County, Tex.

Sterculia wilcoxensis Berry

Plate 26; Plate 27, figure 5

Sterculia puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, pl. 72, fig. 3 (not other figures of this species), 1916.
Sterculia wilcoxensis Berry, U. S. Geol. Survey Prof. Paper 131, p. 17, pl. 14, figs. 1, 2; pl. 15, figs. 3, 4, 1922.

This species was separated from *Sterculia puryearensis* on the basis of smaller size, narrower and more conical lobes, trilobate form, and minor differences in venation. Recently collected material is somewhat variable and larger but preserves the distinctness emphasized in 1922, although the variability of leaves of *Sterculia* in respect to lobation is well known, and the possibility should be borne in mind that the extremes

[36] Maryland Geol. Survey, Upper Cretaceous, p. 857, pl. 80, figs. 1–3, 1916.

[37] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 182, pl. 30, figs. 1–4, 1892.

of variation in the fossil form may really represent a single botanical species.

The maximum size observed in *Sterculia wilcoxensis* is a length of 23 centimeters and a maximum width of 12 centimeters. In these larger forms the lobes become somewhat ovate, and in the larger specimen figured there is a rounded swelling on one side, suggesting an incipient fourth lobe. The base is invariably characteristically cuneate, and the lateral primaries are suprebasilar, both of these features being in striking contrast with these features in *Sterculia puryearensis.*

There is another feature of this species to which attention should be called. *Sterculia wilcoxensis* is intimately associated with the leaves that I have referred to *Ficus mississippiensis.* At the horizon near the top of the cut at Pine Top, Tenn., both are present in greatest abundance and scarcely anything else is associated with them. The venation is practically identical in the two—the sole difference being that one is entire and other trilobate. In view of the fact that *Ficus mississippiensis* departs slightly from the venation typical of *Ficus* and that several existing Sterculias have a venation approaching *Ficus*, as, for example, the existing *Sterculia macrophylla*, there is a possibility that what in the Wilcox flora is called *Ficus mississippiensis*, and which incidentally is exceedingly abundant, widespread, and variable in form, may really represent the entire leaves of *Sterculia wilcoxensis.*

The leaves of *Sterculia wilcoxensis* figured in the present connection show a considerable superficial resemblance to various fossil leaves that paleobotanists have referred to *Aralia* and *Sassafras.* The hemlike veins in the sinuses are features especially associated with lobed *Sassafras* leaves, but they occur in other genera, *Artocarpus* for example, and can not outweigh the gradational series of leaves of the present species of *Sterculia* ending in rhombic conical lobed forms. The secondary venation is also that of *Sterculia* and not like that of *Sassafras* or *Aralia.*

Occurrence: Holly Springs sand, big cut on Gulf, Mobile & Northern Railroad at Pine Top, Hardeman County, Tenn.

Sterculia knowltoni Berry, n. sp.

Plate 46, figures 9, 10

Leaves variable, relatively small, palmately lobed, with three to five principal lobes and a varying number of acuminate serrate lobules; the central lobe no larger than the lateral lobes; the lobules absent or present on both sides of the central lobe, generally on but one side of the adjacent lobes, and this is as commonly the distal as the proximal side. The two halves of some leaves differ in this feature, the lobules being generally absent on the distal side of the lateral lobes and generally present but absent in a few specimens on the basal side. The lobes may be conical acuminate, as in the small specimen figured from the pits of the Bell City Pottery, where they are broadly conical, and the sinuses are open and shallow and extend about one-third of the distance to the base, or they may be narrower and separated by correspondingly narrowly rounded sinuses that extend half the distance to the base. The margins are otherwise entire, and the texture is coriaceous. The base may be broadly rounded or even slightly cordate; more generally it is truncate and slightly decurrent. Length from 4 to 7 centimeters; maximum width from 5 to 8 centimeters. The petiole is usually missing; in a minimum-sized specimen it is stout and preserved for a length of 2 centimeters. Primaries three to five, diverging at acute angles from the top of the petiole, the midrib the same size as the laterals but the basal pair of laterals usually thinner than the three main primaries; they are prominent on the under side of the leaf. The secondaries are rather widely spaced, thin and more or less immersed in the leaf substance, and camptodrome, except that each lobule that is developed has a craspedodrome secondary. The tertiaries are obsolete by immersion.

Like most living and fossil species of *Sterculia* the present species is variable in outline. It is exceedingly common at certain localities in the upper part of the Mississippi Gulf and may represent the smaller and more variant leaves of the two larger forms recorded from the Wilcox. All are abundant at some localities, and the present form has not been observed at the localities where the others occur. In addition to the method of occurrence and the smaller size the following differences may be pointed out: *Sterculia wilcoxensis* Berry is normally three-lobed and the smaller leaves are deeply divided, with narrow lobes, no lobules, a cuneate base, and numerous well-developed camptodrome secondaries. *Sterculia puryearensis* Berry has broadly ovate conical, not acuminate lobes, of which the central is invariably the largest, no lobules, and numerous well-marked camptodrome secondaries. In the light of the material studied there can be no doubt of the distinctness of the present species, which is accordingly named in honor of Frank H. Knowlton.

Among previously described species of *Sterculia* from other parts of North America, the only one that is similar is *Sterculia berryana* Knowlton,[38] of the Raton formation. That species is somewhat larger than *Sterculia knowltoni*, with a predominant central lobe and correspondingly differentiated midvein and

[38] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 337, pl. 102, figs. 3, 4, 1917.

with but two lateral primaries; the base is conspicuously cuneate and decurrent and the secondaries are long and ascending, diverging at much more acute angles.

Both this Wilcox and the Raton species just mentioned greatly resemble the widely distributed American Upper Cretaceous *Sterculia mucronata* Lesquereux [39] of the western interior region, and both may be the modified descendants of this Cretaceous form; in that event, this would be one of the relatively few Wilcox species whose origin was western rather than southern.

Occurrence: Holly Springs sand, Holcomb property, 2 miles south of Paris, Henry County, Tenn.; Will Brooks farm, 2.1 miles northwest of Mercer, Madison County, Tenn.; 2 miles southeast of the town of Spring Creek, Madison County, Tenn.; 100 yards east of the pits of the Bell City Pottery, Calloway County, Ky.

Sterculia puryearensis Berry

Plate 24

Sterculia puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 286, pl. 72, fig. 2 (not fig. 3); pl. 73, fig. 1; pl. 74, fig. 4, 1916.

The specimen figured herewith, from the Holly Springs sand west of Bolivar, shows a nearly complete leaf of this species of the type shown in Plate 74, Figure 4, of Professional Paper 91, and represents the narrowly lobed form in contrast with the broader lobed forms like that shown in Plate 73 of Professional Paper 91, which last is exceedingly like the existing *Sterculia platanifolia* Linné son, of southern China, that is widely planted in the warmer parts of the United States as an ornamental tree. The leaf from the locality west of Bolivar has the complete petiole preserved, and this is 11 centimeters in length. The present species is sparingly represented in the Wilcox but is widely distributed, being found in both the eastern and the western Gulf areas.

Occurrence: Grenada formation, of Wilcox group, Grenada, Miss. Holly Springs sand, of Wilcox group west of hospital, Bolivar, Hardeman County, Tenn. Puryear, Henry County, Tenn. Wilcox formation, Naborton, La.

Genus STERCULIOCARPUS Berry

Sterculiocarpus sphericus Berry, n. sp.

Plate 25, figure 19; Plate 48, figures 9–14

Capsular fruits, apparently indehiscent. Approximately spherical in form and borne on a very stout peduncle, which in some specimens as compressed is 6 millimeters in diameter and 1.75 centimeters in length. Size variable, some specimens (presumably immature or abortive) being but 7 millimeters in diameter; the majority as preserved in a more or less flattened condition are close to 2 centimeters in diameter. These fruits are not uncommon at a number of localities in the upper part of the Holly Springs sand and in the Grenada formation. The preservation is various; some, such as the specimen shown in Plate 25, Figure 19, are slacked carbonized inclusions necessarily doubtfully determined; others are flattened casts without traces of carbonaceous residue; others found in more lignitic argillaceous layers are rather well preserved. The broken specimen shown in Plate 48, Figure 10, has five cavities with stout partitions and a stout wall. These fruits were therefore ligneous at maturity and were probably many seeded, although this last statement is inferential. The apex is slightly umbonate in some specimens with very clear traces of a pentamerous stigmatic surface or five pistils. The stout peduncle merges into the basal part of the fruit without preserving any traces of the receptacle or accessory flower parts.

The botanic affinity of these characteristic and interesting fruits is not determinable with absolute certainty. Fruits of similar structure characterize numerous genera in the order Malvales, especially in the families Sterculiaceae and Ternstroemiaceae, particularly in the former family. This resemblance seems close enough to justify their reference to the form genus *Sterculiocarpus*, and although doubtless they represent a different Eocene genus of Sterculiaceae than the two previously described species in that genus, it seems preferable not to multiply generic terms without sufficient evidence.

Accordingly these fruits are considered to represent a third type of sterculiaceous carpellary remains in the Wilcox flora—obviously different, but with the same type of organization as *Sterculiocarpus eocenicus* Berry [40] and *S. sezannelloides* Berry.[41] There is also a family likeness to the beautifully preserved form from the "Paleocene" of France described by Viguier [42] under the generic name of *Sezannella*.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.; Grable and Atkins pits, Henry County, Tenn.; 4 miles north of Jackson, on Mobile & Ohio Railroad, Madison County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn.

Genus PTEROSPERMITES Heer

Pterospermites cf. P. minor Ward

A single specimen from the Wilcox appears to represent this species, but as the distal part of the leaf is gone, considerable uncertainty attaches to its identi-

[39] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 182, pl. 30, figs. 1–4, 1891 (1892).

[40] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 288, pl. 74, figs. 1–3, 1916.

[41] Idem, pl. 72, figs. 4–6, 1916.

[42] Viguier, René, Rev. gén. botanique, vol. 20, pp. 6–13, pl. 5, figs. 1–7, 10, 1908.

fication. There is also considerable uncertainty regarding the generic identity of the type material, which might readily be referred to other genera than *Pterospermites*.

Pterospermites minor was described by Ward[43] from material coming from the Fort Union formation of Montana, and it was subsequently recorded by Knowlton from the Lance formation of that State.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Order PARIETALES

Family TERNSTROEMIACEAE

Genus TERNSTROEMITES Berry

Ternstroemites crassus Berry, n. sp.

Plate 28, figures 1–3; Plate 38, figure 3

Leaves large, of coarse texture, with inordinately stout petioles and midveins, linear lanceolate. The acute tip shown in the figures is an assumption, for the apex is missing in the specimens. Base broadly cuneate or rounded, decurrent at the petiole. Margin toothed. Teeth varying from minutely serrate to aquiline serrate. Texture coriaceous. Length (estimated), 15 to 20 centimeters; maximum width observed, 5 centimeters. The petiole is about 3 centimeters long, expanded at its base, and about 5 millimeters in diameter. The midvein is very stout and prominent, out of all proportion to the size of the leaf or the rest of the venation. Secondaries stout but relatively thin, rather equally spaced, numerous; they diverge from the midvein at rather wide angles, which are at least over 45° and average about 70°; their general course is outward with but slight upward curvature until the marginal region is reached, where they are camptodrome. The tertiaries are thin and mostly subparallel with the secondaries.

This characteristic form adds a fifth species of the family Ternstroemiaceae to the Wilcox flora. It is unfortunately very sparingly represented in the collections. It differs from the other four Wilcox species in its greater size, coarser texture, more obtuse base, longer and stouter petiole, much stouter midvein, linear form, more close-set, and serrate teeth.

The form shown in Plate 38, figure 3, must be regarded as anomalous. In all its features except form it is identical with the normal linear lanceolate leaves, but it is bifurcate, the upper ovate portion being separated from the basal obovate portion by an interval of naked midvein about 1 centimeter in length.

The accompanying attempted restoration is hypothetical only as regards the tip of the leaf.

[43] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 95, pl. 42, figs. 1–3, 1887.

Occurrence: Holly Springs sand, Fayette County, Tenn., 1 mile southwest of Grand Junction, Hardeman County; west of Bolivar, Hardeman County, Tenn.

Ternstroemites lanceolatus Berry

Plate 44, figure 18

Ternstroemites lanceolatus Berry, U. S. Geol. Survey Prof. Paper 91, p. 296, pl. 77, fig. 5, 1916.

The specimen from the Atkins pit here figured has more the form of the associated *Ternstroemites ovatus* Berry and may possibly represent a variant of that species. It is unusually short and broad for *Ternstroemites lanceolatus* but has the same acuminate tip, marginal teeth, and venation. It is quite possible that *T. lanceolatus* and *T. ovatus* may represent the extremes of variation of a single Wilcox botanic species. The present form is found at a number of localities near the top of the Holly Springs sand and in the Grenada formation, all confined to the eastern shore of the Wilcox Mississippi Gulf.

Occurrence: Grenada formation, Grenada, Miss.; Holly Springs sand, Mill Creek, Hardeman County, Tenn.; Puryear and Atkins pit, Henry County, Tenn.

The accompanying restoration of *Ternstroemites* is a combination of the large flower described as *Antholithes ternstroemioides* Berry and the most abundant leaf species of *Ternstroemites* associated with it in the deposits at Puryear, Henry County, Tenn. These leaves, described as *Ternstroemites eoligniticus* Berry, are exceedingly abundant, and their variations are those illustrated.

There are three other types of *Ternstroemites* leaves found at Puryear, but they are less common than *Ternstroemites eoligniticus*, although the flower might pertain to one or the other of these rarer species, or, as the specific differences between the leaves are not very great, one or more of them might be considered to represent the variants of a single botanical species. In any event the restoration gives a rather accurate idea of the appearance of this exceedingly common lower Eocene type of plant. (See fig. 26.)

Family FLACOURTIACEAE

Genus BANARA Aublet

Banara eocenica Berry, n. sp.

Plate 45, figure 17

Leaves of medium size, ovate, nearly parallel sided, but slightly wider below than above the middle and tapering more distad than proximad. Tip narrowly rounded. Base cuneate. Texture thin but stiff and subcoriaceous. Margin with remote and irregularly spaced teeth, which range in form from slight dentations to serrate; the margin is entire at the extreme base and for a considerable distance in the tip. Length, about 9 centimeters; maximum width about 2.5 centimeters. Petiole very stout, about 1.8 centimeters in length. Midvein stout, prominent on the under side of the leaf, curved, scarcely diminishing distad. The basal secondaries are about half as stout as the midvein, prominent on the lower surface; they diverge from the midvein at acute angles at the top of the petiole, ascending about one-half the length of the leaf, where they arch along the tips of small laterals from the superadjacent secondaries; this basal pair of secondaries might well be called lateral primaries, for their angles of divergence, length, and direction are quite different from the four other pairs of subopposite to alternate secondaries; these diverge at angles about twice those of the basals and curve upward in broad and rather regular camptodrome arches; they are remote and somewhat irregularly spaced. The tertiary venation comprises a series of approximately transverse inosculating veins between the subprimaries and the midvein, a somewhat similar pattern within some of the secondaries, and a combination of transverse and subsecondary veins within some of the other secondaries. Marginally all of the laterals form a diminishing series of arches, and from certain of these short curved nervilles proceed into the teeth. The areolation is for the most part indistinct but consists of a fine and in the main isodiametric polygonal mesh exactly like that of the existing *Banara reticulata* Grisebach of the Bahamas.

After an extended comparison with recent material I can see no reason for doubting that the present species represents an Eocene form of *Banara*. A number of recent species might be enumerated that are rather close to the fossil, especially in their venation, which seems to be characteristic. Among these might be mentioned *Banara vanderbiltii* Urban of Porto Rico and *Banara reticulata* Grisebach, already mentioned. The second is a glabrous form and the first is more or less pilose, especially on the veins on both surfaces. On the whole *Banara reticulata* is extremely close to the fossil, even to the prevailingly curved midvein and hence slightly unsymmetrical outline.

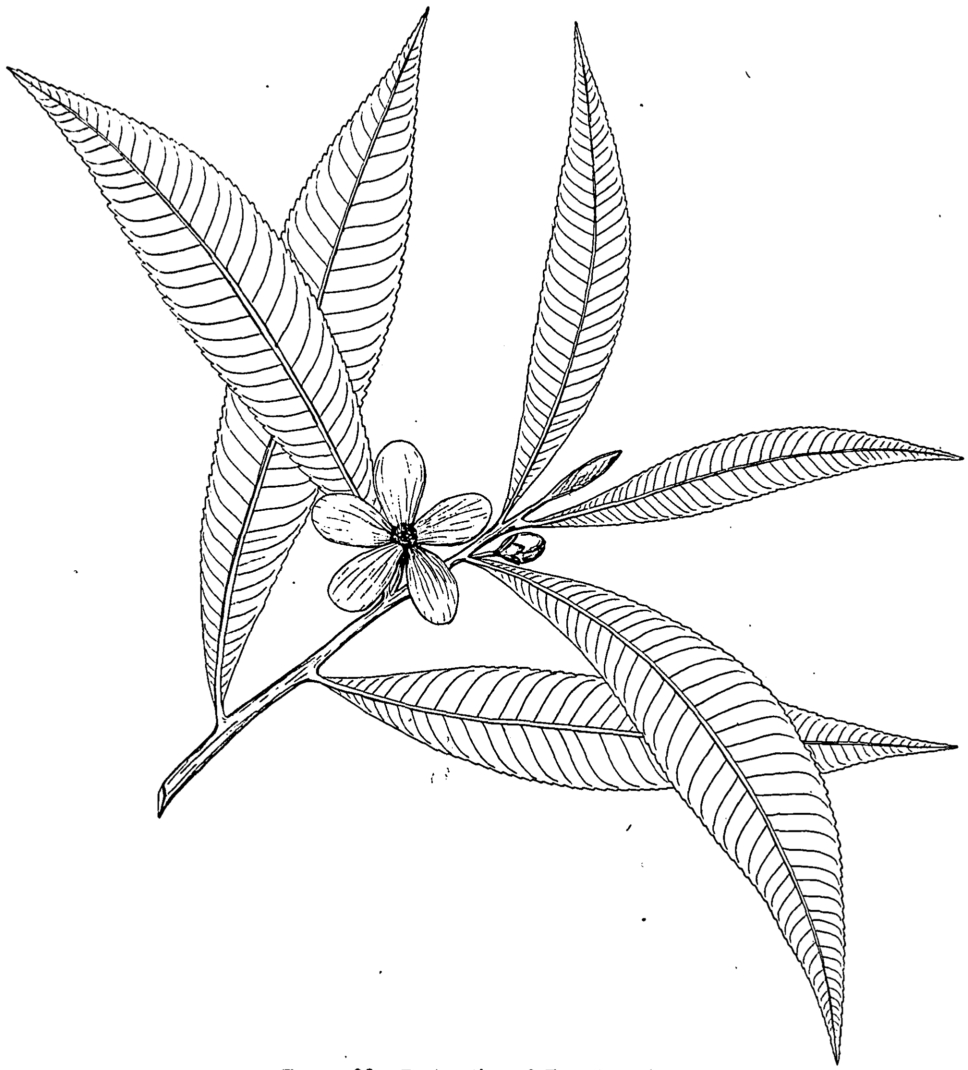

FIGURE 26.—Restoration of *Ternstroemites*

Occasionally the large genus *Viburnum* has species with leaves something like the fossil, as for example the Asiatic species *Viburnum propinquum* Hemsley and *Viburnum foetidum* Wall var. *rectangulum* Graebner, but the resemblance is not at all close. In general the leaves of *Viburnum* have more numerous and more ascending secondaries and the distal ones are ascending like the basal ones. Those leaves that approach the fossil in appearance are also more distinctly ovate in outline. I have been unable to find any species of *Viburnum* from Mexico, the Antilles, or South America that was anything like the present fossil form.

The genus *Banara* contains about a score of existing species of trees ranging from the Bahamas through the Antilles and from Mexico through Central America to Bolivia, southern Brazil, and Paraguay. They are for the most part tropical but ascend to altitudes of 6,500 feet in Colombia, which brings them well within the subtropical altitudinal zone.

But few fossil species have been referred to the family Flacourtiaceae, largely, I imagine, because the foliar characters are less well known to paleobotanists than the more familiar forms of the North Temperate Zone.

Engelhardt[44] has recorded a species of *Banara* from the lower Miocene of Chile, and I have recorded[45] a second fossil species from the Miocene of Patagonia.

Occurrence: Holly Springs sand: Puryear, Henry County, Tenn.; and west of Bolivar, Hardeman County, Tenn.

Family OCHNACEAE

Genus OURATEA Aublet

Ouratea eocenica Berry, n. sp.

Plate 45, figures 1–3

Leaves of medium size, ovate lanceolate, with a gradually narrowed acuminate tip and a more abruptly narrowed acuminate base. Margins entire at the base; above with dimorphic, closely spaced, aquiline serrate, and commonly bluntly pointed teeth. As normally developed the alternate teeth are twice the size of their alternates. In one specimen and its counterpart from the Foundry Church pit, these teeth are developed to an abnormal degree, the larger being at least three times the sizes of the smaller, and many of them extended as a scimitar-shaped tooth 5 to 7 millimeters in length and 1.5 millimeters in maximum width. The leaf substance is thin. Length about 15 centimeters; maximum width, slightly below the middle, about 4 to 5 centimeters. Petiole stout, striated, its length unknown. Midvein stout, prominent, striated. Secondaries thin, numerous, fairly regularly spaced at intervals of 4 to 6 millimeters; diverging from the midvein at angles of about 60° to 70°, subparallel, camptodrome. Tertiaries characteristic, thin, numerous, closely spaced, prevailingly somewhat flexuous, obliquely percurrent, their direction approximately at right angles to the midvein, occasionally forking or anastomosing, generally broken by longer or shorter veins from the midvein subparallel with the secondaries. The terminal camptodrome arches of the secondaries send curved craspedodrome tertiaries to the tips of the marginal teeth.

This form is a characteristic and readily recognizable type of leaf, and I know nothing in the fossil record exactly like it, although it somewhat resembles certain leaves from the Middendorf formation of the Upper Cretaceous of South Carolina that were referred with a great deal of uncertainty to *Salix*.[46]

The figured specimen with the proliferated teeth is one of the most curious of the numerous exceptional leaf specimens found in the Wilcox deposits of western Tennessee.

These leaves exhibit features which ally them with the modern toothed leaves of the genus *Ouratea* of Aublet, which as monographed by Gilg in Die natürlichen Pflanzenfamilien is made to include *Gomphia*, *Ochna*, and other groups. It comprises shrubs and trees, mostly tropical, which Gilg segregates into two sections. The first, *Neoouratea*, contains upward of 100 American species; and the second, *Palaeoouratea*, includes about 30 Old World forms of Asia and Africa. The American forms are largely South American, but the genus is well represented in Central America and the Antilles. It seems to me probable that *Neoouratea* and *Palaeoouratea* are less closely related than Gilg assumes, and it is by no means clear that the generic term *Ouratea* should not be restricted to the American forms.

Even if thus restricted *Ouratea* shows considerable variation in its leaves, some of the Antillean species having entire leaves and other leaves in which the marginal teeth have become so prominent that the leaves suggest *Ilex opaca*. The majority, however, have the facies of the present fossil. A great many have smaller and more uniform teeth, but there is a marked tendency for them to be dimorphic, as, for example, in *Ouratea tuerckheimii* Donnell Smith, *O. podogyna* Donnell Smith, and *O. wrightii* (Van Tieghem) Riley; all Central American forms, and *O. castaneafolia* De Candolle, a South American form.

[44] Engelhardt, Hermann, Senckenberg. naturf. Gesell. Abh., Band 16, Heft 4, p. 667, pl. 8, figs. 2, 4, 1891.

[45] Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 6, p. 220, pl. 6, fig. 1, 1925.

[46] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 34, pl. 8, figs. 10–12, 1914.

Ouratea wrightii, which is a shrubby form of wet forests, is identical with the fossil except that the distal part of the secondaries is more ascending in the recent leaves. All the recent toothed forms have the characteristic tertiary venation shown by the fossil.

I know of no other family with leaves of exactly this type. Certain members of the Flacourtiaceae are similar in size and marginal features, but the tertiary venation, when percurrent, is more open and at right angles to the secondaries instead of thin, closely spaced and at right angles to the midvein, as in *Ouratea.* Furthermore, in the Flacourtiaceae the leaves tend to be ovate in outline and usually more or less tripalmately veined from the base.

I consider the identification of this Wilcox type as rather conclusively established, and it is of unusual interest to find it in the upper part of the Mississippi Gulf during the Eocene and also to find it more like the Central and South American existing forms than it is like those of the Antilles. It seems to me that the Wilcox type is the more primitive type, as are the Central and South American forms, and that the Antillean types are later and derivative.

This conclusion is also in harmony with the idea derived from the Eocene flora of southeastern North America as a whole—that the existing flora of the Antilles is less like that of South America than was that of the Tertiary.

I know of no previous occurrences of *Ouratea* in the geologic record, unless *Gomphia firmifolia* Engelhardt [47] from the lower Miocene of Chile represents it, which is not improbable.

A leaf from the Lisbon formation (of the Claiborne group, middle Eocene) of Mississippi, described by me as a leaflet of *Oreopanax*,[48] is much like *Ouratea* and may well have been wrongly identified.

Occurrence: Holly Springs sand, Foundry Church pit, Henry County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Huckleberry Schoolhouse, 2½ miles south of McLemoresville, Carroll County, Tenn.; Grenada formation, 2.9 miles southwest of Somerville, near Moses Hall, Fayette County, Tenn.

Family GUTTIFERAE

Genus CLUSIAPHYLLUM Berry, n. gen.

Clusiaphyllum eocenicum Berry, n. sp.

Plate 18, figure 2

This fine and botanically characteristic species is unfortunately based solely upon the single imperfect fragment figured, and it is much to be hoped that additional and more complete material will be discovered. Were it not for the fact that it adds a distinctly new type to the Wilcox flora and that its inclusion in the family Guttiferae is indisputable, no attempt would have been made to describe it. Rather than attempt the uncertainty of correct generic determination a new form genus, *Clusiaphyllum*, is erected for its reception, the name denoting the family to which it belongs, since Clusiaceae is used about as often as Guttiferae for the family and is probably more in keeping with the taxonomy of family names if such can be considered to be governed by any canons of nomenclature.

The specimen may be incompletely described as follows: Leaves large and coriaceous. I judge from the contour of the margin and the direction of the veins that it was elliptical rather than obovate in outline, as are so many modern Clusias, but it may have been more or less oblong in outline and rounded or pointed at one or both ends. Dimensions can only be estimated, but the leaf can hardly have been less than 20 to 25 centimeters in length, and the maximum width must have exceeded 13 centimeters. The margin is entire, full, and evenly rounded. The secondaries are relatively thin and immersed in the leaf substance; they diverge from the midvein at wide angles, approaching 90°; they are closely spaced and subparallel, rather straight until they approach the margin, generally inosculating, especially distad. About 1.5 millimeters within the margin their ends are connected by a well-developed marginal vein, which is rather evenly curved parallel with the leaf margin but occasionally shows arching from secondary to secondary.

As has already been pointed out, this specimen has the venation characters of the Guttiferae, among which resemblances to various existing American genera might be pointed out. This is reserved, however, until such time as more complete material will render it more profitable.

Occurrence: Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark.

Order LAURALES

Family LAURACEAE

Genus CRYPTOCARYA R. Brown

Cryptocarya wilcoxiana Berry, n. sp.

Plate 18, figure 1

Leaves large, ovate, widest below the middle. Apex acute, not extended. Base broadly rounded, slightly emarginate at the top of the petiole. Margins entire, full, slightly undulate. Texture coriaceous. Length about 13 centimeters; maximum width about 6.75 centimeters. Petiole very stout, expanded base, 4 centimeters in length. Midrib very stout, curved, promi-

[47] Engelhardt, Hermann, Senckenberg. naturf. Gesell. Abh., Band 16, Heft 4, p. 675, pl. 11, fig. 6, 1891.

[48] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 88, pl. 22, figs. 3, 4, 1924.

nent on the under side of the leaf. Lateral primaries subopposite and suprabasilar, stout, diverging from the midrib at angles of 45° or more, curving upward subparallel with the lower margins, becoming thin and brachiodrome close to the margins about two-thirds of the distance to the tip. Secondaries stout, 5 or 6 alternate pairs, diverging from the midrib at angles of 45° or more, slightly irregularly spaced, but regularly curved and subparallel, camptodrome. Tertiaries relatively stout; percurrent in the marginal regions where the secondaries converge; internally forming an inosculating mesh of more or less percurrent loops and stout rapidly diminishing branches from the midrib. On the outer side of the lateral primaries there is a series of stout camptodrome branches. The venation in the base as shown in the figure is typical. Areolation open, thin but well marked.

The present species is very similar to *Cryptocarya eolignitica* Hollick of the upper Wilcox of Louisiana, and the two may possibly represent the same botanical species. The Tennessee form is, however, ovate rather than oblong in shape, is much wider, with a stouter petiole nearly four times as long, with an emarginate instead of a decurrent base, with more numerous and more regular secondaries, and with considerable differences in the disposition of the tertiaries. The two appear to represent distinct but rather closely related species.

Occurrence: Holly Springs sand, Illinois Central Railroad north of Shandy, Hardeman County, Tenn.

Genus CINNAMOMUM Blume

Cinnamomum ovoides Perkins

Plate 19, figure 1

Cinnamomum ovoides Perkins, Vermont State Geologist Rept., 1903–4, p. 199, pl. 79, figs. 104, 107, 1904.

This fruit appears to be identical with the remains from the lignite of Brandon, Vt., described under this name. I much doubt its relationship with *Cinnamomum* but have no especially constructive remarks to make on the subject, for it resembles fruits of various unrelated modern genera and fossil references. It appears to me to be a stone, and its chief interest is its presence at Brandon and in the Wilcox.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.

Cinnamomum affine Lesquereux

Cinnamomum affine Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, p. 206, 1868; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1869, p. 96, 1869; Idem, for 1872, p. 383, 1873; Idem for 1874, p. 401, 1876; The Tertiary flora, p. 219, pl. 37, figs. 1–4, 7 (not fig. 5), 1878.

Knowlton, U. S. Geol. Survey Bull. 152, p. 68, 1898.

Berry, U. S. Geol. Survey Prof. Paper 91, pp. 13, 299, pl. 3, fig. 2, 1916.

This species was described by Lesquereux from the Denver formation of Colorado. It was subsequently recorded from the Midway(?) formation of central Texas and from several localities in the upper Wilcox of the western embayment in Louisiana and Texas. Various authors have mentioned the difficulty of specific separation in dealing with the polymorphous leaves of *Cinnamomum*, Seward even expressing a doubt of the possibility of distinguishing the genus from certain unrelated genera, among which he mentions *Zizyphus*, *Cocculus*, *Viburnum*, and *Strychnos*.[49] Several additional genera might be mentioned, and it is undoubtedly true that this uncertainty exists when dealing with incomplete or poorly preserved material, and this criticism is appropriately applied to a number of records of supposed Cinnamomums in the literature of paleobotany.

However, I think that it has little point in connection with complete and well-characterized material. On the other hand, specific limits within the genus are always more or less indefinable. There are two general methods of attack. The first is that of most of the older authors, in which no difficulty was seen in considering superficial resemblances in material from any part of the world or from any geologic horizon to warrant the conclusion of specific identity. Whatever botanic interest this method may seem to have, it is obviously of but slight value in relation to questions of floral evolution and completely divorces the subject of any geologic value, in that the elements of both time and space are treated as if they were nonexistent.

The second and, on the whole, the more scientific method consists in the drawing of very fine lines of separation among fossil forms, in considering that analysis must precede synthesis, and in insisting that the factors of time and place have a most important bearing, even in cases where these can not be evaluated, as, for example, in such presumably polymorphous and cosmopolitan forms as have been called *Glyptostrobus europaeus*, *Taxodium dubium*, *Sequoia langsdorfii*, and *Diospyros brachysepala.*

For some forms, as in those cited above, the lines of separation can only be implied and not proved; in others a more scientific study will demonstrate actual differences. All this is relevant to the genus *Cinnamomum*, and especially to the group of forms that appear to me to be ancestral to this early Eocene species that has been called *Cinnamomum affine.*

There is present throughout the Upper Cretaceous of North America, both in the Atlantic Coastal Plain and in the western interior, a *Cinnamomum*-like leaf which has been called *Cinnamomum newberryi* Berry, as well as by several other names. It occurs in Greenland and possibly in the European Upper Cretaceous. I have recently discussed this form at considerable

[49] Seward, A. C., Roy. Soc. London Philos. Trans., ser. B, vol. 215, p. 123, 1926.

length,[50] and there is no need of repeating its supposed geographic and geologic range in this connection.

As it is abundant and typical in the latest Upper Cretaceous (Ripley formation) of the Gulf embayment region, one is inevitably led to consider that it stands in an ancestral relationship to the Eocene species *Cinnamomum affine.* If foliar fossils are worth anything they show that this type of *Cinnamomum* was holarctic in its distribution during the Upper Cretaceous; that during that time it spread from the Atlantic to the Pacific coasts of North America and reached Europe, either through Asia or the Arctic; that it was the progenitor of this Wilcox and Denver species in the United States; and that in all probability the European *Cinnamomum sezannense* Watelet of the "Paleocene" took its origin in this common ancestral stock.

As previously stated, this is not a common Wilcox type, being confined to the western shores of the Mississippi Gulf and appearing in those beds in central Texas which I would regard as Midway in age. In conformity with this distribution is its presence in the basal Eocene of the Rocky Mountain region.

Cinnamomum buchii Heer?

Cinnamomum buchii Heer, Flora tertiaria Helvetiae, vol. 2, p. 90, pl. 95, figs. 1–8, 1856.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 299, 1916.[51]

This species was identified by Hollick in 1899, in a collection of Wilcox plants from Coushatta, La., and, as I stated in 1916, I retained the name because it had been so used, although I have never been able to discover any reason why Heer differentiated *Cinnamomum buchii* and *Cinnamomum spectabile.* They surely represent a single botanical species, both are recorded with a considerable stratigraphic range, and in Europe are especially characteristic of the late Oligocene and basal Miocene, although the former has been recorded from the upper Eocene of Italy and Knowlton recorded the latter from beds of Fort Union age in the Yellowstone Park. This last record was based upon a single incomplete specimen,[52] and I doubt if the form bears any relationship to *Cinnamomum spectabile* or even represents the genus *Cinnamomum.*

As regards strict priority the name *buchii* precedes *spectabile* in Heer's work and should therefore be adopted if the two are considered identical. Granting that this is true, it is difficult to visualize the present form from the lower Eocene of southeastern North America as representing the very much younger European Tertiary type, and I have not the slightest doubt but that distinct botanic species are represented. The European name is, however, retained pending a satisfactory solution of the difficulty.

This species is one of the very few Wilcox species that has been found at but a single locality, and this fact alone would lead me to suspect that its peculiar form represented merely an abnormality of no systematic significance were it not for the fact that it appears to have been the end product of Upper Cretaceous ancestors in this same region. I refer to a *Cinnamomum* discovered in the Ripley, or latest Upper Cretaceous formation of the Mississippi Gulf, and which I described recently[53] as *Cinnamomum praespectabile.* This form was a medium to coarse, apiculate type, obviously related to the Wilcox form that masquerades under the name *Cinnamomum buchii.*

I am inclined to think that by reason of their age and geographic range both of these forms represent distinct but affiliated species, although, judging by what is exemplified in most recent species of *Cinnamomum,* as, for example, in *Cinnamomum camphora* Nees and Ebermaier, a single species may vary greatly in relative width from lanceolate to very broadly ovate-lanceolate, and the broader they become the more pronounced becomes the tendency for them to be apiculate and similar to the fossil forms mentioned above.

Genus PERSEA Gaertner

Persea fructifera Berry, n. sp.

Plate 33, figure 17

The single specimen that constitutes the type of this species is clearly referable to the Lauraceae and appears to represent the fruit of one of the Wilcox species of *Persea* that have been described from the leaves. The fruit is of considerable consistency, fusiform in shape, bluntly rounded at the apex, and about 1.7 centimeters in length by 9 millimeters in maximum diameter. The persistent receptacle shows no divisions, is rhomboidal in outline, ligneous in texture, and about 2 millimeters long by 3 millimeters in diameter at its upper border. The peduncle is stout and curved, about 1.5 centimeters in length.

Several other lauraceous fruits have been described from the Wilcox and referred to the noncommital form genus *Laurus,* but the present specimen is so like certain modern fruits of *Persea,* as well as fossil forms referred to that genus by Heer and others, that it appears safe to refer it directly to *Persea.*

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

[50] Berry, E. W., The flora of the Ripley formation: U. S. Geol. Survey Prof. Paper 136, pp. 75–77, 1925.

[51] The synonymy of this species is given in the paper cited.

[52] Knowlton, F. H., U. S. Geol. Survey Mon. 32, pt. 2, p. 727, pl. 94, fig. 6, 1899.

[53] Berry, E. W., The flora of the Ripley formation: U. S. Geol. Survey Prof. Paper 136, p. 7, pl. 17, figs. 4, 5, 1925.

Genus NECTANDRA Roland

Nectandra wilcoxensis Berry, n. sp.

Plate 40, figures 5, 6

I have brought together as representing a new species of *Nectandra* an abundant series of leaves from the later Wilcox which differ in outline between wide limits but which agree closely in texture and venation. In some features they resemble known species but differ from all these in the important feature of venation, which unites them as representing a hitherto undescribed form.

Leaves exceedingly variable in size and outline, ranging from lanceolate leaves with acuminate ends, like those of *Nectandra pseudocoriacea* Berry, to broadly lanceolate large forms, like the larger leaves of *Nectandra lancifolia* (Lesquereux) Berry. Widest in the middle region. Tips and base invariably acuminate and usually considerably extended. Texture coriaceous. Margins entire, inclined to be undulate. Length from 10 to 20 centimeters; maximum width from 1.75 to 5.5 centimeters. Petiole stout, of unknown length. Midvein stout, prominent on the under side of the leaf. Secondaries not especially stout, but prominent. They are numerous and subparallel, rather regularly and, for the genus, closely spaced, diverging from the midvein at acute angles, which are naturally wider in the wider leaves, ascending in sweeping camptodrome curves. The secondary and tertiary venation are the constant features among a large number of otherwise variable specimens. The tertiaries are thin but prominent, prevailingly at right angles to the secondaries, and closely spaced; they usually anastomose in the median region between adjacent secondaries, but one fork is generally thinner than the other, so that in appearance they seem to be somewhat irregularly percurrent. The areolation is distinct, prominent on the under side of the leaf, and typically lauraceous.

As already indicated, this species in some of its variants is superficially like one or the other of the previously described species of *Nectandra* that have been found in the Wilcox, of which six are known. The smaller leaves are almost identical in form with *Nectandra pseudocoriacea* Berry, but the secondaries are much more ascending, and the tertiary venation is more prominent and differs in the minor particulars mentioned above. All the other previously described forms have fewer secondaries. The larger leaves have an outline like *Nectandra glenni*, which has few irregularly spaced secondaries and different tertiaries and areolation. *Nectandra lancifolia* has more numerous secondaries than *Nectandra glenni*. It is relatively slightly shorter and broader than the new species and also differs in tertiary venation. *Oreodaphne mississippiensis* Berry and *Mespilodaphne eolignitica* (Hollick) Berry from the Wilcox have similar outlines to some varieties of the present species, but both differ decidedly in their venation. Only the smaller and narrower forms have been figured, but the larger and wider keep the venation pattern constant and are readily distinguished from all the numerous species of Lauraceae that have been found in this flora.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Nectandra parvula Berry, n. sp.

Plate 46, figures 3, 4

Leaves small, broadly lanceolate, generally falcate and often slightly inequilateral, widest medianly and tapering with full and rather evenly rounded margins to the equally acute apex and base. Texture coriaceous. Length from 3.25 to 5.25 centimeters; maximum width from 1.1 to 1.5 centimeters. Petiole short and stout, 4 or 5 millimeters in length. Midvein stout, curved, prominent on the under side of the leaf. Secondaries stout, prominent, six or seven opposite to alternate pairs, generally unequally spaced, diverging from the midvein at angles of about 45°, regularly curved ascending, camptodrome. Tertiaries typically lauraceous, well marked.

This small form differs from all the other Wilcox species of Lauraceae not only in size but in its symmetrically lanceolate form and nonextended tip. The specimens have every appearance of maturity and are too numerous to be interpreted as unusually small leaves of one of the previously described species. Superficially these leaves are more like the leaflets of *Cassia fayettensis* Berry than they are like any of the other members of the Wilcox flora. They differ but slightly from this species in form but have a stouter and more prominent venation—primary, secondary, and tertiary—and this is decisively lauraceous and not leguminous.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Genus OREODAPHNE Nees and Martius

Oreodaphne intermedia Berry, n. sp.

Plate 29, figures 8, 9

Leaves of small to medium size, narrowly ovate-lanceolate to ovate, widest below the middle, tapering upward gradually to the obtusely pointed apex. Base broadly rounded, slightly decurrent proximad. Margins entire. Texture subcoriaceous. Length 6.5 to 7 centimeters; maximum width 1.7 to 3.5 centimeters but generally narrower than this maximum. Petiole long and stout, not preserved for its complete length.

Midvein stout and prominent. Lateral primaries or basal secondaries stout, prominent, one on each side diverges from the midvein at an acute angle, at its base, and joins a branch of the lowest secondary near the margin in the median part of the leaf. Secondaries thin but well marked; about 4 pairs diverge from the midvein at generally wide angles, curve regularly upward, and are camptodrome; four or five laterals leave the outside of the lateral primaries at acute angles and are camptodrome. The tertiary venation percurrent at approximately right angles to the secondaries in the usual generic manner.

These generally narrow, stiff, and long-petioled leaves are of a type frequently seen in fossil and living species of *Oreodaphne*. In some respects they suggest certain fossil forms that have been referred to the genus *Cinnamomum*, as well as certain living Old World species of the genus *Litsea*.

The genus *Oreodaphne* is well represented in the large display of Lauraceae found in the Wilcox. Among previously described forms of this genus from beds of this age the present species is approached by two—*Oreodaphne salinensis* Berry [54] and *Oreodaphne puryearensis* Berry.[55] These forms are both larger leaves, widest medianly and narrowing almost equally to the apex and base. The first is relatively more elongate and with a shorter petiole; the second is broadly lanceolate instead of ovate lanceolate and the basal secondaries have not assumed the character of lateral primaries; it has, however, the same long petiole and the same textural and venation facies as *Oreodaphne intermedia*, which I regard, as the name indicates, as intermediate in character between these two previously described species, but one, however, that is specifically distinct.

Oreodaphne intermedia is not uncommon in the upper Wilcox of western Tennessee.

Occurrence: Holly Springs sand, west of Bolivar; Mill Creek; Bolivar-Jackson road just north of Clover Creek; all in Hardeman County, Tenn.

Genus MESPILODAPHNE Nees

Mespilodaphne coushatta Berry

Mespilodaphne coushatta Berry, U. S. Geol. Survey Prof. Paper 91, p. 307, pl. 80, fig. 6; pl. 87, fig. 3, 1916.

Specimens of this species from the locality cited below have quite different proportions from those previously collected, being 7 centimeters in length and 4 centimeters in maximum width. Otherwise they are identical with the type.

Occurrence: Holly Springs sand, Atkins pit, Henry County, Tenn.

[54] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 303, pl. 82, figs. 1, 2, 1916.

[55] Idem, p. 301, pl. 83, fig. 1.

Genus LAURUS of authors

Laurus collinsi Berry, n. sp.

Plate 19, figure 2; Plate 49, figure 9

It is not surprising that with so many species of Lauraceae in the Wilcox occasional specimens of flowers and fruits should be collected. Flowers were described from Tennessee in 1916,[56] and in a more recent publication [57] very typical fruits were described from Louisiana. It is usually impossible to identify such fruits generically, and they are therefore referred to the form genus *Laurus*, which is not used in the botanic sense in which it is applied to recent species.

The present species represents a second Wilcox species of lauraceous fruit and is named for the collector. It may be characterized as follows:

The whole fruit fusiform in shape, consisting of two parts—a prominent cupule formed by the accrescent calyx with its short and stout peduncle, and the inclosed berrylike fruit. The fruit is a considerably prolate spheroid, 8 to 9 millimeters in length by about 4 millimeters in maximum diameter, and is about half buried in the thick-walled cupule. The whole fruit including the peduncle is about 1.4 centimeters in length and 5 millimeters in maximum diameter.

There can be but slight doubt as to the propriety of referring this form to the Lauraceae, but its proper generic relationship can not be determined. It might represent any of the genera that are represented by foliage in the Wilcox flora. Among the fruits of recent species it is much like those of *Sassafras*, although I do not regard this as of more significance than showing the general family likeness.

Occurrence: Holly Springs sand, at western edge of La Grange, west of road and south of Southern Railway, Fayette County, Tenn.

Laurus hardemanensis Berry, n. sp.

Plate 19, figure 3

A third Wilcox species of fruit of some species of Lauraceae is represented by the cupule shown in the accompanying illustration as viewed from the proximal end. This cupule is relatively thin, ligneous, deeply excavated, slightly roughened, with a pronounced peduncular scar and traces of a 6-parted small calyx. Its generic relationship is uncertain.

Occurrence: Holly Springs sand, big cut on Gulf, Mobile & Northern Railroad at Pine Top, Hardeman County, Tenn.

[56] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 313, pl. 86, figs. 5, 6, 1916.

[57] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, p. 18, pl. 16, figs. 2–7, 1922.

Order MYRTALES

Family MELASTOMATACEAE

Genus MELASTOMITES Unger

Melastomites ovatus Berry, n. sp.

Plate 19, figures 4, 5

The present species differs but slightly in general outline from *Melastomites americanus* Berry,[58] which is common at a number of localities in the middle and upper Wilcox. It is, however, conspicuously different in venation. It is somewhat wider and less elongate, with a shorter and stouter petiole. The characteristic features of venation are the four acutely diverging and pseudo-acrodrome primaries from the base, which are subparallel with the margins, and the presence of an alternate pair of secondaries in the lower half of the leaf, which diverge from the curved midvein at very acute angles and which are acrodrome or are prevented from being strictly acrodrome by the interposition of a small curved secondary in the tip of the leaf. The tertiaries are thin, angularly anastomosing, and prevailingly transverse. None of the venation is prominent.

A comparison of the illustration of the venation of this species with that in the published figures of *Melastomites americanus* will show how strikingly different these two forms are in the characters of their venation.

Occurrence: Holly Springs sand, at western edge of La Grange, Fayette County, Tenn.

Melastomites verus (Berry)

Cinnamomum vera Berry, U. S. Geol. Survey Prof. Paper 91, p. 297, pl. 79, figs. 3–8; pl. 87, fig. 4, 1916.

Further comparison of this species, which has previously been recorded from Oxford and Holly Springs, Miss., and Puryear, Tenn., with recent material has demonstrated that it is not a *Cinnamomum* but is referable to the family Melastomataceae, greatly resembling the leaves of the tropical American genus *Tococa* Aublet.

The venation, especially the number of lateral primaries, is not that of *Cinnamomum*.

Recently collected material shows that the leaves were probably hirsute, for the well-preserved impressions in the very fine grained clay show the leaves to be covered with uniform and regularly distributed dots.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

[58] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 327, pl. 97, figs. 1–3, 1916.

Family MYRTACEAE

Genus MYRCIA De Candolle

Myrcia vera Berry

Plate 36, figure 3

Myrcia vera Berry, U. S. Geol. Survey Prof. Paper 91, p. 314, pl. 90, fig. 3, 1916.

The leaf of this species figured from Carroll County, Tenn., differs from the normal in its larger size and more falcate form. It is about 8 centimeters long and 2.2 centimeters in maximum width, in other respects being typical of this species. It is found to be widely distributed in the Wilcox, being present at that time along both the eastern and the western shores of the Mississippi Gulf.

Occurrence: Holly Springs sand, Oxford, Lafayette County, Miss.; La Grange, Fayette County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Puryear, Henry County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn. Wilcox formation, Boydsville, Clay County, and sec. 10, T. 14 S., R. 21 W., Nevada County, Ark.

Family COMBRETACEAE

Genus COMBRETUM Löfling

Combretum leve Berry, n. sp.

Plate 29, figures 3, 4

Three species of *Combretum*, in addition to flowers described as *Combretanthites*, have been recorded from the Wilcox. The present species adds a fourth well-characterized form, which may be described as follows:

Leaves of medium to large size, ovate, with an acute tip and a broadly rounded or broadly cuneate, slightly decurrent base. Margins entire but noticeably undulate. Texture subcoriaceous. Length 12 to 18 centimeters; maximum width, in the lower half of the leaf, 5.5 to 8 centimeters. Petiole very stout, its full length not preserved. Midvein stout, prominent. Secondaries stout, eight or nine somewhat irregularly spaced pairs, diverging from the midvein at angles of 45° or more, curving upward parallel with the lateral margins, along which they form loops. Tertiaries fairly stout but largely immersed, partly percurrent and partly inosculating midway between the secondaries. Areolation obsolete.

This species resembles somewhat *Combretum obovale* Berry, differing from that form especially in the wider base and pointed apex and the more ascending secondaries.

Occurrence: Holly Springs sand, Smiths Church, three-fourths mile northwest of Pattersonville, Fayette County, Tenn. Grenada formation, Somerville-Williston road, Fayette County, Tenn.

Combretum wilcoxense Berry

Plate 31, figure 2

Combretum wilcoxensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 321, pl. 89, figs. 1, 2, 1916.

The specimen here figured, found west of Bolivar, shows the observed limits of narrowness and ovateness in this species. The species was described originally from Puryear and has been found to be sparingly represented but rather widely distributed in the Wilcox, occurring in both the eastern and the western Gulf areas.

Occurrence: Holly Springs sand, west of Bolivar and doubtfully 2¼ miles north of Shandy, Hardeman County, Tenn.; 1½ miles northeast of Williston, Fayette County, Tenn.; Puryear, Henry County, Tenn. Carrizo sandstone, 5 miles northeast of La Pryor, Zavala County, Tex.

Genus LAGUNCULARIA Gaertner

Laguncularia preracemosa Berry

Laguncularia preracemosa Berry, U. S. Geol. Survey Prof. Paper 91, p. 320, pl. 95, figs. 4–8, 1916.

Both the foliage and the associated fruits of this species were described from the Holly Springs sand in 1916. These materials are now combined in the restoration shown in Figure 27, which is based on the habit of the existing *Laguncularia racemosa* Gaertner, for which the fossil species was named.

The small size and lack of carpellary swelling of these fruits suggest that they were probably immature, but they have not been modified from their actual fossil condition.

Genus TERMINALIA Linné

Terminalia vera Berry

Plate 49, figures 21–27

Terminalia vera Berry, Torrey Bot. Club Bull., vol. 53, p. 61, figs. 1–5, 1926.

This species is based upon the rather abundant winged fruits of a *Terminalia*, which may very well represent one of the described Wilcox species based upon foliar remains. It may be described as follows: Fruits elongate, bialate, elliptical in outline, pedunculate, consisting of an axial thickened fusiform seed cavity, ligneous in appearance as preserved as a carbonaceous impression. This seed cavity extends from the area near the base almost to the tip of the fruit and occupies from one-third to one-half of its transverse diameter. The wings are scarious, very finely veined, truncate or rounded proximad and more or less emarginate distad, with entire margins. The venation is thin and largely immersed in the wing substance; it is reticulate throughout and apparently all of one caliber; over the seed cavity it is prevailingly longitudinally elongated, the long axis of the meshes curving outward toward the margins of the seed cavity, where they pass outward onto the wings and are there transverse below, becoming more ascending toward the tip of the fruit.

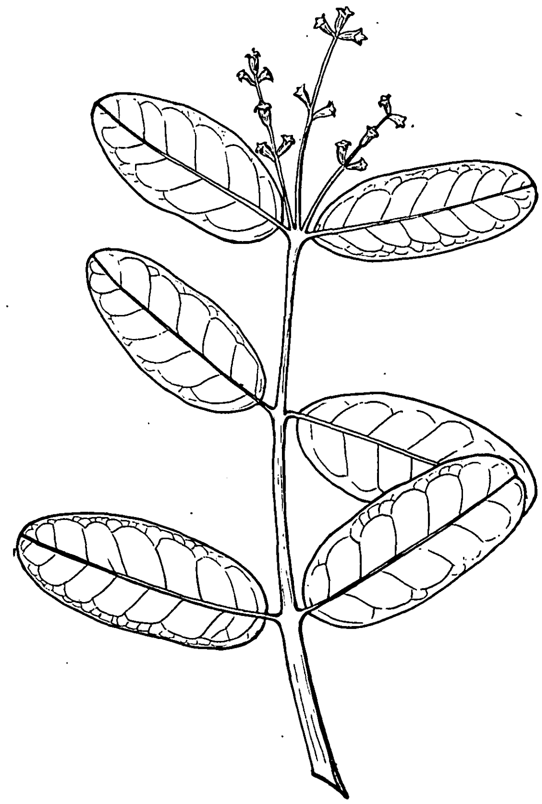

FIGURE 27.—Restoration of *Laguncularia preracemosa* Berry

These fruits vary considerably in size and in the degree of elongation of their elliptical outline. The peduncle is short, stout, generally curved and about 4 millimeters in length; it is usually broken off before fossilization but is preserved in some specimens. The whole fruit ranges from 1.7 to 3.5 centimeters in length and from 1 to 1.5 centimeters in maximum width, which is midway between the apex and the base.

These fruits are readily distinguishable from the somewhat similar Wilcox fruits, which have been referred to *Ptelea*, *Dodonaea*, and *Carpolithus prangosoides* Berry, and there is not the slightest doubt that they represent the genus *Terminalia*.

This genus comprises over 100 existing species, which are usually segregated into four sections according as the fruit is fleshy, ligneous, or variously winged. The present fossil form obviously belongs in the section Diptera, which is represented in modern floras in South America, Asia, and Africa.

I have made comparisons with as many winged fruits of *Terminalia* as I had opportunity to study, although I have only seen about 10 per cent of all the species. All of the American bialate forms that I have seen have the wings transversely extended so that the fruits are much wider than high. On the other hand, existing forms with the proportions of these fossils are to be found in both African (for example, *Terminalia brownei* Fresen of Abyssinia) and Asiatic species (for example, *Terminalia darlingii* Merrill of the Philippines). In fact, the last is extremely close to the fossil. Whether the greater

FIGURE 28.—Restoration of *Terminalia* from the Wilcox

resemblance of this Eocene form to existing African and Asiatic forms has any significance, or whether there are existing American forms with fruits of this character I can not say—I have not seen any.

A considerable number of fossil forms have been referred to *Terminalia*. These species have usually, although not entirely, been based upon leaf remains. In southeastern North America two species based upon leaves and a third, based upon fruits of the *Catappa* type, have already been described from the Wilcox group (lower Eocene). There are two additional leaf species in the Claiborne group (middle Eocene), and one of these continues into the Jackson (Upper Eocene).

Occurrence: Holly Springs sand, Grable pit and Puryear, Henry County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; 100 yards east of Bell City Pottery pit, Calloway County, Ky.

Restorations have been attempted of two species of *Terminalia* based upon two species of foliage and two distinct types of fruit. As there is no evidence to show which type of leaf was associated with the winged and which with the nutlike fruit, the restorations are, to this extent, uncertain.

The leaves of *Terminalia lesleyana* (Lesquereux) Berry are common in the Ackerman formation and Holly Springs sand of the eastern embayment and in the middle or upper Wilcox of the western embayment. With this foliage I have associated the winged *Terminalia* fruits described as *Terminalia vera* Berry, which are common in the upper part of the Holly Springs sand in northwestern Tennessee and western Kentucky. (See fig. 28.) The habit is based on the existing *Terminalia chebula* Retz.

The second restoration (fig. 29) is based upon the foliage described as *Terminalia hilgardiana* (Lesquereux) Berry, a common foliar type from the bottom to

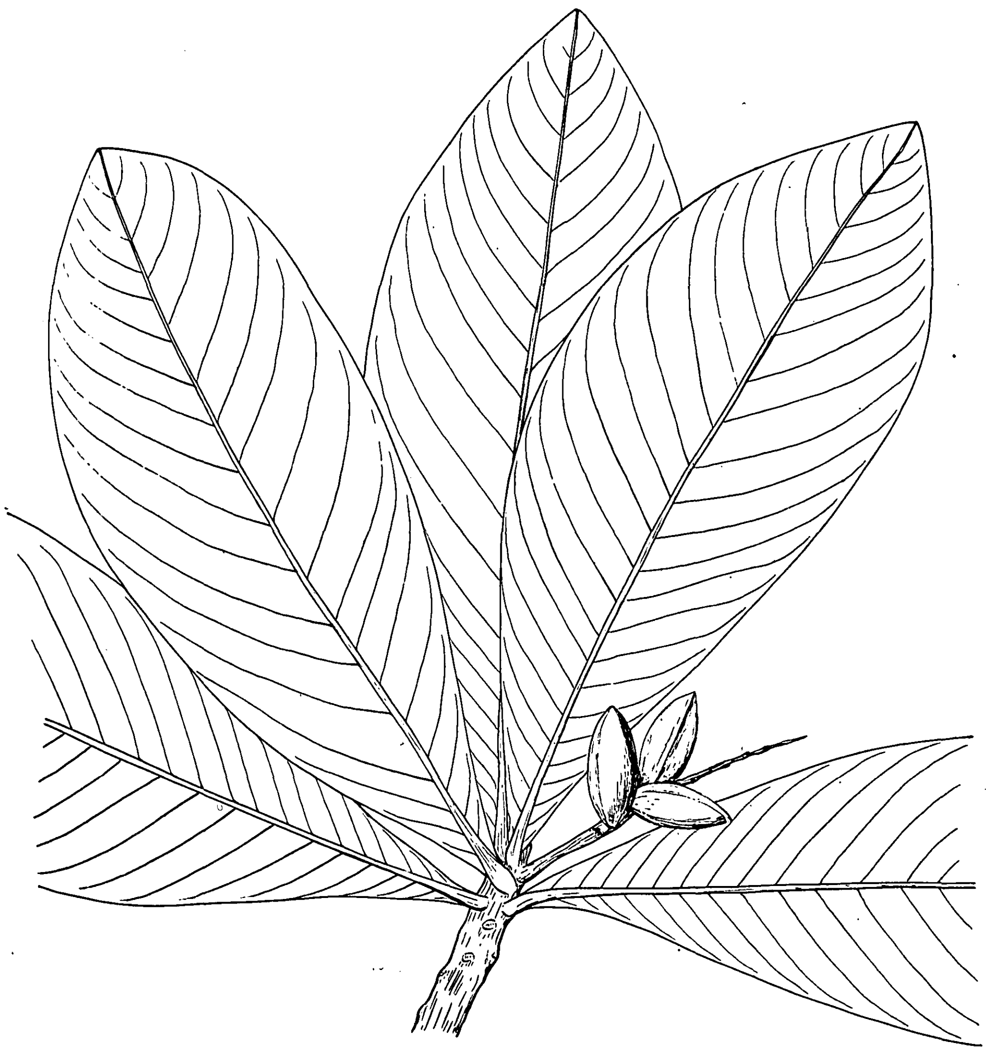

FIGURE 29.—Restoration of *Terminalia* from the Wilcox

the top of the Wilcox from Mississippi to Texas. This form is combined with the nutlike fruits described as *Terminalia wilcoxiana* Berry, which is associated with this type of foliage at Puryear, Henry County, Tenn. The habit is based on the existing *Terminalia catappa* Linné.

Order UMBELLALES

Family ARALIACEAE

Genus OREOPANAX Decaisne and Planchon

Oreopanax wilcoxensis Berry, n. sp.

Plate 20; Plate 21, figures 1–4

Leaves relatively small, with long, stout petiole. Lamina palmately divided by deep sinuses into two to five lanceolate lobes. These lobes are widest medianly, tapering to the acute tips and proximad to the narrow sinuses. Margins strictly entire and evenly curved. Leaf substance fairly stiff but not thick. The lobes increase in size from the lower laterals to the terminal median one. In the nearly perfect specimen of this species from Tennessee figured the dimensions are: Terminal, 8.5 centimeters long by 1.9 centimeters wide; intermediate, 7.25 centimeters long by 1.9 centimeters wide; lateral, 5.5 centimeters long by 1.6 centimeters wide.

An incomplete specimen from Texas also figured has but four well-developed lobes, one lateral being much reduced and the other represented by an acuminate projection from the intermediate. The dimensions of this specimen are: Terminal, 2 centimeters wide; intermediate, 1.4 and 2.25 centimeters wide; and lateral, 9.5 millimeters wide.

The distal parts are gone, so lengths can not be given but are comparable to those given for the specimen from Tennessee, except that the lateral is only about 3.5 centimeters in length. One fragmentary specimen has a median lobe 11 centimeters long and 3 centimeters wide.

The deep sinuses in both specimens narrow toward the base, so that the margins of the lobes may overlap slightly; they extend to less than 1.5 centimeters of the top of the petiole, giving the specimens the appearance at first sight of being compound and well illustrating the way the sections Lobatae and Digitatae of the genus *Oreopanax* intergrade.

The two-lobed, three-lobed, and four-lobed specimens are all smaller than the five-lobed, which may be considered the normal form of the species, whereas the two, three, and four-lobed forms may be regarded as young or impoverished leaves. The smallest three-lobed specimen, which is but 2 centimeters in length and 2.75 centimeters in maximum width, has relatively wide lobes and an incipient basal lobe on one side and would doubtedless grow into a normal four-lobed or five-lobed leaf. The three-lobed leaves are all relatively small but not uncommon. In these leaves the lateral lobes may be widely spread or ascending. Specimens showing each extreme are figured.

The petiole is stout and was presumably long but is only preserved in lengths of 1.25, 1.5, 1.75, 2, and 2.75 centimeters.

The primaries diverge from the top of the petiole and are as numerous as the lobes. They diverge at acute angles and in the normally five-lobed leaves the laterals are almost exactly at right angles to the petiole. They are comparatively straight, stout, and prominent on the under side of the leaf. The secondaries are very numerous, thin, subparallel, and camptodrome.

This characteristic species belongs to the section Lobatae, into which Harms segregates the genus *Oreopanax*, thus differing from the two previously described Wilcox species, which belong to the section Digitatae. In these forms I can see no warrant for perpetuating the use of the more or less meaningless generic term *Aralia*, three species of which have been recorded from the Wilcox. It is possible, although I regard it as improbable, that the trilobate leaf from the Grenada formation, which was referred doubtfully to *Aralia jorgenseni* Heer, may represent a trilobate form of *Oreopanax wilcoxensis*. Only a complete series of forms would establish this supposition.

That statements of abundance or rarity of a fossil species have to be made with extreme caution is illustrated by the present species, which is based upon numerous leaves at one locality in Tennessee, a few at a second near-by locality in Tennessee, and a single distorted specimen from Texas 850 miles southwest of the localities in Tennessee, indicating an abundance that must have been out of all proportion to the specimens discovered.

The section Lobatae of Harms includes a large number of the fossil species that have been referred to *Aralia*. It includes more than a score of existing species of the Antilles and Central and South America.

Occurrence: Holly Springs sand, Mill Creek (common); gully west of Illinois Central Railroad, 2¼ miles north of Shandy; Bolivar, west of hospital; all in Hardeman County, Tenn. Carrizo sandstone, east bank of Nueces River, 5 miles N. 30° E. of La Pryor, Zavala County, Tex. (collected by G. Jeffreys).

Oreopanax wilcoxensis crenulatus Berry, n. var.

Plate 27, figure 3

Although several specimens of this form have been collected, the only reasonably complete one is that figured. It represents a deeply bilobed leaf, with a cuneate base. The stout primaries diverge at an acute angle from the extreme base, curving slightly inward and constituting the midveins of what practically amounts to a bifoliate leaf, for the narrowly rounded central sinus that separates the two lobes extends within a centimeter of the base. Above the basal part each lobe is practically symmetrical and lanceolate or slightly falcate, rather abruptly acute at the tip. The margin, which is entire for the lower third, is beset with somewhat flattened crenate teeth for the upper two-thirds of its course, the crenulations dying out in the tip. The secondaries are regularly spaced and subparallel, diverging from the primaries at angles of more than 45°; they are regularly curved and camptodrome. The tertiaries can not be made out.

There is a great deal of uncertainty regarding the nature and affinities of this form and whether it is to be regarded as a characteristic form of foliage of some lower Eocene plant or an abnormality, either in the form of a crenulated leaf of a normally entire margined form, or a normally bifoliate leaf which is partly concrescent, as of a *Hymenaea*, for example, or a palmately bilobate form of a species with normally several lobes. An alternative interpretation, which has some reasons to commend it, would be to consider this form to be an anomalous leaf of *Oreopanax wilcoxensis*, which is occasionally bilobate, though normally with a greater number of lobes, and this latter is the course adopted after much thought.

Oreopanax is rather common at the same outcrop and is variable in the number and development of its lobes. The general form, size, texture, and venation of these lobes is very close to that of the present variety, and the chief difference is the entire margin of the one and the crenate margin of the other, but the existing species of *Oreopanax* indicate that this is not a bar to relationship.

The only fossil anything like the present one is *Hymenaea primigenia* Saporta [59] in which the leaflets are larger and petiolulate. This is compared by Velenovsky with the existing leguminous genera *Hymenaea*, *Bauhinia*, and *Inga*. Another species described by Velenovsky as *Hymenaea inaequalis* [60] is entire or sparingly toothed and also petiolulate. Both are from the Cenomanian of Bohemia.

I was at first disposed to refer the present species to the form genus *Leguminosites* and to point out its similarities to *Hymenaea* and *Bauhinia*, characteristic species of both having been found in the Upper Cretaceous of the Gulf Coastal Plain, but after studying the leaves of both the fossil and existing species of these genera, I have become convinced that the present fossil can not belong to the leguminous alliance, and I have given above the reasons, which seem to me sufficient to warrant the description of the present form as a variety of the contemporaneous *Oreopanax wilcoxensis*.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northeast of Shandy, Hardeman County, Tenn.

Genus SCHEFFLERA Forster

Schefflera formosa Berry, n. sp.

Plate 30, figures 9–12; Plate 44, figure 17

The leaflets of this species have been under observation for several years, and a large number of leaves of existing genera has been passed in review in an effort to arrive at their botanical affinity. A considerable amount of fossil material has been collected, and it has been found possible to readily distinguish these leaflets from those of the many diverse genera with lanceolate or ovate lanceolate leaves that are represented in the Wilcox flora. The restoration of the complete leaf shown in Figure 30 is hypothetical with respect to the number of leaflets, a somewhat variable feature in the existing species of *Schefflera*, and in the length of the common petiole. As conceived from the analogy of the recent digitate species, it shows a large leaf with a long, stout petiole and six long-stalked, digitately arranged leaflets. If the leaflets were considered to have numbered from 5 to 7 this restoration would probably represent the form accurately.

The leaflets show considerable variation in size and outline, ranging from relatively short ovate-lanceolate forms, through lanceolate to linear lanceolate; they are not obviously inequilateral, but one side of the lamina is invariably wider than the other. In length they range from 5.5 to 15 centimeters. The collection contains fragments of leaflets that are broader than any of the complete leaflets, but whether these were correspondingly elongated can not be determined. The maximum width is invariably in the lower half of the leaflet and ranges from 1 to 3.2 centimeters. The base is rounded or abruptly rounded-acute, in some specimens slightly inequilateral. The leaflets taper upward to an abruptly acute or obtusely pointed tip. The margins are entire but tend to be faintly to considerably undulate in the larger forms. The texture is subcoriaceous. The petiolules are stout and long; their full extent is preserved only in the smaller leaflets, where its length ranges from 1.75 to 5 centimeters. Midvein stout and prominent. Secondaries relatively thin but well marked, somewhat remotely spaced; they diverge from the midvein at wide angles, commonly approaching 90°; they tend to be relatively straight in their early courses, particularly in the smaller leaflets; as they approach the margins they

[59] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, Teil 3, p. 9, pl. 5, fig. 4; pl. 6, figs. 1–4, 1884.
[60] Idem. p. 9, pl. 6, figs. 2, 5.

sweep upward in broad curves and are camptodrome. The tertiaries are thin, percurrent toward the margins, but forming an open quadrangular or polygonal mesh in the central part of the lamina, where the space between the secondaries is greatest.

This handsome species adds a striking new element to the flora of the upper Wilcox. It is closely simulated by several existing species of *Schefflera* (=*Sciadophyllum* P. Browne), although some of these species tend to have broader, more rounded tips.

The genus *Schefflera* contains a large number of widely distributed shrubs and trees in the existing flora, where they are confined to the warmer parts of

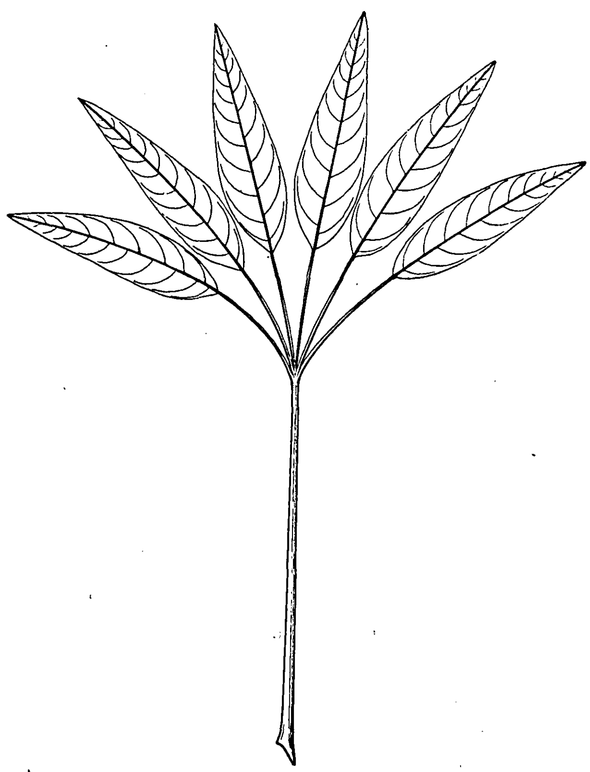

FIGURE 30.—Restoration of a complete leaf of *Schefflera formosa* Berry

America, Africa, Asia, and Australia. There are a large number of American species in the region between Mexico and the Antilles on the north and eastern Peru and Brazil on the south.

Several fossil species of the so-called Aralias have been rather definitely correlated with *Schefflera*. These species include a not very decisive form from the early Tertiary of western Greenland identified by Heer,[61] two Oligocene species from France described by Saporta,[62] and Miocene species in France and Bohemia described by Saporta[63] and Ettingshausen[64] respectively.

All of these show similarities and essential features in common with one another and existing species, and all are much like the Wilcox species in general facies. Among these *S. gaudini* is perhaps the most similar to the Wilcox form, which may be compared with numerous existing forms of tropical America, among which may be mentioned *Schefflera brownei*, *S. rubiginosa*, and *S. villosa*. Only a single specimen from the locality west of Bolivar can be considered to afford definite proof of the habit. This specimen is a small but characteristic leaflet, the petiolule of which is attached to a similar petiolule whose leaflet is missing.

Occurrence: Holly Springs sand, west of Bolivar and on Mill Creek, Hardeman County, Tenn.; Somerville-Williston road, Fayette County, Tenn.

Schefflera? elliptica Berry, n. sp.

Plate 41, figure 10

Leaflets small, elongate elliptical, widest medianly and tapering slightly to the equally rounded apex and base. Margins entire. Texture subcoriaceous. Length about 3.5 centimeters; maximum width about 1.1 centimeters. Petiolule stout, about 1 centimeter in length. Midvein stout, prominent, curved. Secondaries numerous, stout, regularly spaced, subparallel, and camptodrome, diverging from the midvein at angles between 60° and 70°, and rather straight in their courses. Tertiaries thin but well marked, mostly at right angles to secondaries and inosculating in the middle region between them but including some from the midvein subparallel with the secondaries. Areolation fine, indistinct.

This form appears to be congeneric with the well-marked Wilcox form *Schefflera formosa* Berry, differing, however, in well-marked specific characters which are obvious from a comparison of the figures without the necessity of enumeration.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

Genus ARALIA of authors

Aralia? semina Berry, n. sp.

Plate 8, figures 2, 3

Seeds small, more or less unsymmetrically elliptical, compressed, longitudinally broadly and shallowly ribbed, with about 10 ribs. Length about 3 millimeters; maximum width about 1.5 to 2 millimeters.

[61] Heer, Oswald, Flora fossilis arctica, Band 2, p. 476, pl. 42, figs. 6–8, pl. 49, fig. 4e, 1871.

[62] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, pp. 231, 232, pl. 9, figs. 2, 3, 1863.

[63] Idem, vol. 2, p. 299, pl. 9, fig. 3, 1865.

[64] Ettingshausen, Constantin von, Die fossile Flora des Tertiär-Beckens von Bilin, Teil 3, p. 2, pl. 40, fig. 1, 1869.

These seeds are abundant at the locality cited below. Although the features shown by the fossils are scarcely sufficient to establish their affinity with certainty, they appear to represent the family Araliaceae, and they are tentatively so considered and referred to *Aralia*, which must be regarded as a form genus. Leaves of several species of Araliaceae, described in *Aralia*, *Oreopanax*, and *Schefflera* are not uncommon in the Wilcox, and these seeds may represent any one of these.

Occurrence: Holly Springs sand, pit of Bell City Pottery, Calloway County, Ky.

Family CORNACEAE

Genus NYSSA Linné

Nyssa tennesseensis Berry, n. sp.

Plate 19, figure 9

Leaves of medium size, ovate, widest below the middle. Apex acute. Base cuneate, slightly acuminate at the top of the petiole. Margins entire, slightly irregular-undulate. Texture subcoriaceous. Length about 7.5 centimeters; maximum width about 3.75 centimeters. Petiole very stout, curved, about 1.5 centimeters in length. Midvein stout, prominent, curved. Secondaries stout, about nine irregularly spaced pairs, diverging from the midvein at varying angles, about 45° above, greater in lower half of the leaf, camptodrome. Tertiaries mostly obsolete.

This species appears to be referable to *Nyssa*, and among the few fossil leaves of this genus that have been described it is similar to *Nyssa lanceolata* Lesquereux [65] of the Raton and Denver formations of Colorado. It differs from that species in its less ascending secondaries and more tapering upper half.

Several typical species of *Nyssa* based upon characteristic stones have already been described from the Wilcox, but this is the first leaf of this genus to be recognized; in fact, leaves of *Nyssa* appear to be generally rare as fossils. Possibly this is more apparent than real and is based on lack of recognition, for the stones have been recorded in abundance from many geologic horizons ranging in age from Upper Cretaceous to Pleistocene. A few leaves with approximately this same geologic range have been described.

No stones have been found at this outcrop, but they are present at this horizon in near-by areas.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

[65] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 343, pl. 108, fig. 1; pl. 113, fig. 2, 1918.

Nyssa curta Perkins

Plate 19, figure 10

Nyssa curta Perkins, Vermont State Geologist Rept., 1903–4, p. 199, pl. 79, fig. 111, 1904; Idem, 1904–1905, p. 219, pl. 57, figs. 4, 6, 1906.

This supposed species of *Nyssa* was briefly described by Perkins from the lignite at Brandon, Vt. It seems doubtfully related to *Nyssa* and is similar to a considerable variety of fossil fruits that have been referred to genera like *Nyssa*, *Viburnum*, and *Cornus*. There is little to be gained by comparing it with a variety of fruits in recent genera which it resembles, and its

FIGURE 31.—Restoration of *Nyssa*

chief interest is in its apparent identity with the Brandon fossil.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.

The restoration shown in Figure 31 represents a combination of the foliage from Mill Creek, Tenn., described as *Nyssa tennesseensis* Berry and drupes whose contours are derived from the stones of *Nyssa eolignitica* Berry like the Puryear specimen shown in another publication.[66] The flesh is conceived to have been thin, and the large size of the stones suggests a fruiting habit like that of the existing *Nyssa ogeche* Marsh or *N. aquatica* Marsh, rather than that of the existing *Nyssa sylvatica* Marsh or *N. biflora* Walter. The length of the peduncle in the restora-

[66] U. S. Geol. Survey Prof. Paper 91, pl. 99, fig. 8, 1916.

tion is problematic and is made intermediate between *N. ogeche* and *N. aquatica.* The stones of *Nyssa* are not uncommon in the Wilcox deposits, and two other nominal species have been described, both considerably smaller than those of *Nyssa eolignitica.* Those of *Nyssa wilcoxiana* Berry are especially common and vary greatly in size, some of them approaching *Nyssa eolignitica* but more pointed. It is possible that one of these other species of stones belongs to the same botanic species as the leaves; if so, the restoration should be modified by representing the drupes as smaller and slightly less spheroidal.

Occurrence: Wilcox formation, Naborton, La. Holly Springs sand, of Wilcox group, Saulsbury and west of Bolivar, Hardeman County, Tenn.; Puryear, Henry County, Tenn.; Bell City Pottery pit and 100 yards west of the pit, Calloway County, Ky.

Nyssa wilcoxiana Berry

Plate 19, figures 6–8; Plate 39, figures 8, 9

Nyssa wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 331, pl. 99, figs. 5–7, 1916.

This form shows a great deal of variability and possibly represents something more than the normal variation of a single botanic species. There are not only great extremes in diameter for the same length but differences in the prominence of the ribs.

In the narrow stones, such as those figured from Hardeman County, Tenn., the long axis is not straight but slightly curved and the two ends are nearly equally pointed. The specimens from Kentucky are somewhat atypical and are tentatively determined. These stones are not found at a large number of localities but occur in the Holly Springs sand and its probable equivalent in both the eastern and western parts of the embayment and are not uncommon at the localities where they occur.

Superorder GAMOPETALAE

Order EBENALES

Family EBENACEAE

Genus DIOSPYROS Linné

Diospyros eolignitica Berry, n. sp.

Plate 27, figure 4

Leaves of medium size, ovate-acuminate, widest below the middle, tapering upward to the acuminate apex, the lower margins broadly rounded to the widely cuneate base. Margins entire, evenly rounded. Leaf substance rather thin. Length about 12 centimeters; maximum width about 5 centimeters. Petiole stout, about 1 centimeter in length. Midvein stout and prominent. Secondaries stout, seven irregularly spaced and commonly subopposite pairs; they diverge from the midvein at angles of 45° or more, sweep upward in broad subparallel curves, and are camptodrome. Tertiaries relatively stout and well marked, forming an open quadrangular or polygonal mesh.

This is the third species of *Diospyros* in the Wilcox flora based upon foliar remains. The present is readily distinguished from the other two species but is, on the other hand, very similar to a number of fossil species described from other horizons, as well as a considerable number of existing species in this large genus.

Occurrence: Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark. Holly Springs sand, of Wilcox group, west of Bolivar, Hardeman County, Tenn.

Diospyros madisonensis Berry, n. sp.

Plate 36, figure 6

Calyx relatively small, gamosepalous, divided into four round-tipped coriaceous veinless lobes about as long as broad. Total diameter 1.25 centimeters. Clearly distinct from previously described forms.

The present form is the second distinct type of *Diospyros* calyx discovered in the Wilcox, and it is readily distinguishable from the rugose calyx of *Diospyros asper* Berry. Leaves of three nominal species of this genus are also more or less widely distributed in the Wilcox deposits, and although these calices probably represent one or the other of these leaf species they are not found closely associated, and there is no clue to their interrelationships, so that of necessity all have been given different names.

Diospyros calices are not at all uncommon in the Tertiary, and a rather characteristic calyx about the same size as the present form is found in the Upper Cretaceous of the Atlantic Coastal Plain [67] associated with the leaves known as *Diospyros primaeva* Heer. In the European Tertiary calices referred to the leaf species *Diospyros brachysepala* are very similar to this Wilcox calyx in size and outline, but the sepals have mucronate tips instead of being evenly rounded.[68]

From the evidence of these two types of Wilcox calices the Wilcox persimmons had much smaller fruits than *Diospyros miriflorianа* [69] of the Jackson Eocene of this general region. A calyx very similar to that of *Diospyros madisonensis* and considered a variety of it, is present in the Yegua formation of Texas.

Occurrence: Holly Springs sand, one-fourth mile south of Mandy, Madison County, Tenn.

[67] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 418, pl. 19, fig. 5, 1911.

[68] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, p. 11, pl. 102, figs. 10–12, 1859.

[69] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 195, pl. 40, fig. 5, 1924.

Diospyros asper Berry, n. sp.

Plate 25, figure 32

Calyx relatively small, four-parted, rugose through the development of pointed papillae. Divisions wide, conically pointed. Intervening sinuses shallow. Diameter about 1.75 centimeters. Calyx lobes about 6 millimeters long and 6.5 millimeters wide at the base, of a coriaceous consistency. The concrescent calices of this genus differ greatly in size and are either four-lobed or five-lobed. The genus is a large one both in the Tertiary and recent floras and goes back with unaltered characters as far as the Upper Cretaceous. A considerable number of modern species have rugose calices much like the present fossil. For example those of the Indian species *Diospyros lanceolata* Roxburgh are four-parted and almost exactly like the present species in size, outline, and ornamentation. A somewhat similar fossil form, with five instead of four sepals, however, is *Diospyros rugosa* Saporta [70] of the Oligocene of southeastern France.

A number of *Diospyros* leaves have been recorded from the Wilcox, and the genus is represented in southeastern North America from the Upper Cretaceous throughout the Eocene, a very characteristic calyx being recorded from the upper Eocene.

The present species may, of course, represent the same botanic species as the Wilcox leaves, although no *Diospyros* leaves have been found in association with the calyx at the Mill Creek locality.

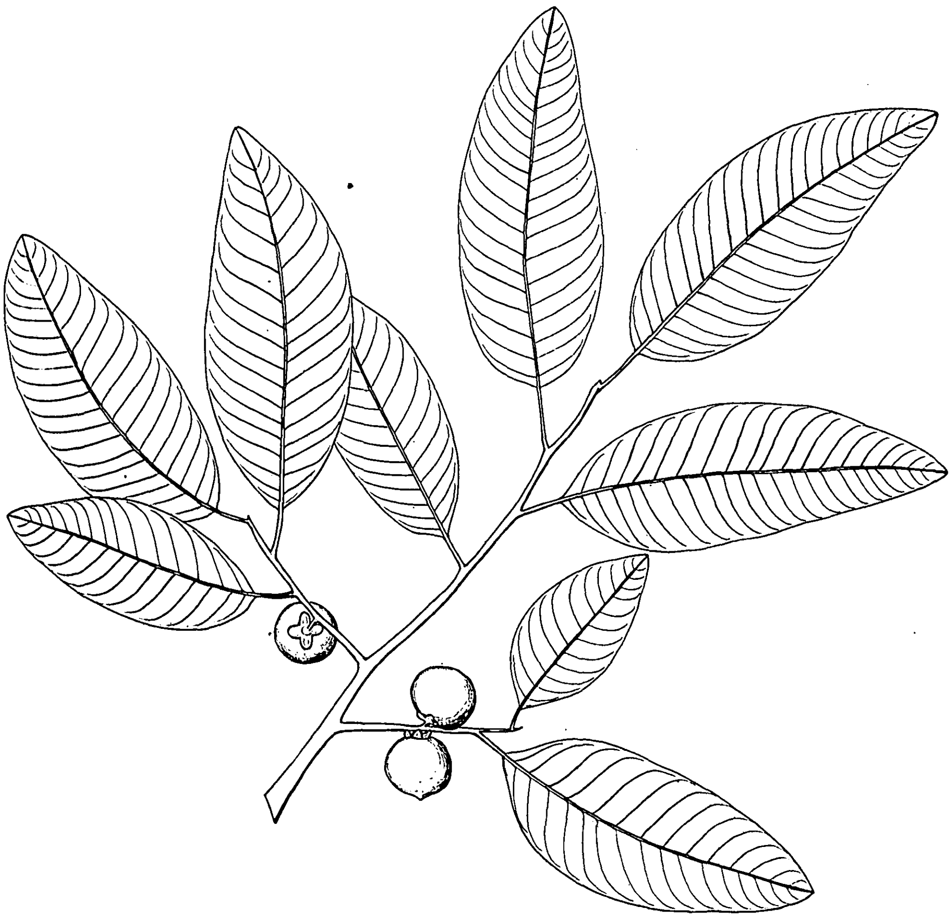

FIGURE 32.—Restoration of *Diospyros*

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

Diospyros sp.

What appears to be a calyx of a species of *Diospyros*, although too poorly preserved for description, is represented by a single specimen and its counterpart. It is considerably larger than the calyx of *Diospyros madisonensis* Berry and about the size of the calyx of the existing *Diospyros virginiana* Linné, being about 2.5 centimeters in maximum diameter. Whether or not it represents a new species can not be determined.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

[70] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 111, pl. 11, fig. 3, 1863.

Diospyros wilcoxiana Berry

Plate 47, figure 3

Diospyros wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 334, pl. 101, figs. 1, 2, 1916.

The magnificent specimen from Puryear figured herewith is complete in every way. It shows a leaf somewhat longer and narrower than the type with about equally pointed apex and base, a stout prominent midvein and secondaries, a slightly undulate margin, and a stout petiole about 1.5 centimeters long.

The leaf figured has a length of 19 centimeters and a maximum width of 5.5 centimeters and must be regarded as near the maximum of size for this species. It is very abundant at Puryear and occurs at three additional and widely scattered localities on both shores of the Wilcox Mississippi Gulf of late Holly Springs age.

The restoration of *Diospyros* shown in Figure 32 is based on the robust foliage of *Diospyros wilcoxiana* Berry of the upper part of the Holly Springs sand in the upper embayment region. With it are associated the calices described as *Diospyros madisonensis* Berry from a near-by locality at about the same horizon. From the size of the calyx the fruits are inferred to have been of small size, and the general habit is that of *Diospyros virginiana* Linné and other existing species.

Occurrence: Holly Springs sand, of Wilcox group, west of Bolivar, Hardeman County, Tenn.; Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.; Puryear, Henry County, Tenn. Wilcox formation, Mansfield, La.

Family SAPOTACEAE

Genus BUMELIA Swartz

Bumelia americana (Lesquereux) Berry

Plate 19, figures 11, 12

Bumelia americana (Lesquereux) Berry, U. S. Geol. Survey Prof. Paper 91, p. 337, pl. 100, fig. 6, 1916.

This upper Wilcox species was described from a locality near Somerville, Tenn., by Lesquereux as a species of *Sapotacites*. It also occurs at Puryear and at the new locality cited below.

Occurrence: Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn. Grenada formation, 1 mile south of Somerville and 1.2 miles south of Somerville, Fayette County, Tenn.

Bumelia pseudolycioides Berry, n. sp.

Plate 44, figure 20

Leaves of medium size, oblanceolate to slightly obovate, with abruptly pointed tip and narrowly cuneate decurrent base. Margins entire. Texture coriaceous. Length about 4.25 centimeters; maximum width, slightly above the middle, about 1.4 centimeters. Petiole long for the genus, stout, curved, about 1.5 centimeters in length. Midvein stout, curved. Secondaries stout, about six pairs, diverging from the midvein at angles of 45° or less, ascending subparallel with the lateral margins. Tertiaries obscure.

The type has the two halves of the leaf folded together, which may indicate an immature conduplicate form, a generic characteristic. It has also been thrown into minute folds by differential movement of the two cuticles, which I take to mean that the leaf was coriaceous.

Bumelia leaves usually have shorter petioles. Among recent species the fossil greatly resembles *Bumelia lycioides* Gaertner, a form ranging from Virginia and Illinois to Florida and Texas. The only conspicuous difference is the shorter petiole of the recent form.

The genus *Bumelia* or the form genus *Sapotacites*, which includes forms related to *Bumelia*, is not uncommon in the Upper Cretaceous of the Mississippi Gulf. It is exceedingly well developed in the Wilcox, having a total of seven different species referred to it. Of these the present species and three others, namely *B. grenadensis*, *B. pseudohorrida*, and *B. pseudotenax*, are above suspicion; the other three are types commonly referred to *Bumelia* by paleobotanists but probably more properly referable to the form genus *Sapotacites*, as they are clearly members of the family Sapotaceae but are less certainly referred to *Bumelia*. The genus has not been recognized in the Claiborne but is present in the Jackson Eocene and the later Tertiary of southeastern North America.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Genus MIMUSOPS Linné

Mimusops prenuntia Berry, n. sp.

Plate 39, figures 1–3

Leaves on the whole considerably variable, obcordate to broadly spatulate, invariably widest above the middle and commonly just below the tip. The tip truncate and slightly or greatly emarginate. Base broadly to narrowly cuneate. Margins entire, somewhat irregular. Texture coriaceous. Length from 5 to 7 centimeters; maximum width from 3 to 3.75 centimeters. Petiole stout, in one specimen preserved with a length of about 1 centimeter. Midvein exceedingly stout, prominent, scarcely diminished in caliber to the tip. Secondaries stout but mostly immersed in the leaf substance, three to five pairs variously spaced and ascending, relatively straight or regularly curved.

camptodrome. Tertiaries mostly obsolete by immersion, sapotaceous in character.

These leaves are of the form that paleobotanists have usually referred to *Sapotacites* or *Bumelia*, to the latter of which three species from the Wilcox that more or less resemble this form have already been referred. There can be no doubt of their reference to the family Sapotaceae, and in looking over the recent species I have been impressed with their relationship to *Mimusops* rather than to *Bumelia*. The genus *Mimusops*, and to a less extent *Sideroxylon*, are notably variable in leaf form, and the usual extent of this variability corresponds admirably with that shown by the present fossil species. It is possible that these emarginate forms are abnormal leaves of *Mimusops eolignitica* Berry or *Sideroxylon premastichodendron* Berry. Irrespective of the shape of the present fossils, on which, perhaps, little reliance can be based, they differ consistently in their venation, and I believe are distinct specifically. Several existing species approach this fossil in foliar features. Perhaps the most similar is *Mimusops duplicata* Urban, a common Antillean forest tree. At one of the localities the present species is associated with the characteristic leaves of *Mimusops eolignitica*.

Occurrence: Holly Springs sand, Atkins pit and Bradley pit, Henry County, Tenn.; Will Brooks farm, Madison County, Tenn.

Order GENTIANALES

Family APOCYNACEAE

Genus APOCYNOPHYLLUM Unger

Apocynophyllum mississippiense Berry

Plate 40, figures 3, 4

Apocynophyllum mississippiensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 342, pl. 108, fig. 6, 1916.

The specimens of this species here figured have less pointed tips than the type. They are of interest in that they bring out very clearly the stout alate petioles which are characteristic of this species.

It is widely distributed and common, being present on both the eastern and western shores of the Wilcox Mississippi Gulf, and in both the Holly Springs sand and Grenada formation.

Occurrence: Grenada formation, of Wilcox group, Grenada, Miss.; about 1 mile north of Somerville; north of Loosahatchie River, float in ironstone; and 5 miles southwest of Williston, all in Fayette County, Tenn. Holly Springs sand, of Wilcox group, Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.; Foundry Church, Bradley, Grable, and Atkins pits, Henry County, Tenn. Wilcox formation, Boydsville, Ark., and Mansfield, La.

Apocynophyllum mississippiense ovatum Berry, n. var.

Plate 19, figure 15

Leaves ovate, widest medianly, with evenly rounded margins tapering upward to the acute but not extended tip and downward to the decurrent base. Length about 10 centimeters; maximum width about 3.85 centimeters. Midrib stout, prominent, curved. Secondaries thin, about 13 pairs, slightly irregularly spaced, ascending, relatively straight, camptodrome. The lower margins are decurrent to the base, and there is no free petiole.

This form is extremely close to the type, from which it differs chiefly in its shorter and broader form and in its more numerous and more regularly spaced secondaries. It is quite possible that it represents a variant of the foliage of a single botanic species, but if such was the case the two forms would be expected in association, which has thus far not been observed.

Occurrence: Holly Springs sand, Shepherd Price farm, near Whiteville, and Mill Creek, Hardeman County, Tenn.

Apocynophyllum sapindifolium Hollick

Plate 19, figures 13, 14; Plate 44, figure 19

Apocynophyllum sapindifolium Hollick, in Harris, G. D., and Veatch, A. C. A preliminary report on the geology of Louisiana, p. 288, pl. 46, fig. 3, 1899.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 344, pl. 102, fig. 1; pl. 108, fig. 5, 1916.

This upper Wilcox species is figured from two new localities in Tennessee and Arkansas. It is common in the Holly Springs sand of Hardeman and Fayette Counties, Tenn.

New occurrence: Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark. Holly Springs sand, of Wilcox group, road west of La Grange, La Grange, and gully 1 mile west of Laconia, all in Fayette County, Tenn.; big cut at Pine Top, gully 1 mile northeast of Cloverport, and Mill Creek, all in Hardeman County, Tenn., Silerton road, Taylor farm, Chester County, Tenn.

Apocynophyllum parvulum Berry, n. sp.

Plate 41, figure 6

This small leaf appears to be mature or if it reached larger size no such specimens have been discovered. Leaf lanceolate, widest medianly or slightly below the middle, falcate, equally acuminate at the apex and base. Margins entire, even. Texture subcoriaceous. Length about 4.5 centimeters; maximum width about 8.5 millimeters. Petiole stout, expanded proximad, about 5 millimeters in length. Midvein very stout, prominent, curved. Secondaries stout, prominent, numerous, regularly spaced and subparallel; diverging from the midvein at angles of about 70°, rather straight until they are abruptly camptodrome by means of a flat marginal arch. Tertiaries immersed.

This small form adds another to the numerous Wilcox species that have been referred to this genus. It is so distinct from the others as not to require comment.

Occurrence: Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

Apocynophyllum crassum Berry, n. sp.

Plate 37, figure 1

Leaves large, slightly inequilateral, lanceolate, widest slightly above the middle, narrowed regularly to the acuminate apex and to the extended, narrowly cuneate base. Margins entire, full but slightly irregular. Texture subcoriaceous. Length about 28 centimeters; maximum width about 5.25 centimeters. Petiole stout, presumably short. Midvein exceedingly stout and prominent. Secondaries relatively thin, rather regularly spaced, and subparallel, diverging from the midvein at angles of about 45° at intervals of about 5 millimeters, camptodrome. Tertiaries thin, forming a coarse, isodiametric, polygonal mesh.

This large species is conspicuously different from the numerous other Wilcox species of *Apocynophyllum.* Among previously described forms it is closest to *Apocynophyllum linifolium* Knowlton [71] of the Raton formation in Colorado. It differs from this western form in its inordinately stout midvein, in its more ascending secondaries, its inequilateral form, and in being widest above instead of below the middle.

Its features suggest that it may have been derived from the Upper Cretaceous (Ripley formation) species *Apocynophyllum giganteum* Berry [72] of the embayment region.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Apocynophyllum preplumiera Berry, n. sp.

Plate 42, figures 1, 2

The fragments of a large leaf shown in Plate 42, Figures 1, 2, are entirely too incomplete for purposes of adequate description. They represent, however, a type of leaf new to this flora, and its features indicate rather definitely that it belongs in the family Apocynaceae. In this family it is much like various existing species of the genus *Plumiera* not definitely recognized in the Tertiary of the Western Hemisphere except in the Miocene flora of Trinidad,[73] the Pliocene flora of Bahia,[74] and the Tertiary of Porto Rico [74a] and Ecuador.[74b]

Leaves evidently large, ovate. Base unknown. Apex pointed. Margins entire, full to repandness. Texture subcoriaceous. Length unknown; maximum width 5.5 to 11.75 centimeters. Midvein exceedingly stout, prominent. Secondaries numerous, stout, prominent; diverging from the midvein at wide angles at intervals of 5 to 12 millimeters, nearly straight, subparallel; their tips joined just within the margins by a stout subacrodrome series of flat arches. Tertiaries obsolete.

The genus *Plumiera* contains several supposed forms in the Miocene of Europe. The recent species, numbering about two score shrubs and trees, are largely American and range from the Antilles and Mexico to eastern Peru and southern Brazil.

Another genus suggested is *Thevetia* Linné, which consists of seven or eight species of shrubs and small trees ranging from Mexico to Paraguay. Some of these, as, for example, the Mexican *Thevetia plumierifolia,* have leaves that are much like the present fossil.

It is hoped that more complete material of the Wilcox form will eventually be discovered.

Occurrence: Holly Springs sand, west of Bolivar and gully west of Illinois Central Railroad, 2¼ miles north of Shandy, Hardeman County, Tenn.

Apocynophyllum linifolium Knowlton (?)

Apocynophyllum linifolium Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 346, pl. 104, fig. 3, 1917.

This fine large species, which was described by Knowlton from the Raton formation of southeastern Colorado, is doubtfully distinct from *Apocynophyllum wilcoxense* Berry as identified by Knowlton [75] from the Raton formation, although it is certainly distinct from the material so identified in the Wilcox. My impression is that *Apocynophyllum wilcoxense* is not common to the Wilcox and Raton but that the forms so named in the Raton flora are the variables of a different species, which should be called *Apocynophyllum linifolium.*

This species is probably common to the Wilcox, but I have queried the determination, for it is based on a single incomplete specimen and its counterpart from the locality cited below. This form is undoubtedly an *Apocynophyllum,* but it is somewhat wider than Knowlton's type of *A. linifolium.*

[71] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 346, pl. 104, fig. 3, 1918.

[72] Berry, E. W., U. S. Geol. Survey Prof. Paper 136, p. 86, pl. 21, fig. 2, 1925.

[73] Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 6, p. 128, pl. 2, fig. 2, 1925.

[74] Hollick, Arthur, and Berry, E. W., idem. No. 5, p. 105, pl. 13, fig. 6, 1924.

[74a] Hollick, Arthur, New York Bot. Garden Bull., vol. 12, p. 315, pl. 10, fig. 5, 1924.

[74b] Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 10, p. 121, pl. 6, fig. 1, 1929.

[75] Knowlton, F. H., op. cit., p. 345, pl. 103, fig. 3; pl. 105, figs. 1, 2; pl. 106, fig. 1.

Occurrence: Holly Springs sand, road cut 1 mile east of Water Valley, Yalobusha County, Miss.

Family ASCLEPIADACEAE?

Genus ACERATES of authors

Acerates wilcoxiana Berry, n. sp.

Plate 19, figures 16, 17

Leaves small, linear-lanceolate and slightly falcate, with an acute apex and a gradually narrowed acutely cuneate base. Margins entire. Texture subcoriaceous. Length about 4.5 centimeters; maximum width about 3 millimeters. Midrib relatively stout, prominent on the under side of the leaf. Secondaries thin, immersed in the leaf substance, diverging from the midrib at wide angles at well-spaced but irregular intervals, straight, their tips connected by flatly arching marginal veins. Areolation immersed, of polygonal isodiametric meshes, seen only where the leaf substance is partly eroded.

This form is a very characteristic type of leaf usually referred to *Acerates*, a form genus for generically unallocated members of the family Asclepiadaceae but closely approached in appearance by various members of the allied family Apocynaceae. In the present state of our knowledge it is impossible to differentiate between the two families in dealing with leaves of the character of the present species, and I simply follow a somewhat arbitrary custom in referring it to *Acerates.*

Among previously described fossil forms the present species is especially like *Acerates veterana* Heer,[76] which this author has identified from the early Tertiary of western Greenland and from the somewhat later Tertiary of Europe. The Wilcox leaf has the same general form and venation but is slightly smaller and relatively slightly shorter. It is also like the smaller leaves from the Miocene of Switzerland referred by Heer to *Echitonium sophiae* C. O. Weber,[77] a species that is reported from many localities in the Oligocene and Miocene of Europe.

The genus *Acerates* has been recorded from the Atane, Patoot, and early Tertiary of Greenland; from the Raritan formation of New Jersey, the Black Creek formation of North Carolina; the Tuscaloosa formation of Alabama; and the Tertiary of Europe.

The genus *Echitonium* was proposed by Unger as a member of the Apocynaceae. About 10 species have been referred to it, ranging in age from Eocene to Miocene and recorded from North America, Greenland, Europe, and Australia. It is already represented in the Wilcox by a characteristic species. In general the leaves that have been referred to *Echitonium* are larger than those that have been referred to *Acerates*, but some have a venation identical with that of the present form; others differ somewhat in venation, as do certain of the forms referred to *Acerates.*

Some fossil leaves of the type of *Acerates wilcoxiana* have also been referred to the genus *Lomatia* of the family Proteaceae, greatly resembling the leaves of certain existing species of that genus, but such a relationship is deemed to be very improbable for the forms from the North American Eocene.

Occurrence: Holly Springs sand, La Grange, west of road and south of the Southern Railway, at western edge of town, Fayette County, Tenn.

Order PERSONALES

Family SOLANACEAE

Genus SOLANITES Saporta

Solanites sarrachaformis Berry, n. sp.

Plate 25, figure 31

Flower gamopetalous. Calyx presumably inferior, gamosepalous. Corolla rotate, slightly depressed internally, the limb five-parted, with angular sinuses and conical segments about as wide as long. Diameter about 12 millimeters. Corolla lobes about 3.5 millimeters long and 4 millimeters in width at the base.

These floral remains are very similar to those described from the Holly Springs sand of Mississippi as *Solanites saportanus* Berry.[78] They differ from that species in being over 70 per cent larger, with wider corolla lobes and a shallower throat. They are very similar to the type of the genus *Solanites brongniarti* Saporta,[79] of the Oligocene of southeastern France. They are also practically identical with the flowers of the existing genus *Sarracha*, which comprises about a dozen living species distributed from Mexico to Bolivia.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Solanites crassus Berry, n. sp.

Plate 25, figures 34–36

Corolla strictly rotate, of medium to relatively large size, orbicular or pentagonal in outline. The specimens are of some consistency and as preserved are nearly flat in the clays, but all show a fold along the axis of what would be the corolla lobes or petals if these were developed, indicating a certain concavity in life. Specimens are not at all uncommon and range from 8 to 20 millimeters in diameter. In one of the

[76] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, p. 20, pl. 104, figs. 5–8, 1859; Flora fossilis arctica, Band 3, Abt. 2, p. 23, pl. 5, fig. 5, 1874.

[77] Weber, C. O., Palaeontographica, Band 2, p. 187, pl. 20, fig. 17, 1852.

[78] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 348, pl. 106, figs. 4, 5, 1916.

[79] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 109, pl. 11, fig. 2. 1863.

larger specimens there is some indication of five large stamens alternating with the corolla folds, but this feature is very indistinct and uncertain.

These flowers resemble those of several genera of the Solanaceae and are not at all unlike those of certain modern species of the genus *Solanum*, as, for example, those of *Solanum bonariense* Linné. The genus contains more than 1,000 existing species of herbs, shrubs, or trees and appears to be of occidental origin. The exact affinity of these flowers is uncertain, but they are clearly referable to this family, thus making three different solanaceous flowers recorded from the Wilcox.

Occurrence: Holly Springs sand, Mill Creek, railroad cut north of Shandy, Hardeman County, Tenn.

Solanites pusillus Berry, n. sp.

Plate 48, figures 21–23

Flowers small but of considerable consistency, about 1 centimeter in diameter, corolla rotate, gamopetalous, deeply divided into five conical lobes which are slightly longer than wide, and acute. Each lobe has a relatively prominent midvein and generally a less prominent subparallel lateral on either side. In one specimen there appear to be small acute calyx lobes alternating with those of the corolla, but this is not conclusive. Most of the specimens are flat impressions of the face of the flower, and in these the receptacle forms an elevated ring, well shown in Plate 48, Figure 22. Two specimens are obliquely flattened, and in these the peduncle swells into the receptacle as if the latter were cup-shaped and the flower epigynous. No traces of pistil or stamens can be made out.

This type is not uncommon in the collections and is entirely distinctive from the other flowers that have been found in this flora.

This is the fourth flower in the Wilcox flora that appears to be referable to the Solanaceae, apparently emphasizing an Upper Cretaceous or early Tertiary radiation from South America through Central America or a more or less continuous land mass in the Antillean region.

The present type is readily distinguishable from *Solanites saportanus* Berry, *S. sarrachaformis* Berry, and *S. crassus* Berry by its size, its conical veined lobes, and its cuplike receptacle.

It resembles the flowers of a number of genera of Solanaceae, particularly those of the tropical American genus *Capsicum* Linné, now naturalized in our Southern States, and those of some of our native species of *Solanum*, such as the so-called nightshades. When comparisons are extended to the existing Solanaceae of tropical America, which seems to be the original home of the family, a great many similar forms can be enumerated.

Occurrence: Holly Springs sand, Grable pit (common), Henry County, Tenn.; La Grange (one specimen), Fayette County, Tenn.

Family BIGNONIACEAE

Genus BIGNONICAPSULA Berry, n. gen.

Bignonicapsula formosa Berry, n. sp.

Plate 43, figure 3

This is the type and only known species of the genus, which will serve as a repository for capsules referable to this family and of uncertain generic affinity. It is based on the unique specimen figured, which was somewhat damaged in shipment but which is still sufficiently complete to corroborate the careful sketch made by Mr. R. L. Collins at the time it was collected. It represents a large fusiform capsule, which is nearly twice as long as wide, widest medianly, with an acuminate tip, narrowed proximad to a stout peduncle which is about 1.75 centimeters long and 5 millimeters in diameter as preserved in a slightly compressed condition. The peduncle is gently curved, and the capsule is slightly less inflated on the outer than on the inner side of the continuation of this curve, the result being a nearly symmetrical form. The specimen, as shown in Plate 43, Figure 3, indicates that the capsule was somewhat compressed in life in the plane of bedding of the sediments and was therefore elliptical in cross section and was bivalved. The surface is smooth, and the substance must have been more or less ligneous to have resisted flattening during fossilization. This character is also indicated by the wall, which is thick, and about twice as thick along the margin of the valve that appears to have borne a parietal placenta. The dimensions of the capsule (exclusive of the peduncle) are length 6.5 centimeters; maximum diameter 3.25 centimeters. The cavity is packed with irregularly elliptical, thin, winged seeds, arranged transversely to the axis of the capsule and all oriented away from the thick-walled (placental) side of the specimen. These seeds are preserved as impressions by the infiltered mud that formed the clay and are not particularly clearly shown. They are thin and flat, elliptical or slightly reniform in outline, with entire, slightly undulate margins, and are marked by fine flabellate veins radiating from the proximal focus of the ellipse. They are about 2.25 centimeters in length and about 1.5 centimeters in maximum width.

This form is a new and striking element in the Wilcox flora. It suggests comparisons with the families Bignoniaceae, Apocynaceae, Asclepiadaceae, and the South American genus *Embothrium* Förster of the family Proteaceae. The bivalved capsules of *Embothrium grandiflorum* Lamarck, a shrub of the Peruvian Andes, are of about the same size and proportions as the fossil, but they are crowned with the persistent pistil, which is as long or longer than the peduncle, and the spatulate and inequilateral winged seeds have their long axes parallel with the long axis of the capsule, instead of at right angles to it, as in the fossil.

Many of the Apocynaceae and Asclepiadaceae have fruits which are similar in size and form to the fossil, but the seeds are relatively small and inflated and plumose instead of winged. It is in the family Bignoniaceae that the true homologies of the fossil are to be found.

I do not have sufficient recent material to enable me to determine the precise botanic affinity of the fossil, but the genera *Anemopaegma* and *Callichlamys* of the tribe Bignoneae and *Rhigozum* and *Deltostoma* of the tribe Tecomeae may be mentioned as especially similar to the Wilcox form. The genus *Rhigozum* Burchell is a South African genus unlikely to be found fossil in North America, and although superficially the capsule is much like the fossil its seeds are borne on the two sides of a central partition, which is oriented at right angles to the valves and are much larger and have a narrower encircling wing.

The genus *Deltostoma* Don, which might well be represented in the North American Tertiary, as its five or six existing species occur in the equatorial Andes, has seeds exceedingly like the fossil except that they are wider than long. The capsules, however, are somewhat less inflated, and, like *Rhigozum*, the seeds are borne on the partition at right angles to the valves.

In both *Anemopaegma* and *Callichlamys* the seeds are either borne on a parietal placenta, or the partition is parallel with the valves, as in the fossil. In both genera the capsules of the existing forms are somewhat larger than the fossil capsule. The genus *Callichlamys* Miquel comprises four or five South American climbing plants ranging from Colombia to Brazil and Peru. The capsules are relatively less inflated than the fossil and are rounded at the extremities. In the genus *Anemopaegma* Martius, on the other hand, the capsules, although slightly larger, have the exact form and organization of the fossil, and I suspect that a real relationship is indicated. *Anemopaegma* comprises about 25 species of climbing shrubs of tropical America with a maximum representation in Brazil.

The family Bignoniaceae contains over 100 genera and over 600 species in the existing flora. It has not hitherto been recognized in the lower Eocene of southeastern North America, although the genera *Tecoma*, *Catalpa*, and *Chilopsis* are found in this region at the present time. The family is cosmopolitan between latitudes 40° N. and 34° S., but two-thirds of the genera recognized are American. The tribe Bignoneae, in which the present fossil form belongs, contains about 45 genera and over 300 existing species. All these genera except four, which are of somewhat doubtful affinities, are also American.

Very few fossil species have been referred to this family, and the record is so incomplete that it is not worth enumerating at the present time. A number of forms have been described recently from the Tertiary of South America, and it seems probable that the fossil record will be much amplified as the paleobotany of equatorial America becomes better known.

Occurrence: Holly Springs sand, northeast corner of crossroads one-fourth mile east of Denmark, Madison County, Tenn.

Order RUBIALES

Family RUBIACEAE

Genus RUBIACITES Weber

Rubiacites wilcoxensis Berry, n. sp.

Plate 45, figure 8

Small two-celled and apparently two-seeded indehiscent or tardily dehiscent capsules, turbinate in form. About 5 millimeters in length and 4 millimeters in maximum diameter toward the tip, decurring to a short and stout peduncle about 2 millimeters in length. Apparently ligneous, but wall poorly preserved.

These small fruits appear to represent some genus of the family Rubiaceae, and they are therefore re-referred to the form genus *Rubiacites* of Weber, although this does not imply that they are congeneric with the European Tertiary forms so named. The family is represented by three species of leaves in the Wilcox which have been referred to *Guettarda*, *Exostema*, and *Psychotria*. In the first the fruit is a many-seeded, two-celled, and two-valved capsule. *Psychotria* has forms somewhat like the fossil, which probably represents some Wilcox member of the Ixoreae or Psychotrieae—which tribe it is impossible to determine.

A large species from the Oligocene of the Panama Canal Zone has been referred by me to *Rubiacites*, otherwise it has not been hitherto recorded from North America. Perkins[80] has proposed the generic term *Rubioides* for what are apparently rubiaceous seeds from the Eocene lignite of Brandon, Vt., but these are quite different from the Wilcox forms.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.; 100 yards east of Bell City Pottery pit, Calloway County, Ky.

Rubiacites sphericus Berry, n. sp.

Plate 45, figures 9–11

Relatively large two-celled, two-seeded, indehiscent or tardily dehiscent capsules, approximately spherical in form, ranging from about 8 to 13 millimeters in

[80] Perkins, G. H., Vermont State Geologist Rept. 1903–4, p. 193, 1904.

diameter, slightly narrowed to a stout peduncle. Wall relatively thin but ligneous, thickened toward the base. The large seeds are flat on the inner side, where they abut against the partition, otherwise rather symmetrically rounded and nearly smooth, slightly more tapering proximad than distad.

These fruits differ from *Rubiacites wilcoxensis* in their much larger size and spherical form. They appear to be definitely referable to the Ixoreae or Psychotrieae of the family Rubiaceae, but beyond this it is unsafe to suggest their generic affinity. Although nowhere individually abundant they occur at four different localities near the top of the Holly Springs sand. Moreover, they are a readily recognizable element in this flora and therefore deserve to be made a part of the published record.

Occurrence: Holly Springs sand, Puryear and Bradley pit, 2.7 miles south of east of Puryear, Henry County, Tenn.; Huckleberry Schoolhouse, 2½ miles south of McLemoresville, Carroll County, Tenn.; Bell City Pottery pit, Calloway County, Ky.

Rubiacites? pellicieraformis Berry, n. sp.

Plate 49, figure 19

A two-seeded nut or unilocular indehiscent capsule. Somewhat lenticular in shape with a broad decurrent base and a prominently rostrate and slightly curved pointed apex. Length about 2.1 centimeters; width 1.1 centimeters; thickness about half the width. Shell ligneous, slightly less than a millimeter in thickness. Surface with rounded contours, faintly and irregularly longitudinally fibrously striate.

Seeds two, apparently borne on a central placenta, pointed distad and slightly bilobed proximad, slightly curved, and approximately circular in cross section.

This species, based on the single specimen figured and its counterpart, suggest at first sight some species of *Hicoria* and in a superficial way greatly resemble the Jackson species *Hicoria rostrataformis* Berry.[81] In *H. rostrataformis*, however, it is the husk which is rostrate, and this husk incloses a more or less spherical nut, which shows normal *Hicoria* kernels inside. In the present form the nut is rostrate and the seeds are fusiform and quite unlike *Hicoria*.

Its botanic position is uncertain, but I have referred it tentatively to the form genus *Rubiacites* and given it a specific name in allusion to its superficial resemblance to the fruits of the genus *Pelliciera* Triana and Planchon, a Central American genus of the Ternstroemiaceae, in which, however, there is but a single seed.

Occurrence: Holly Springs sand, big cut at Pine Top (just above Midway contact), Hardeman County, Tenn.

[81] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 257, pl. 56, 1924.

POSITION UNCERTAIN

Genus CARPOLITHUS

Carpolithus delicatulus Berry, n. sp.

Plate 33, figure 9

A small delicate inflorescence with a central axis and irregularly spaced lateral branches about 3 millimeters long and at nearly right angles to the axis. These branches bear at their ends delicate oblong ribbed fruits or concrescent calices about 3 millimeters long and 1.5 millimeters in maximum diameter. Botanic affinity not determinable.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Carpolithus aggregatus Berry, n. sp.

Plate 33, figure 10

A small racemose inflorescence bearing numerous nearly orbicular nutlike fruits about 2 millimeters in diameter, on a stout peduncle. Botanic affinity not determinable.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Carpolithus banisteroides Berry, n. sp.

Plate 33, figures 5, 6

A narrowly compressed, ovate, asymmetrically winged fruit or seed. Essential part small and narrowly elliptical at the pointed proximal end. Wing expanded, margined all around, one margin wider and thicker than the other and containing the trunk lines of the vascular system. The veins recurve from this margin, anastomosing freely, and end in the opposite margin at approximately right angles to it. Length about 1.6 centimeters; maximum width about midway between the apex and the base, 6.5 millimeters. The essential part is but slightly thickened, and the wing part is membranous or scarious.

The botanic position of this specimen can not be positively determined, although I am inclined to consider it referable to *Banisteria* or some allied genus of the family Malpighiaceae. A somewhat similar but clearly distinct alate form was described from the Wilcox in 1916 as *Banisteria fructuosa*.[82]

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

Carpolithus malpighiaformis Berry, n. sp.

Plate 25, figure 33

A somewhat woody, indehiscent, asymmetric winged carpel, about 1.5 centimeters in length. The carpel is somewhat triangular in outline and convex, the proximal point oblique with respect to the long axis of the

[82] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 257, pl. 56, figs. 8, 9, 1916.

whole. The thickened proximal nucleus continues distad as a gradually diminishing axis of the wing whose free limbs are narrow and pointed.

This fruit shows some resemblance to a *Liriodendron* carpel but differs in its asymmetry, and, although its botanic position remains uncertain, it very likely represents some member of the family Malpighiaceae, especially the genus *Banisteria*, leaves of several species of which have been recorded from the Wilcox.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Carpolithus ailanthioides Berry, n. sp.

Plate 32, figure 9

Apparently a winged fruit or samara, much compressed, elliptical in outline. Margin thickened all around. Near the middle of the thicker margin there is attached a large, flat, nearly orbicular seed. The whole is obscurely reticulate veined. Length about 1.5 centimeters; maximum width, 8.5 millimeters.

The single specimen figured is the only one that has been found, and its features do not permit a definite determination. It might represent some indehiscent or tardily dehiscent single-seeded legume, but seems more like the samara of some species of *Ailanthus*, although nothing more than a suggestion of resemblance is implied by the specific name proposed. The genus *Ailanthus*, of the family Simarubaceae, comprises about seven existing species of large trees native in eastern Asia and the East Indies, but it is not uncommon throughout the Tertiary of Europe and is present in the middle and upper Eocene and the middle Miocene of western North America. Whether or not the genus was ever represented in southeastern North America is problematic.

Occurrence: Holly Springs sand, west of Bolivar, Hardeman County, Tenn.

Carpolithus alatus Berry, n. sp.

Plate 25, figure 30

Small single-winged fruits or seeds of undeterminable botanic relationship. Essential part elliptical, about 4.5 millimeters in length and 2 millimeters in width. Wing oblique, with linear sides and inequilaterally rounded tip, about 6 millimeters long and 3 millimeters wide, thin.

Alate seeds or fruits of this character are present in a variety of botanic families, such as the Meliaceae, Bignoniaceae, Malpighiaceae, and Proteaceae, and in the present form there are no features warranting a decision. The species is, therefore, referred to the form genus *Carpolithus*, although it is strikingly like the winged seeds of the genus *Embothrium* of the Proteaceae. For the same reason comparison with recent forms or with described fossils of similar appearance is of little worth. The species is obviously new and unlike previously known members of the Wilcox flora, in which several other winged seeds have already been described.

Occurrence: Holly Springs sand, Center Church, about 5 miles north of Grand Junction, Hardeman County, Tenn.

Carpolithus shandyensis Berry, n. sp.

Plate 25, figure 1

An ovate, nutlike fruit, narrowed at the base and acuminate at the apex. About 1.5 centimeters in length and 8 millimeters in maximum diameter at a point below the middle. The surface is roughened by tiny irregular longitudinal ridges. The botanic nature, other than that it is carpologic, is conjectural. It might represent a nutlike fruit or it might be one valve of a two-valved capsule. It would require the destruction of the type and single specimen to determine this point. On the other hand, it possibly represents the stone of some drupaceous fruit.

The specimen is, however, a perfectly characteristic object in both form and surface markings, and doubtless similar material will be present in future collections, which may enable its true affinity to be determined. It bears some resemblance to the smoother fruits of *Chrysobalanus* and is likewise like the essential part of certain lauraceous fruits.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Carpolithus gronovii Berry, n. sp.

Plate 25, figures 2–5, 20

Ovate or orbicular fruits which are single-celled stones of some drupaceous fruit. They vary somewhat in size and outline and are much compressed, averaging about 6 millimeters in length, 4 millimeters in width, and 1 millimeter in thickness. The surface is rough and indistinctly and somewhat irregularly longitudinally ribbed.

These stones are exceedingly common in the lignite band at the Taylor farm and at once suggest comparisons with those of the genus *Nyssa*. I have yielded to this suggestion to the extent of naming the species in honor of Gronovius, the pre-Linnean describer of *Nyssa*. They are less bulky and less distinctly ribbed than is usual in *Nyssa*, although a considerable number of fossils that have been supposed to represent *Nyssa* are not unlike the present fossils. They may also be matched by the stones of certain existing species of *Viburnum* and doubtless by those of many other and unrelated genera, so that their true botanic position is probably undeterminable.

Among previously described fossil forms the only one to which it seems pertinent to call attention is

Nyssa jacksoniana Berry,[83] a common species in the Fayette sandstone of Texas, of Jackson age. *Nyssa jacksoniana* is somewhat stouter, somewhat larger, and with decidedly more definitely developed and prominent longitudinal ribs.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.; gully on old Bolivar-Somerville road(?), west of State hospital, Hardeman County, Tenn.

Carpolithus silertonensis Berry, n. sp.

Plate 25, figures 6, 7

A lenticular nutlet, seed, or ligneous berry, somewhat compressed and circular in outline, about 4 millimeters in diameter and 2 millimeters in thickness, with a somewhat roughened surface.

These fruits are suggestive of those of the genus *Myrica* but are not botanically determinable. What appears to be the same form as that in the lignite band at the Taylor farm occurs in the clays at Mill Creek.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.; Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Carpolithus taylorensis Berry, n. sp.

Plate 25, figure 8

Seed believed to be leguminous but of entirely uncertain botanic affinity. Relatively small, compressed, elliptical in all sections, with a smooth surface. Length about 3 millimeters; width about 2 millimeters; thickness slightly under 1 millimeter.

This fossil much resembles the seeds of the Old World genus *Cystisus*, as well as numerous other leguminous genera in which the seeds are small. It may also be matched in various other plant families, and nothing is gained by comparisons with either recent or known fossil forms. The prominent longitudinal mark in the illustration is a shrinkage crack.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.

Carpolithus chesterensis Berry, n. sp.

Plate 25, figure 9

This is possibly a less elongated form of the associated fruit referred to *Cinnamomum ovoides* Perkins. It is almost circular in outline, compressed; separated into low, scarcely perceptible ridges by wide, shallow longitudinal depressions. Length 7 millimeters; width 6 millimeters; thickness 2 millimeters. Of undeterminable botanic affinity, having the appearance of being a stone of some drupaceous fruit.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.

[83] Berry, E. W., U. S. Geol. Survey Prof. Paper 92, p. 192, pl. 65, fig. 7, 1924.

Carpolithus longepedunculatus Berry, n. sp.

Plate 25, figures 16, 17

Somewhat compressed ovate, nutlike drupaceous or capsular fruits, with a mucronately pointed tip. Base decurring to a long, stout striated peduncle. Surface apparently somewhat ligneous, with fine longitudinal striations, with two apparent broad ribs on the exposed face, which may be contours caused by the pressure of the sediment and compression of the fruit wall over two falcate fusiform hard seeds or stones. Both specimens, which are from different localities, are somewhat unsymmetrical, but whether this is normal or due to compression can not be determined, although it seems probable that the latter explanation is correct. Length about 1.25 centimeters; maximum width about 8 millimeters. Length of the peduncle 2 to 2.5 centimeters.

No opinion regarding the botanic position of these characteristic fruits can be hazarded at the present time.

Occurrence: Holly Springs sand, Mill Creek, 2¼ miles north of Shandy, Hardeman County, Tenn.

Carpolithus rotundalatus Berry, n. sp.

Plate 44, figures 4–7

An orbicular compressed fruit or seed, with an inequilateral thinly lenticular nucleus, which is reticulately veined, about 16 subparallel longitudinal veins being the most prominent, the surface between them slightly thickened, forming very low, incipient ribs. Very slightly pointed distad and prominently recurved to the point of attachment proximad, surrounded by a thin meridional wing which shows no veins and has a scarious appearance. Dimensions over all ranging from 5.5 to 8 millimeters in diameter at right angles to the axis and from 5 to 6.5 millimeters in diameter along the axis.

A well-marked type, readily recognizable but of uncertain botanic relationship.

Occurrence: Holly Springs sand, Mill Creek and west of Bolivar, Hardeman County, Tenn.; Bradley pit, Henry County, Tenn.

Carpolithus bolivarensis Berry, n. sp.

Plate 45, figures 4, 5

Compressed seeds or capsules, ovate in outline, about half of the proximal lateral margin on one side truncated and thickened. Margin entire and elsewhere full and evenly rounded. Length about 1.25 centimeters; maximum width about 6 or 7 millimeters. Somewhat thickened centrally, with what is the seed or the essential part of the seed, if the whole object is a seed. This thickened portion is obovate in outline and faintly longitudinally lined. The way this central portion merges with the scarious winglike margins suggests comparisons with various samaras, and I believe the whole is not capsular in nature, but a winged seed, or at least a seed in which two-thirds of the margin is extended as a keel. This margin was not membranous nor does it show any traces of venation, so that it is not comparable to such winged fruits as those in the Malpighiaceae, for example. The present species is superficially much like *Carpolithus somervillensis* Berry, but the two are clearly distinct, *C. somervillensis* lacking the truncated thickened margin on one side, the contrasting central swelling, and marginal keel and being marked with oblique wrinkles.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.; west of Bolivar, Hardeman County, Tenn.

Carpolithus somervillensis Berry, n. sp.

Plate 45, figures 6, 7

An obliquely obovate or subelliptical compressed seed, somewhat ligneous texturally. Hilum at the more narrowed end; broadly rounded at the apex. Surface marked by oblique veins, which start at the base and are massed along the more curved lateral margin, from which they diverge and cross the surface obliquely to the other margin. Length about 11 or 12 millimeters; maximum width about 5.5 millimeters.

This form is superficially like *Carpolithus bolivarensis* Berry, being about the same size and outline. It lacks the keel, the truncated side, and central swelling of *C. bolivarensis* and differs also in the oblique veining. Botanic affinity unknown.

Occurrence: Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

Carpolithus collinsi Berry, n. sp.

Plate 25, figure 10

This species is represented by what appears to be a small ligneous stone of some drupaceous fruit. It is somewhat fusiform, compressed, minutely apiculate at the apex, and extended and bluntly pointed at the base. About five or six low, rounded, somewhat obscure ribs, separated by shallow rounded sinuses. The surface is smooth. Length about 6 millimeters; maximum width about 4 millimeters. Thickness about 1 millimeter but probably twice this in life. Botanic affinity unknown.

Occurrence: Holly Springs sand, lignite seam, Silerton road, Taylor farm, Chester County, Tenn.

Carpolithus puryearensis Berry

Plate 25, figure 11

Carpolithus puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 351, pl. 104, fig. 8, 1916.

The present form is slightly different in outline from the type, which came from Puryear, Henry County, Tenn., being about 11 millimeters in length and 5 millimeters in maximum width. It shows the same axial sinus and coriaceous texture and is believed to be part of a capsular fruit of the same plant. Its botanic relationship can not be suggested.

Occurrence: Holly Springs sand, Whiteville gully, south of negro schoolhouse and west of Nashville, Chattanooga & St. Louis Railway, Hardeman County, Tenn. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

Carpolithus sapindoides Berry, n. sp.

Plate 25, figure 14

A specimen that appears to be an obovate capsular valve suggestive of some species of Sapindaceae. It is broadly rounded distad and on one side, pointed proximad, and nearly straight along one side, compressed, with a feebly rugose surface. Length about 9 millimeters; maximum width about 5 millimeters.

Distinct from the numerous other carpellary remains found in the Wilcox but of uncertain botanic relationship, although it may be referable to the Sapindaceae, a family abundantly represented by a variety of leaves in the Wilcox and by several fruits.

Occurrence: Holly Springs sand, near Center Church, 5 miles north of Grand Junction, Hardeman County, Tenn.

Carpolithus burseraformis Berry, n. sp.

Plate 48, figure 6

Seed or stone somewhat compressed, elongate-elliptical, widest medianly, with a rounded base and a cuneate and truncate apex. Texture coriaceous. Surface with longitudinal impressed lines. Length about 1.5 centimeters; maximum width about 4 millimeters. The botanical affinity of this form is entirely problematic, and the specific name emphasizes a resemblance which may be purely superficial.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Carpolithus fagaraformis Berry, n. sp.

Plate 48, figure 31

Carpels two, borne on a stout, curved peduncle. Circular, ligneous, about 4 millimeters in diameter, somewhat compressed. Peduncle about 6 millimeters long. Based upon a single specimen with the features mentioned. An alternative interpretation would be that the supposed pair of carpels represent the two valves of a capsule.

The botanic affinity is entirely problematic, and the specific name emphasizes a resemblance to the carpels of the genus *Fagara*, of the family Rutaceae, a resemblance which may be entirely illusory.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Carpolithus poaformis Berry, n. sp.

Plate 25, figure 12

This specimen represents the inflorescence of some species of grass or the two-valved capsule of some member of the family Salicaceae. As the fruits of the Salicaceae are pedunculate and as no member of this family has been recognized in the Wilcox flora, the evidence points to the former interpretation, but nevertheless it is entirely inconclusive.

The single specimen shows a pair of divergent ovate, acutely pointed tiny glumes or valves, about 3 millimeters long and 1.5 millimeters in width, the surface finely longitudinally striate, and the outer margin, or keel, thickened.

Occurrence: Holly Springs sand, on the road to Bolivar near Center Church, about 5 miles north of Grand Junction and just east of Illinois Central Railroad, Hardeman County, Tenn.

Carpolithus juncaformis Berry, n. sp.

Plate 25, figure 18; Plate 49, figure 20

The two specimens figured appertain to the same species and appear to represent some lower Eocene relative of the Juncaceae. The first specimen shows a stalk about 1.75 centimeters long, dichotomously divided about halfway up into two divergent branches, which expand at their ends into a turbinate receptacle, bearing a low, rounded central carpel (?), surrounded by divergent pointed segments of a perianth, of which three can be clearly seen in the left-hand fruit. As preserved the details are obscure and the fruit is about 4.2 millimeters in width.

The second specimen shows a shorter forked stalk with three lanceolate bracts at the fork. The right branch is somewhat shorter than the left and expands into a terminal fruit exactly like those of the first specimen. Four lanceolate perianth segments are clearly seen, and there is an obscure trace of a fifth. The left branch is slightly longer than the right and more expanded distad and appears to have borne an entirely normal carpel and a second one of the same length but only one-half the width of the normal one. Around the margin of this receptacle there are several pointed perianth segments to be seen; that at the right is apparently longer than the others and sigmoid, but the others may be foreshortened by flattening in the clays.

These interesting objects represent a plant that is obviously new to this flora. Unfortunately the character of the material does not permit a complete elucidation of their nature, but they are strikingly similar in appearance to fruiting specimens of the Juncaceae—a family of supposed reduced Monocotyledonae whose geologic history is very obscure. There would be no point in enumerating the supposed fossil Juncaceae that have been described, as most of them are more or less uncertain. Heer has described some remains of this sort from the Tertiary of Switzerland which seem rather convincing, and which also are superficially similar to these Wilcox remains.

Occurrence: Holly Springs sand, La Grange, at western edge of town, west of road and south of Southern Railway, Fayette County, Tenn.

Carpolithus hiraeaformis Berry, n. sp.

Plate 48, figures 19, 20

A small inequilateral obovate samara, evenly rounded distad, narrowed proximad to a blunt base. The seed or seed cavity is slightly more than halfway above the base and is circular or elliptical, of considerable consistency and about 1.75 millimeters in diameter; it is connected with the hilum by a relatively stout vertical vascular strand. The scarious wing is netted veined, encircling the compressed seed or seed cavity as a wide, evenly rounded border on one side and the apex but narrowed and straightened on the other side.

The whole specimen is about 7 millimeters long and 3.75 millimeters in maximum width. The central region has the appearance of a seed cavity containing a single compressed elliptical seed about one-half the diameter of the cavity, as shown in Plate 48, Figure 20.

Among previously described fossil forms this one is superficially much like *Carpolithus dictyolomoides* Berry [84] from the upper part of the Holly Springs sand at Puryear, Tenn. This resemblance is purely superficial, as *C. dictyolomoides* is falcate and acute at one end, with a larger nucellus and a more finely reticulate veined wing, which is absent on one side of the nucellus. *Carpolithus dictyolomoides* appears conclusively a winged seed, and its comparison with the genus *Dictyoloma* of the Rutaceae seems most appropriate. The present form is clearly not a winged seed but a winged fruit, and the only comparisons that seem legitimate to me are with the genus *Ulmus* of the Ulmaceae and various genera of the Malpighiaceae. As no leaves of the former type have been found in the Wilcox and as leaves of the latter are not uncommon at this horizon, it would seem that the second assumption was more likely to be correct. The two genera of Malpighiaceae represented by leaves in the Wilcox are *Banisteria* and *Hiraea*. In *Banisteria* the fruits are more like maple (*Acer*) keys. *Hiraea* has similar fruits, which are generally more symmetrical and have a relatively and more uniformly wider wing. Thus the fossil departs in the same re-

[84] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 353, pl. 111, figs. 2, 3, 1916.

spects from both *Ulmus* and *Hiraea*, and its affinity remains unsettled.

Occurrence: Grenada formation, north of Somerville, about one-half mile north of Nashville, Chattanooga & St. Louis Railway, at fork of road leading to Yum Yum, Fayette County, Tenn.

Carpolithus plumosus Berry, n. sp.

Plate 48, figure 3

A plumose fruit, or more probably a group of small achenes with an elongated filiform tail. The whole specimen is about 1.3 centimeters long and 3 millimeters wide at the rounded and inequilateral base, which suggests that the peduncle of the receptacle was oblique. The appendages curve upward and are flat and narrow, with a maximum width of 0.5 millimeter, narrowing distad to filiform points, and about a centimeter in length. The details of the basal part are obscure, but the plumes preserve their identity proximad; whether or not they swell into small seeds or achenes can not be determined. The fact that these plumes are of unequal length suggests that they represent an aggregation of plumed seeds or achenes of small size rather than a single plumose carpel.

From the illustrations it might seem that this form was the same as what I have called *Calycites puryearensis*, but the two are obviously different despite their superficial resemblance. *Calycites puryearensis* is plainly five-sepalous, with a distinct central peduncle, and certainly represents a calyx.

The botanic nature of *Carpolithus plumosus* is problematic; the only comparison which seems fruitful is with existing species of *Clematis* and its allies.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Carpolithus biseminatus Berry, n. sp.

Plate 49, figure 17

Fruit apparently a bilocular stone or indehiscent capsule, prolate spheroidal in shape, possibly somewhat compressed in life, for it is much compressed as fossilized. Elliptical in outline, about 1.2 centimeters in length and 6 millimeters in maximum width. Wall about 1 millimeter thick. Seeds elongated, two in number, smooth, rounded proximad and somewhat narrowed and bluntly pointed distad.

It is impossible to decide whether this form represents a capsule such as characterized, among others, the family Rubiaceae; or whether it is a two-celled stone such as characterizes, among others, the genus *Cornus*. A somewhat similar but considerably larger and more ligneous form was described by me[85] from the Gatun formation of the Panama Canal Zone and referred to the form genus *Rubiacites* of the Rubiaceae, and it is my impression that the present fossil should be referred to this family.

Occurrence: Holly Springs sand, Bradley pit, 2.7 miles south of east of Puryear, Henry County, Tenn.

Carpolithus leitneriaformis Berry, n. sp.

Plate 49, figure 10

This form, unfortunately based only upon the single specimen figured, represents a characteristic object and is markedly distinct from the numerous other carpologic remains that have been found in the Wilcox. The features exhibited do not permit a decision regarding its botanic affinities. It may be incompletely described as follows: Fruit fusiform, or possibly somewhat compressed in life, widest above the middle, oblanceolate, tapering downward to what appears to be a persistent receptacle. The specimen has the appearance of having been somewhat fleshy in life, but not soft, and of considerable consistency. Length 1.1 to 1.2 centimeters; maximum width about 4 millimeters. Peduncle stout, curved, about 5 millimeters long.

The species is named from its resemblance, perhaps purely superficial, to the dry drupes of the monotypic American family Leitneriaceae, which occurs rather sparingly along the northern coasts of the Gulf of Mexico in the existing flora. The presence in the fossil of what appears to be a sepaliferous receptacle, if the interpretation is correct, precludes a relationship with *Leitneria*. Schenk[86] has figured the fruits of an existing species of *Ficus* which appears to be exceedingly close to the present fossil, and it is quite possible, I might even say probable, that we are dealing with a fossil fig. However, as I can not satisfactorily convince myself that it is a *Ficus*, I prefer to refer it to the noncommital form genus *Carpolithus*.

Occurrence: Holly Springs sand, Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

Carpolithus bicapsulis Berry, n. sp.

Plate 48, figure 26

Fruit capsular, double; consisting of a stout peduncle about 5 millimeters long, carrying two apparently subglobular capsules, which are about 4 millimeters long and 2 millimeters in maximum diameter and are crowned by persistent styles that account for about one-fourth of the length.

This species is based upon the single specimen figured, and this suggests comparisons with certain Rutaceae and Rubiaceae, but the preservation is such that complete certainty is impossible. Another possible interpretation is that the specimen represents a single two-valved terminal capsule, the two valves of which have been rotated upon one another to the

[85] Berry, E. W., The fossil higher plants from the Canal Zone: U. S. Nat. Mus. Bull. 103, p. 43, pl. 18, figs. 9–12, 1918.

[86] Schenk, August, Palaeophytologie, p. 479, figs. 283–288, 1890.

orientation shown in the fossil. There is no evidence of this having occurred, and I do not regard it as probable. I have no suggestion to offer as to its botanic affinity.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

Carpolithus inequilateralis Berry, n. sp.

Plate 48, figures 27, 28

Fruit apparently an indehiscent capsule, elliptical in outline and presumably prolate spheroidal in life, although it may have been somewhat compressed. Length about 5 millimeters; maximum width about 3 millimeters. Borne upon a stout peduncle about 3.5 millimeters long, which is continuous with one side (presumably the ventral) of the capsule, which is somewhat flatter than the opposite side. The illustration does not show this feature very accurately.

I have no conjectures to offer regarding the botanic affinity of this form, which is based upon the single specimen figured.

Occurrence: Holly Springs sand, La Grange, Fayette County, Tenn.

Carpolithus kentuckyensis Berry, n. sp.

Plate 49, figure 16

Fruit a stone, apparently single seeded, compressed ovate and nearly equilateral in outline, thin except around the margin, smooth in life, hilum at one end. Length about 9 millimeters; maximum width about 5 millimeters.

This form is clearly distinct from the other carpologic remains that have been described from the Wilcox, but there is no basis for determining its botanic affinity. It is not related to *Cornus*, *Cinnamomum*, *Nyssa*, or *Viburnum*, to mention the names of genera to which have been assigned fossils that are superficially similar to the present fossils.

Occurrence: Holly Springs sand, pit of the Bell City Pottery, Calloway County, Ky.

Carpolithus callowayensis Berry, n. sp.

Plate 48, figures 29, 30

Fruit a bilocular capsule or a pair of septicidal capsules, varying considerably in size and length of peduncle, circular or elliptical in outline as preserved, and apparently more or less compressed in life. Surface tuberculate. Length 9 millimeters to 1.3 centimeters; maximum width 8 millimeters to 1.1 centimeters. Peduncle stout, varying from 5 millimeters to 1.2 centimeters in length.

This species is based upon five specimens, which are more or less ferruginized replacements. At first sight the smaller and longer pedunculate forms appear to be distinct from the larger and shorter pedunculate forms, but both dehisce in the same manner and have a similarly ornamented surface. Superficially they resemble fossil forms which are figured in the literature of paleobotany and which have been referred to the genus *Fagus*, but they are clearly not related to that genus. I have no conjectures to offer regarding their real botanic affinity.

Occurrence: Holly Springs sand, pit of the Bell City Pottery, Calloway County, Ky.

Genus ANTHOLITHES

Antholithes mimosaformis Berry, n. sp.

Plate 25, figures 23–25

A single imperfect specimen represents this fossil flower. It shows parts of both the calyx and corolla with a single exsert pistil and numerous exsert stamens with slender filaments and large two-celled anthers united at the tip of the filament. The stamens appear to have been more or less coalescent proximad and appear to be in two groups of five or six each, although most have lost their anthers. There were probably 10 or 12 stamens in life, more or less coherent. The whole flower is about a centimeter in length.

In so far as its features can be made out, this flower appears to represent one of the Mimosaceae, and it shows a striking resemblance to the modern flowers of the genus *Pithecolobium*, leaves of three species of which have been recognized in the Wilcox.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

Antholithes ternstroemioides Berry, n. sp.

Plate 42, figures 5, 6

This large flower is represented by the two specimens figured, one flattened parallel with the peduncle and the other at right angles to the peduncle. As imperfectly preserved it does not afford features for a positive determination, but its resemblance to the flowers of several genera of the Ternstroemiaceae and the abundance of the leaves of *Ternstroemites* associated with it at Puryear suggest that it should be referred to this family and also suggest the specific name *ternstroemioides*.

As nearly as the material can be interpreted, it represents a polypetalous flower with five large obovate petals, seemingly of delicate texture, but sufficiently durable to be fossilized. The sepals, of unknown number, appear to have been about one-third the length of the petals and relatively narrower. The stamens and pistil, obviously present, are so mashed that no definite statement can be made regarding their features. The peduncle is stout and about a centimeter in length. The petals, variously folded and distorted in the specimens, are about 2.5 centimeters in length and 1.5 centimeters in maximum width; they are very delicately veined, with reticulated, much elongated, narrow meshes. The specimen preserved in profile is considerably smaller than the other specimens, its most nearly complete petal being 2.25 centimeters in length and 1.1 centimeters in maximum width. The larger flower has a diameter of about 6 centimeters (estimated).

This flower appears to belong to the Ternstroemiaceae; in fact, it is very similar to those of both species of the genus *Gordonia* indigenous in the present flora of the Atlantic Coastal Plain, especially the larger flowered *Gordonia lasianthus* Elliott, which occurs in shallow swamps from southern Virginia to southern peninsular Florida and westward along the Gulf coast to the Mississippi River. The genus *Gordonia*, so far as I know, has not been recorded in the fossil state. It contains 10 or a dozen existing species in the region noted above and in tropical Asia and the Malay Archipelago.[80a]

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Antholithes iliciformis Berry, n. sp.

Plate 44, figures 8–10

Flowers small, pedunculate, about 4 millimeters in diameter. Only one set of floral envelopes can be made out, but these could readily represent the corolla, and the calyx could be present in the material, although it has not been observed. Petals six in number, ovate in form, widest medianly, with rounded tips; apparently united proximad to a disklike or cuplike central portion, faintly longitudinally veined, of considerable consistency. The material is flattened and consists of two specimens. One of these is flattened along the axis and the other at right angles to it. The former shows a relatively stout peduncle about 3 millimeters long.

There is little beyond the six-parted corolla (or calyx) to furnish a clue to the botanic relationship of these flowers. As the specific name indicates, they suggest the Ilicaceae to me, although somewhat similar forms from the Baltic amber have been referred to *Sambucus* by Conwentz. In this family the calyx and corolla are four to six parted and the flowers small and pedunculate and closely comparable in these respects with the fossil. In the genus *Ilex* two of our native species, *I. decidua* and *I. monticola*, commonly have the flower parts in sixes. The family is not a prominent element in the Wilcox flora, and it is quite possible that these flowers are not related to it.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

[80a] Leaves and seeds of *Gordonia* from the late Miocene of Idaho and Washington have been described recently (Berry, E. W., Am. Jour. Sci., 5th ser., vol. 18, pp. 429–432, 3 figs., 1929).

Antholithes pruniformis Berry, n. sp.

Plate 44, figures 11, 12

This small flower, of which the specimen figured is the only one known, is different from any of the other flowers found in the Wilcox. It is about 4 millimeters in diameter and shows five rather delicate obovate petals, a cast of a central single pistil (style) and traces of numerous stamens, at least twice as many as the petals, and probably more.

It is not possible to arrive at any conclusive results as to affinity, but it appears to be almost certainly referable to the Rosaceae and is very much like the various existing smaller flowered species of *Prunus*. As characteristic pits of *Prunus*, both plum and cherrylike, are not rare in the Wilcox, there is some justification for considering this flower to have represented some lower Eocene species of cherry resembling those of the existing *Prunus demissa*, *P. serotina*, *P. alabamensis*, or *P. sphaerocarpa*.

Occurrence: Holly Springs sand, Bradley pit, 2.7 miles south of east of Puryear, Henry County, Tenn.

Antholithes wilcoxensis Berry, n. sp.

Plate 50, figures 6, 7

A small gamopetalous flower represented by only the single incomplete specimen figured. This specimen shows the under side of the flower and furnishes the accompanying proximal and lateral views. The flower is detached from the peduncle, which has left a prominent scar at the apex of the receptacle. The receptacle is of considerable consistency as if it inclosed a partly developed hard fruit, for it stands up in the impression as a hemispherical mound with striated sides. The persistent calyx is gamosepalous and divided about halfway to the base into five equal conical obtusely pointed lobes. At one side a part of the corolla appears to be represented by a single flat conical rounded lobe, which is about twice the size of the calyx lobes. If this lobe is what it appears to be, the corolla was gamopetalous and divided about halfway to the center into five equal petaloid lobes. The calyx is about 1 centimeter in diameter and the corolla about 1.5 centimeters in diameter. The calyx alone shows considerable resemblance to the corolla described as *Solanites pusillus* Berry, but its lobes lack the prominent veins and pointed tips of that species; the receptacle, if it is a receptacle and not the cup-shaped central part of the calyx pressed down over the spherical ovary, is more hemispheric and less turbinate in form than in the *Solanites*; and if the petaloid lobe is in organic union with the calyx, as it appears to be, there can be no question of the distinctness of the two forms. The botanic affinity of this species appears to me to be entirely conjectural, for many of the sympetalous families contain some forms which have flowers of this general plan.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Antholithes amentiferus Berry, n. sp.

Plate 44, figure 23

These objects represent stout catkins that are several centimeters in length and about 7 millimeters in diameter as preserved in the clay. The details are obscure, but a great many anthers can be made out. These are grouped in individual flowers, but no bracts or other flower parts can be made out, and there is no trace of pistillate parts, so that I conclude that the catkins preserved are wholly staminate.

They are not referable to the Salicaceae but might represent some member of the Juglandaceae or Fagaceae—the genus *Dryophyllum* of the Fagaceae being a prominent Wilcox type. Until better material comes to light or a definite correlation with foliage can be made, their botanical position must remain uncertain.

Catkins have been found fossil at several localities and horizons in the Wilcox, but none of the other remains of this nature are identical with the present form.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Antholithes grablensis Berry, n. sp.

Plate 45, figure 15

It is difficult to decide whether the object figured represents a flower or a bilocular capsule with the crushed contents preserved in the center. The first is the interpretation which I have given it. The specimen shows an elongated and relatively stout peduncle that is about 8 millimeters in length. On either side at its apex is shown a pair of rounded, reticulate veined petaloid parts, and these are either thickened along a keel or the petaloid parts are subtended by stout lanceolate sepals or bracts. In the crushed central mass there is seen an axial median extension which might be considered to represent a single central pistil, and this is surrounded by an indefinite shorter group of superimposed parts which might represent stamens. The whole is vaguely defined in the specimens, of which there are two, but it has a definiteness that stamps it as something new to this flora and not to be altogether ignored, even though its botanic affinity can not be determined at the present time.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

Genus CALYCITES

Calycites milanensis Berry, n. sp.

Plate 49, figures 6–8

I have figured three of the five specimens of this form collected. The form is a large gamosepalous calyx divided for one-third to one-half the distance inward toward the round hole representing the receptacle into five parabolically rounded lobes. The diameter of the largest specimen is 2.6 centimeters, the texture is coriaceous, and the transverse profile is gently curved as though it was accrescent and had subtended a subspherical fruit. No traces of venation are visible.

I have no very definite conjectures to offer regarding the botanic affinity of this form, except to point out that it might possibly represent some species of *Diospyros* in which the calyx was five-parted. This calyx occurs in some species of *Diospyros*, and similar objects have been referred to that genus, but in the absence of any conclusive clue to relationship I prefer to refer it to the form genus *Calycites*. Since describing this form I have seen a number of accrescent calices of various genera of palms which greatly resemble this fossil. None are exactly like it, and those I have seen are either six-lobed or entire. However, I believe that these fossils are more likely to represent palms than any other type with which I am familiar. Doubtless eventually more perfect material will come to light, which will enable its botanic affinity to be determined beyond reasonable doubt.

Occurrence: Holly Springs sand, 1 mile west of Milan, Gibson County, Tenn.

Calycites puryearensis Berry, n. sp.

Plate 48, figure 4

Calyx persistent, with a peduncle about 2.5 millimeters in length; rounded proximad; deeply divided into five erect, lanceolate lobes, which are slightly over 1 centimeter in length and about 3 millimeters in maximum width at the base, of considerable consistency.

This form is a distinctive type of unknown botanic relationship. It is superficially like *Carpolithus plumosus* in the figures but is clearly distinct and is conclusively a calyx and not a quinquelocular capsule. It may well have been accrescent, however, and have contained a carpel of some kind, but no traces of such are indicated in the two specimens.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Calycites rhizophoroides Berry, n. sp.

Plate 45, figure 12

This species is based upon a single specimen, but it is impossible to determine conclusively whether this specimen represents a calyx or a corolla. It is believed to represent a calyx, largely because of certain resemblances which it appears to show and also because of its coriaceous nature, although that is recognized as a not very convincing reason. A canvass of its possible botanic relationship appears to point to the genus *Rhizophora*. It is certainly not, in my judgment, referable to *Diospyros*, to which paleobotanists have referred somewhat similar remains. There appear to be traces of a single pistil and of one short stamen, but these points are not at all certain and may be a false interpretation of the crushed receptacle. What can be made out positively is a four-parted coriaceous calyx 2.4 centimeters across, deeply divided into nearly linear lobes 2.5 times as long as wide, rounded distad to an abrupt point. These lobes are united with the crushed receptacle.

It is of about the same size as the calyx of our common existing *Rhizophora mangle* Linné, differing in that the calyx lobes are linear rather than conical. In comparing the fossil with the flowers of the existing species one is easily led to see the turbinate tube with the partly inferior ovary, the bracts, and traces of the central pistil and short stamens, although these may be subjective. The petals are caducous in *Rhizophora* and not likely to have been preserved. The actual points of agreement between the fossil and a *Rhizophora* flower are the greatly thickened and deeply four-parted calyx on a turbinate tube. The botanical relationship can not therefore be proved, and I have indicated my own preference by the specific name *rhizophoroides*. No traces of foliar remains have been found in the Wilcox which can be attributed to *Rhizophora*, but it is present in this same area in the overlying Claiborne (middle Eocene), and it is therefore not improbable that it was present in the lower Eocene, as various mangrove associates, such as *Avicennia*, *Conocarpus*, and *Combretum*, have been rather definitely recognized in the Wilcox.

Occurrence: Holly Springs sand, Grable pit, Henry County, Tenn.

Genus PHYLLITES

Phyllites grenadensis Berry, n. sp.

Plate 45, figures 13, 14

A tiny leaf or bract, broadly lanceolate, slightly falcate, widest medianly, and about equally pointed at both ends. Base flat, without a petiole, and apparently appressed in life. Margins entire. Texture relatively coriaceous for so small an object. Veins thin, all of a size, diverging dichotomously in the base, six to eight in number above the initial forking; usually forked a second time about halfway up, the second forks in some places anastomosing, all arched inward distad to join the adjacent vein subtended.

This form may possibly represent a distinct species of Wilcox plant, but it is more likely of the nature of a bract. Its affinities have not been determined, but it is perfectly distinct and should be readily recognizable in future collections.

Occurrence: Grenada formation, Cottage Grove, Henry County, Tenn.

Undeterminable leaf

Plate 25, figure 21

This fragment of a leaf can not be satisfactorily determined. It is figured because it is an additional and distinct member of the Wilcox flora. The single specimen indicated a small elongate elliptical or lanceolate leaf, of delicate texture and acrodrome venation. The venation comprises a flat midvein and two pairs of lateral acrodrome primaries with irregular cross veinlets.

It appears to me to represent some monocotyledonous plant, and may well represent a species of *Potamogeton*, which it not only resembles but which would agree with the indicated environment at the locality where it was found.

Occurrence: Holly Springs sand, 2 miles southeast of Bolivar, on the Oak Hill road (Murrell property), Hardeman County, Tenn.

Flower petals

Plate 48, figures 15–17

There are numerous specimens in the collections from Puryear which seem to be clearly those of petals of some fairly large polypetalous flower. Those figured range from 1.4 to 1.8 centimeters in length and from 6 to 14 millimeters in maximum width toward the apex. They are emarginate or retuse at the tip and either spatulate or with a more expanded limb, narrowing abruptly or gradually to the truncated base. They are of considerable consistency, but this is by no means incompatible with their supposed nature.

In the past attempts have been made to determine their botanic affinity, and somewhat similar objects have been identified as petals of a magnoliaceous flower. The present form is by no means incompatible with such a relationship, but there are a great many other things which it might equally well represent, and I have no conjectures to offer as to its probable affinity.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn.

Bracts

Plate 48, figures 24, 25

Small ovate-lanceolate foliar appendages occur at a number of localities in the Wilcox, and these evidently represent bracts or bud scales. They are abruptly rounded and slightly inequilateral at the base with a subcentral scar of attachment, which seems to preclude considering them to represent stipules. They range in length from 1 to 1.75 centimeters, and from 3 to 7 millimeters in maximum width. They have pointed tips and fine parallel venation. Their botanic position is problematic.

Occurrence: Holly Springs sand, Puryear, Henry County, Tenn. Grenada formation, Cottage Grove, Henry County, Tenn.

OSTRACODA

Cypris wilcoxensis Berry, n. sp.

Plate 33, figure 11

Species based on the single specimen figured. This is as far as I know the first ostracode to be encountered in the Wilcox, although several species have been described from the early Eocene of Maryland.[87] The shell is unusually large, being 4 millimeters long and 2 millimeters high. The surface is entirely smooth and nonpunctate, and the margins are entire. The general outline is elongate reniform, the dorsal margin being more curved than the ventral, and the shell tapers forward and downward. It is rather evenly arched but wider behind the middle, the posterior margin being slightly flattened.

The visible characters are insufficient for any proper specific diagnosis, but there is little doubt that it represents the genus *Cypris*, and as animal remains are so rare in the leaf-bearing areas of the Wilcox, a large and presumably fresh-water species is an item of considerable interest.

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

[87] Ulrich, E. O., Maryland Geol. Survey, Eocene, pp. 116–122, pl. 16, 1901.

NEUROPTERA

Generically undeterminable

Caddis fly larval cases usually referred to the pseudogenus Indusia

There are two specimens in the collections from Mill Creek that can hardly represent anything but the larval cases of some Wilcox species of caddis fly. The larger specimen is 1.4 centimeters long and not quite 3 millimeters in diameter as preserved. The other is 1.1 centimeters long and slightly over 2 millimeters in diameter. Both are straight and apparently tubular, truncated at the ends, approximately of equal diameter throughout, the smaller one slightly tapering. They are both composed of similar materials, apparently selected sand grains approximately 0.5 millimeter in diameter and of quartz and small plates of mica.

The remains are too incomplete for naming or framing any adequate specific diagnosis, but their character and the fact of their occurrence in a fine-grained plastic clay lacking either quartz sand or mica precludes assigning them to anything but an organic agency, and so far as they show characters they agree absolutely with the tubes formed by the aquatic larvae of some of the Trichoptera, and from a rather limited knowledge of this group I should say represent some species of the family Sericostomatidae or Leptodoceridae. Fossil caddis flies are not rare throughout the Tertiary in various parts of the world, and Fritsch[88] has described what appears to be a larval case from the Upper Cretaceous of Bohemia, so that their presence in the lower Eocene of the Southeastern States is not especially remarkable. I have also described specimens from the Wilcox[89] and from the Miocene of the western United States.[90]

Occurrence: Holly Springs sand, Mill Creek, Hardeman County, Tenn.

[88] Fritsch, A., and Bayer, E., Naturwiss. Landesd. Böhmen Archiv, Band 11, No. 2, p. 169, fig. 10, 1900.

[89] Berry, E. W., U. S. Nat. Mus. Proc., vol. 71, art. 14, 1927.

[90] Berry, E. W., Washington Acad. Sci. Jour., vol. 18, pp. 60–61, 1928.

PLATES 7-50

PLATE 7

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1. *Equisetum* sp., Berry. Fragment of rhizome or underground stem with three tubers. Holly Springs sand, gully 1 mile west of Laconia, Fayette County, Tenn. 47

2, 3. *Salvinia preauriculata* Berry. Photograph and drawing of a floating leaf. Holly Springs sand, Jackson-Bolivar road north of Clover Creek, Hardeman County, Tenn. 47

4. *Lygodium hastataforme* Berry, n. sp. A single pinna. Carrizo sandstone, Nueces River north of La Pryor, Zavala County, Tex. 50

5. *Lygodium trilobatum* Berry, n. sp. A single trilobate pinna. Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn. 50

6. *Phanerophlebites knowltoni* Berry, n. sp. Fragment of a pinna, illustrating the usual poorly preserved method of occurrence. Holly Springs sand, gully on Jim Davenport property, Fayette County, Tenn. 48

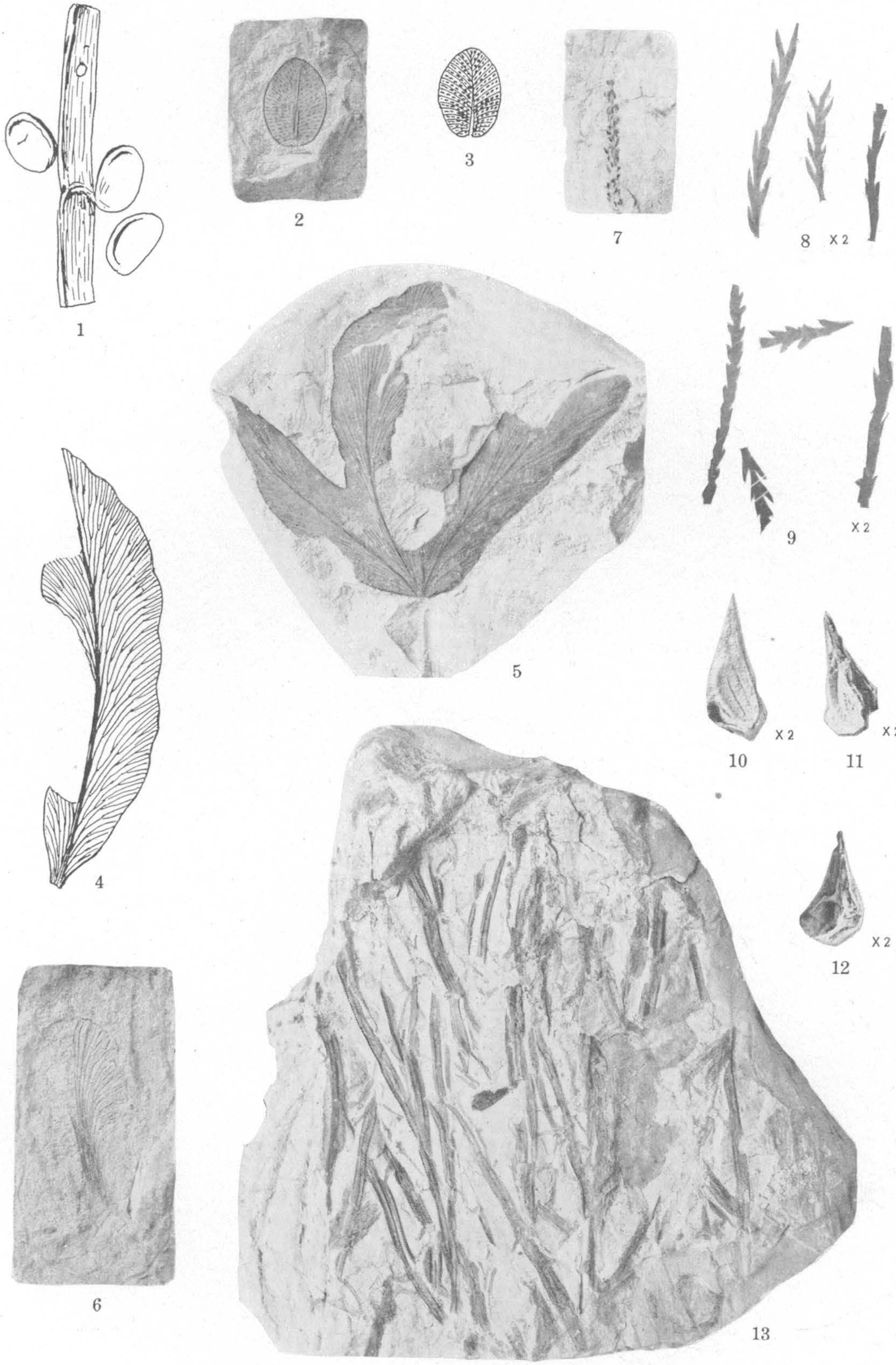
7–9. *Glyptostrobus europaeus* (Brongniart) Heer 52

7. Twig preserved in clay. Holly Springs sand, road west of La Grange, Fayette County, Tenn.

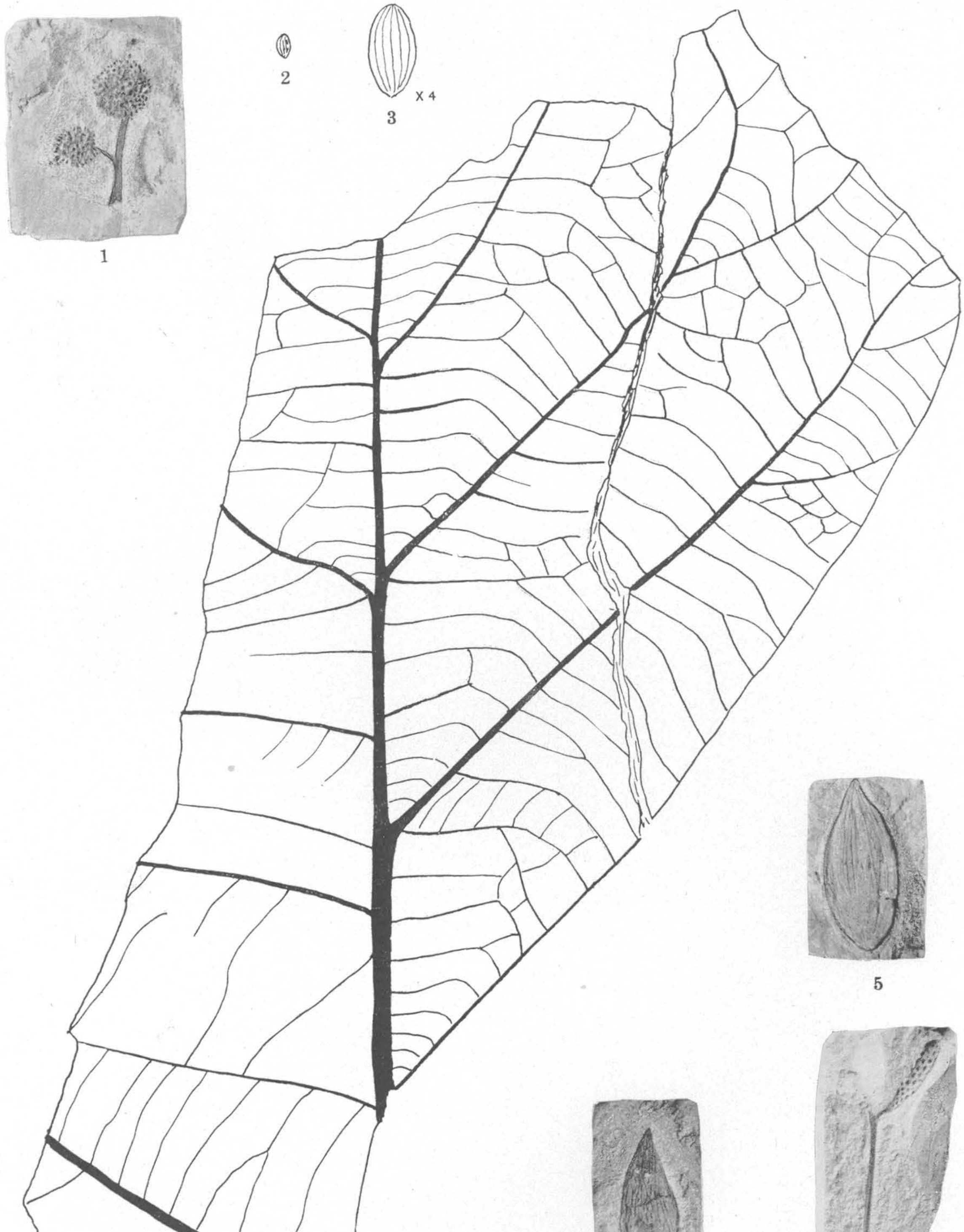
8, 9. Fragments of twigs washed out of the lignite seam in the Holly Springs sand on Taylor farm, Chester County, Tenn.

10–12. *Taxodium wilcoxianum* Berry, n. sp. Characteristic seeds washed out of the lignite seam in the Holly Springs sand on Taylor farm, Chester County, Tenn. 53

13. *Poacites* sp. Photograph of a specimen of clay from the Holly Springs sand to show the abundance of grasslike foliage. Gully 1 mile west of Laconia, Fayette County, Tenn. 53



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 8

PLATE 9

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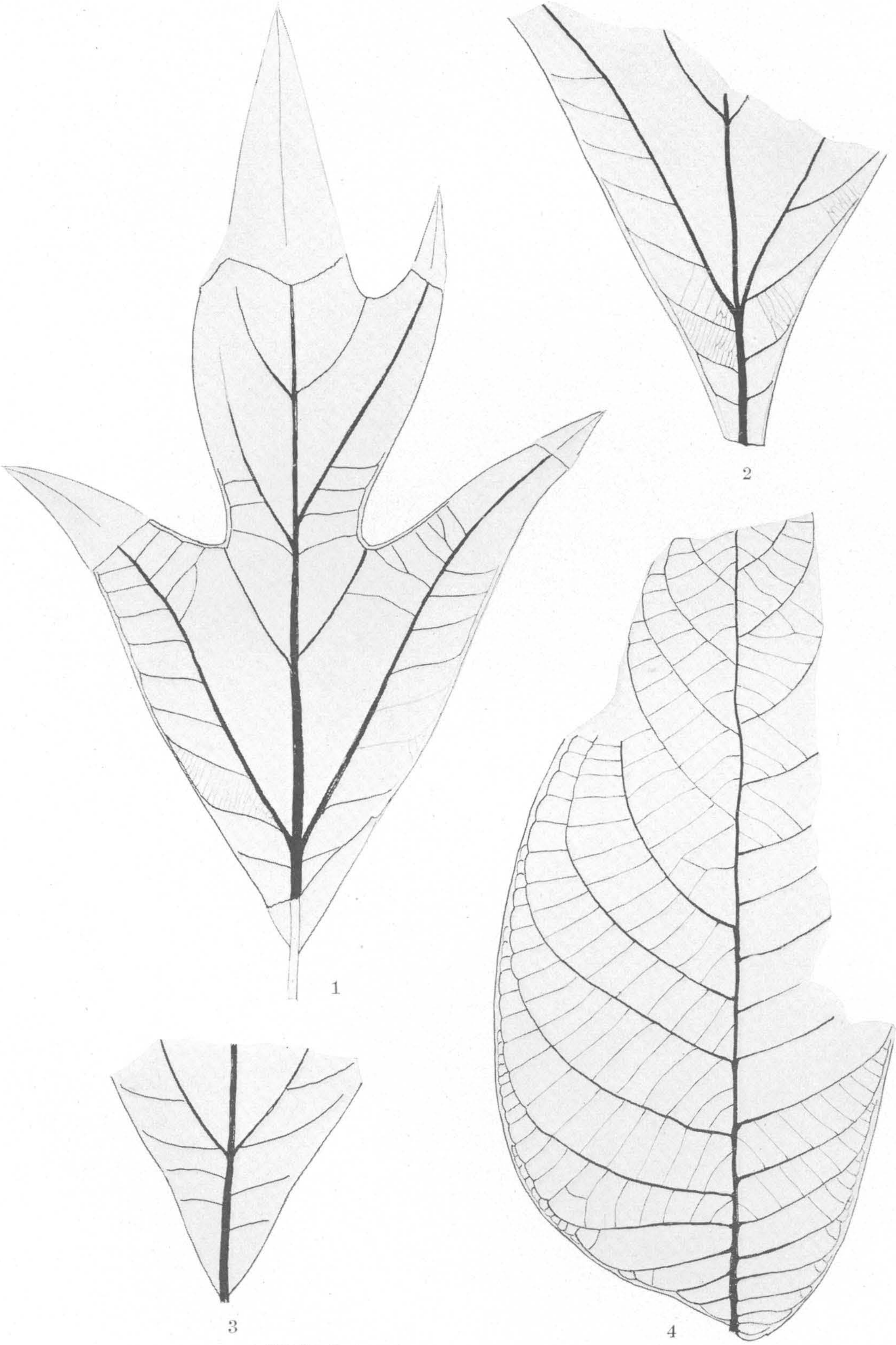
1–3. *Artocarpus pungens* (Lesquereux) Hollick ---------- 63

1. Small leaf of breadfruit.

2, 3. Basal parts of leaves to show venation. Taylor farm, Chester County, Tenn.

4. *Juglans occidentalis* Newberry. A complete leaflet of this Wilcox species of walnut. Murrell place, Hardeman County, Tenn ---------- 58

All from the Holly Springs sand.



FOSSIL PLANTS OF THE WILCOX GROUP

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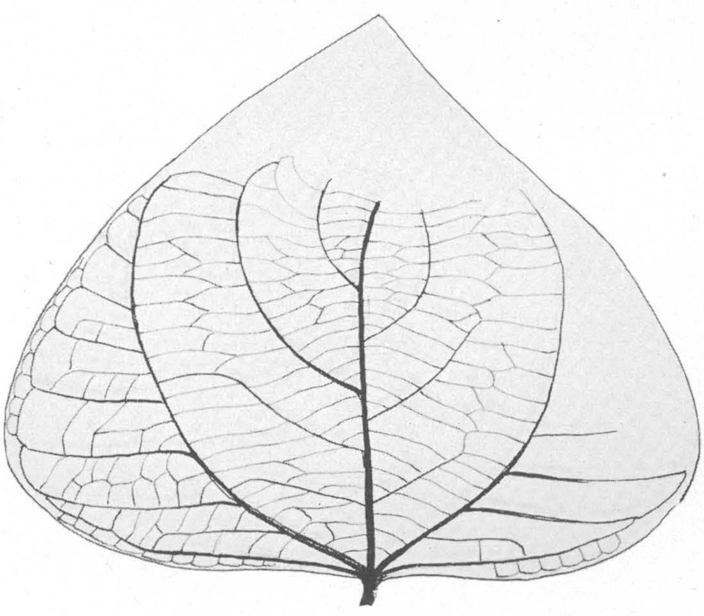

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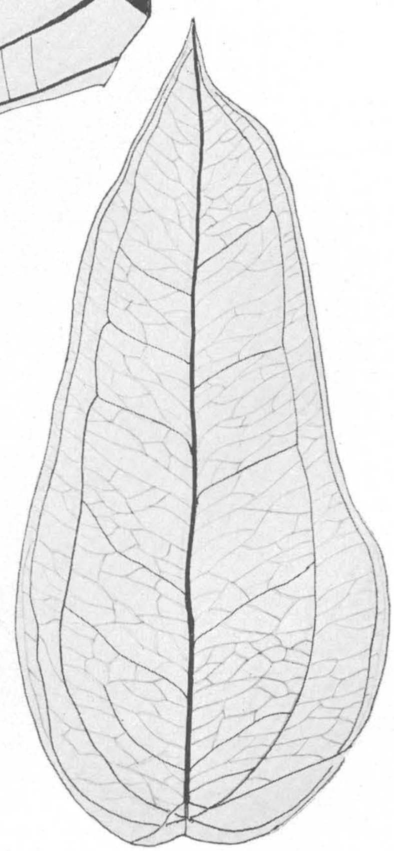

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FOSSIL PLANTS OF THE WILCOX GROUP

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1.	*Platanus nobilis* Newberry. Basal lateral lobe of a large leaf, showing the character of the margin and the characteristic tertiary venation. Big cut at Pine Top, Hardeman County, Tenn	62
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All from the Holly Springs sand.

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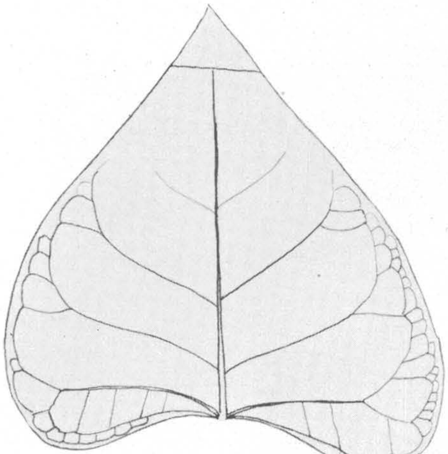
5, 6. *Pisonia fructifera* Berry, n. sp. ---- 68

5. Photograph of a characteristic fruit of this species.

6. Drawing of same, enlarged. Mill Creek, Hardeman County, Tenn.

7. *Platanus nobilis* Newberry. Fragment of a leaf showing typical tertiary venation. Murrell place, Hardeman County, Tenn. ---- 62

All from the Holly Springs sand.



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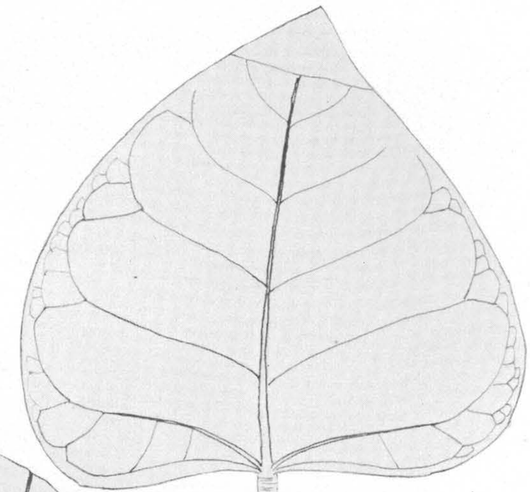

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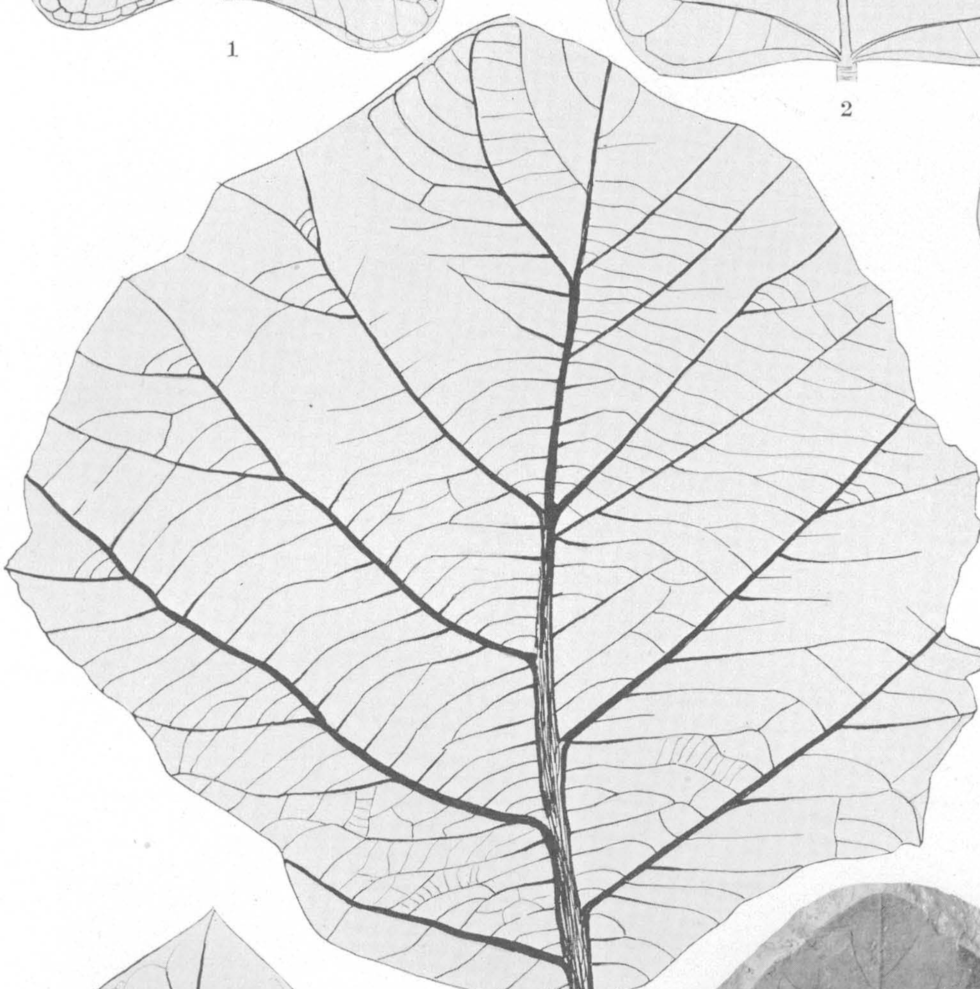

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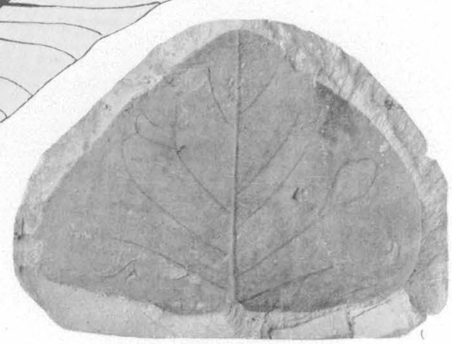

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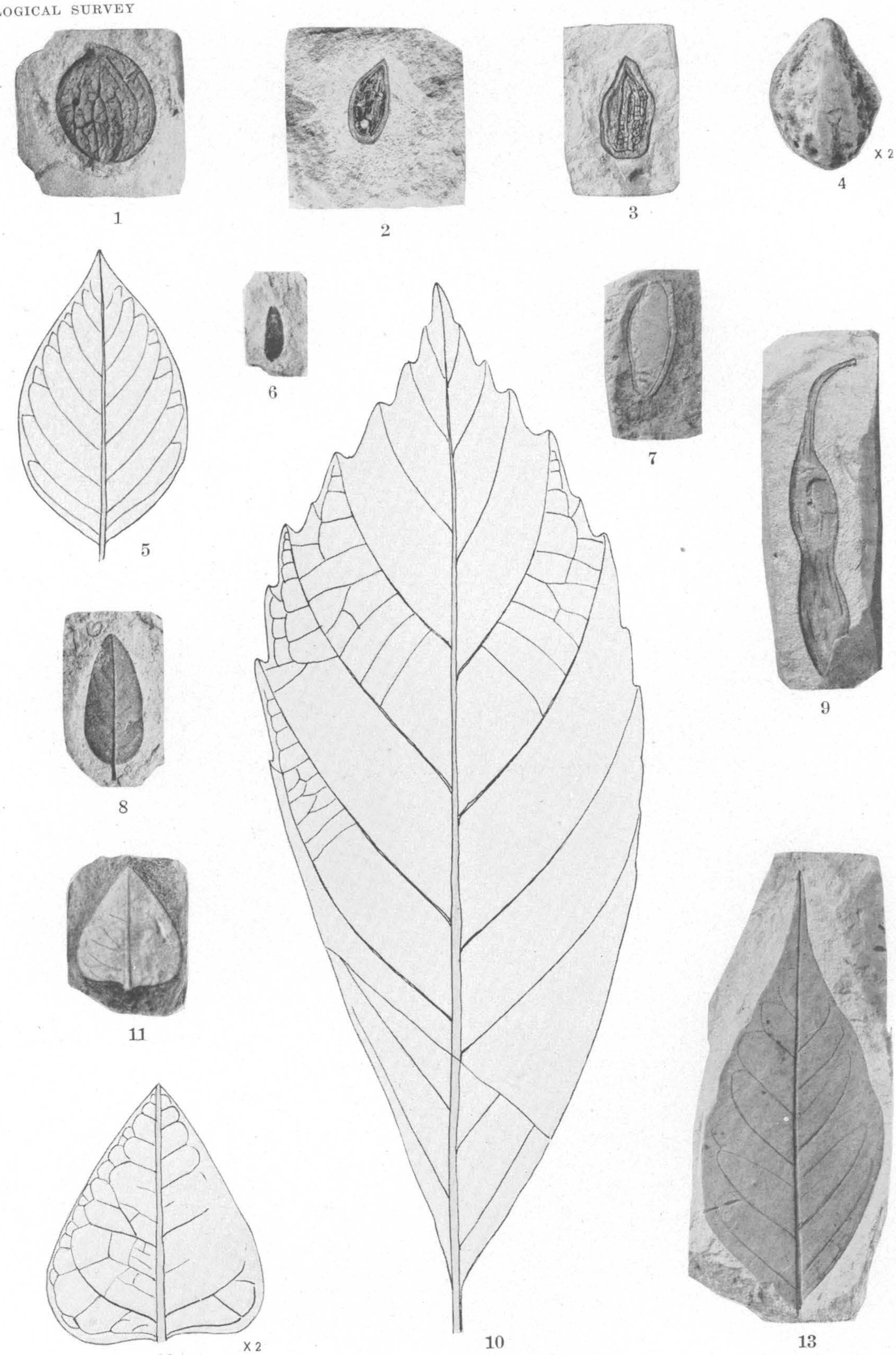
FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

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2–4. *Chrysobalanus eocenica* Berry. Stones of the Wilcox cocoa plum. 73

   2, 3. Reproduced from U. S. Geological Survey Professional Paper 91, showing mode of preservation in clay.

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5. *Canavalia acuminata* Berry. A small leaflet from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 86

6. *Mimosites variabilis* Berry. Leaflet from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 73

7. *Cassia wilcoxiana* Berry. A small pod of this species from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 79

8. *Cassia fayettensis* Berry. A small leaflet from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 79

9. *Parkinsonia eocenica* Berry, n. sp. Fragment of the moniliform pod of this species from the Holly Springs sand at La Grange, Fayette County, Tenn. 77

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11, 12. *Leguminosites drepanocarpoides* Berry, n. sp. Leaflets from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 86

   12. Enlarged to show venation.

13. *Cassia puryearensis* Berry. Leaflet from the Holly Springs sand at Mill Creek, Hardeman County, Tenn. 81

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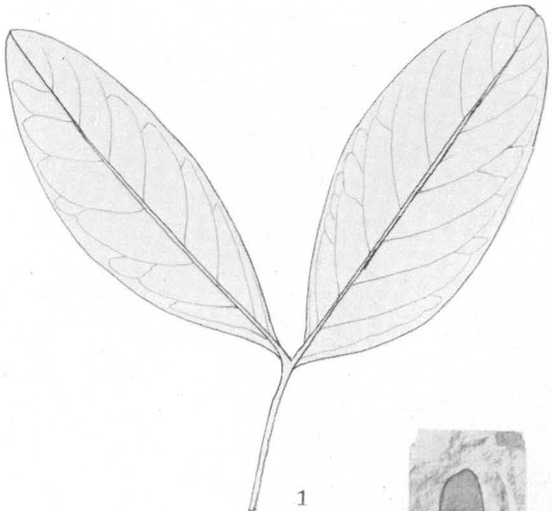
1.	*Hymenaea eocenica* Berry, n. sp. Bifoliate leaf from the Holly Springs sand at Mill Creek, Hardeman County, Tenn.	82
2.	*Hymenaea candolleana* Humboldt, Bonpland, and Kunth. Nature print of a leaf of a modern species from Colombia introduced for comparison with *Hymenaea eocenica* Berry.	
3.	*Leguminosites shandyensis* Berry, n. sp. Leaflet from the Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.	88
4, 5.	*Leguminosites andiraformis* Berry, n. sp. Leaflets from the Holly Springs sand, road west of La Grange, Fayette County, Tenn.	87
6, 7.	*Leguminosites collinsi* Berry, n. sp. Fragments of pods from the Holly Springs sand, Mill Creek, Hardeman County, Tenn.	89
8.	*Leguminosites ingafructoides* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn.	87



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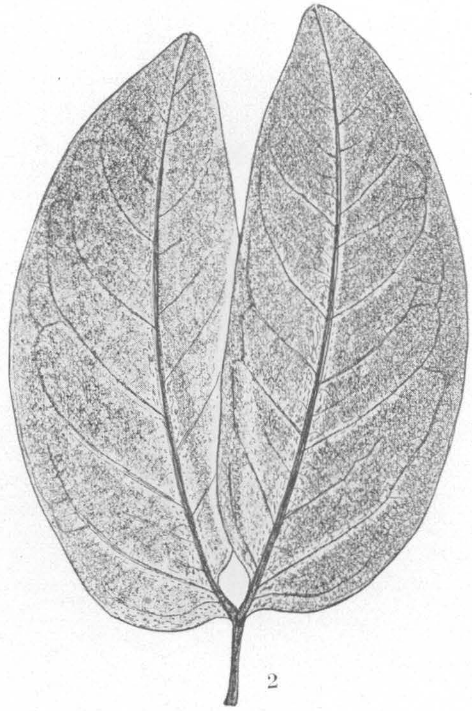

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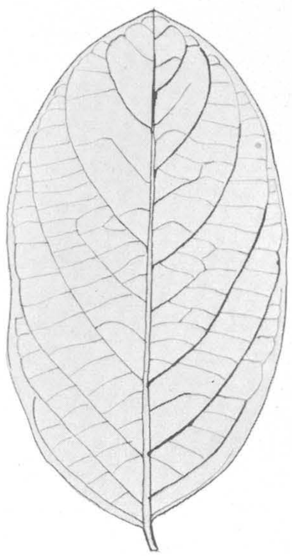

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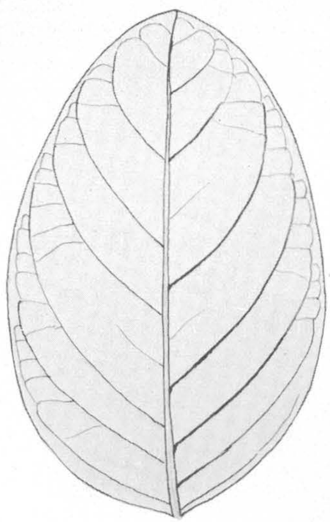

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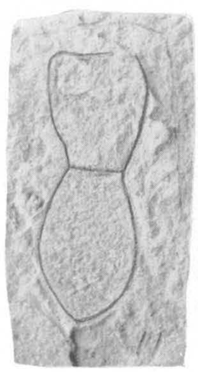

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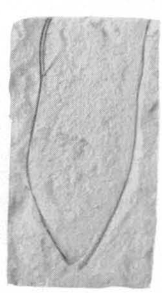

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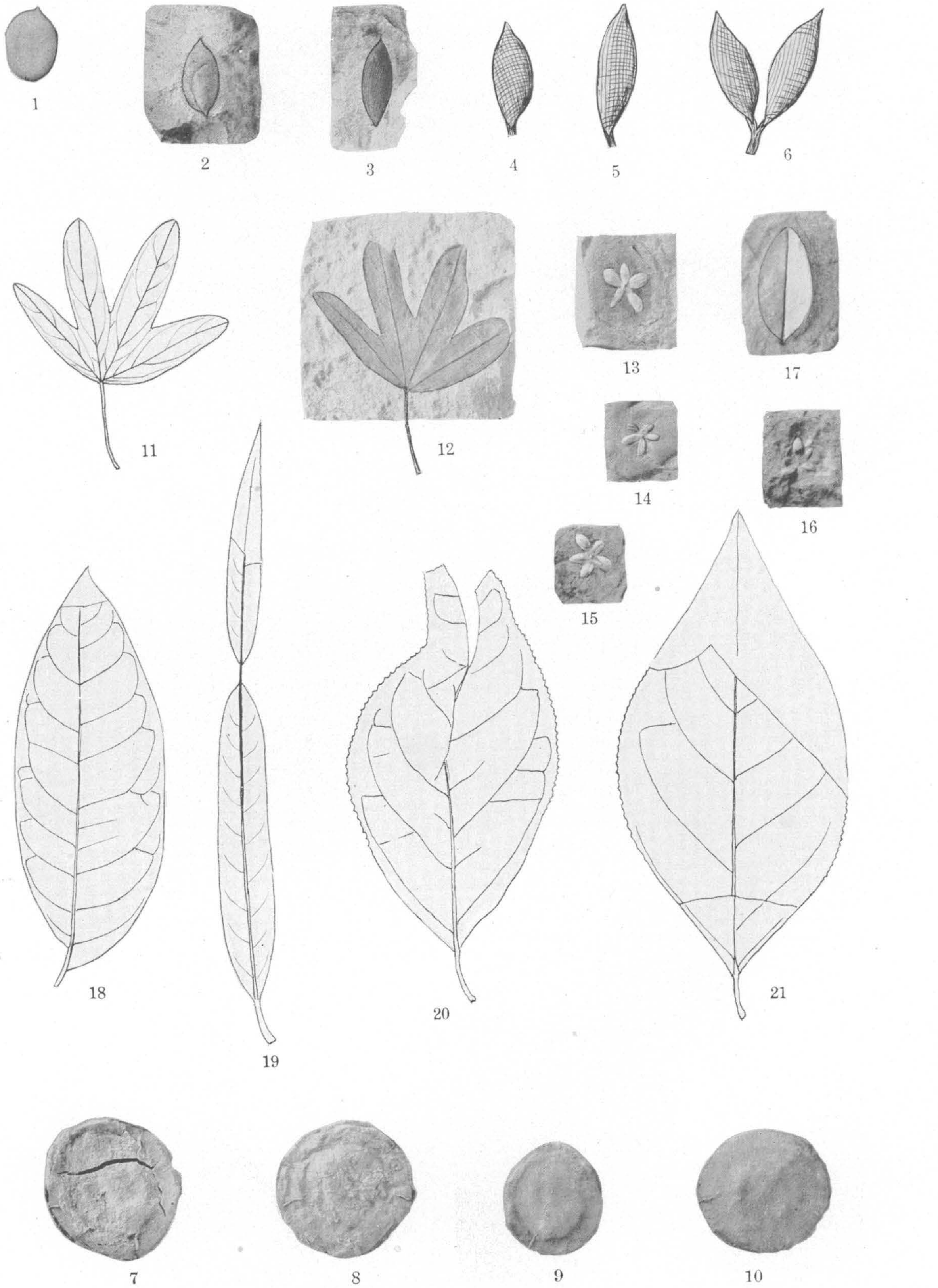
FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 14

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PLATE 15

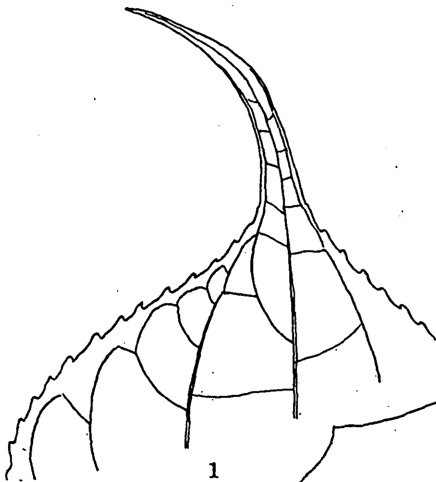
Page

1–3. *Grewiopsis tennesseensis* Berry. Fragments of large leaves of this species ---------- 106

1. Extended acuminate tip. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.

2. Median portion of a large leaf with characteristic margin and venation. Same horizon and locality as **1.**

3. Basal part of leaf. Holly Springs sand, west of Bolivar, Hardeman County, Tenn.



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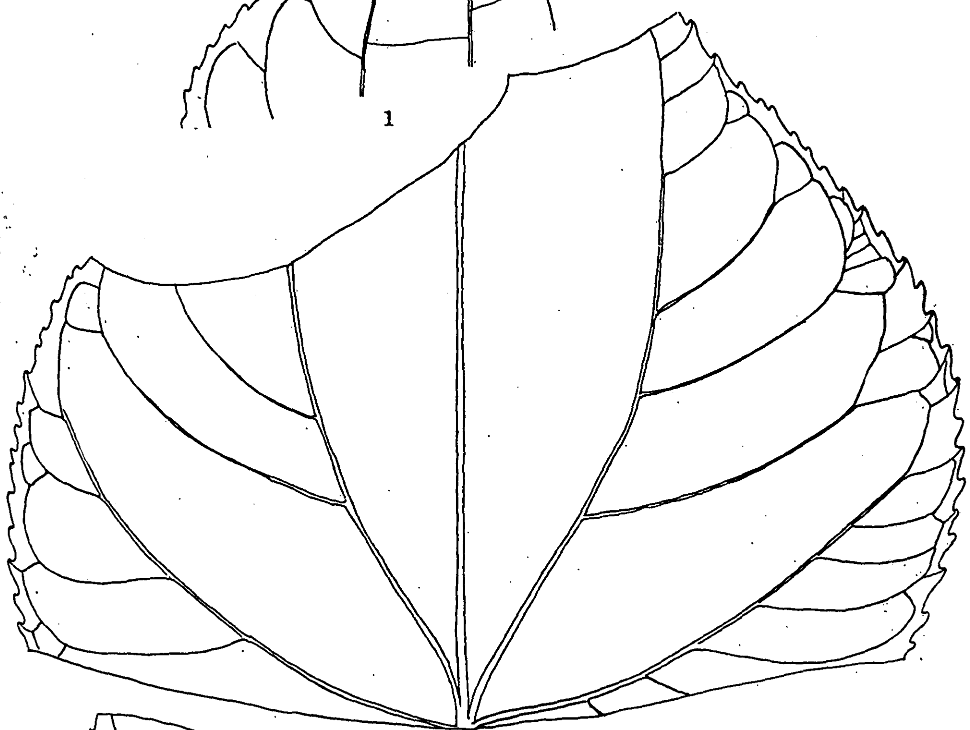

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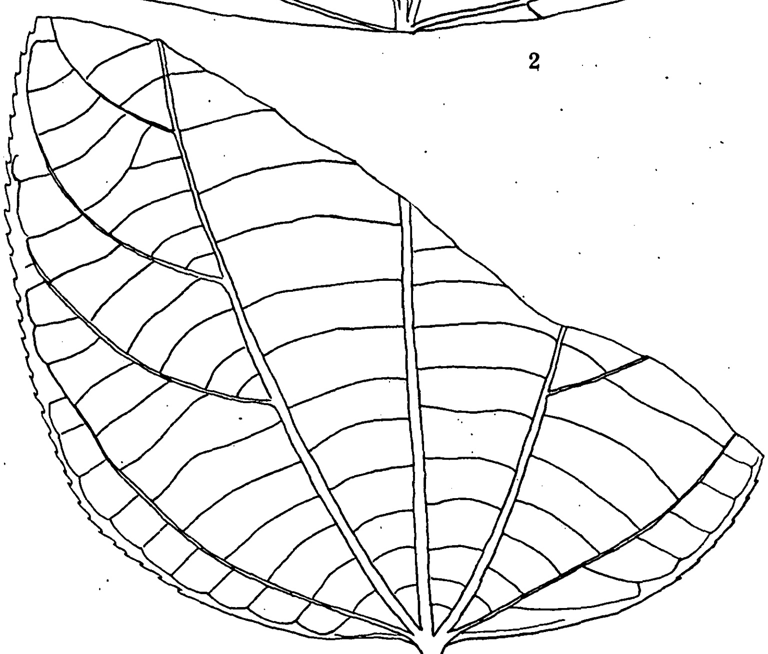

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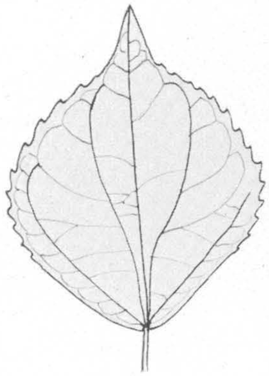
FOSSIL PLANTS OF THE WILCOX GROUP



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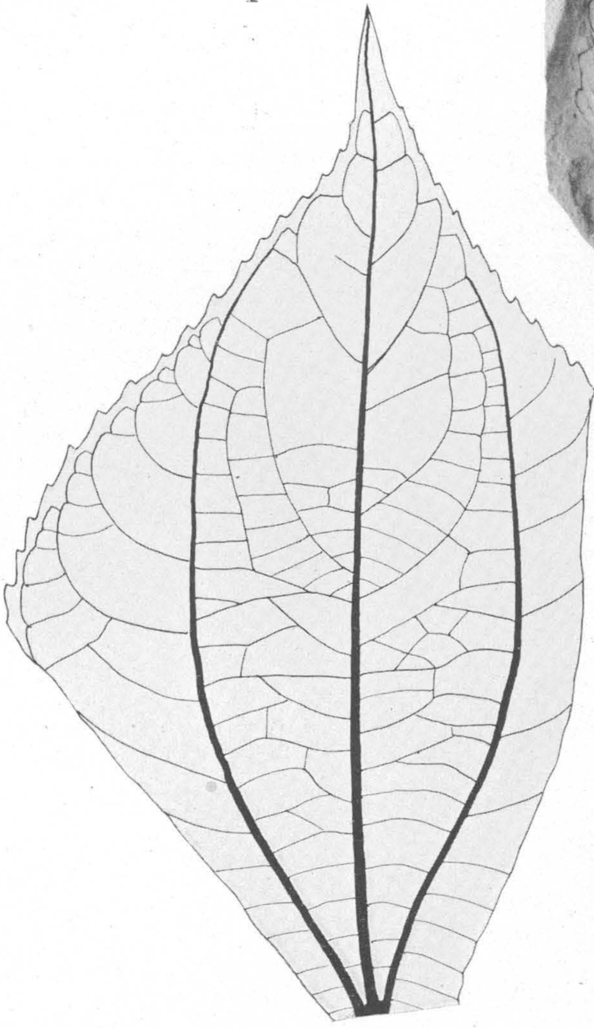

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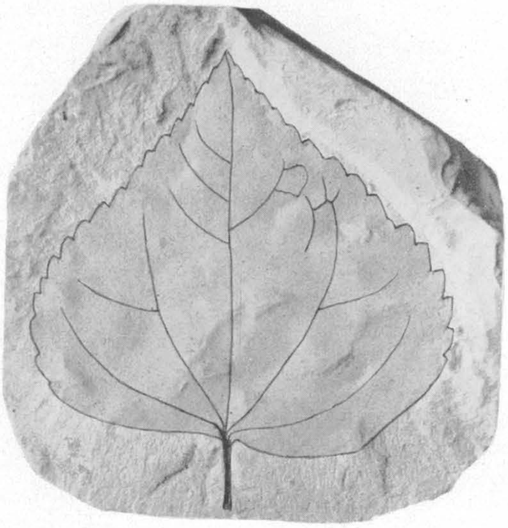

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FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 16

		Page
1-4.	*Grewiopsis tennesseensis* Berry. Showing variations in this species	106
	1. A very small leaf. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.	
	2. A large leaf much less acuminate than that shown in Plate 15, Figure 1. Same horizon and locality as **1.**	
	3, 4. Holly Springs sand, in Fayette County, Tenn., 1 mile southwest of Grand Junction, Hardeman County.	

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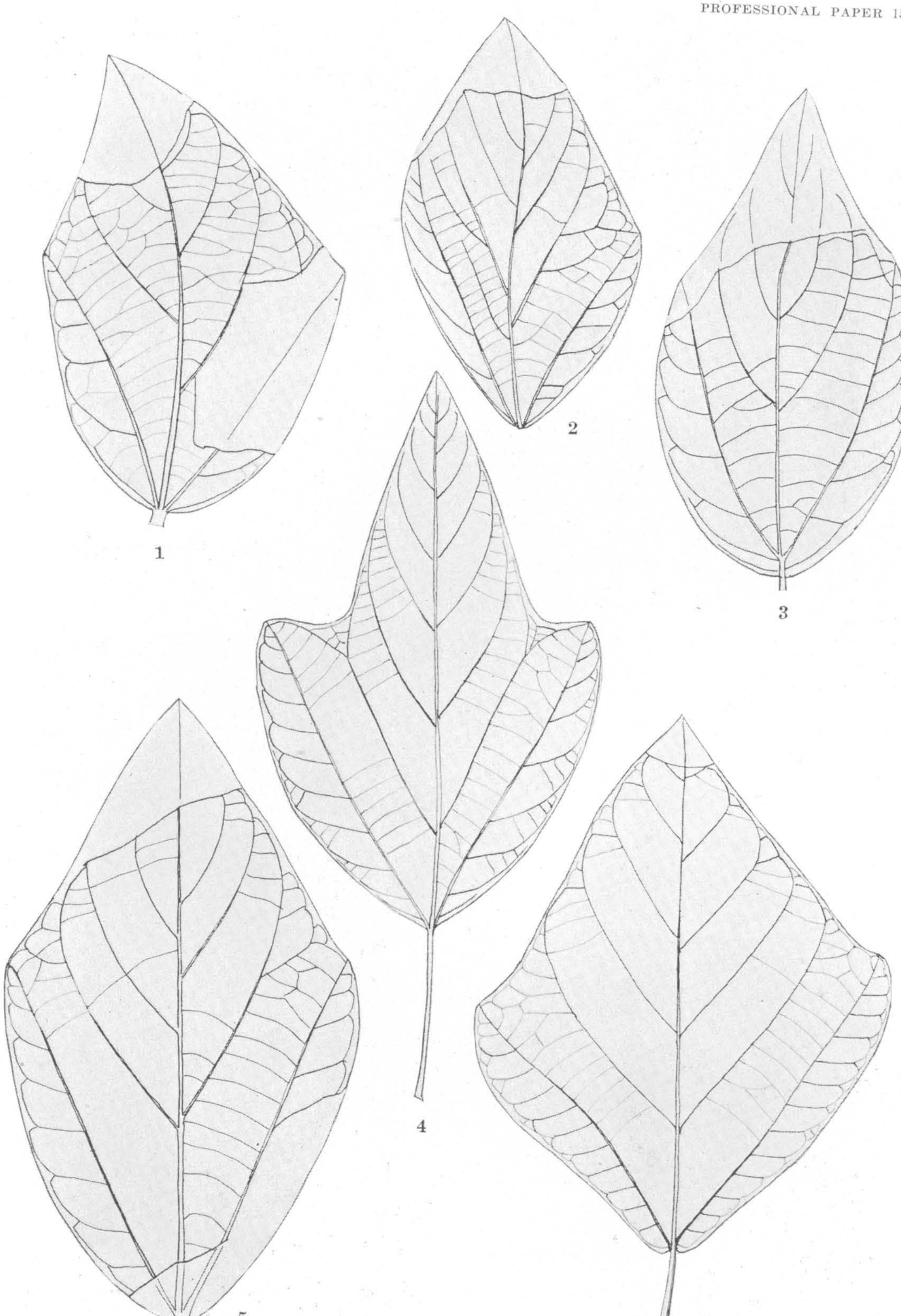
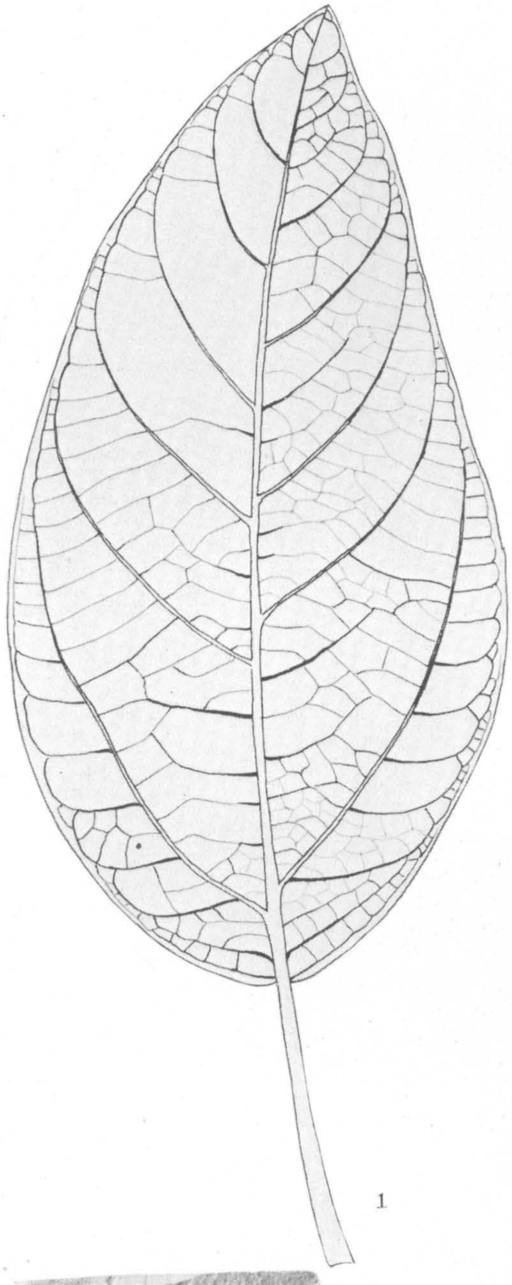
1–6. *Cissites collinsi* Berry, n. sp. Showing the variations in outline and venation of this species. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 102



FOSSIL PLANTS OF THE WILCOX GROUP



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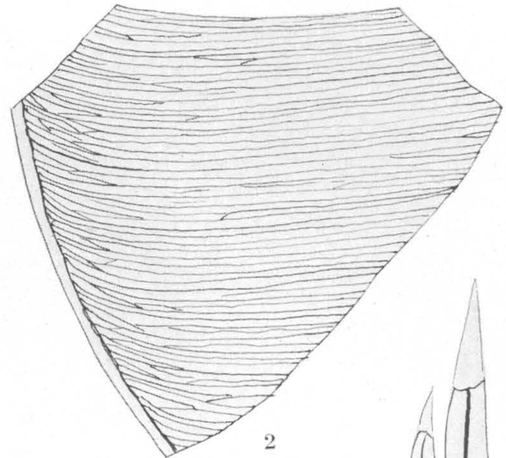

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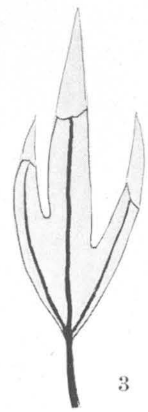

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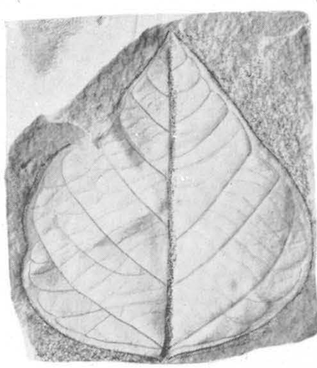

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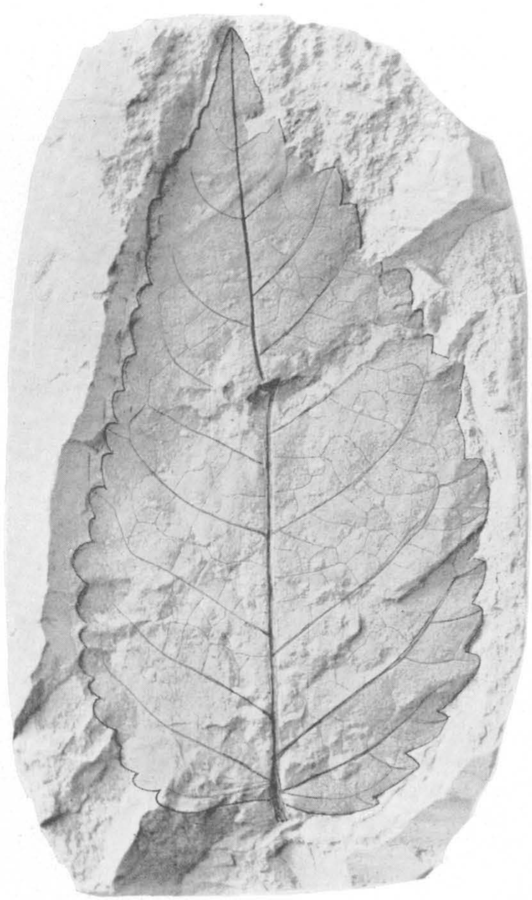

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FOSSIL PLANTS OF THE WILCOX GROUP

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2.	*Clusiaphyllum eocenicum* Berry, n. sp. Fragment of a large leaf from Wilcox formation in sec. 10, T. 14 S., R. 21 W., Nevada County, Ark	113
3.	*Sterculia zavalana* Berry, n. sp. Probably an anomalous leaf form. Carrizo sandstone, Nueces River, north of La Pryor, Zavala County, Tex	107
4.	*Buettneria eocenica* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn	107
5.	*Grewiopsis elegans* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn	105

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1. *Cinnamomum ovoides* Perkins. Fruit washed out of lignite seam in Holly Springs sand on Taylor farm, Chester County, Tenn ---- 114

2. *Laurus collinsi* Berry, n. sp. Fruit of some lauraceous plant. Holly Springs sand, La Grange, Fayette County, Tenn ---- 117

3. *Laurus hardemanensis* Berry, n. sp. Proximal view of a cupule of some lauraceous fruit. Holly Springs sand, big cut at Pine Top, Hardeman County, Tenn ---- 117

4, 5. *Melastomites ovatus* Berry, n. sp. Holly Springs sand, western edge of La Grange, Fayette County, Tenn ---- 118

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6–8. *Nyssa wilcoxiana* Berry. A species of gum of the Holly Springs sand ---- 126

6. Large form of stone. Bolivar-Somerville road, Hardeman County, Tenn.

7, 8. Narrow stones from Saulsbury, Hardeman County, Tenn.

9. *Nyssa tennesseensis* Berry, n. sp. Gum leaf from Holly Springs sand, Mill Creek, Hardeman County, Tenn ---- 125

10. *Nyssa curta* Perkins. Stone washed out of lignite seam in Holly Springs sand on Taylor farm, Chester County, Tenn ---- 125

11, 12. *Bumelia americana* (Lesquereux) Berry. Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn ---- 128

13, 14. *Apocynophyllum sapindifolium* Hollick ---- 129

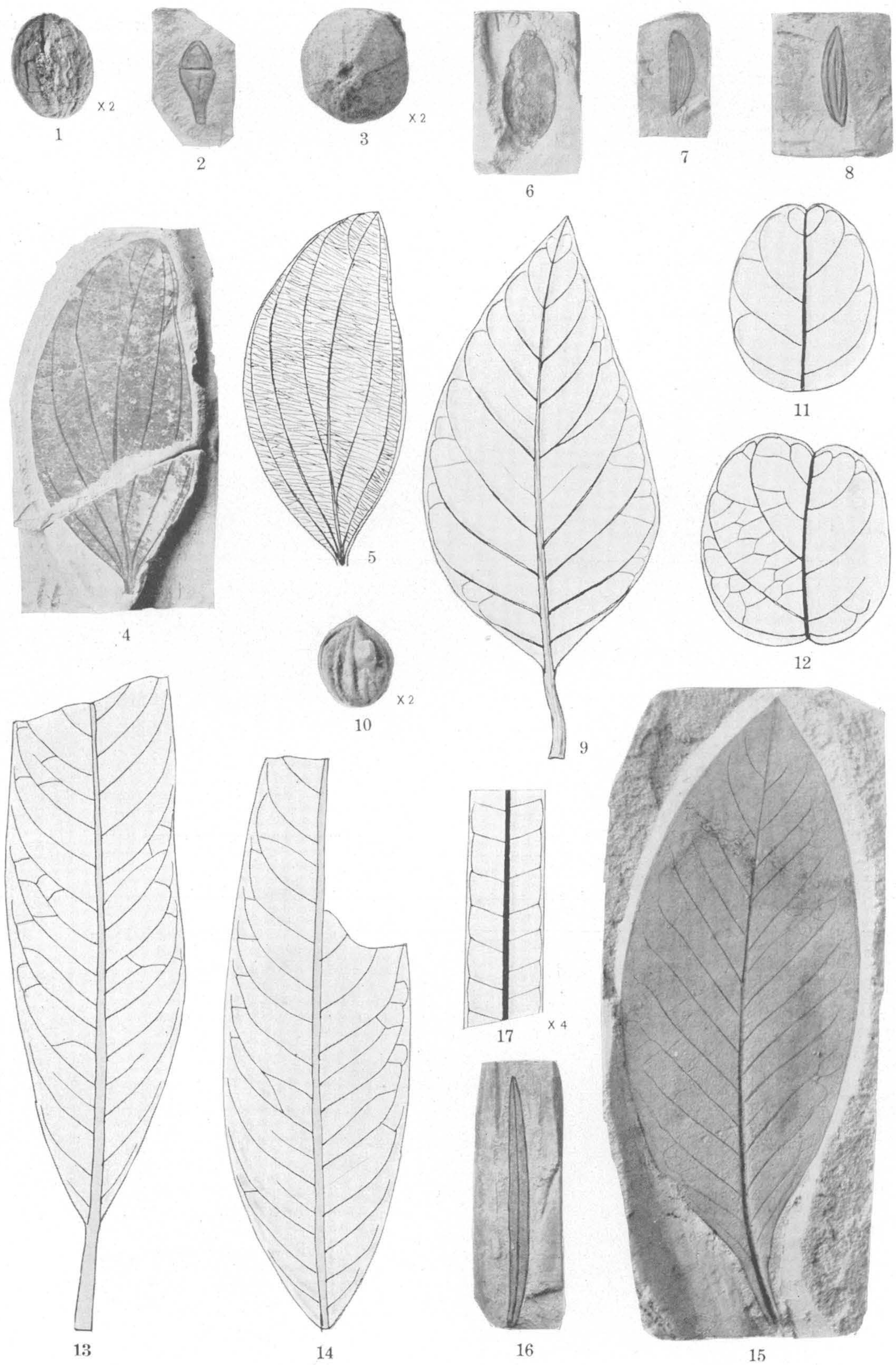
13. Holly Springs sand, near Cloverport, Hardeman County, Tenn.

14. Wilcox formation, sec. 10, T. 14 S., R. 21 W., Nevada County, Ark.

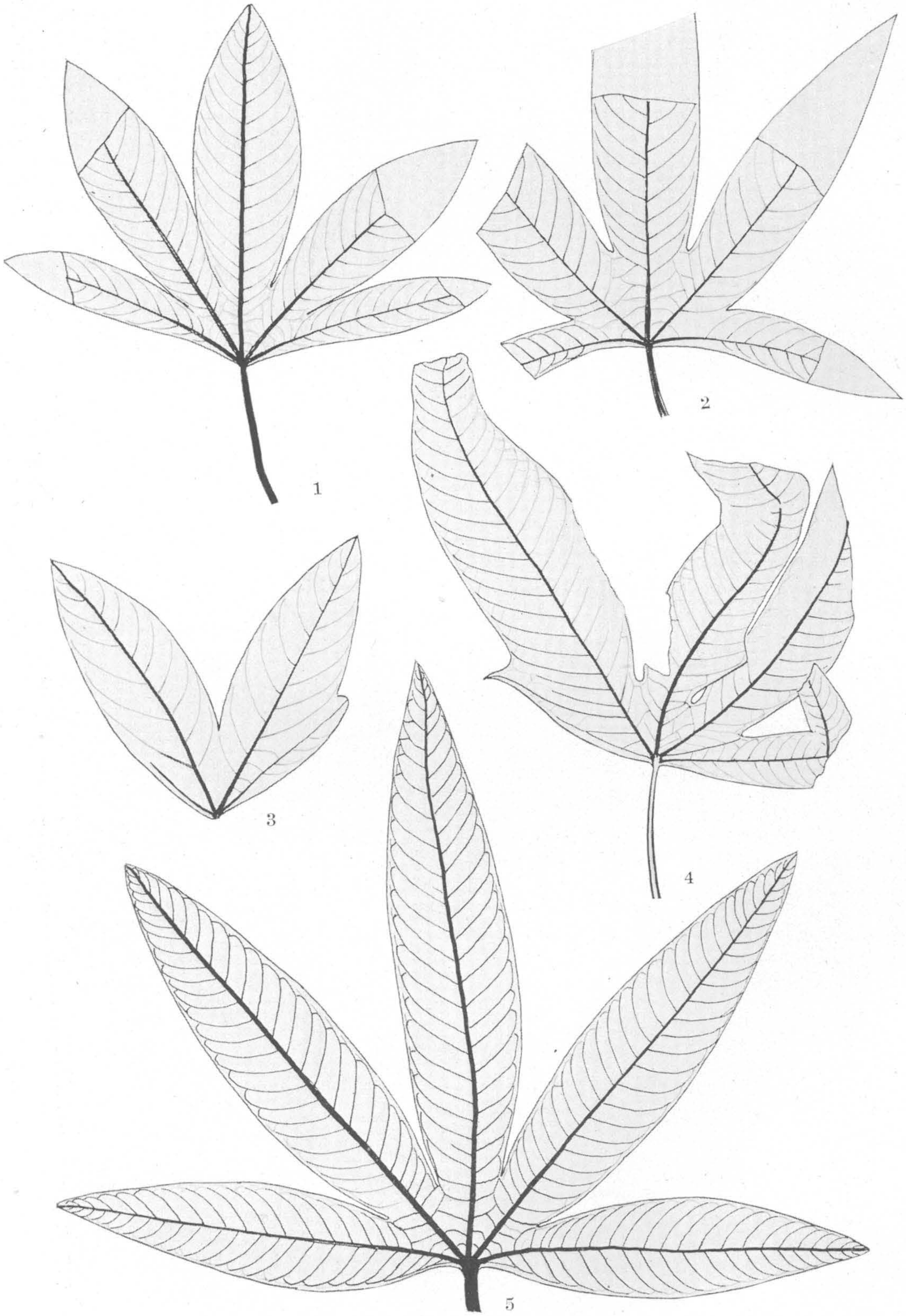
15. *Apocynophyllum mississippiense ovatum* Berry, n. var. Grenada formation, Whiteville gully, Hardeman County, Tenn ---- 129

16, 17. *Acerates wilcoxiana* Berry, n. sp. Holly Springs sand, La Grange, Fayette County, Tenn ---- 131

17. Part of leaf enlarged to show the characteristic venation.



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

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1–5. *Oreopanax wilcoxensis* Berry, n. sp. Showing the variations in the highly characteristic digitately lobed leaves of this species 122

1–3. Holly springs sand, Mill Creek, Hardeman County, Tenn.

4. Carrizo sandstone, Nueces River north of La Pryor, Zavala County, Tex.

5. Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn.

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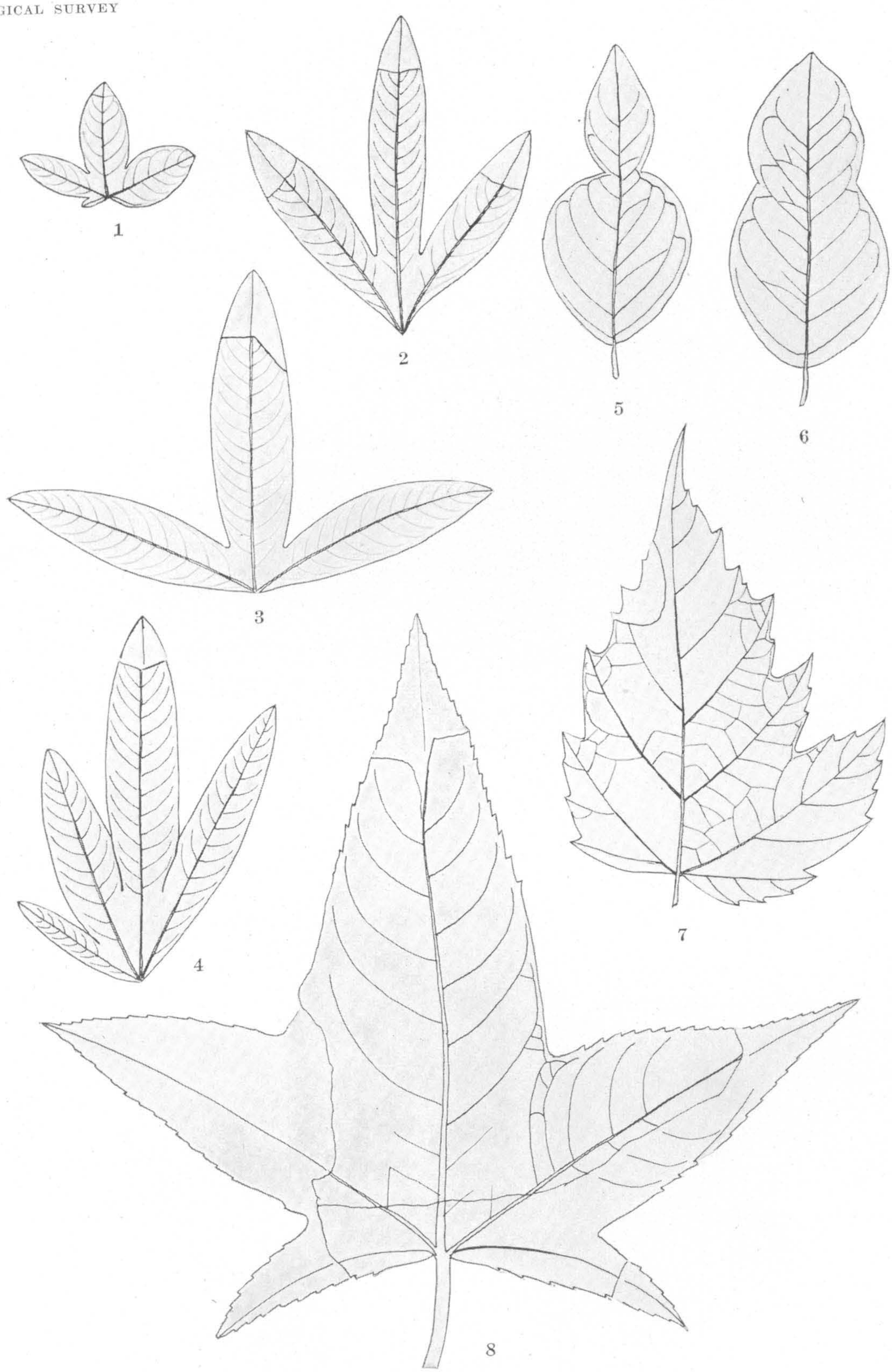
1–4. *Oreopanax wilcoxensis* Berry, n. sp. Extremes of variation in the small digitately lobed leaves of this species. Holly Springs sand, Mill Creek, Hardeman County, Tenn ---- 122

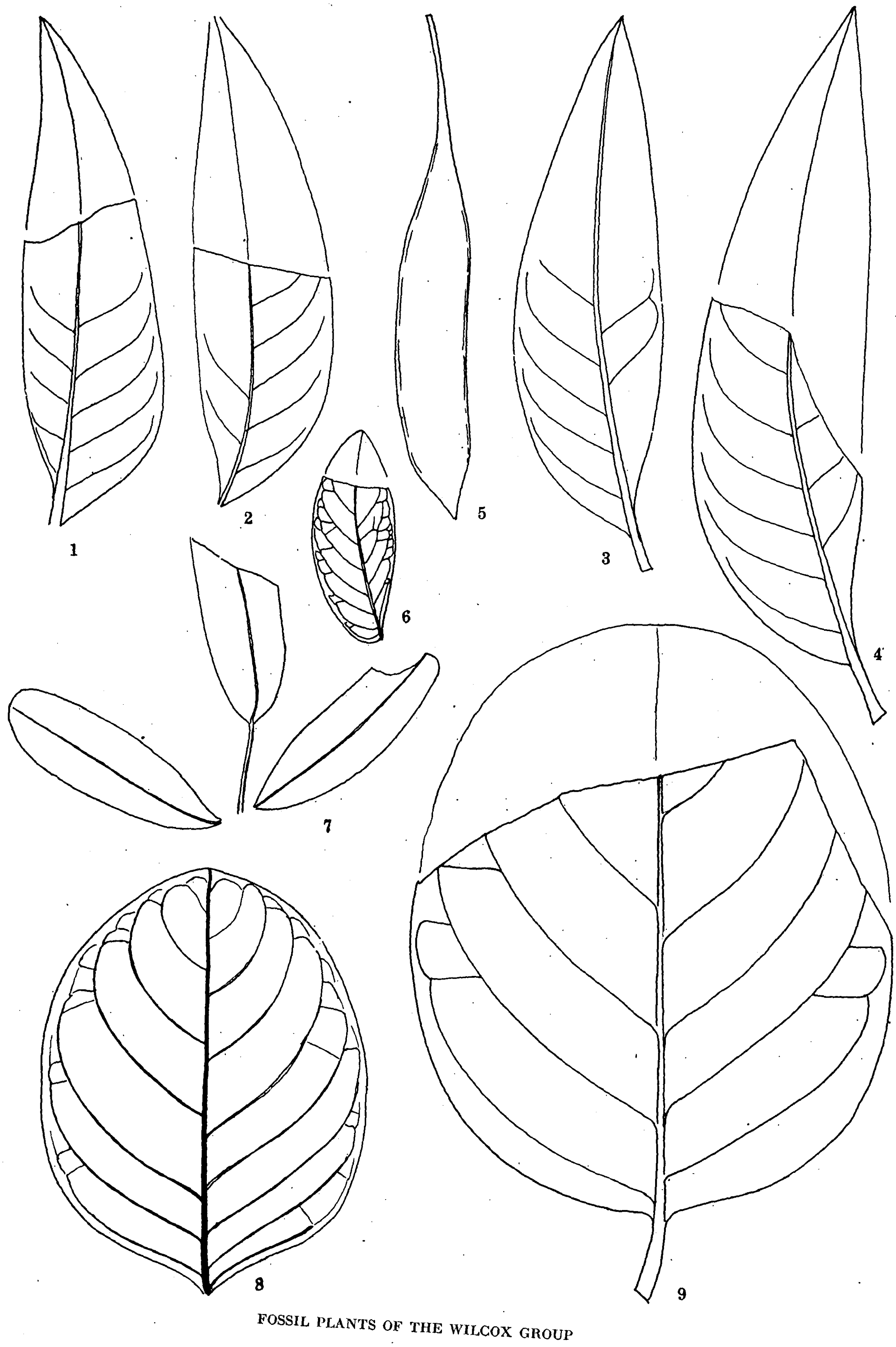
5, 6. *Ficus pandurifolia* Berry, n. sp. Holly Springs sand, west of Bolivar, Hardeman County, Tenn ---- 64

7. *Negundo knowltoni* Berry, n. sp. A lateral leaflet. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn ---- 98

8. *Liquidambar wilcoxianum* Berry, n. sp. A leaf of the Wilcox red gum. Holly Springs sand, west of Bolivar, Hardeman County, Tenn ---- 72



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

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1–4.	*Inga laurinafolia* Berry. Showing the variation in the leaflets of this species at the locality 6 miles north of Scottsville, Harrison County, Tex	76
5.	*Leguminosites collinsi* Berry, n. sp. Pod supposed to be related to the genus *Cercis*. Near top of Holly Springs sand, northwest of Pattersonville, Fayette County, Tenn	89
6.	*Pithecolobium? tennesseense* Berry, n. sp. Leaflet from bed near the top of the Holly Springs sand, northwest of Pattersonville, Fayette County, Tenn	75
7.	*Simaruba eocenica* Berry. Part of the apex of an odd-pinnate leaf. Holly Springs sand, west of Bolivar, Hardeman County, Tenn	93
8.	*Leguminosites andiraformis* Berry, n. sp. Leaflet from bed near the top of the Holly Springs sand, northwest of Pattersonville, Fayette County, Tenn	87
9.	*Coccolobis uviferafolia* Berry. A nearly complete leaf of this species from the Wilcox formation 6 miles north of Scottsville, Harrison County, Tex	67

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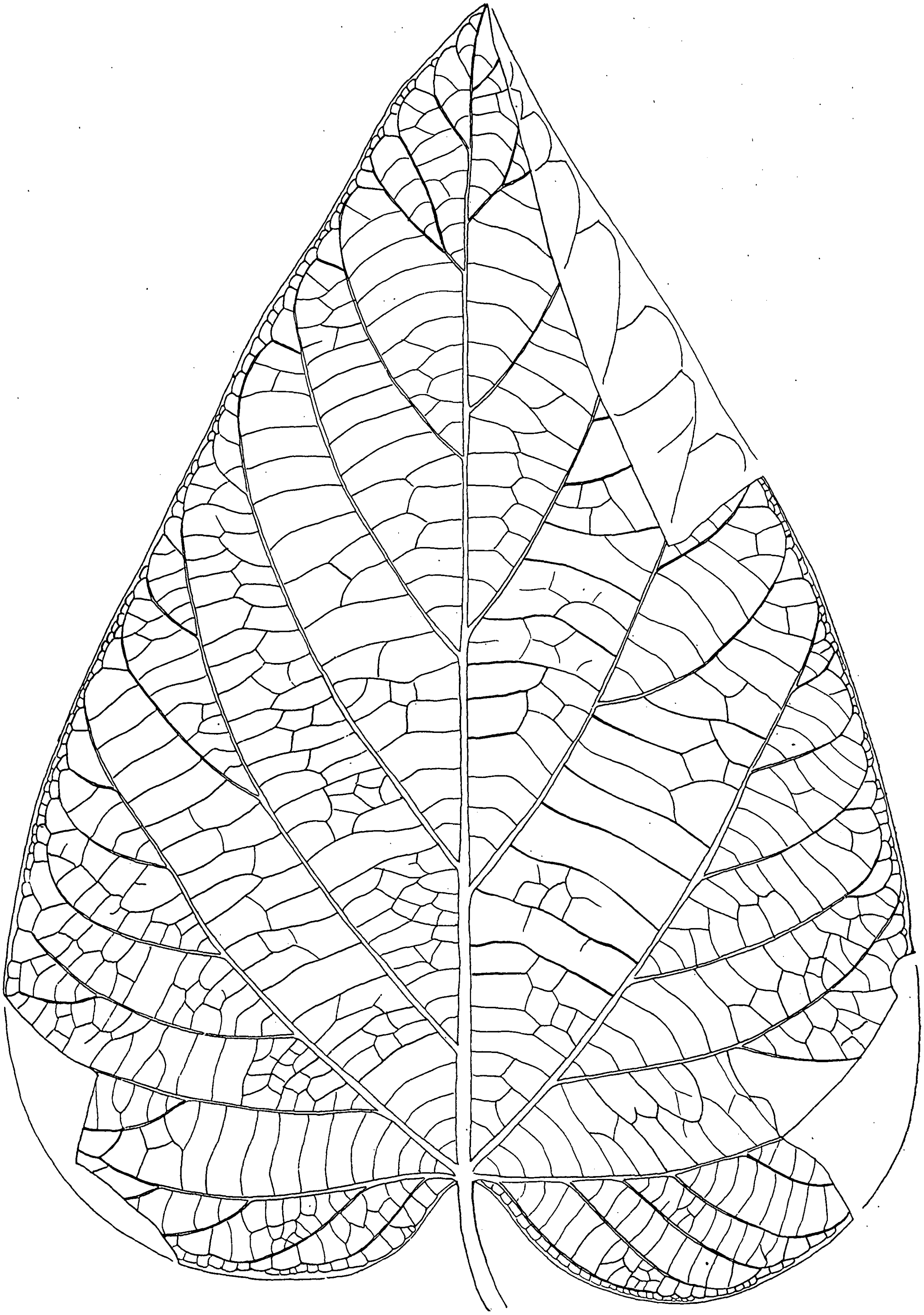
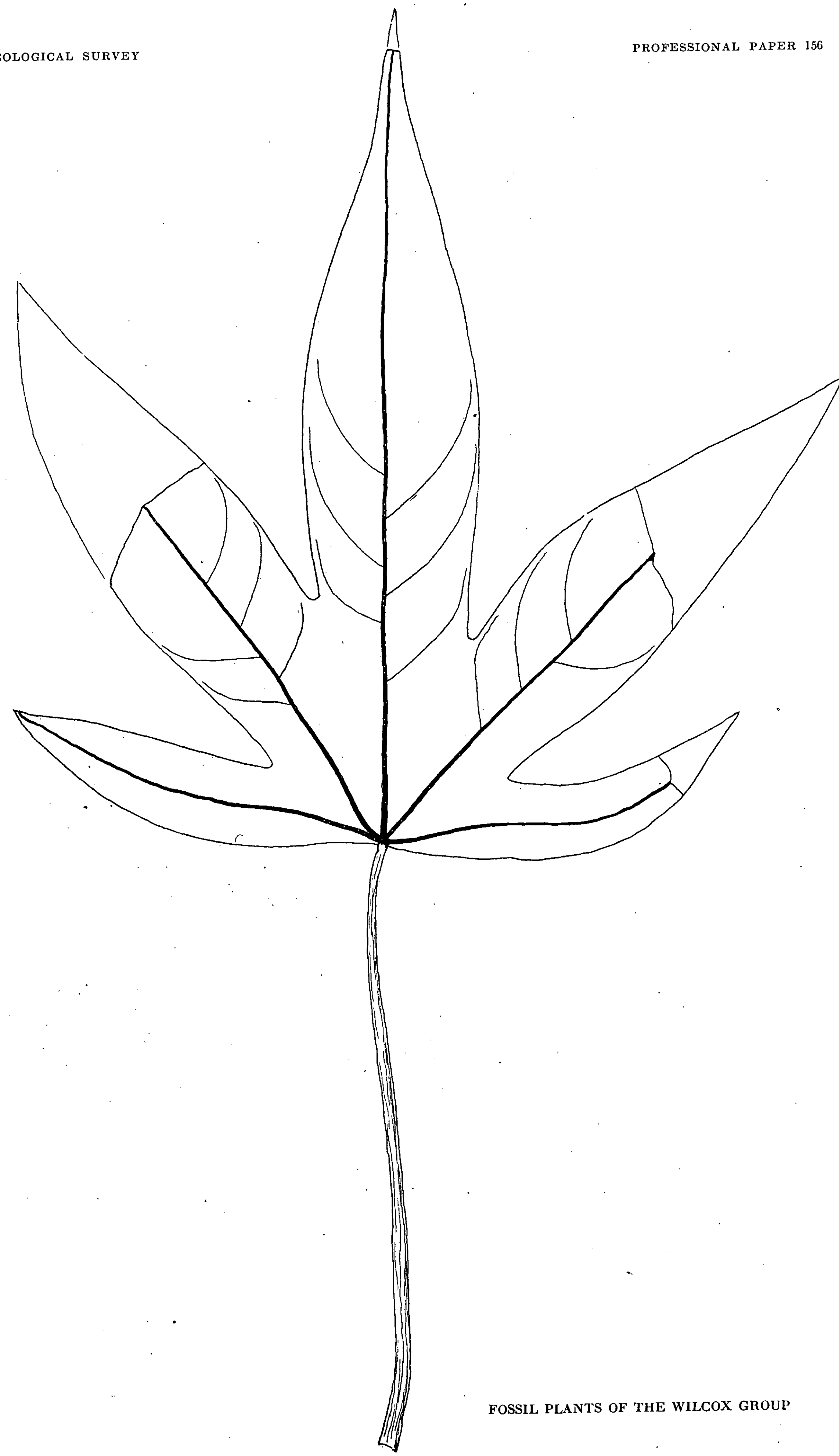
PLATE 23



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 24

PLATE 25

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1.	*Carpolithus shandyensis* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn	135
2–5.	*Carpolithus gronovii* Berry, n. sp. Lignite seam in Holly Springs sand, Taylor farm, Chester County, Tenn	135
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	7. Lignite seam on Taylor farm, Chester County, Tenn.	
8.	*Carpolithus taylorensis* Berry, n. sp. Lignite seam in Holly Springs sand, Taylor farm, Chester County, Tenn	136
9.	*Carpolithus chesterensis* Berry, n. sp. Lignite seam in Holly Springs sand, Taylor farm, Chester County, Tenn	136
10.	*Carpolithus collinsi* Berry, n. sp. Lignite seam in Holly Springs sand, Taylor farm, Chester County, Tenn	137
11.	*Carpolithus puryearensis* Berry. Grenada formation, Whiteville gully, Hardeman County, Tenn	137
12.	*Carpolithus poaformis* Berry, n. sp. Holly Springs sand, Bolivar road near Center Church, about 5 miles north of Grand Junction and just east of Illinois Central Railroad, Hardeman County, Tenn	138
13.	*Euonymus? fructescens* Berry, n. sp. Holly Springs sand, old Murrell place, southeast of Bolivar, Hardeman County, Tenn	98
14.	*Carpolithus sapindoides* Berry, n. sp. Fruit supposed to represent the genus *Sapindus.* Holly Springs sand, Bolivar road near Center Church, about 5 miles north of Grand Junction and just east of Illinois Central Railroad, Hardeman County, Tenn	137
15.	*Leguminosites monospermoides* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn	90
16, 17.	*Carpolithus longepedunculatus* Berry, n. sp. Holly Springs sand	136
	16. Mill Creek, Hardeman County, Tenn.	
	17. 2¼ miles north of Shandy, Hardeman County, Tenn.	
18.	*Carpolithus juncaformis* Berry, n. sp. Fruit supposed to represent a rush (*Juncus*). Holly Springs sand, La Grange, Fayette County, Tenn	138
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20.	*Carpolithus gronovii* Berry. Holly Springs sand, gully on old Bolivar-Somerville road, Hardeman County, Tenn	135
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23–25.	*Antholithes mimosaformis* Berry, n. sp. Flowers supposed to represent some mimosaceous form. Holly Springs sand, Mill Creek, Hardeman County, Tenn	140
	23. Photograph of specimen, natural size.	
	24. Photograph of a specimen, enlarged.	
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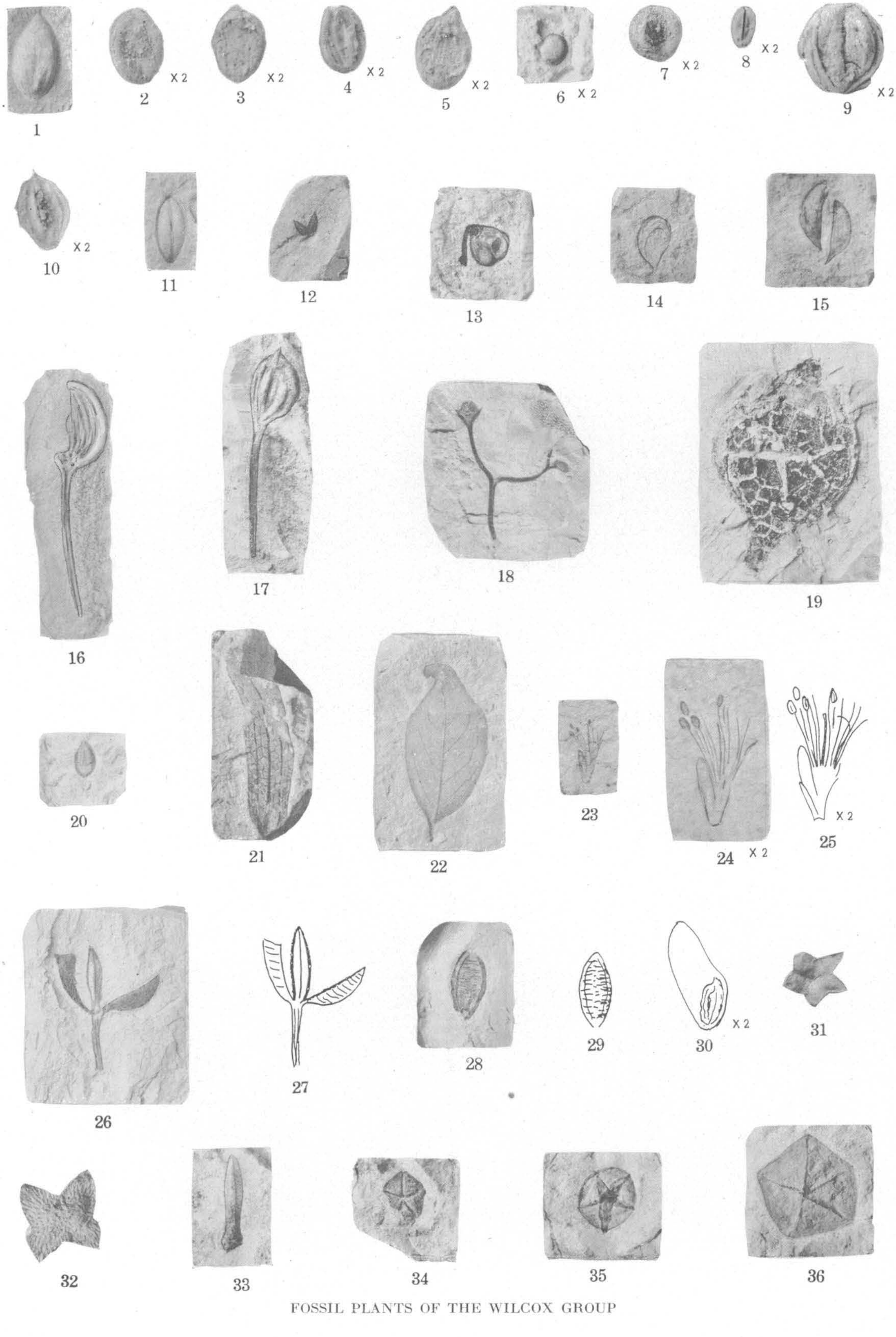
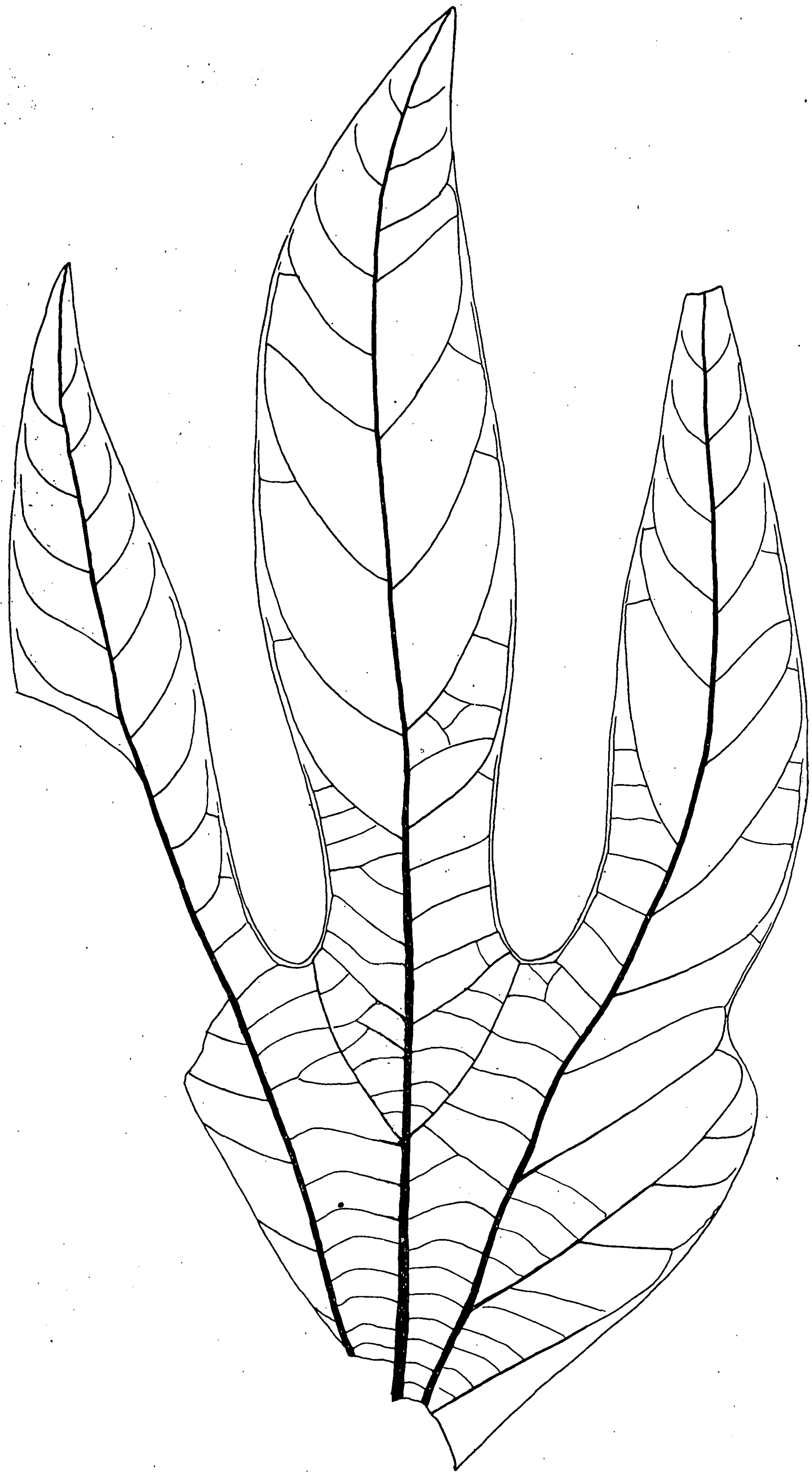
26–29.	*Celastrocarpus eocenicus* Berry, n. sp. Fruit of some member of the family Celastraceae. Holly Springs sand, just south of Saulsbury, Hardeman County, Tenn	97
30.	*Carpolithus alatus* Berry, n. sp. Holly Springs sand, Bolivar road near Center Church, about 5 miles north of Grand Junction and just east of Illinois Central Railroad, Hardeman County, Tenn	135
31.	*Solanites sarrachaformis* Berry, n. sp. Flower or calyx. Holly Springs sand, Mill Creek, Hardeman County, Tenn	131
32.	*Diospyros asper* Berry, n. sp. Rough calyx of a Wilcox species of persimmon. Holly Springs sand, Mill Creek, Hardeman County, Tenn	127
33.	*Carpolithus malpighiaformis* Berry, n. sp. Holly Springs sand, west of Bolivar, Hardeman County, Tenn	134
34–36.	*Solanites crassus* Berry, n. sp. Showing the variable flowers or calices of some member of the family Solanaceae. Holly Springs sand, Mill Creek, Hardeman County, Tenn	131



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 26

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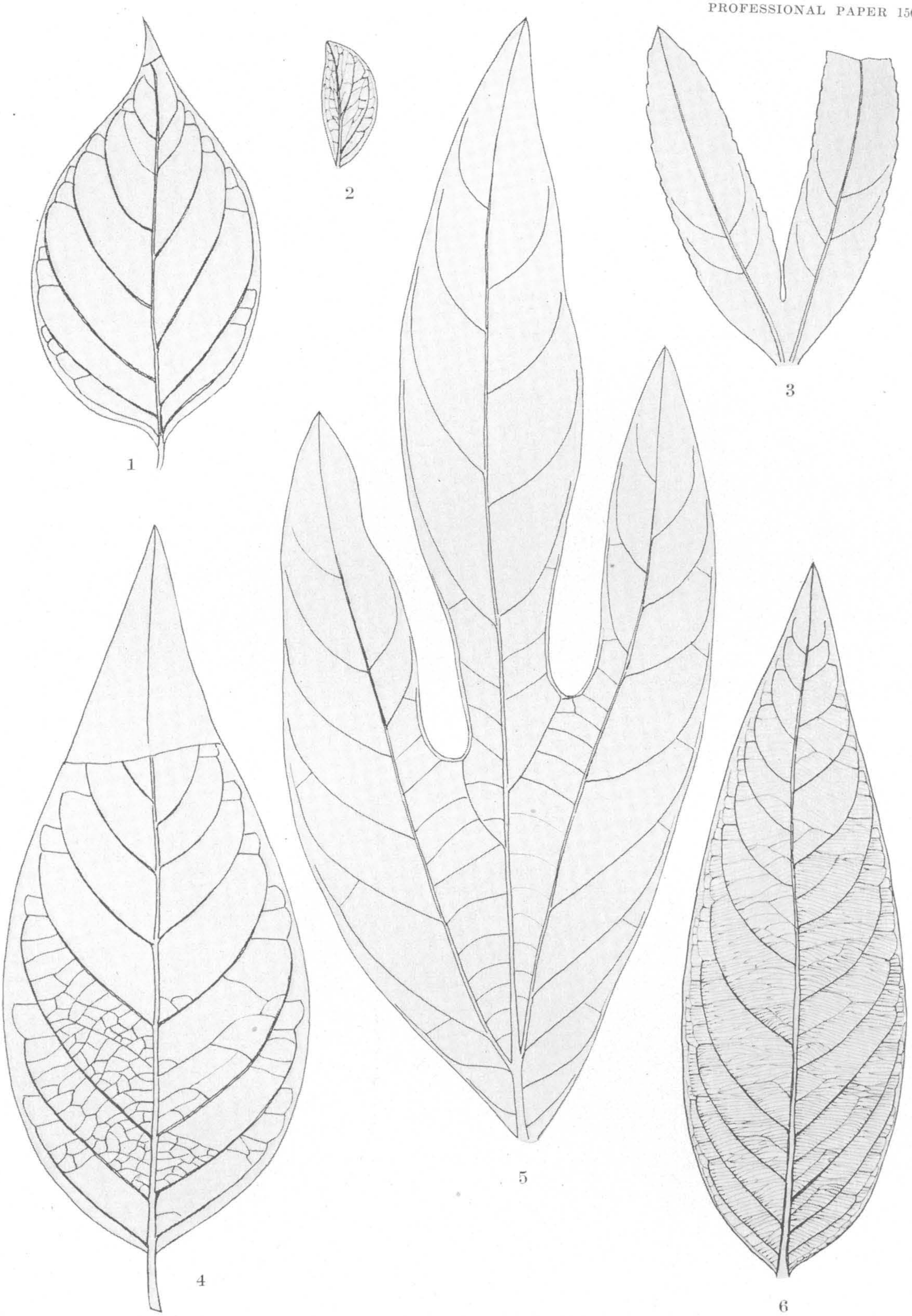
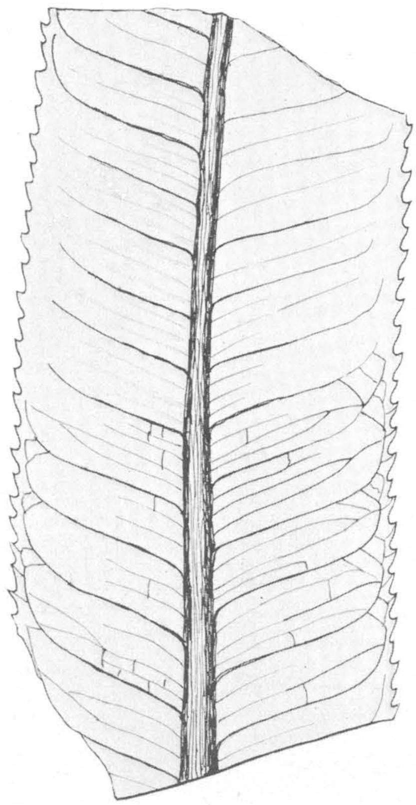
A large leaf of *Sterculia wilcoxensis* Berry from the upper plant bed in the big cut in the Holly Springs sand at Pine Top, Hardeman County, Tenn. 107

PLATE 27



FOSSIL PLANTS OF THE WILCOX GROUP



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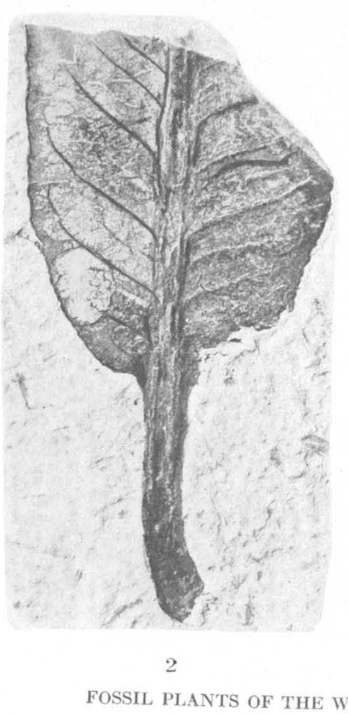

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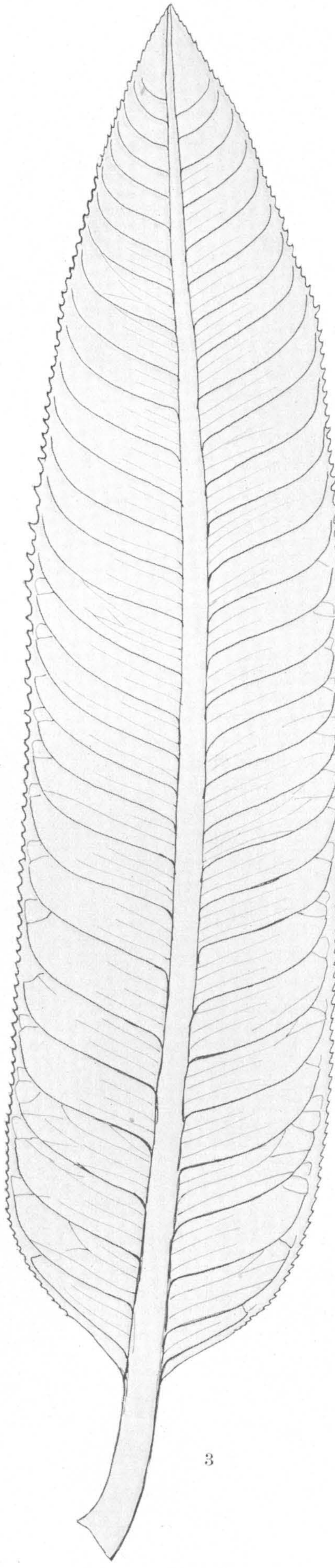

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FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 28

Page

1–3. *Ternstroemites crassus* Berry, n. sp. A remarkably large and coarse new species from the Holly Springs sand........ 110

1. Showing basal lamina and extraordinarily stout petiole. Locality in Fayette County, Tenn., 1 mile southwest of Grand Junction, Hardeman County, Tenn.
2. West of Bolivar, Hardeman County, Tenn.
3. Restoration of a complete leaf.

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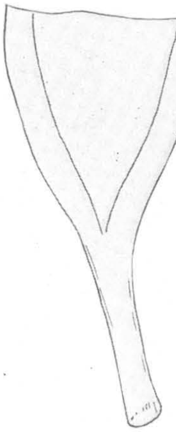
1.	*Leguminosites ingafructoides* Berry, n. sp. Proximal part of a pod showing the peduncle. Holly Springs sand, west of Bolivar, Hardeman County, Tenn	87
2.	*Celastrus bolivarensis* Berry, n. sp. Holly Springs sand, west of Bolivar, Hardeman County, Tenn	97
3, 4.	*Combretum leve* Berry, n. sp. An elongate, coarse species from the Holly Springs sand, Smiths Church, northwest of Pattersonville, Fayette County, Tenn	118
5.	*Potamogeton incertus* Berry, n. sp. A floating leaf of a Wilcox species of pondweed. Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn	54
6.	*Simaruba eocenica* Berry. A leaflet from the Holly Springs sand, west of Bolivar, Hardeman County, Tenn	93
7.	*Anacardites inequilateralis* Berry, n. sp	96
8, 9.	*Oreodaphne intermedia* Berry, n. sp. Showing the limits of variation of this species. Holly Springs sand **8.** Mill Creek, Hardeman County, Tenn. **9.** West of Bolivar, Hardeman County, Tenn.	116



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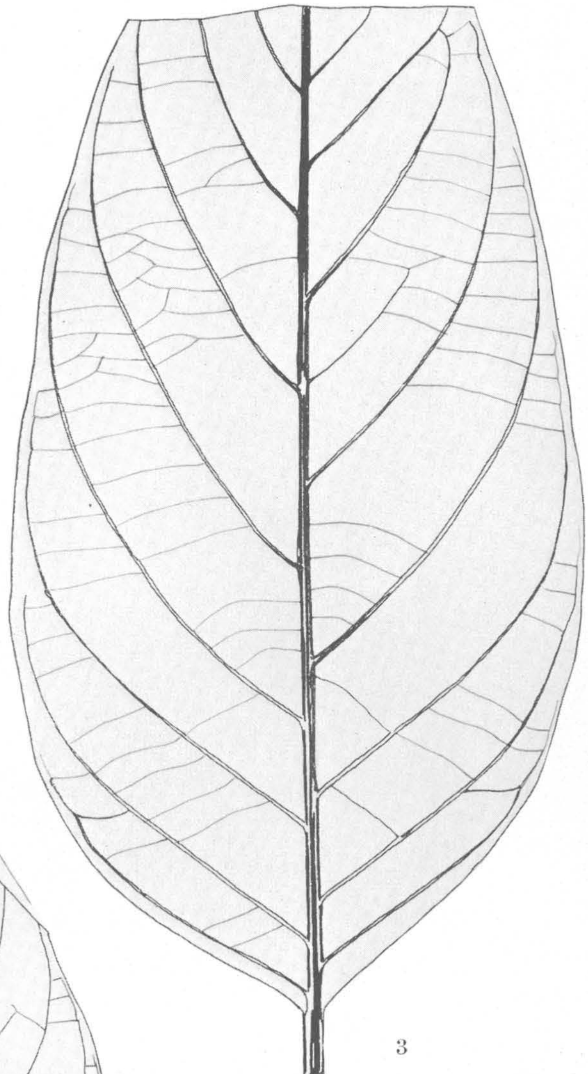

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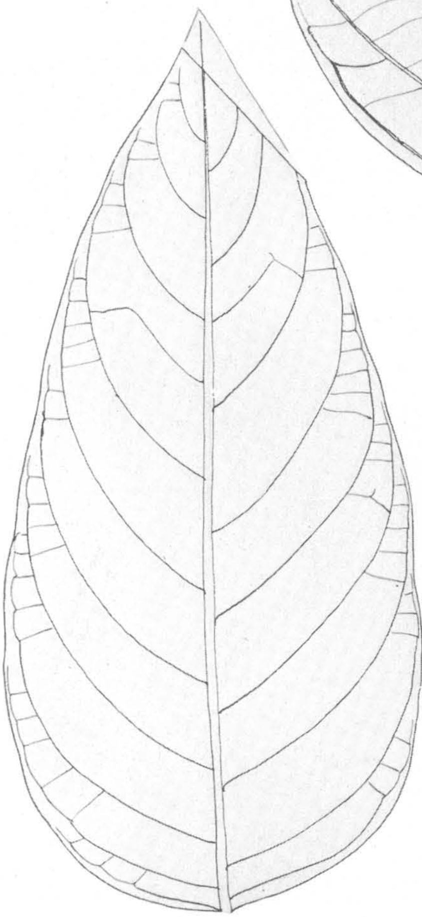

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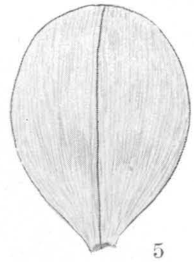

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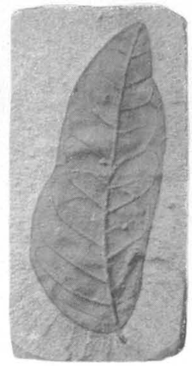

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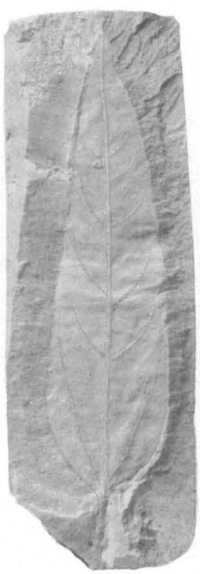

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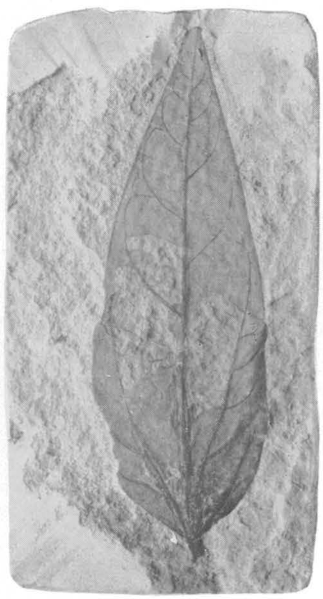

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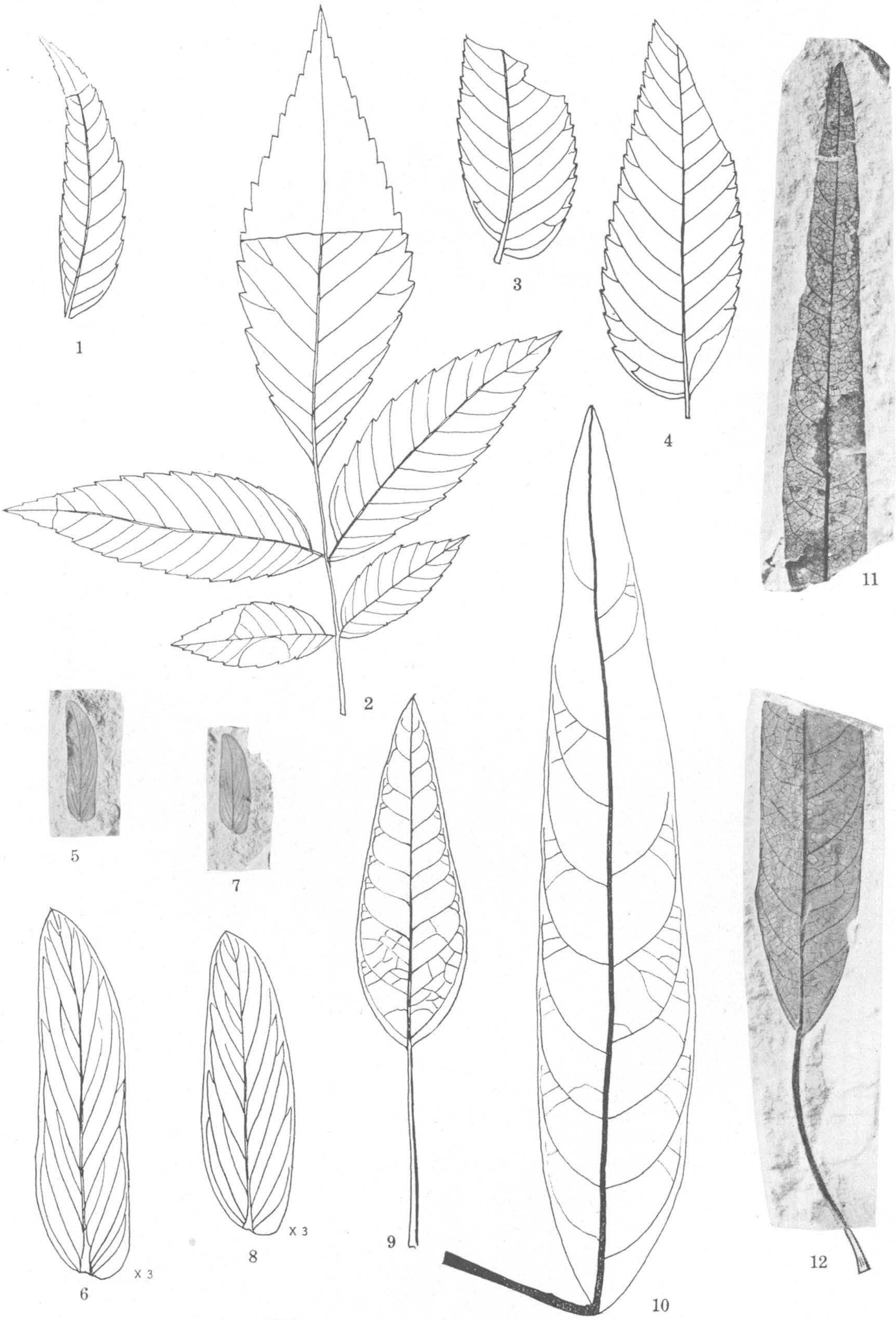
FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 30

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1–4. *Cupanites formosus* Berry, n. sp 98

1. A detached lateral leaflet from bed near the top of the Holly Springs sand, Smiths Church, northwest of Pattersonville, Fayette County, Tenn.

2. A nearly complete compound leaf. Grenada formation, northwest of Somerville, Fayette County, Tenn.

3. A lateral leaflet from ironstone float in the Grenada formation, southwest of Somerville, Fayette County, Tenn.

4. A lateral leaflet. Grenada formation, 5 miles southwest of Williston, Fayette County, Tenn.

5–8. *Mimosites acaciafolius* Berry. Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn 74

5, 7. Leaflets.

6, 8. Same, enlarged to show the detailed venation.

9–12. *Schefflera formosa* Berry, n. sp. Showing the variations in the leaflets of this species. Holly Springs sand, west of Bolivar, Hardeman County, Tenn 123

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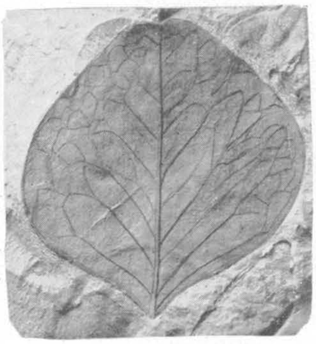
1. *Zygophyllum? eocenicum* Berry, n. sp. Leaflet. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 94
2. *Combretum wilcoxense* Berry. Leaf showing the characteristic stout petiole of this species. Holly Springs sand, west of Bolivar, Hardeman County, Tenn. 119
3. Fragment of clay from the Holly Springs sand from locality west of Bolivar, Hardeman County, Tenn., showing the abundance of the leaves of *Banksia tenuifolia* Berry 66



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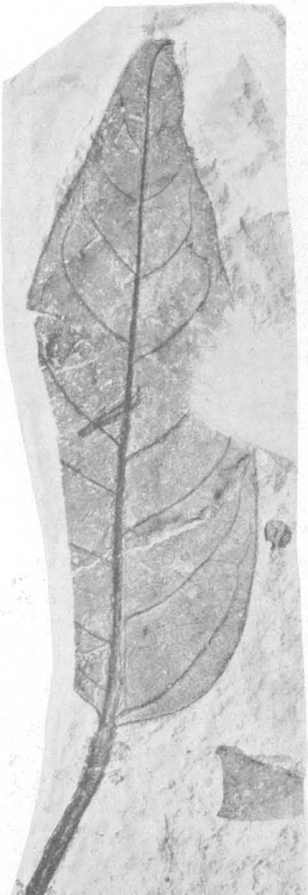

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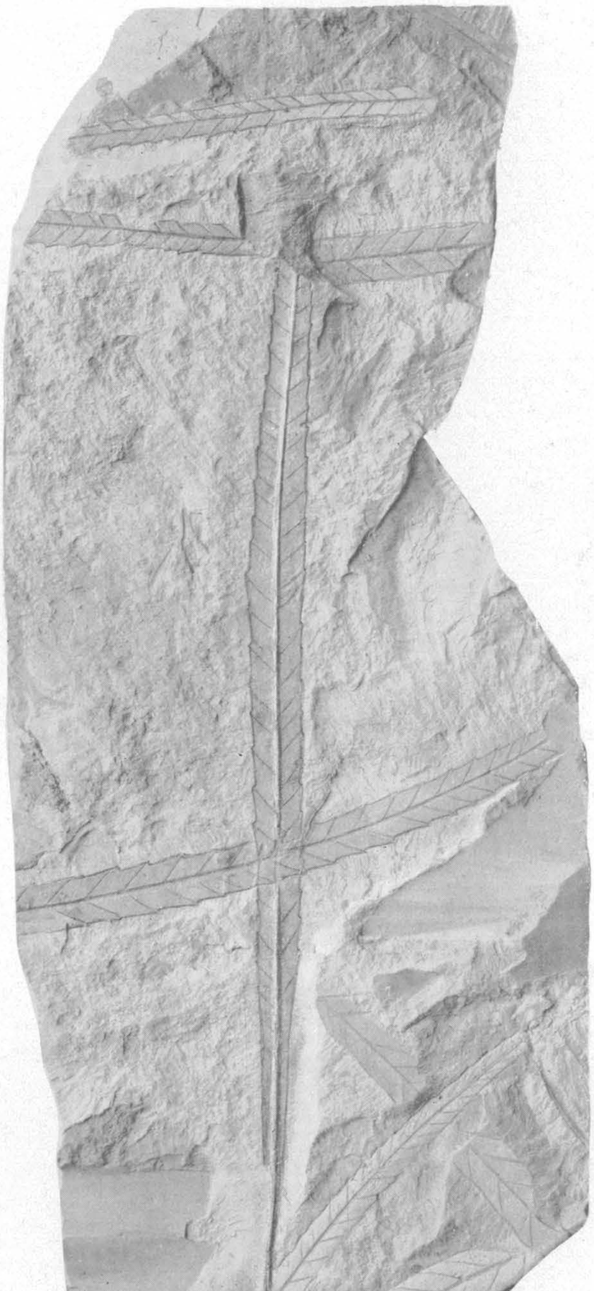

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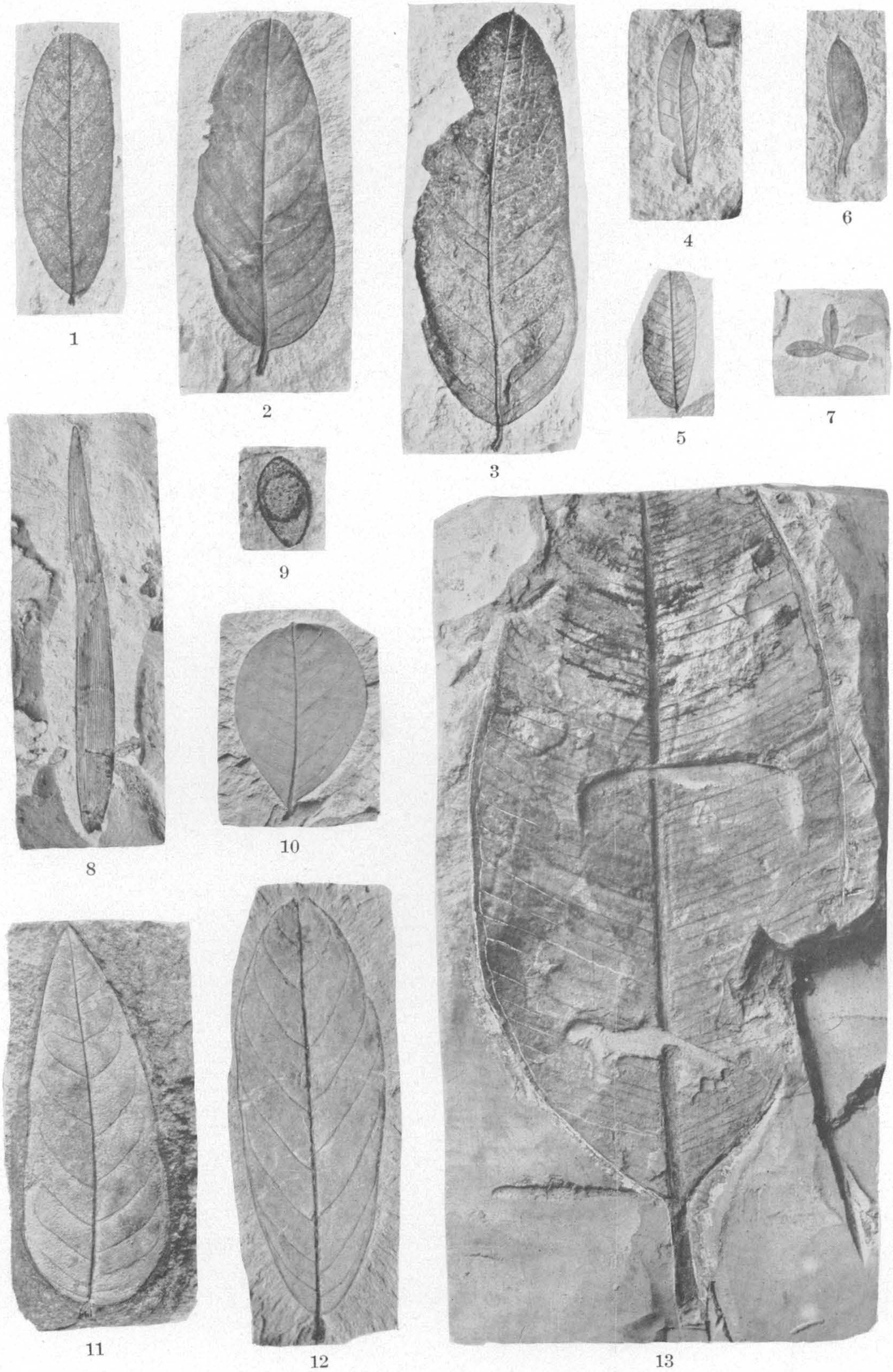
FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 32

		Page
1–3.	*Sophora mucronata* Berry. Showing the limits of variation of the leaflets, west of Bolivar, Hardeman County, Tenn	86
4, 5.	*Cassia bolivarensis* Berry, n. sp. Leaflets from west of Bolivar, Hardeman County, Tenn	81
6.	*Leguminosites pongamioides* Berry, n. sp. Pod from west of Bolivar, Hardeman County, Tenn	88
7.	*Mimosites variabilis* Berry. Showing the terminal part of a compound leaf from Mill Creek, Hardeman County, Tenn	73
8.	*Zamia tennesseeana* Berry, n. sp. A detached pinnule of a Wilcox species of cycad from west of Bolivar, Hardeman County, Tenn	51
9.	*Carpolithus ailanthioides* Berry, n. sp. Winged fruit possibly related to the *Ailanthus* from west of Bolivar, Hardeman County, Tenn	135
10.	*Pithecolobium eocenicum* Berry. Leaflet from Mill Creek, Hardeman County, Tenn	75
11.	*Canavalia acuminata* Berry. Leaflet from bed near the top of the Holly Springs sand at Smiths Church, northwest of Pattersonville, Fayette County, Tenn	86
12.	*Canavalia eocenica* Berry. Leaflet showing the inflated petiolule. La Grange, Fayette County, Tenn	86
13.	*Ficus myrtifolia ampla* Berry, n. var. Showing the characteristic venation of this variety. Smiths Church, northwest of Pattersonville, Fayette County, Tenn	65

All the specimens figured on this plate are from the Holly Springs sand.

PLATE 33

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1–4. *Dodonaea parvula* Berry, n. sp. Holly Springs sand, west of Bolivar, Hardeman County, Tenn. 100

1, 3. Small fruits of this species.

2, 4. Same, enlarged, showing details of venation and peduncle.

5, 6. *Carpolithus banisteroides* Berry, n. sp. Holly Springs sand, La Grange, Fayette County, Tenn. 134

5. Photograph of the type, supposed to represent some member of the family Malpighiaceae.

6. Same, enlarged to show details and venation of the wing.

7, 8. *Ceratophyllum incertum* Berry, n. sp. Grenada formation, northwest of Somerville, Fayette County, Tenn. 71

7. Photograph of the type.

8. Same, enlarged. In this drawing the spines should have been shown as variable in length and the apical one should be larger than the others.

9. *Carpolithus delicatulus* Berry, n. sp. Holly Springs sand, west of Bolivar, Hardeman County, Tenn. 134

10. *Carpolithus aggregatus* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 134

11. *Cypris wilcoxensis* Berry, n. sp. Carapace of an ostracode. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 144

12–14. *Berchemia eocenica* Berry, n. sp. Showing the limits of variation of the leaves of this species. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 104

15. *Citrophyllum bifoliatum* Berry, n. sp. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn. 91

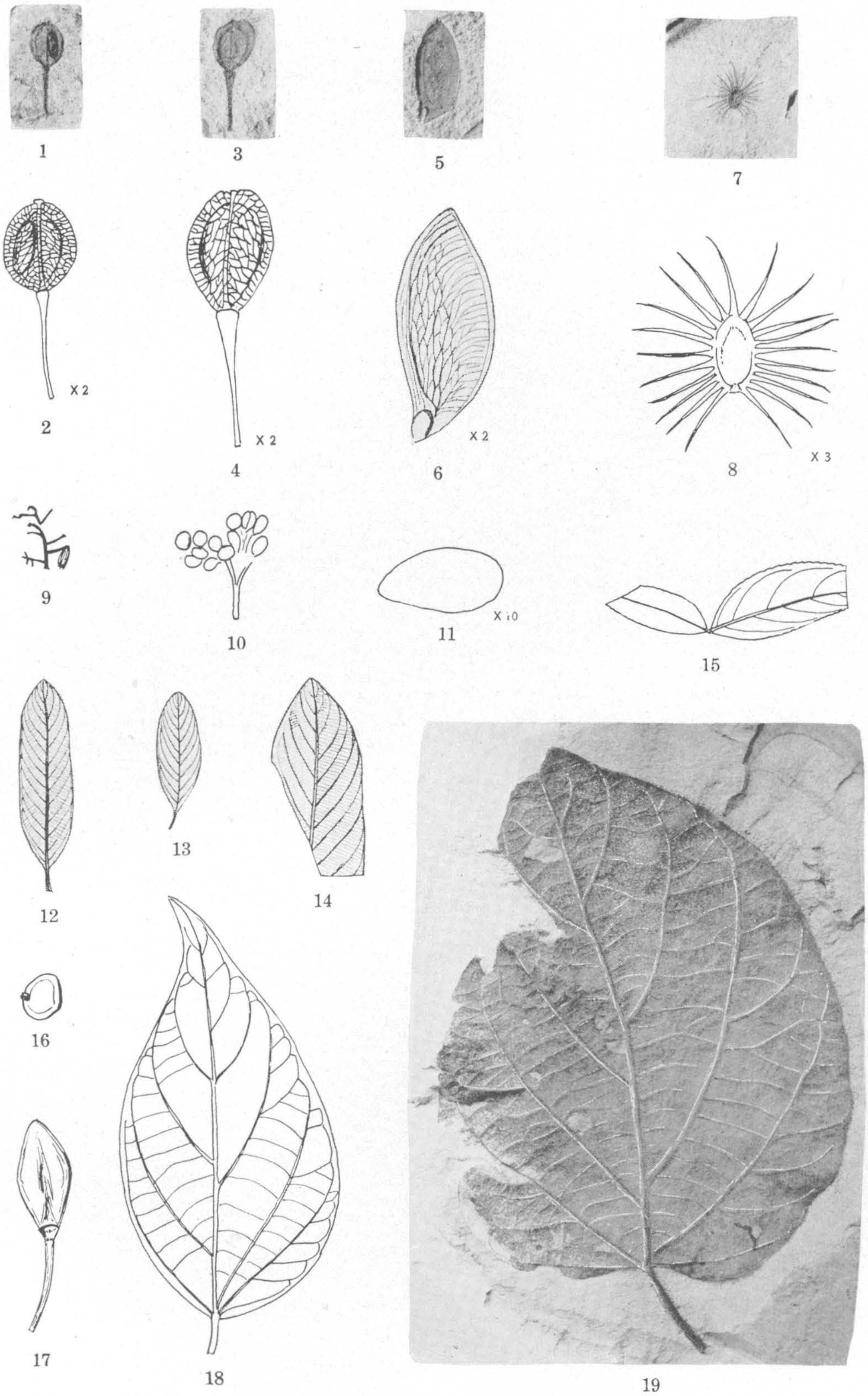
16. *Sapindus fructiferus* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 102

17. *Persea fructifera* Berry, n. sp. Holly Springs sand, Mill Creek, Hardeman County, Tenn. 115

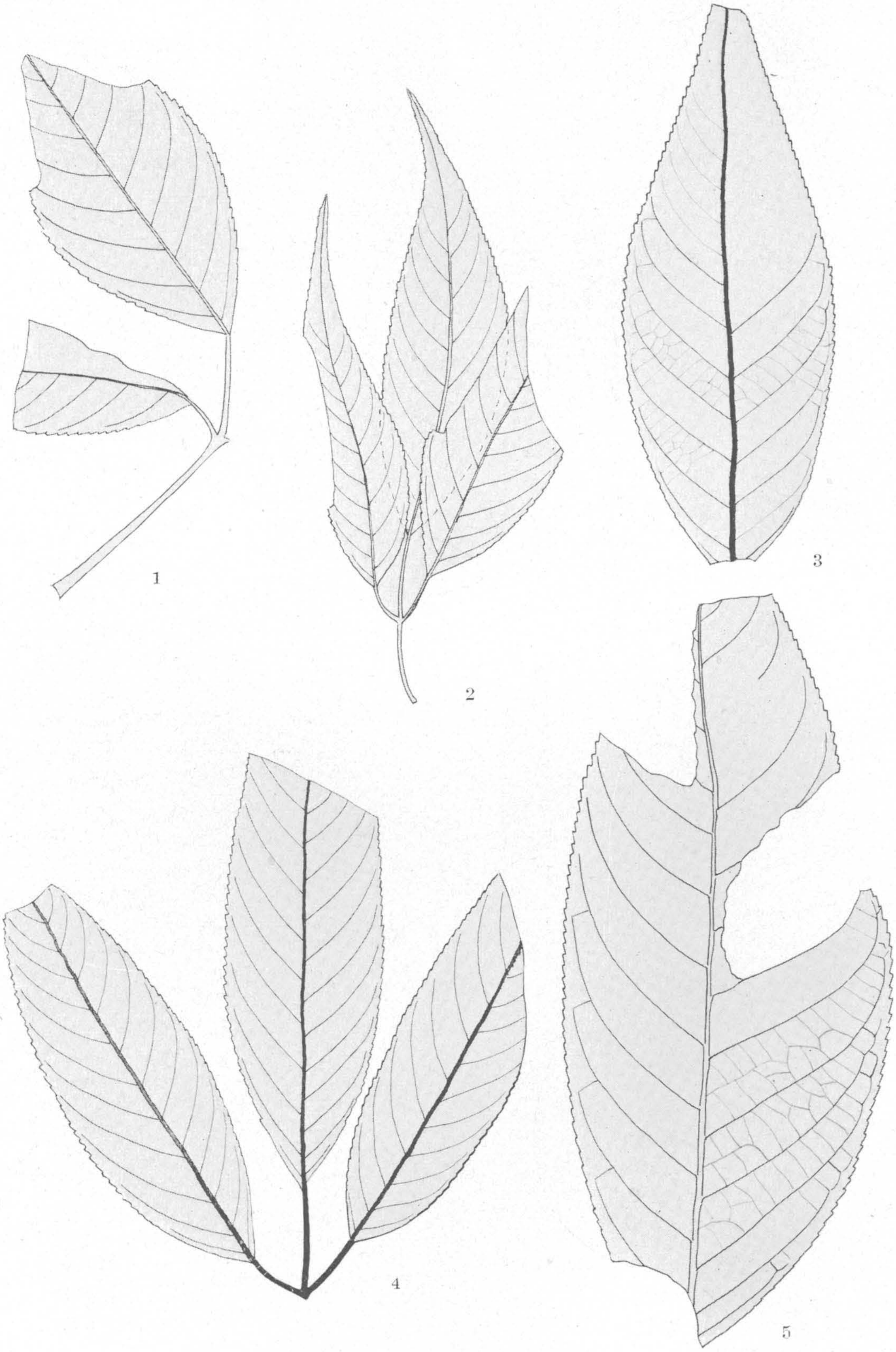
18, 19. *Ficus tennesseensis* Berry, n. sp. Showing limits of variation of the leaves of this fig of the Grenada formation. 63

18. Northwest of Somerville, Fayette County, Tenn.

19. About 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn.



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 34

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1–5. *Hicoria crescentia* Knowlton. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn 59

1. A united terminal and lateral leaflet.
2. A terminal and two lateral leaflets.
3. A single terminal leaflet.
4. A terminal and two lateral leaflets.
5. A very large lateral leaflet.

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1–5. *Cissites asymmetricus* Berry, n. sp. Grenada formation, 2.9 miles southwest of Somerville, near Moses Hall, Fayette County, Tenn ---------- 103

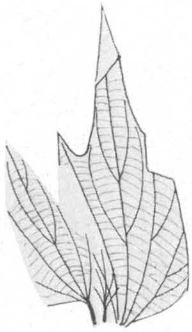
1. Parts of three small leaflets.

2–4. Larger leaflets and characteristic venation.

5. Restoration of a large leaflet of this species.

6. *Cyperacites minutus* Berry, n. sp. Fruit of a sedge from lignite seam in Holly Springs sand on Taylor farm, Chester County, Tenn ---------- 53

7. *Cyperacites wilcoxensis* Berry, n. sp. A more typical fruit of a second species of sedge from same horizon and locality as the preceding ---------- 53



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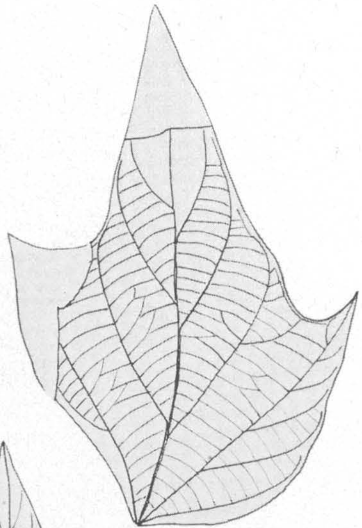

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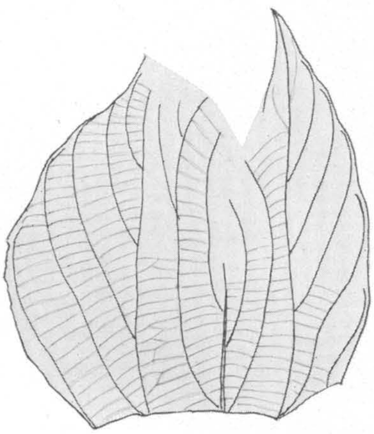

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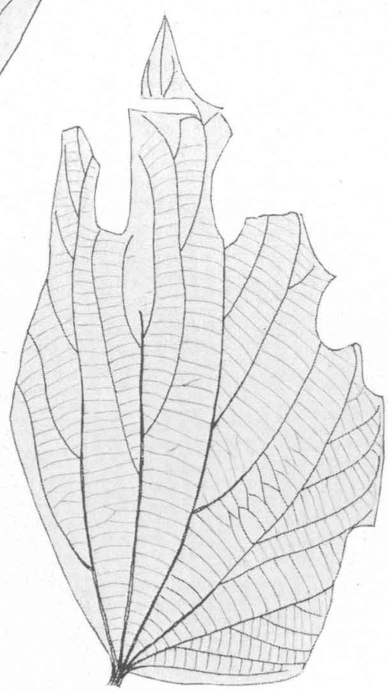

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FOSSIL PLANTS OF THE WILCOX GROUP

FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 36

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1, 2. *Taxites* (?) sp., Berry. Near the top of the Holly Springs sand, Holcomb property, 2 miles south of Paris, Henry County, Tenn ---------- 52

1. A leafy twig of this coniferous tree.

2. A leaf enlarged to show the decurrent base and the two stomatiferous bands of the under surface.

3. *Myrcia vera* Berry. An unusually large leaf of this species showing the characteristic venation. Holly Springs sand, Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn ---------- 118

4, 5. *Capparis eocenica ampla* Berry, n. var. Showing variation in form. Holly Springs sand ---------- 71

4. Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.

5. Will Brooks farm, 2.1 miles northeast of Mercer, Madison County, Tenn.

6. *Diospyros madisonensis* Berry, n. sp. Showing the concrescent calyx of a persimmon fruit from bed near the top of the Holly Springs sand, one-fourth mile south of Mandy, Madison County, Tenn ---------- 126

7. *Sapindus formosus* Berry. An unusual specimen showing the distal part of a leaf with nine leaflets preserved, illustrating the even-pinnate habit. Holly Springs sand, one-fourth mile south of Mandy, Madison County, Tenn ---------- 101

8. *Bombacites eocenicus* Berry, n. sp. Holly Springs sand, Bell City Pottery pit, Calloway County, Tenn ---------- 106

PLATE 37

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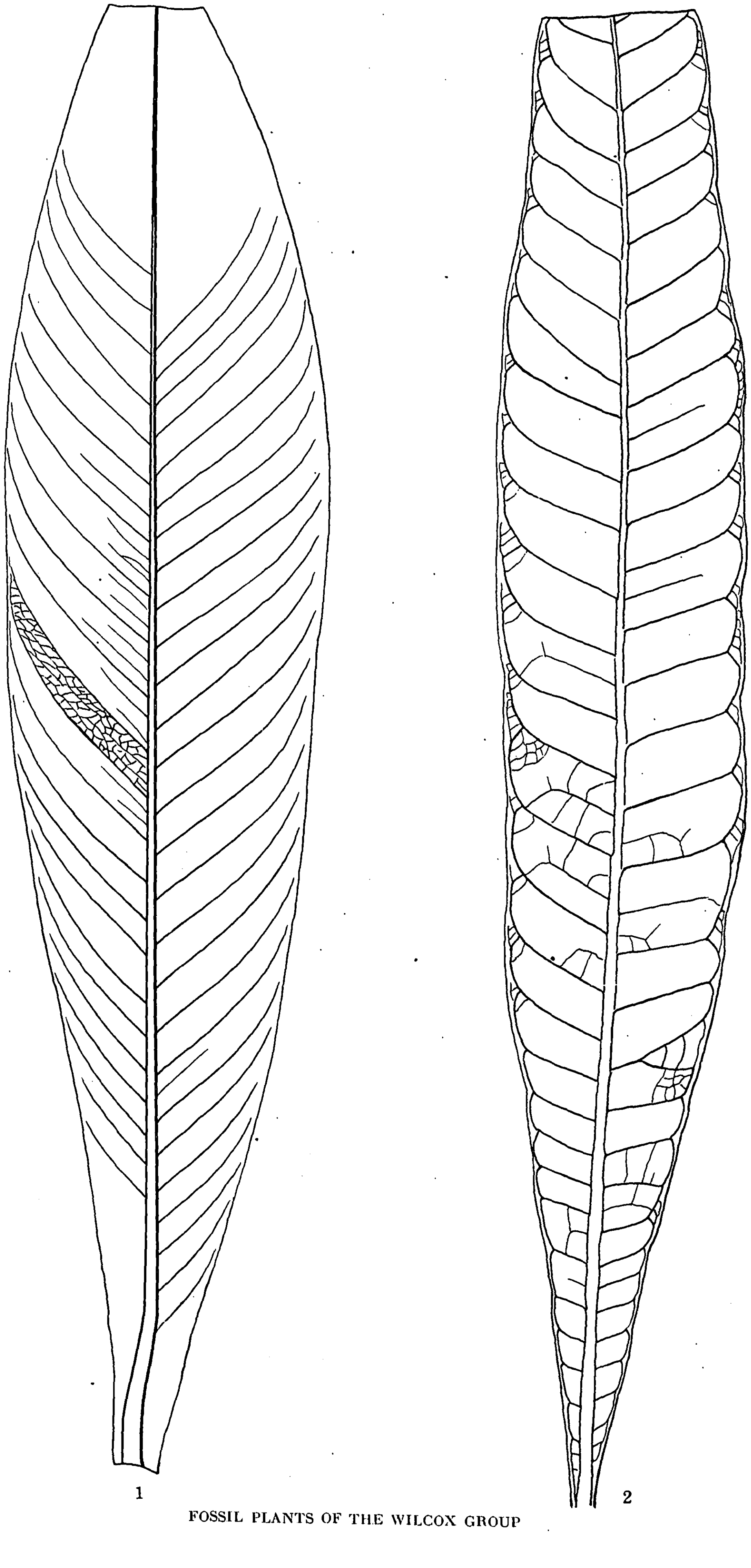
1. *Apocynophyllum crassum* Berry, n. sp. A nearly complete leaf, showing the characteristically enlarged midvein and venation. West of Bolivar, Hardeman County, Tenn ---------- 130
2. *Magnolia leei angusta* Berry, n. var. A nearly complete leaf of this narrow elongate variety, showing characteristic venation. Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn ---------- 70

All from the Holly Springs sand.



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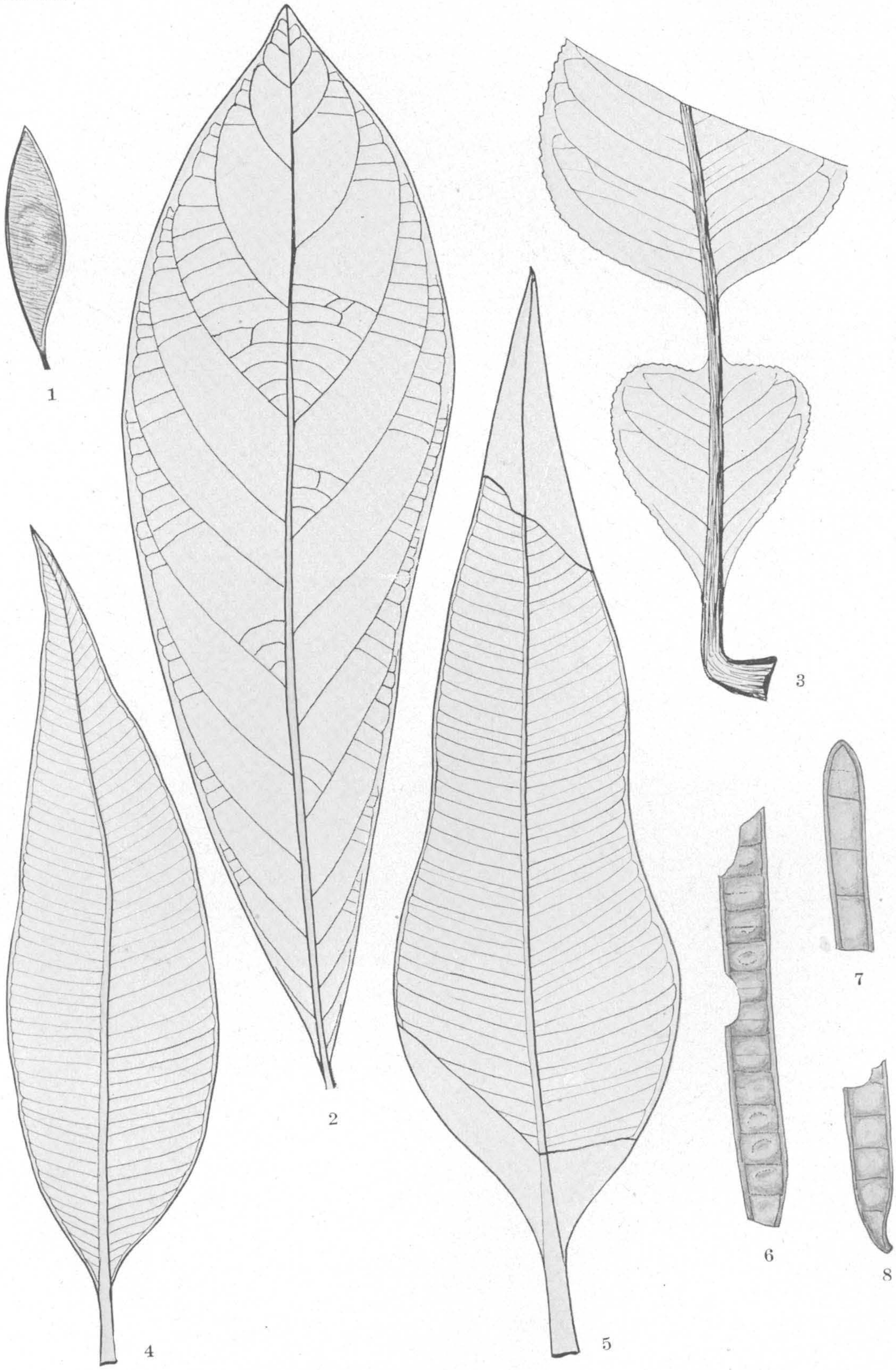
FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 38

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1. *Dalbergia attenuata* Berry, n. sp. The slender, single-seeded pod of this species from bed near the top of the Holly Springs sand, Grove pit, Henry County, Tenn ---- 85
2. *Magnolia angustifolia* Newberry. A characteristic leaf. Atkins pit, Henry County, Tenn ---- 70
3. *Ternstroemites crassus* Berry, n. sp. An abnormal leaf of this species from locality west of Bolivar, Hardeman County, Tenn. Compare with the normal leaves shown in Plate 28 ---- 110

4, 5. *Ficus myrtifolia ovata* Berry, n. var ---- 66

4. One-fourth mile south of Mandy, Madison County, Tenn.
5. Jim Tomphson farm, 3¼ miles northeast of Jackson, Madison County, Tenn.

6–8. *Mimosites wilcoxensis* Berry, n. sp ---- 74

6, 8. Pods from Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn.

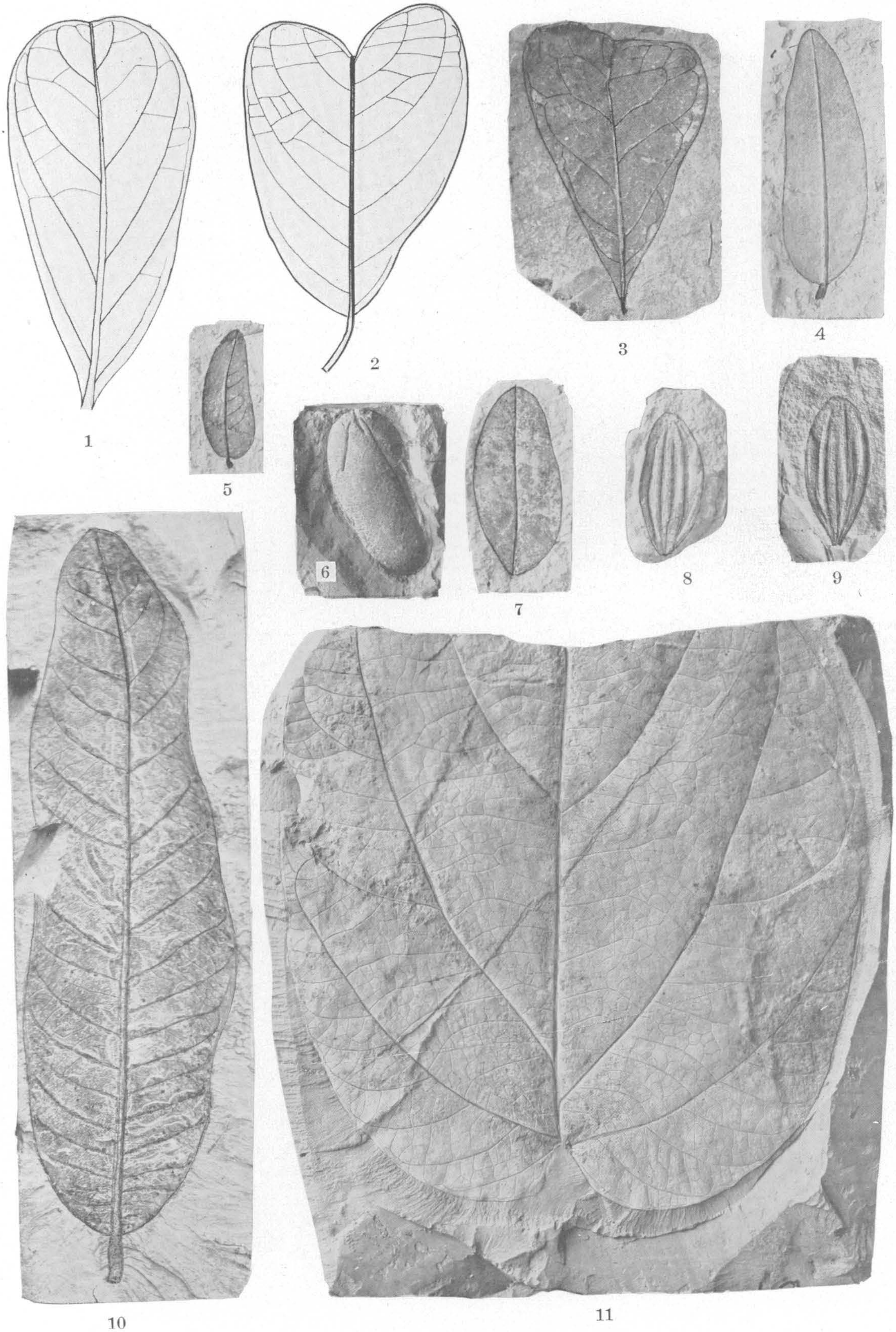
7. Mill Creek, 2½ miles northwest of Shandy, Hardeman County, Tenn.

All from the Holly Springs sand.

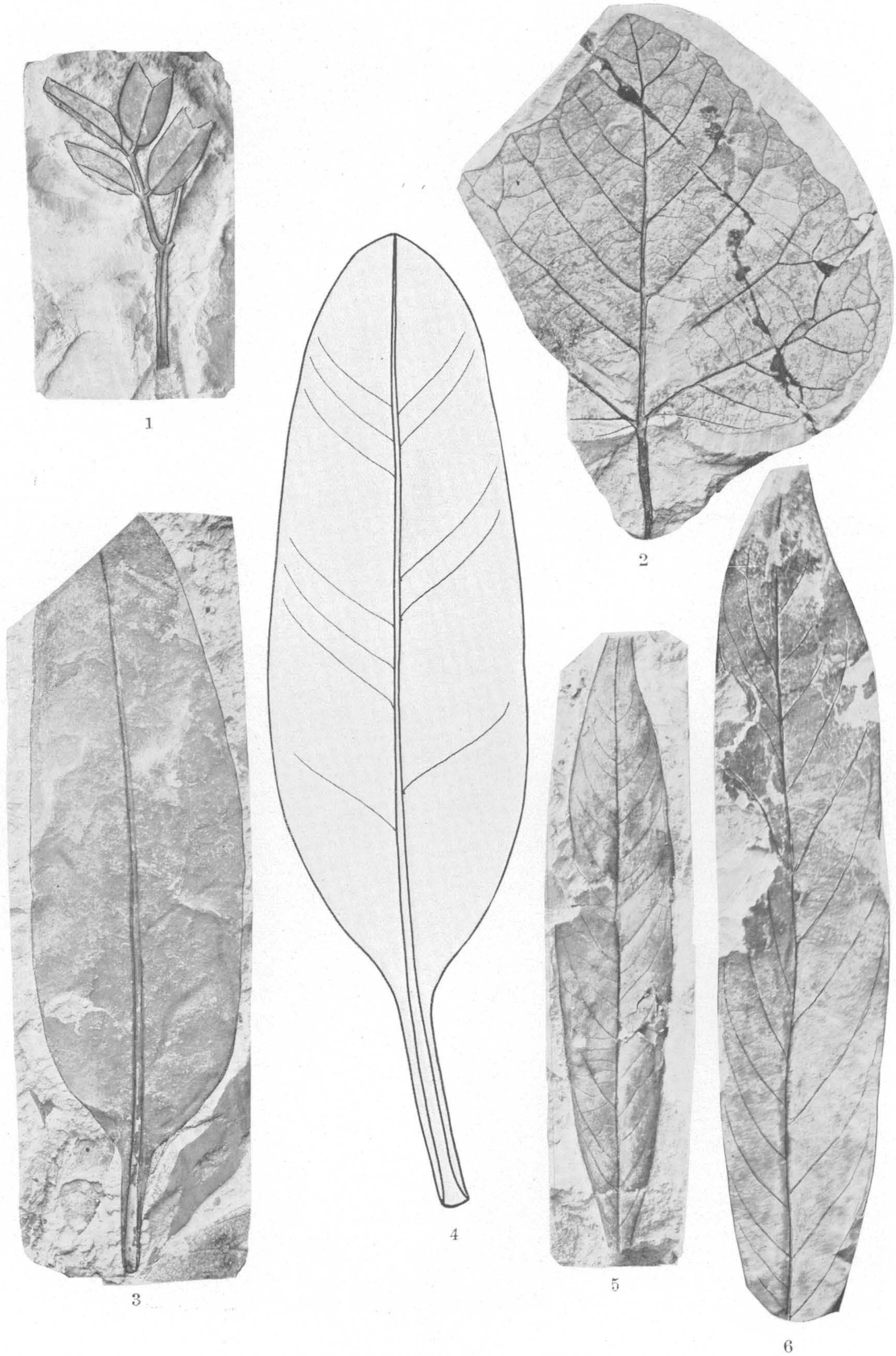
PLATE 39

		Page
1–3.	*Mimusops praenuntia* Berry, n. sp. Showing the variations in form and venation of this Wilcox species of dilly	128
	1. Bradley pit, Henry County, Tenn.	
	2. Will Brooks farm, 2.1 miles northeast of Mercer, Madison County, Tenn.	
4.	*Cassia fayettensis* Berry. A leaflet from the Grable pit, Henry County, Tenn	79
5.	*Caesalpinites mississippiensis* Berry. A leaflet from the Grable pit, Henry County, Tenn	79
6.	*Leguminosites astragaliformis* Berry, n. sp. Inflated pod of this species from 1 mile west of Milan, Gibson County, Tenn	87
7.	*Pithecolobium? tennesseense* Berry? A leaflet from the Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn	75
8, 9.	*Nyssa wilcoxiana* Berry. Stones of this species from the Bell City Pottery pit, Calloway County, Ky	126
10.	*Carapa eolignitica* Berry. A medium-sized leaf from La Grange, Fayette County, Tenn	95
11.	*Ficus mississippiensis cordata* Berry, n. var. A mutant from Huckleberry Schoolhouse, 2½ miles south of McLemoresville, Carroll County, Tenn	65

All from the Holly Springs sand.



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 40

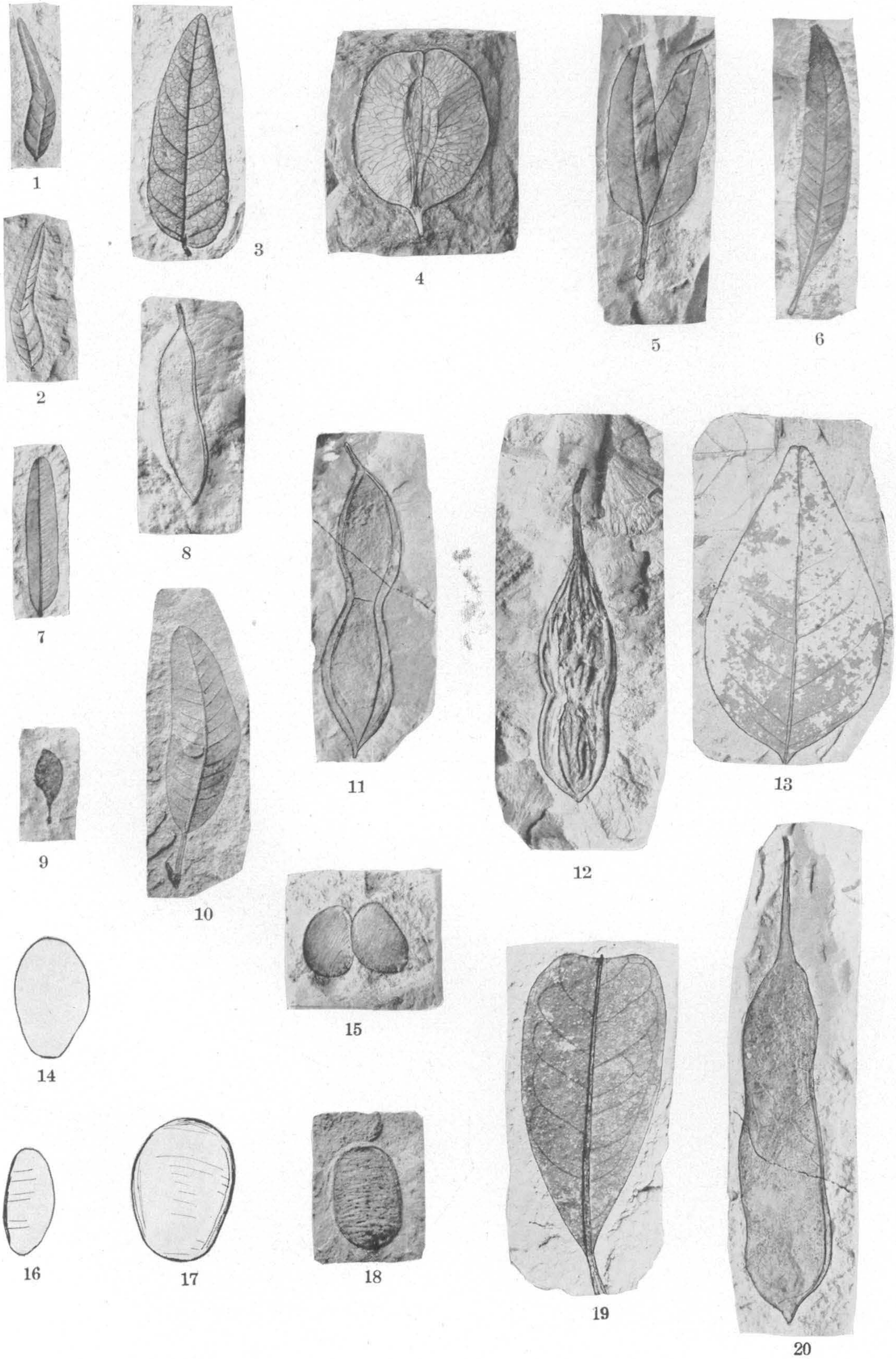
		Page
1.	*Caesalpinia wilcoxiana* Berry. A unique specimen showing an even-pinnate leaf or a branch of a large decompound leaf. Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn	78
2.	*Grewiopsis wadii* Berry. Showing the distinctive features of venation and marginal undulations. Holly Springs sand, Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn	105
3, 4.	*Apocynophyllum mississippiense* Berry. Holly Springs sand	129
	3. Grable pit, Henry County, Tenn.	
	4. A more elliptical leaf showing the characteristic decurrent base and stout petiole. Atkins pit, Henry County, Tenn.	
5, 6.	*Nectandra wilcoxensis* Berry, n. sp	116
	5. A small narrow leaf.	
	6. A larger lanceolate form. Both from the Grenada formation. Cottage Grove, Henry County, Tenn.	

PLATE 41

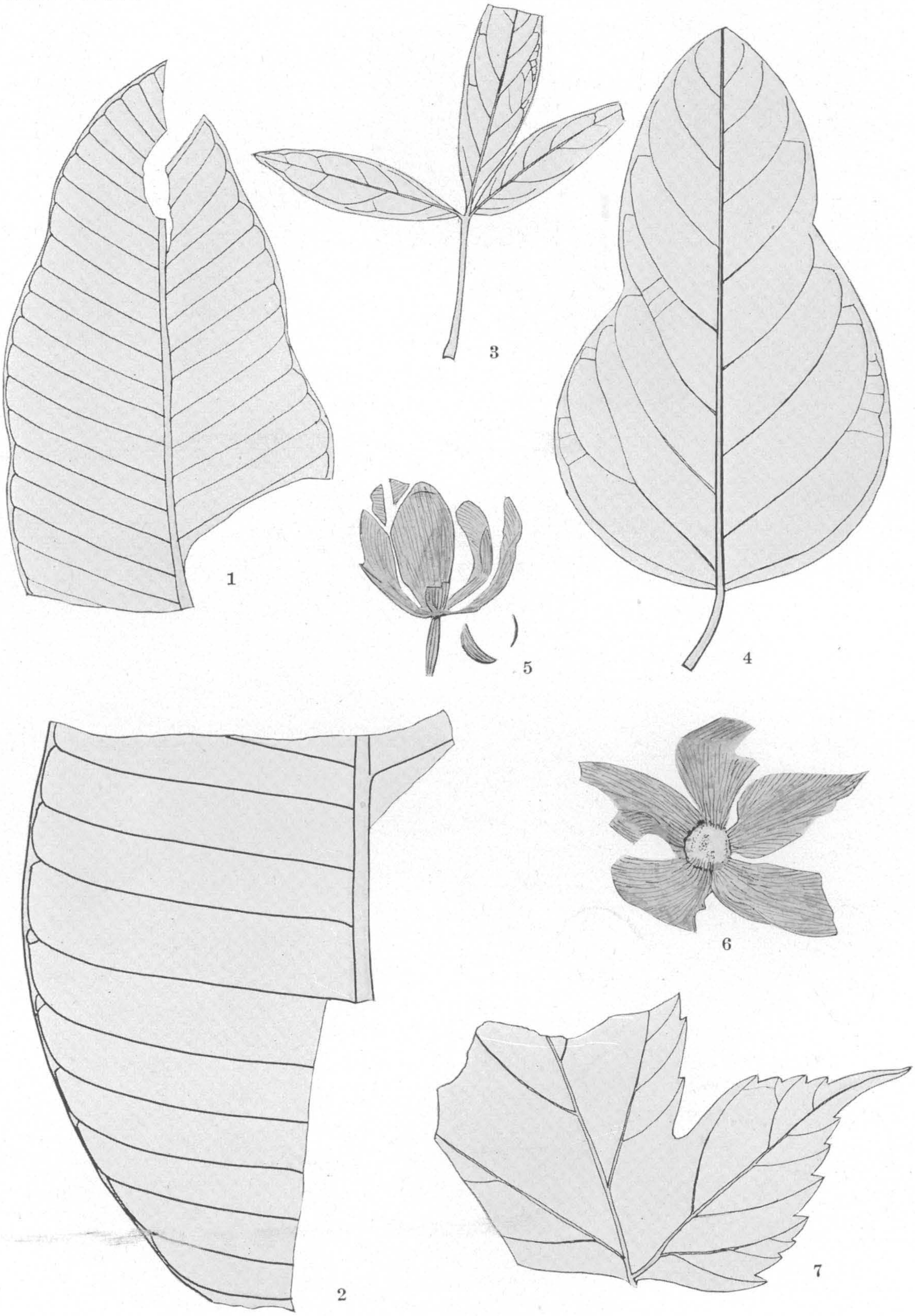
		Page
1, 2.	*Cedrela mississippiensis minor* Berry, n. var. Characteristic leaflets from the Holly Springs sand, Grable pit, Henry County, Tenn	95
3.	*Cedrela mississippiensis major* Berry, n. var. A lateral leaflet from the Holly Springs sand, Grable pit, Henry County, Tenn	95
4.	*Ptelea eocenica* Berry, n. sp. Winged fruit from the Holly Springs sand, in Fayette County, Tenn., 1 mile southwest of Grand Junction, Hardeman County	92
5.	*Hymenaea wilcoxiana* Berry, n. sp. Characteristic bifoliate leaf from the Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn	84
6.	*Apocynophyllum parvulum* Berry, n. sp. Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn	129
7.	*Cassia robertsi* Berry, n. sp. Leaflet from the Grenada formation, Cottage Grove, Henry County, Tenn	80
8.	*Cassia nictitanioides* Berry, n. sp. Pod from the Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn	81
9.	*Leguminosites hoffmanseggiaformis* Berry, n. sp. Pod from the Holly Springs sand, west of Bolivar, Hardeman County, Tenn	87
10.	*Schefflera? elliptica* Berry, n. sp. Leaflet from the Holly Springs sand, Grable pit, Henry County, Tenn	124
11.	*Parkinsonia eocenica* Berry, n. sp. Pod from the Holly Springs sand, Mill Creek, Hardeman County, Tenn	77
12.	*Cladrastis eocenica* Berry, n. sp. Pod from the Holly Springs sand, 2¼ miles north of Shandy, Hardeman County, Tenn	84
13.	*Cassia glenni* Berry. Leaflet from near the top of the Holly Springs sand, Atkins pit, Henry County, Tenn	82
14–18.	*Anona robertsi* Berry, n. sp.	70

14. Holcomb property, 2 miles south of Paris, Henry County, Tenn.
15. 1 mile west of Milan, Madison County, Tenn.
16. Jim Tomphson farm, Madison County, Tenn.
17. Cottage Grove, Henry County, Tenn.
18. Bell City Pottery pit, Calloway County, Ky.
14, 15, 16, 18 from the Holly Springs sand; **17** from the Grenada formation.

19.	*Reynosia praenuntia* Berry. Holly springs sand, Puryear, Henry County, Tenn	104
20.	*Leguminosites collinsi* Berry, n. sp. Pod supposed to represent the genus *Cercis*. Grenada formation, Cottage Grove, Henry County, Tenn	89



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 42

		Page
1, 2.	*Apocynophyllum preplumiera* Berry, n. sp. Fragmentary specimens of this characteristic species. Holly Springs sand	130
	1. West of Illinois Central Railroad, 2¼ miles north of Shandy, Hardeman County, Tenn.	
	2. West of Bolivar, Hardeman County, Tenn.	
3.	*Rutaphyllum trifoliatum* Berry, n. sp. Nearly complete trifoliate leaf. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn	92
4.	*Ficus pandurifolia* Berry, n. sp. An unusually large leaf of this species. Holly Springs sand, Bolivar-Jackson road north of Clover Creek, Hardeman County, Tenn	64
5, 6.	*Antholithes ternstroemioides* Berry, n. sp. Lateral and distal views of flowers believed to belong to the family Ternstroemiaceae. Near top of Holly Springs sand, Puryear, Henry County, Tenn	140
7.	*Negundo knowltoni* Berry, n. sp. An unusually lobate leaflet of this species. Grenada formation, about 1 mile north of Somerville, north of Loosahatchie River, Fayette County, Tenn	98

PLATE 43

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1, 2. *Cupanites amplus* Berry, n. sp. Incomplete leaflets of this large species 99

1. Thompson & Barksdale prospect 2 miles south of McKenzie, Carroll County, Tenn.

2. Huckleberry Schoolhouse, 2½ miles south of McLemoresville, Carroll County, Tenn.

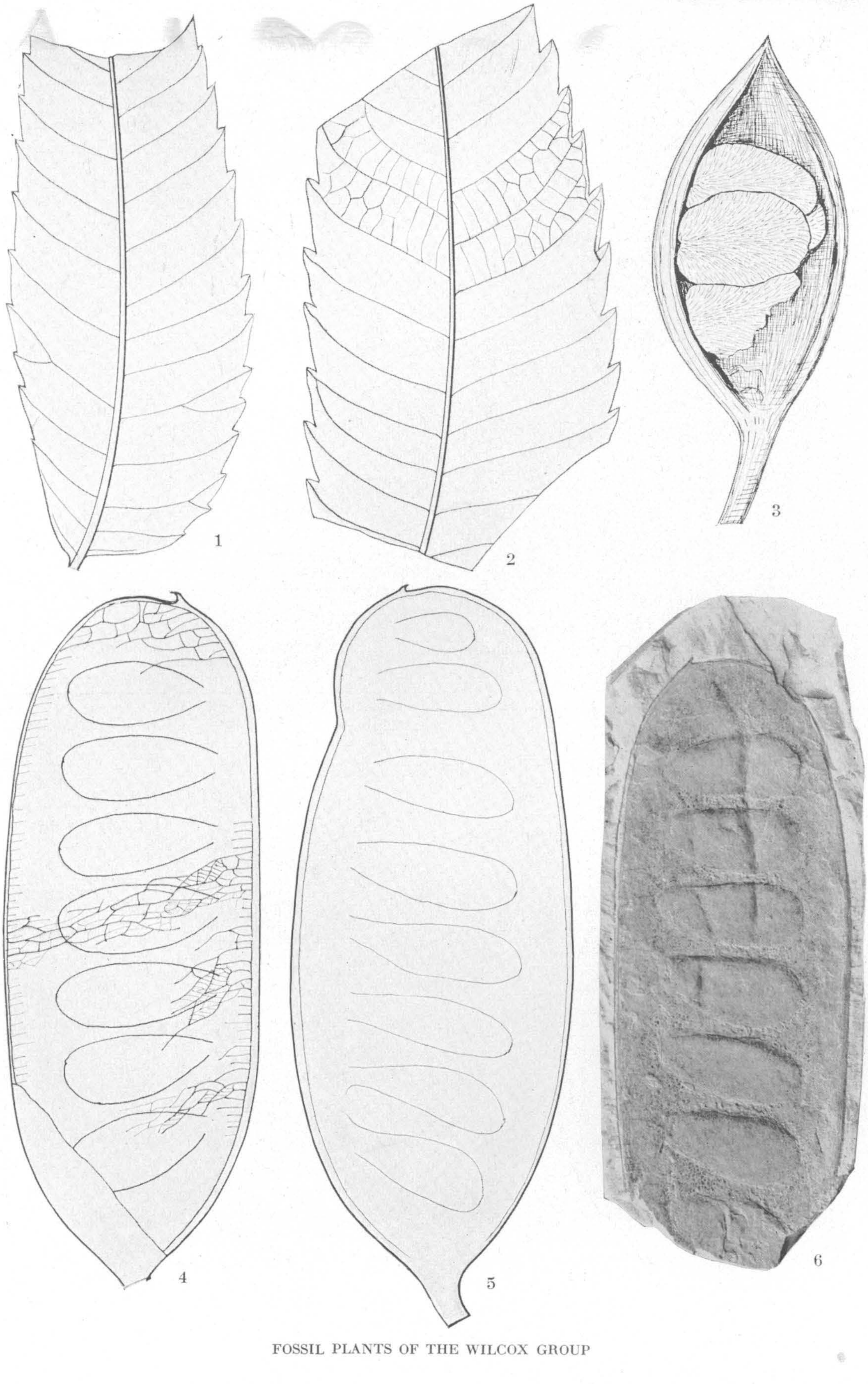
3. *Bignonicapsula formosa* Berry, n. sp. Large capsule showing some of the contained large, flat, winged seeds 132

4–6. *Leguminosites phyllocarpoides* Berry, n. sp. Large characteristic pods showing contained seeds, believed to be related to the genus *Phyllocarpus* 90

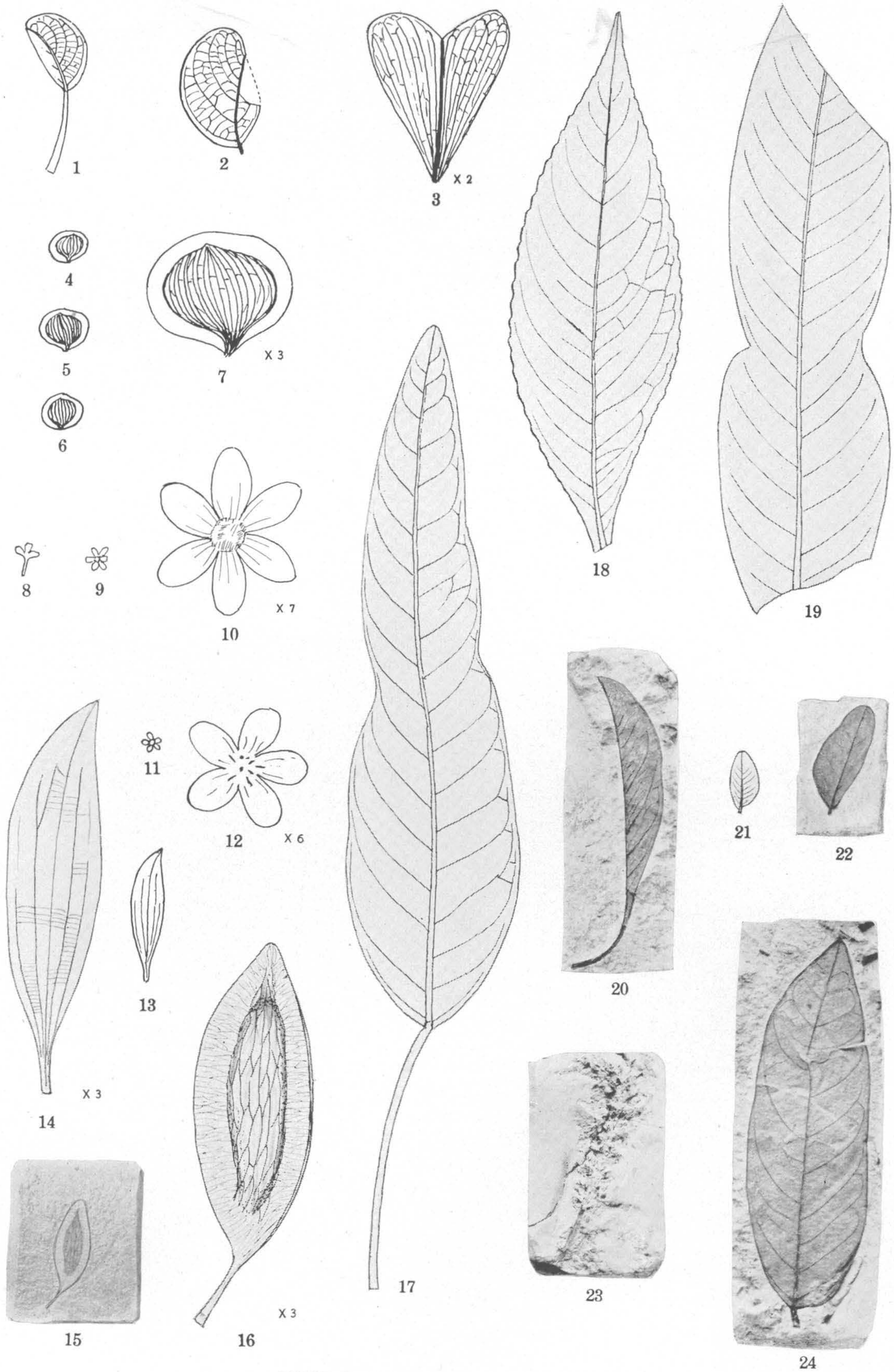
4, 6. Grable pit, Henry County, Tenn.

5. Jim Tomphson farm, Madison County, Tenn.

All from the Holly Springs sand.



FOSSIL PLANTS OF THE WILCOX GROUP



FOSSIL PLANTS OF THE WILCOX GROUP

PLATE 44

		Page
1, 2.	*Pithecolobium eocenicum anomalum* Berry, n. var. Holly Springs sand	75
	1. Puryear, Henry County, Tenn.	
	2. Thompson & Barksdale prospect, 2 miles south of McKenzie, Carroll County, Tenn.	
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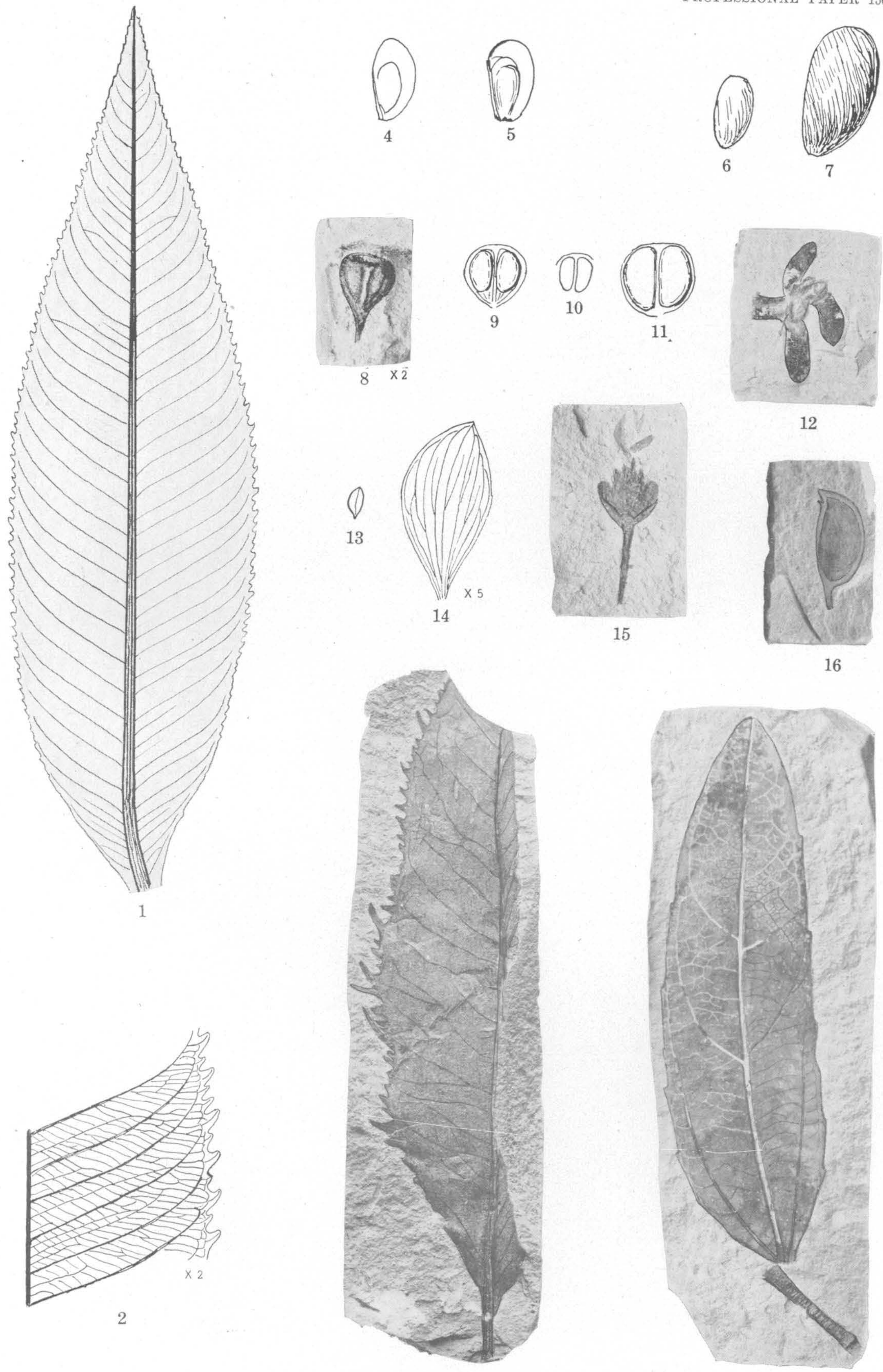
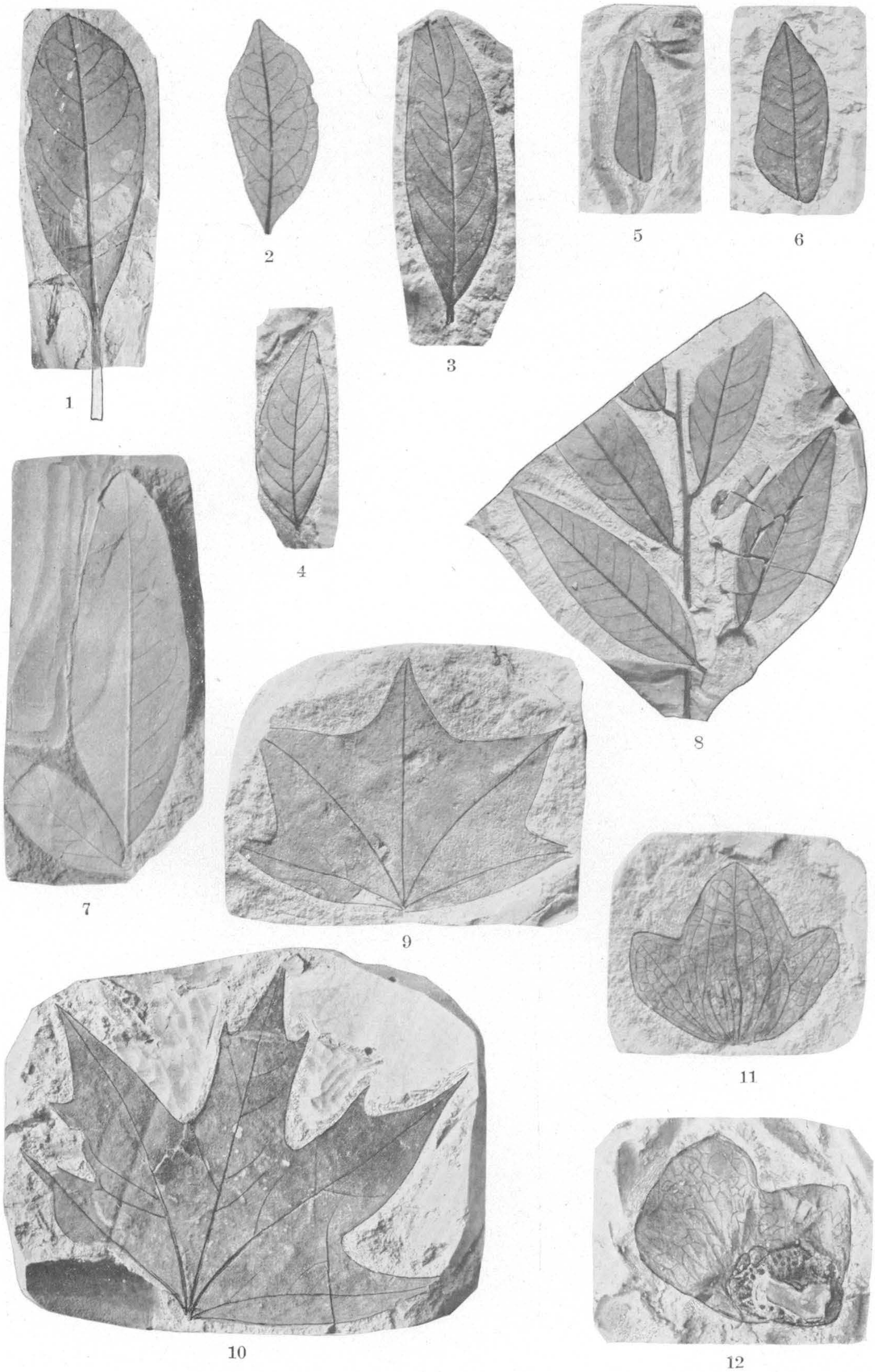


FOSSIL PLANTS OF THE WILCOX GROUP



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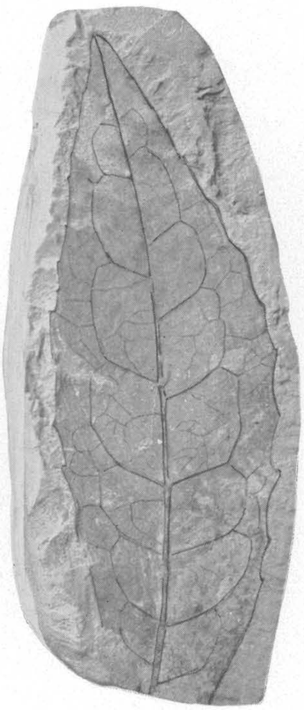

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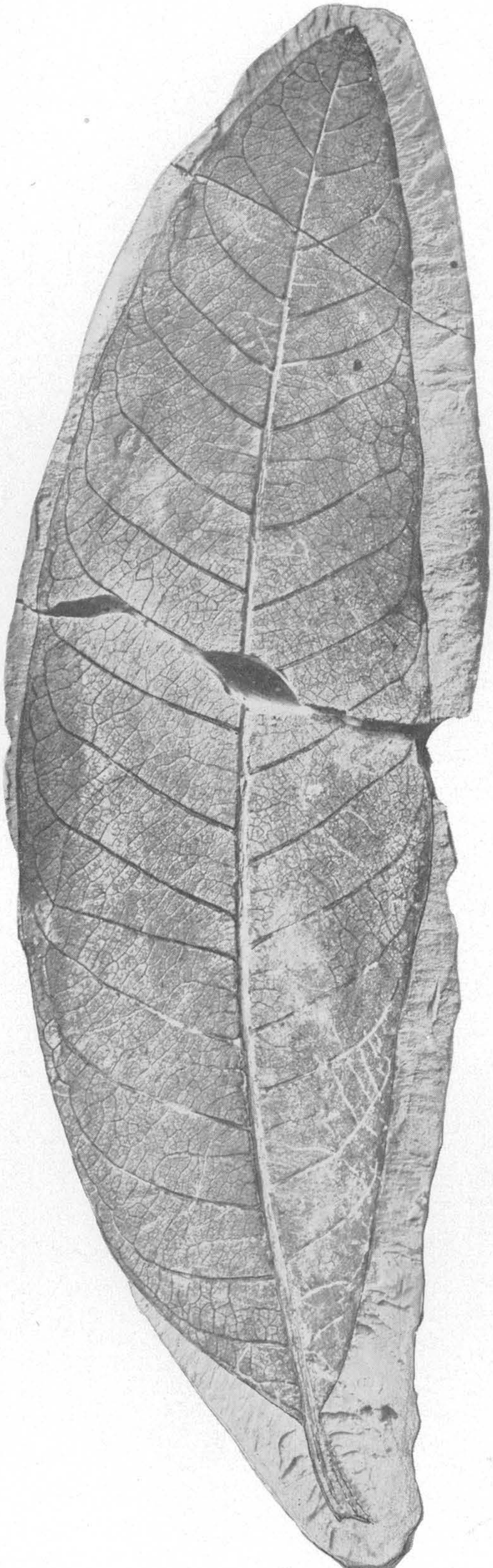

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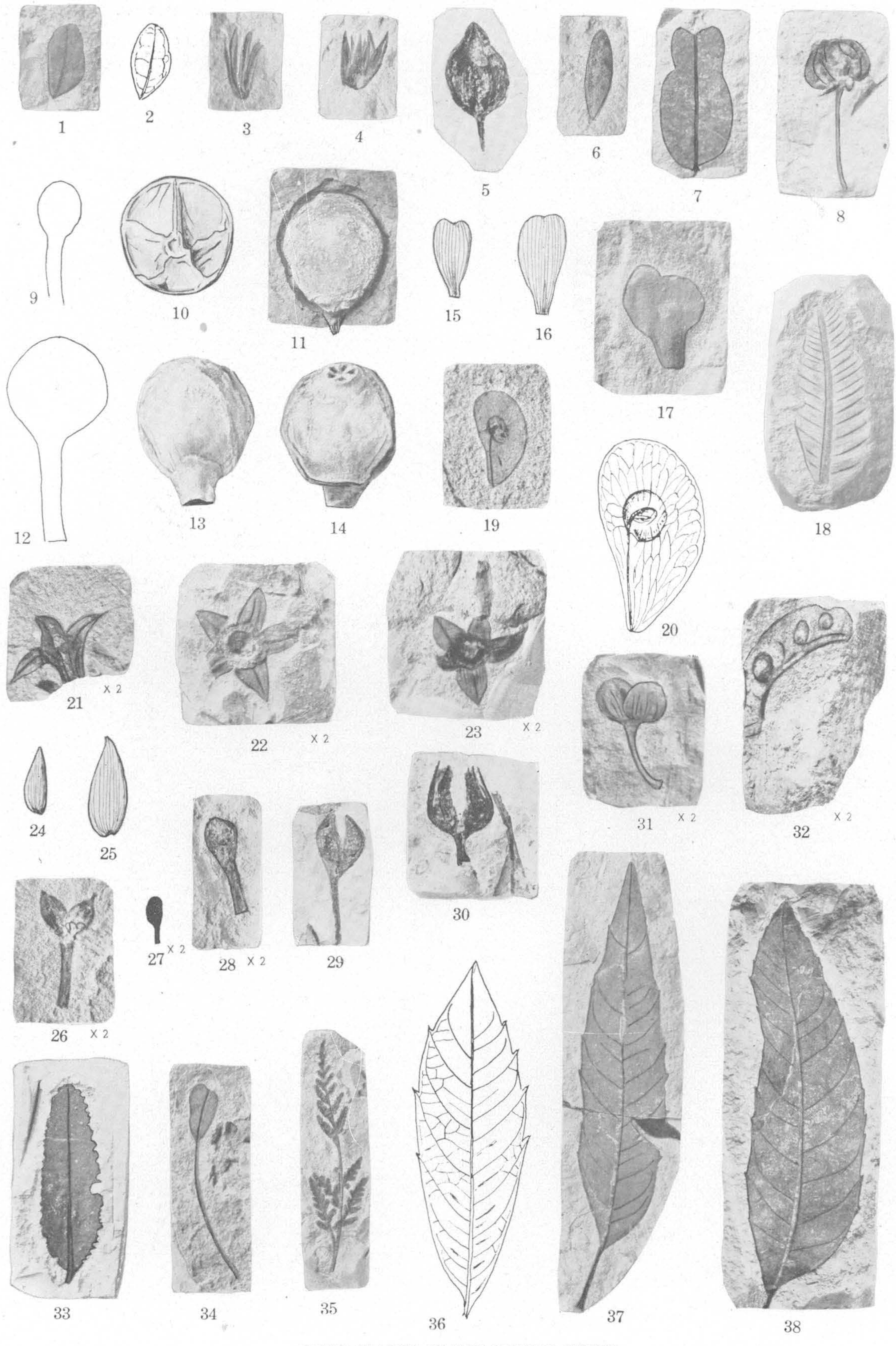

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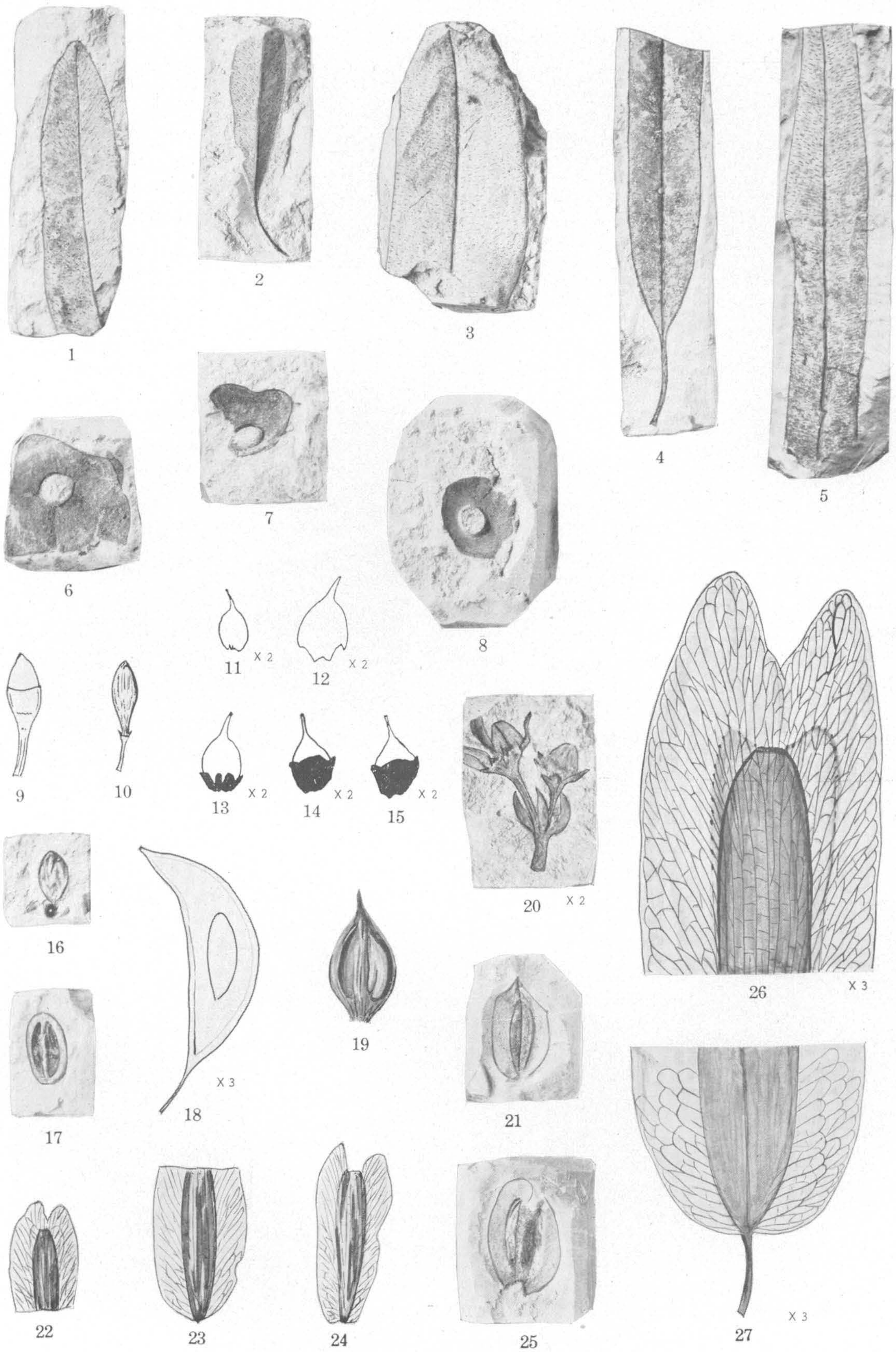
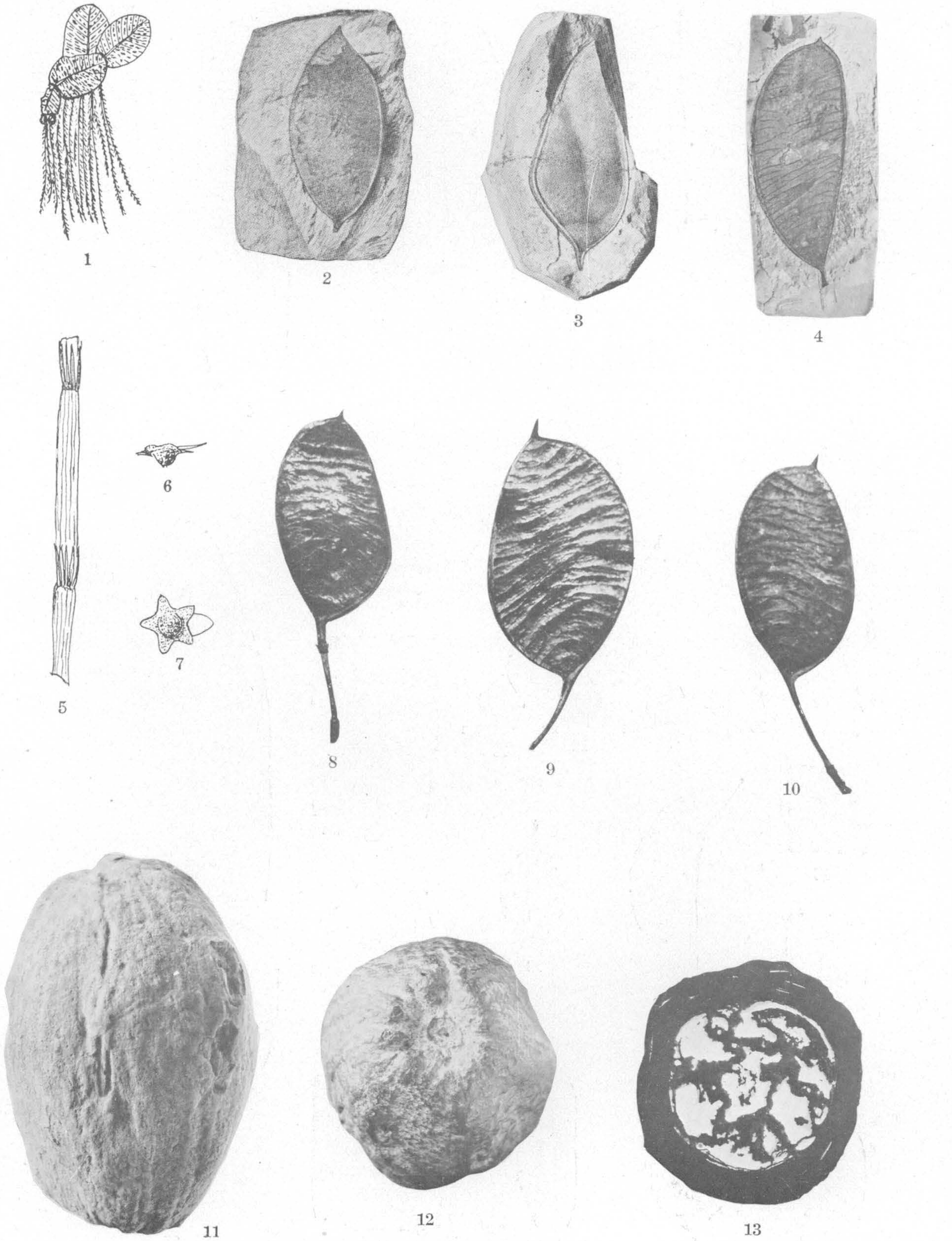


FOSSIL PLANTS OF THE WILCOX GROUP



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