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THE LOWER EOCENE FLORAS OF SOUTHEASTERN NORTH AMERICA

BY

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THE LOWER EOCENE FLORAS OF SOUTHEASTERN NORTH AMERICA.

By Edward Wilber Berry.

INTRODUCTION.

SCOPE OF REPORT.

This paper presents the results of several years of field and office studies of the fossil plants of the Southern Coastal Plain and treats of the lower Eocene, including beds thought to be basal Eocene. The main body of the material examined comes from beds embraced in the stratigraphic unit known as the Wilcox group; the remainder was obtained from strata regarded as a part of the Midway formation, although they may possibly be of Wilcox age. The Midway is a typically marine series of deposits throughout nearly the whole extent of its outcrop and is consequently poor in plant remains, whereas the Wilcox comprises littoral and estuarine sediments over wide areas and contains one of the most abundant and varied fossil floras known to science. Both these floras are of the greatest importance alike to the geologist and the biologist. To the geologist they furnish for the first time a means for direct paleobotanic comparisons between the much disputed plant-bearing formations of the Rocky Mountain province and the marine Tertiary formations of the Atlantic and Gulf waters. To the biologist they furnish ecologic, distributional, and phylogenetic data of vital bearing upon succeeding and existing floras.

When William Maclure read his "Observations on the geology of the United States" before the American Philosophical Society in 1809, he referred the whole Atlantic Coastal Plain to the "Alluvial formation," the fourth of the grand divisions of the geologic column according to the Wernerian classification.

John Finch, fifteen years later, was the first to suggest that the "Alluvial" was more complex and was the equivalent of the "newer Secondary and Tertiary formations" of Europe and elsewhere. American students like Say, Morton, Conrad, and Lea, by temperament more interested in paleontology and broad correlations and realizing the futility of detailed correlations based on lithology, applied themselves assiduously to the study of the organic remains (chiefly invertebrates) collected from the richly fossiliferous horizons from New Jersey to Mississippi.

The name Eocene first appears in American literature in connection with American deposits in Lea's "Contributions to geology," published in 1833, where it is applied to the classic fossiliferous outcrop at Claiborne Landing, Ala.

My own studies, the results of which are here presented, arose from the necessity of carrying the correlation of the Tertiary formations across the States of Mississippi, Tennessee, Kentucky, Illinois, Arkansas, and Louisiana, where the earlier Eocene (Midway and Wilcox), because of the conditions of sedimentation, in places lacks the succession of marine faunas developed in the Alabama region.

In connection with the study of the floras of the underlying Cretaceous and the overlying Tertiary I have been occupied with this work since the beginning of 1909, having spent several months in the field during 1909, 1910, 1911, and 1913 and having visited every locality throughout the whole area that promised to furnish any facts bearing on the problem in hand.

The Tertiary floras of the southern Atlantic Coastal Plain are checked nearly throughout by intercalated marine faunas. More chronologic units are represented than in any other general region of North America, since here the Oligocene, Miocene, and Pliocene, as well as the Eocene, are plant bearing, whereas elsewhere in North America there are practically no known Oligocene or Pliocene floras. It is planned to consider these floras in subsequent contributions, the preparation of which is already far advanced. I am indebted to many friends for assistance during the progress of the work and wish especially to acknowledge my indebtedness for collections and information to my associates in the study of the Coastal Plain, particularly Mr. T. Wayland Vaughan, who has had general charge of the Coastal Plain investigations and to whom the credit for their character and comprehensive scope is so largely due.

The Philippine Bureau of Science furnished me with the picture showing the habitat of the nipa palm (Pl. VII, *A*, p. 177), the New York Botanical Garden with that showing the black mangrove (Pl. VII, *B*), and the Augustana Book Concern with that showing associations of Coccolobis (Pl. VIII, p. 213) at St. Croix, for all of which I make grateful acknowledgment.

All measurements of leaves throughout this work are exclusive of petioles, which are given separately wherever they are known.

AREA COVERED BY REPORT.

The geographic term "southeastern North America," as used in the present work, can be precisely defined. The area includes the mainland south of latitude 41° N. and east of longitude 100° W. These limits are fixed by the events of geologic history, for no Tertiary plants are known from this area except those preserved in what were coastal deposits, all of which are included within the present Gulf and Atlantic Coastal Plain.

The region has at no time during the long ages of the Tertiary period been coextensive with the floral or faunal province of which it was a part. From the close of the Cretaceous to the dawn of the Miocene it formed a part of the floral province that included also the varying lands to the south—the Antillean region to the southeast and the Central American country to the southwest, both avenues of more or less close connection with northern South America. Too little is known of either the geologic history or the Tertiary flora of the Antillean or Mexican regions to bring them within the scope of the present discussion, although both present a variety of problems of almost infinite interest, and doubtless the history of the evolution of the Tertiary floras of southeastern North America can not be fully deciphered, even in its broader details, until these strategic areas are studied.

Nor did the floral province during the Tertiary terminate on the north with latitude 41°. Obviously, the coastal flora that is so largely represented in the collections studied did not continue inland as a unit over the land remote from the estuaries and coastal lagoons in which the relics of these floras were preserved. At the same time there is much evidence to show that the land was low, at least during the Eocene and Oligocene, and the fortunate preservation of some evidence of the inland flora in the fluviatile or lacustrine lignites at Brandon, Vt., substantiates the conclusion that the pre-Miocene Tertiary flora had the same general facies throughout this whole area and extended northward beyond the limits fixed at the beginning of this chapter.

Most of the fossils discussed in the present study came from the area known as the Mississippi embayment, and mainly from a relatively small area in this extensive region in Louisiana, Arkansas, Kentucky, Tennessee, and Mississippi. The limits of this area are also fixed by the geologic history of the region, since here the shallow shifting marginal waters furnished almost ideal conditions for receiving and preserving the vegetable débris of the near-by mainland.

The area thus defined embraces roughly 1,500,000 square miles and in times past doubtless furnished congenial habitats for several thousand specific types, of which we can never hope to know more than a small number. When it is recalled that nearly all these types have irrevocably vanished and that this vast area is tenanted to-day by an entirely new set of plants, some idea of the dynamic and epic character of the floral history is forced upon the dullest imagination.

OUTLINE OF GEOLOGIC HISTORY.

The geologic history of this region includes the withdrawal of the marine waters of the late Upper Cretaceous Mississippi embayment an undetermined distance southward and an interval of emergence, followed by a rapid transgression of the shallow Midway sea approximately to the limits of the Ripley sea. The waters of the Midway sea, however, appear to have been deeper and the transgression falls somewhat short of reaching the Ripley shore line except at the head of the Mississippi Gulf in southern Illinois and in the vicinity of Little Rock, Ark. At the close of the Midway most of the area again became land, as will be shown in the subsequent discussion of the Wilcox group. At the maximum of the Wilcox transgression, which followed this period of emergence, most of this area was again submerged, but the whole upper part of the embayment was a region of lagoons and shifting sands with littoral and palustrine deposits, marine faunas not having been found north of latitude 33°, while the deposits of Wilcox age extend to latitude 37° at least.

MIDWAY FORMATION.

STUDY OF THE STRATIGRAPHY.

Interest in the study of the Midway formation has been confined wholly to its geology and paleozoology. I know of no mention of fossil plants, aside from lignitic material, except Glenn's [1] statement of their occurrence in a cut on the Southern Railway just east of Middleton, Tenn.

With regard to the nomenclature of the Midway, it is to be noted that Hilgard [2] in 1860 divided the Tertiary of that State into Great Northern Lignitic, Claiborne, Jackson, and Vicksburg, the first including as its basal member the so-called Flatwoods clay. In 1864 Safford [3] proposed the name Porters Creek group for the basal Eocene in west Tennessee. In 1887 Smith and Johnson [4] differentiated in southern Alabama three formations, which they named Midway (basal deposits of Midway group, later called Clayton limestone), Black Bluff (=Sucarnoochee), and Naheola or Matthews Landing, retaining them as members of Hilgard's Lignitic group, the Midway taking its name from Midway Landing on the west bank of Alabama River in Wilcox County, Ala. In 1894 the paleozoologic studies of Harris [5] led him to propose the term Midway stage for these and synchronous deposits in adjoining States. These constitute the Midwayan stage of Dall's correlation paper [6] published two years later. The detailed history of the study of these deposits, both before and subsequent to this date, is not within the province of this sketch of the nomenclature.

The Midway is singularly poor in remains of land plants, which abound in subsequent Eocene deposits, especially those of the Wilcox and Claiborne groups, so that the study of the flora contributes but little to the elucidation of the Midway deposits, much less than it does to any other Tertiary horizon of southeastern North America.

CHARACTER AND DISTRIBUTION.

Except for thin exposures of the Black Mingo formation carrying Midway invertebrates in the Santee drainage basin of South Carolina, the easternmost known exposures of Midway strata occur in Houston County, in central Georgia. To the east they are buried by the transgressions of both the Claiborne and Jackson. To the west they outcrop as a narrow belt of sands, clays, and limestones estimated to be more than 400 feet thick. Along the Chattahoochee the Midway is represented by about 200 feet of calcareous sands and limestones. These strata form a continuous belt across Alabama, where the Midway becomes a group, differentiated into three formations—the Clayton limestone, Sucarnoochee clay, and Naheola formation. The first is an impure limestone, the second a brown or black clay, and the third a sandy glauconitic clay. Toward the western border of Alabama the strike of the Midway deposits swings around toward the northwest. It becomes almost due north soon after entering Mississippi, and crosses the northeastern part of that State, where the deposits are lithologically bipartite instead of tripartite, consisting of limestones below and clays above. The clays form the so-called Flatwoods, and to them has been applied the name Porters Creek clay, used by Safford in Tennessee. They are supposed to represent the Sucarnoochee and Naheola formations of western Alabama. The strike of the beds of Midway age becomes east of north across western Tennessee, where they have also been called Porters Creek clay. They consist of more than 200 feet of dark clays, with some limestones and glauconitic sands. In Marshall County, Ky., the belt of outcropping deposits of Midway age, which is 10 to 12 miles in width, turns westward, crossing Ohio River into Pulaski County, Ill. It is cut out by the

1 Glenn, L. C., U. S. Geol. Survey Water-Supply Paper 164, p. 32, 1906.
2 Hilgard, E. W., Report on the geology and agriculture of Mississippi, pp. 110–111, 1860.
3 Safford, J. M., Am. Jour. Sci., 2d ser., vol. 37, p. 368, 1864.
4 Smith, E. A., and Johnson, L. C., U. S. Geol. Survey Bull. 43, p. 18, 1887.
5 Harris, G. D., Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, pp. 8, 9, 22, 1894; Bull. Am. Paleontology, vol. 1, pp. 11–13, 1896.
6 Dall, W. H., U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, table opp. p. 334, 1898.

Mississippi and Cache River bottoms or covered with Pleistocene deposits west of the Illinois area, although Shepard identifies it in at least one well in southeastern Missouri. The Midway deposits reappear in Independence County, Ark., from which locality they may be traced southwestward with but few breaks. In the vicinity of Little Rock the Midway, which there consists of calcareous sands and fossiliferous limestones, overlaps the Cretaceous and rests on the Paleozoic.

The Midway is extensively developed from Arkansas southwestward across Texas to the Rio Grande. Usually it has not yet been subdivided and the name is used in a formational rather than a group sense, although the thicknesses indicate the presence of deposits laid down during the time interval represented by the typical Midway of Alabama. In the Texas area the Midway consists of 200 to 400 feet of lignitic clays and sands with fossiliferous concretions. According to Dumble[1] it extends an undetermined distance into Mexico.

There is an erosional unconformity at the base from Georgia to the Rio Grande, although it is largely obscured by the lithologic similarity between the Upper Cretaceous and the basal Eocene.

LOCAL SECTIONS.

As has been already stated, the Midway in its type area contains few if any determinable plant remains, although lignitic inclusions are widespread and carbonaceous clays and less finely divided remains of former vegetation testify to the nearness of shores covered with a luxuriant plant growth. All the determinable Midway (?) plants have come from a single outcrop near Earle, in Bexar County, Tex., and only two local sections are here presented.

At Earle,[2] about 11 miles due south of San Antonio, in a gully just south of Medina River, a hard calcareous sandstone carrying fossil leaves has been quarried. This rock is the indurated portion of a greenish-gray cross-bedded, rather fine sand formation. The whole thickness is exposed for more than 40 feet, but the country is flat and exposures are rare and disconnected. Along Medina River, about 5¼ miles west of the leaf-bearing outcrop, at a slightly lower stratigraphic horizon, Deussen has collected Midway invertebrates, and in his opinion there is little doubt of the Midway age of the plant-bearing bed at Earle.

The only other section of deposits of Midway age worth mentioning in the present connection is along the Southern Railway 2 miles east of Middleton, in Hardeman County, Tenn. At this locality a low exposure in the Porters Creek clay shows about 10 feet of yellowish weathered, slightly glauconitic sand, grading down into a friable sandy micaceous drab clay with ferruginous films, that carries both broken leaves and casts of invertebrates. The drab clay is exposed for about 4 feet. None of the leaves are specifically determinable, but at least two species of Ficus and several other genera are represented. About half a mile west of this outcrop a sandy micaceous glauconitic clay of the same age contains a considerable Midway fauna.

RELATIONS OF THE FLORA.

The flora thus far found in Midway deposits is so extremely scanty that it affords little basis for extended comparisons with other floras of about the same age or those immediately older and younger. However, as the probability of the discovery of extensive plant-bearing deposits of Midway age in the future is slight, certain conclusions may be deduced from the present collections. Only 10 species are described in the systematic section devoted to this flora, all leaves of dicotyledonous plants, including representatives of the families Moraceæ, Platanaceæ, Lauraceæ, Anonaceæ, Papilionaceæ and Combretaceæ. The family Moraceæ is the most abundant, four species and fragments of other unidentifiable forms having been obtained at different localities. When comparisons are made with the immediately antecedent floras of the Upper Cretaceous in this and other areas a very great discontinuity is at once apparent, in spite of the smallness of the known Midway (?) flora.

The areal distribution of the Upper Cretaceous deposits of southeastern North America has been studied in detail during the last six or seven years by Mr. L. W. Stephenson, who is an experienced and assiduous collector of fossil plants. I have also been over most of the area, so that the failure to discover fossil plants can not be attributed to the lack of careful and

[1] Dumble, E. T., Science, new ser., vol. 33, pp. 232–234, 1911.

[2] I am indebted to L. W. Stephenson and Alexander Deussen for collections and notes on this locality.

intelligent work. The initial Upper Cretaceous deposits in this area, represented by the Woodbine sand of northeastern Texas and the Tuscaloosa formation of northeastern Mississippi and western and central Alabama, have furnished an abundant flora, which I have recently monographed.

The succeeding Eutaw formation or its equivalents has furnished a considerable flora in central Alabama and western Georgia, chiefly from its basal beds. The Eutaw formation is succeeded by more than 2,000 feet of marine strata, represented by the Selma and Ripley formations or their equivalents, which are practically without plant remains. The Selma is a lithologic rather than a chronologic unit and represents an immense deposit of argillaceous chalk in a region where at that time terrigenous materials appear to have been reduced to a minimum. This in a measure accounts for the absence of fossil plants, although the waters are known to have been shallow, for certainly none have ever been discovered. I have never seen the trace of a leaf impression or a piece of petrified wood, and even small lignitized sticks are extremely rare. The Ripley deposits at many places exhibit the appearance of near-shore sediments of terrigenous material and are commonly somewhat carbonaceous, but they have not yielded a representative flora. In western Georgia and in western Tennessee, where they most markedly show a shallowing of the Cretaceous sea, some few determinable plants have been found. These plants show some affinities with those of the upper part of the Montana group of the Rocky Mountain province but not the slightest hint of Laramie affinities. The conclusion seems reasonable, in spite of the negative character of the evidence, that the Laramie flora is unrepresented in southeastern North America. In other words, the emerged area in this region available for study at the present time was also above the sea during at least a part of the time when the Laramie deposits were being laid down in the Rocky Mountain province. This fact is of greatest importance, for though there is an evident physical break between the Ripley deposits and those of the Midway, this break does not show intrinsic evidence of any great magnitude. The faunas, however, which are so much more representative than the floras in both the Ripley and the Midway, are decidedly different, and the little floral evidence available indicates a very great floral change between the Ripley and the Midway. If there were no corroborative evidence, though, as I have just stated, there is considerable, I would be obliged to predicate an interval of great magnitude to account for the evolution and intermigration of floras which intervened between the Ripley and the earliest plant-bearing Eocene.

There is then little in common between the Midway (?) flora of Earle, Tex., and the Cretaceous flora. The genera Ficus, Platanus, Cinnamomum, Asimina, and Laurus occur in both, but they are all long-lived genera, which appear at the base of the Upper Cretaceous and continue to the present time, and all but the genus Asimina have a very large number of species. None of these Midway (?) species occur in the Cretaceous of this or any other area, in spite of the fact that both the Upper Cretaceous flora in this area as well as that of the Midway (?) contain plants of similar low coastal habitats and warm humid climatic conditions.

Only 2 of the 10 Midway (?) species are new, and the genera to which they are referred are not even represented in described Cretaceous or Eocene floras. The other 8 species have been found also in other places. The following species are found in the overlying deposits of the Wilcox group: *Ficus denveriana*, Ficus sp., and *Terminalia hilgardiana*. The following species occur in the Raton formation of the Raton Mesa coal field in Colorado and New Mexico: *Ficus occidentalis*, *Ficus denveriana*, *Platanus aceroides latifolia*, and *Terminalia hilgardiana*. Five of the 8 species or 50 per cent of the known Midway (?) flora occur in the Denver formation of the Denver Basin of Colorado. These are *Ficus denveriana*, *Ficus occidentalis*, *Cinnamomum affine*, *Laurus wardiana*, and *Asimina eocenica*. This fact is of great importance, as some geologists dispute the Eocene age of the Denver formation, but no one can dispute the age of the Midway (?) plants, which are underlain by beds containing an unquestionable marine fauna and these outcrop on the landward side of all the Tertiary leaf-bearing deposits of southeastern North America from Chattahoochee River to the mouth of the Ohio and southwestward to the Rio Grande.

The Midway (?) flora furnishes but meager data for conjectures regarding the physical conditions under which it grew in southern Texas. The plants are all forms whose modern representatives flourish in a warm humid climate in low-lying coastal lands, and such evidence as may be deduced from so few species indicates that temperatures were higher during the initial Eocene than during the deposition of the Upper Cretaceous in this region.

The European floras most similar to that of the Midway (?) are those, likewise poorly represented in marine deposits, of the Montian and Thanetian stages in the so-called Paris Basin in northern France, Belgium, and southeastern England.

SYSTEMATIC DESCRIPTIONS.

Order URTICALES.

Family MORACEÆ.

Genus POUROUMA Aublet.

POUROUMA TEXANA Berry, n. sp.

Plates I and II.

Description.—Leaves of large size, trilobate, petiolate. Maximum size observed, 21 centimeters in length by 20 centimeters in width from tip to tip of the lateral lobes. Margins entire, slightly undulate. Lobes conical and pointed, directed upward, separated by broad, shallow rounded sinuses which reach less than one-third the distance to the base. Base broadly (truncately) rounded, the margins curving downward at the petiole. Petiole long and stout. Primaries three in number, stout, diverging at angles of about 30° from the extreme base. In some specimens the outer laminæ join the lateral primaries some distance above their base. Midrib stoutest of the three, straight. Laterals nearly straight, more or less curved outward, distad. Secondaries numerous, thin, approximately parallel, regularly spaced, branching from the primaries at angles of about 35° to 45°, rather straight in their course, abruptly arching at the margin to join the secondary next above. The undulations of the margins of the lobes follow closely these camptodrome arches of the secondaries. Tertiaries thin, mostly percurrent. Texture coriaceous.

These large, rigid, coriaceous leaves are striking objects and strongly suggest a relationship with those protean forms from the Upper Cretaceous referred to the genus Araliopsis, as for example *Araliopsis cretacea* (Newberry) Berry [1] or more especially *Araliopsis breviloba* Berry.[2]

Pourouma texana is variable in size and shows a superficial resemblance to the gigantic *Aralia notata* Lesquereux [3] of the lower Eocene Fort Union and Denver formations of the Rocky Mountain region. It is, however, smaller than the western species, has a much less developed median lobe, and all the lobes are less full and much more conical in outline. It is by no means certain that *Aralia notata* is really an Aralia, and it is quite possible that it is congeneric with *Pourouma texana* and that both should be referred to a new genus.

The present species shows resemblances to the section Lobatæ of the genus Sterculia, which includes species of tropical Asia, Africa, the East Indies, and especially of tropical America. In general form it is much like some fossil species of Sterculia, suggesting a relationship with the Cretaceous *Sterculia snowii* Lesquereux [4] or with the Tertiary Oligocene and Miocene species of Europe, *Sterculia tenuinervis* Heer.[5]

It also greatly resembles various modern species of the family Moraceæ and is especially like the lobate-leafed species of Pourouma, which has a score or more species in the existing flora of tropical South America. The present species may be compared more especially with *Pourouma guianensis* Aublet of the Caribbean coast of South America.

It is common at Earle, occurring in a gray quartzitic sandstone.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen and L. W. Stephenson).

Collection.—U. S. National Museum.

Genus FICUS Linné.

FICUS DENVERIANA Cockerell.

Ficus spectabilis. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 379, 1873.

Lesquereux, The Tertiary flora, p. 199, pl. 33, figs. 4–6, 1878.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

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[1] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 413, 1911.

[2] Idem, p. 417.

[3] Lesquereux, Leo, The Tertiary flora, p. 237, pl. 39, figs. 2–4, 1878.

[4] Lesquereux, Leo, The flora of the Dakota group: U. S. Geol. Survey Mon. 17, p. 183, pl. 30, fig. 5; pl. 31, figs. 2, 3; pl. 32; pl. 33, figs. 1–4, 1892.

[5] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 35, pl. 109, fig. 7, 1859.

Laurus utahensis. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.
Ficus goldiana. Lesquereux, idem, p. 25. (Specimen No. 2471.)
Ficus denveriana. Cockerell, Torreya, vol. 10, p. 224, 1910.

Description.—This species was described by Lesquereux from the Denver formation and was based at first on the large leaf shown in figure 5 of Plate XXXIII of "The Tertiary flora." Subsequently leaves of all sizes and showing a considerable range of variation were referred to this species. It is abundant in the western half of the Mississippi embayment area and may be recharacterized as follows: Leaves of variable size, ranging from 6 to 15 centimeters in length and from 2.25 to 8.5 centimeters in maximum width, which is at or more commonly below the middle. Broadly ovate in outline and with a somewhat extended acuminate tip and a broadly rounded, slightly decurrent base. Margins entire. Texture coriaceous. Midrib stout, prominent on the lower surface of the leaf. Secondaries of medium size, numerous, opposite to alternate, close or somewhat remotely placed, generally subparallel, diverging from the midrib at angles of about 45°, camptodrome in the marginal region. The lower pair may be opposite and somewhat stouter, with outside lateral camptodrome branches, thus simulating a palmately triveined leaf. This is true of some of the Louisiana material as well as of some of the type material from the Denver formation, but in general the secondaries are all similar and subparallel.

This species makes its appearance in the Midway (?) of Texas as well as the basal Eocene of the Rocky Mountain province. It continues throughout the Wilcox in Arkansas and Louisiana, but has not been detected in the Eastern Gulf area.

Occurrence.—Midway (?) formation, near Earle, Bexar County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

FICUS OCCIDENTALIS (Lesquereux) Lesquereux.

Dombeyopsis occidentalis. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 380, 1873.
Ficus occidentalis. Lesquereux, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.
Lesquereux, Harvard Coll. Mus. Comp. Zool. Bull., vol. 16, p. 50, 1888.

Description.—Leaves of large size, orbicular in general outline, with a narrowed and produced tip. Base truncate or slightly cordate. Length about 12 centimeters. Maximum width, at or below the middle, about 8.5 centimeters. Margins entire. Texture coriaceous. Primaries stout, prominent, three in number, diverging from the base of the leaf, the midrib being the stoutest. Secondaries numerous, stout, camptodrome. Tertiaries thin but well marked, percurrent, forking near the middle.

The type of this species came from the Denver formation at Golden, Colo., and was originally referred to Dombeyopsis by Lesquereux because of its supposed resemblance to the existing genus Dombeya Cavanailles of the Sterculiaceæ. It resembles *Ficus tiliæfolia* and also *Ficus harrisiana*, which was described by Hollick from the Wilcox Eocene of Louisiana. It is not uncommon in the Raton formation of New Mexico. It occurs in a fragmentary condition in the Midway (?) collections from Texas and is also a member of the succeeding Wilcox flora.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen and L. W. Stephenson).

Collection.—U. S. National Museum.

FICUS sp.

Description.—Leaves of large size and ample width, either entire or more or less trilobate. Length at least 20 centimeters. Maximum width about the same as the length. Margin not preserved. Leaf substance subcoriaceous. Venation open, not stout, tripalmate from at or near the base. Lateral primaries of the same caliber as the midrib. Secondaries subopposite and subparallel. Tertiaries numerous, regular, subparallel, percurrent. Areolation open, largely quadrangular.

This large-leafed species is represented only by fragments. Though it appears to represent a new species it is too incomplete for specific characterization. It is, however, identical with similar fragments described by me from the Holly Springs sand of the Wilcox group at Holly Springs, Miss. It resembles a number of existing and fossil large-leafed species of the genus Ficus, but it is not certainly a Ficus, although it is clearly a member of the family Moraceæ. It also suggests the allied genus Cecropia Linné, which has from 30 to 40 existing species in tropical America, where they range from Mexico to Brazil. Ettingshausen referred a fossil form from the Aquitanian of

Bohemia to this genus, describing it as *Cecropia heerii*,[1] which, in so far as comparisons are possible, is very close to the form under discussion. Another species has been described by this author from the same horizon, and he also records [2] a species of Cecropia from the lower Eocene (Ypresian) of Alum Bay, England, which unfortunately was never described or figured.

This species is represented by fragments both in the Midway (?) of Texas and the Holly Springs sand of the Wilcox group of Mississippi.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

Order PLATANALES.

Family PLATANACEÆ.

Genus PLATANUS Linné.

PLATANUS ACEROIDES LATIFOLIA Knowlton.

Platanus aceroides latifolia. Knowlton, U. S. Geol. Survey Prof. Paper (MS.).

Description.—This variety of the widespread *Platanus aceroides* of the European and American Tertiary is similar to the type but is proportionately wider and less elongated, and the margin is less prominently toothed, the teeth being numerous, small, and rather blunt. It is represented by several incomplete specimens in the Midway (?) collection, all of which agree admirably with the complete and abundant material from the Raton formation of New Mexico and Colorado, on which Knowlton based this new variety.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

Order RANALES.

Family LAURACEÆ.

Genus CINNAMOMUM Blume.

CINNAMOMUM AFFINE Lesquereux.

Plate III, figure 2.

Cinnamomum affine. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1869, p. 196; idem for 1872, p. 383; idem for 1874, p. 401.

Lesquereux, The Tertiary flora, p. 219, pl. 37, figs. 1–5, 7, 1878.

Description.—Leaves ovate-lanceolate in outline, somewhat variable in form and decidedly variable in size. Apex and base acuminate. Primaries three, slightly suprabasilar. Dimensions of Texas specimen: Length, 8.5 centimeters; maximum width, in lower half of leaf, 2.5 centimeters.

This species was described by Lesquereux from Golden, Colo., and Carbon, Wyo., and it appears to be not at all uncommon in the earlier Eocene of the Rocky Mountain province. It ranges in size to a maximum which led Lesquereux to suggest its identity with *Cinnamomum mississippiense* of the Wilcox group. The species is represented in Texas by the single fragmentary specimen figured, which is identical in every particular with the original specimen collected in the West.[3] Cinnamomum leaves are notoriously polymorphous, and the smaller leaves of this species may be compared with those of the widespread European species *Cinnamomum lanceolatum*, *C. scheuchzeri*, and *C. polymorphum*.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

Genus LAURUS Linné.

LAURUS WARDIANA Knowlton.

Laurus ocoteoides. Lesquereux (not Massalongo, 1858), The Tertiary flora, p. 215, pl. 36, fig. 10, 1878.

Laurus Wardiana. Knowlton, U. S. Geol. Survey Bull. 152, p. 129, 1898.

Description.—Leaves of rather large size, elongate-lanceolate in general outline, tapering gradually upward to the acuminate tip. Base narrowly cuneate. Length about 17 centimeters. Maximum width, in the basal half of the leaf, about 3 centimeters. Margins entire, more or less slightly undulate. Texture coriaceous. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries relatively thin, numerous, evenly spaced, subparallel. They diverge from the midrib at angles of about 55° and are relatively little curved until the marginal region is reached, where they are camptodrome. Tertiaries obsolete. Both secondary and tertiary venation is obscured by the fact that my material shows only the upper surface of leaves. Notwithstanding the coriaceous leaf substance, both systems of venation may have been well marked on the under side of the leaf, as is so common in modern Lauraceæ.

[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin: K. Akad. Wiss. Wien, Math.-Nat. Cl., Denkschr., vol. 26, pt. 1, p. 82, pl. 27, fig. 7, 1867.

[2] Roy. Soc. London Proc., vol. 30, p. 232, 1880.

[3] Lesquereux, Leo, The Tertiary flora, pl. 37, fig. 4.

This species is rare. It was described by Lesquereux from a single specimen found in the Denver formation at Golden, Colo. The Texas material is scanty and broken but, fortunately, shows all parts of the leaf, which are in exact agreement with the type.

As commonly used by paleobotanists the term Laurus represents a form genus inherited from the days when its modern use was not restricted. The fossil species of Laurus are not closely related to the existing species of Laurus but represent the modern genera Persea, Oreodaphne, Mespilodaphne, Nectandra, and others. In my discussion of the succeeding Wilcox flora, where ample materials were available for study, I have endeavored to refer the numerous species of Lauraceæ to their proper genera but do not think it wise to attempt any closer generic determination of this species. It greatly resembles a number of existing tropical American species of Oreodaphne and Nectandra.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by L. W. Stephenson).

Collection.—U. S. National Museum.

Family ANONACEÆ.

Genus ASIMINA Adanson.

ASIMINA EOCENICA Lesquereux.

Asimina eocenica. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 387, 1873. Lesquereux, The Tertiary flora, p. 251, pl. 43, figs. 5–8, 1878.

Description.—Lesquereux in 1878 described the species as follows:

> Leaves very entire, lanceolate, equally gradually tapering downward to a short, thick petiole and upward to a point; nervation pinnate, camptodrome. I have seen a large number of specimens of these leaves, varying in size from 8 to 15 centimeters long and from 2½ to 4 centimeters broad in the middle, where they are the widest, and there oblong, gradually narrowing upward and downward. The consistence of the leaves is somewhat thick but not coriaceous; the midrib thick, the lateral veins numerous, parallel, all under the same angle of divergence of 50°, slightly curved in traversing the lamina, generally simple or branching once toward the borders, which they follow in a series of bows, formed by anastomoses with veinlets or branches. The nervilles are distinctly marked, at least upon some well-preserved specimens like the one of figure 8; they are generally joined in the middle of the areas by oblique veinlets, forming large equilateral meshes, the ultimate areolation being indiscernible. These leaves differ especially from our *A. triloba* by their oblong-lanceolate shape, those of the living species being generally enlarged upward and more distinctly oblong-obovate and proportionally broader. The nervation compared in both the small and the large leaves of the living species fully agrees with that of these fossil leaves, the lateral veins becoming closer and more distinctly marked in the small leaves, as it is in figure 5. It is the same with the tertiary intermediate nerves, which are scarcely, if ever, distinctly marked upon the small or middle-sized leaves of the papaw, while they appear, if not numerous, at least perfectly distinct in the large ones. A fruit referable to this genus is described in the Wilcox flora of the Mississippi as *Asimina leiocarpa* Lesquereux.

This species is common in the Denver formation at Golden, Colo., occurring also at Carbon and Black Buttes, Wyo. It has been recorded by Knowlton [1] from the Montana group, but that identification seems to me to be erroneous.

The so-called Montana specimen is smaller, with more ascending secondaries. The material from Texas on which the identification of this species rests comprises several incomplete specimens of large leaves, which were about 15 centimeters in length by 4 centimeters in maximum width, with stout prominent midribs and the general form and venation of this species. It is not unlike specimens from the Raton formation which have been referred to the European Tertiary species *Juglans acuminata* Alexander Braun.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen and L. W. Stephenson).

Collection.—U. S. National Museum.

Order ROSALES.

Family PAPILIONACEÆ.

Genus DOLICHITES Unger.

DOLICHITES DEUSSENI Berry, n. sp.

Plate III, figure 3.

Description.—Leaves trifoliate. Lateral leaflets apparently sessile, cordate, or deltoid in general outline, inequilateral, with a pointed apex and a shallowly cordate or truncate broad base. Length about 8 to 10 centimeters. Maximum width, at or below the middle, about 10 centimeters. Margins entire. Texture thin. Midrib stout, curved, especially distad. Lateral primaries stout, thinning distad, one on each side of the midrib, from which they diverge at angles of about 40° at its

[1] Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 57, pl. 14, fig. 3, 1900.

extreme base, curving upward subparallel with the midrib and the lateral margins of the leaflets, eventually inosculating with the thin camptodrome secondaries from the upper part of the midrib. On their outer side the lateral primaries each give off three or four fairly stout camptodrome secondaries, the basal one of which as a rule diverges at the extreme base, giving the leaflets the appearance of having five primaries. Tertiaries mostly obsolete.

This species is unfortunately based on a few incomplete specimens which obviously represent leaflets of some trifoliate-leafed Midway representative of the Papilionaceæ. Several existing genera of this family furnish material with which to compare the fossils. Among these genera Dolichos Linné offers many points of similarity, which leads me to refer this new form to the genus Dolichites, established by Unger in 1850, for leaves and pods that resemble those of the living genus Dolichos, which contains about 30 species, mostly found in the Tropics of the Old World, though several live in the American Tropics. Several species based on both foliage and pods from the European Tertiary have been referred to Dolichites.

Dolichites deusseni may also be compared with the leaflets of *Erythrina arborea* (Chapman) Small, a shrub or small tree of the Florida Keys. It also resembles somewhat the Wilcox leaf referred to Cercis, but differs in venation and certain minor distinctive characters. It also suggests the Laramie and Denver forms referred by Lesquereux to the genus Dombeyopsis Unger of the family Sterculiaceæ.

Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

Order MYRTALES.

Family COMBRETACEÆ.

Genus TERMINALIA Linné.

TERMINALIA HILGARDIANA (Lesquereux).

Plate III, figure 1.

Magnolia hilgardiana. Lesquereux, in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 319, pl. 6, fig. 1, 1860.

Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 20, fig. 1, 1869.

Lesquereux, The Tertiary flora, p. 249, pl. 44, 1878.

Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 282, pl. 39, 1899.

Knowlton, in Lindgren, U. S. Geol. Survey Prof. Paper 73, pp. 60, 61, 1911.

Magnolia laurifolia. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 20, figs. 2, 3, 1869; U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Quercus Lyellii. Lesquereux (not Heer), Am. Philos. Soc. Trans., vol. 13, p. 415 (part), pl. 17, fig. 3 (not figs. 1 and 2).

Description.—Leaves medium to large, oblong-ovate in general outline. Apex not preserved in any of the material. Base narrowly or broadly cuneate. Length ranges from 15 to 25 centimeters. Maximum width, at or above the middle, ranges from 4 to 10 centimeters. Margins entire, more or less irregularly undulate. Leaf substance thin but coriaceous. Only fragments of the petiole preserved; it was evidently short and very stout. Midrib stout, more or less curved, prominent on the lower surface of the leaf. Secondaries relatively thin, numerous, subparallel, about 20 rather regularly spaced, opposite to alternate pairs. They diverge from the midrib at angles of 40° to 70°, averaging about 50°, curving slightly and regularly. Camptodrome close to the margins.

The type material of this species was collected by Hilgard from the Wilcox at Hurleys, Benton County, Miss., and first figured by Lesquereux in the second Arkansas report. It can not be found in the remains of the Hilgard collection at the University of Mississippi. When Lesquereux came to describe and illustrate this material he differentiated two species, although there is obviously only one form represented. The species is abundant in the Midway(?) of Texas, rather widespread in the Wilcox, and occurs in the lower Eocene of Fishers Peak, N. Mex. It has also been recorded from the Fort Union formation of Montana and the Eocene of Lassen County, Cal.

In the small collection from Earle that has been available for study there are ten fragmentary but characteristic specimens of this species.

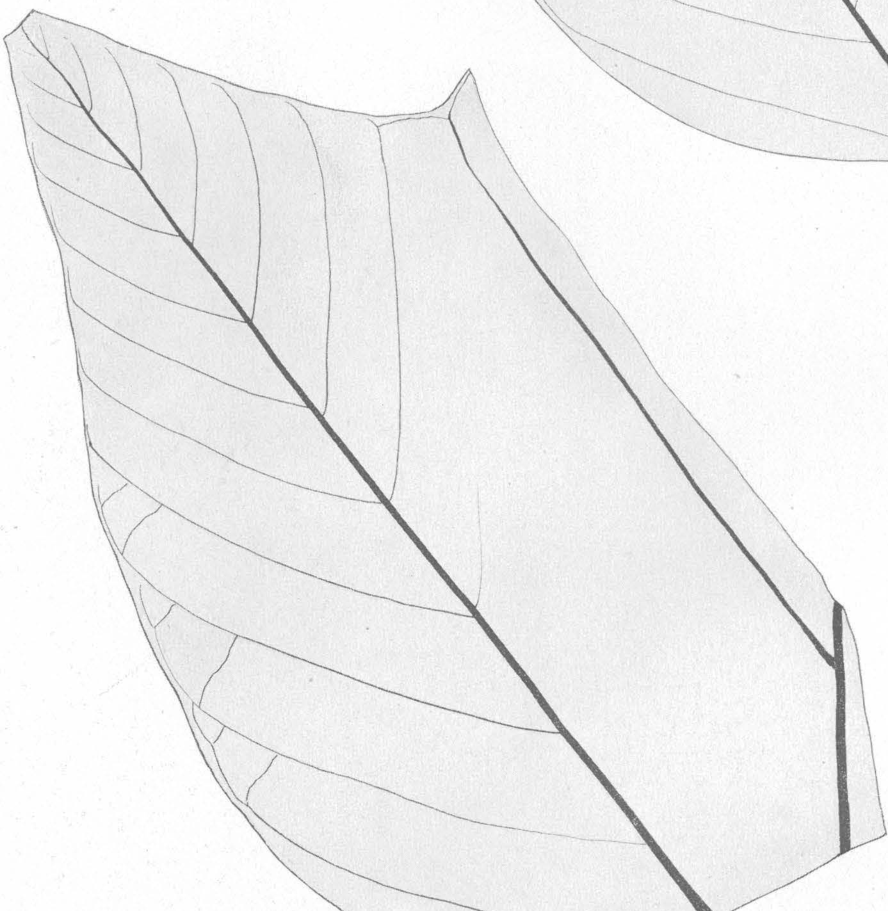
Occurrence.—Midway (?) formation, Earle, Bexar County, Tex. (collected by Alexander Deussen and L. W. Stephenson).

Collection.—U. S. National Museum.

PLATES I–III.

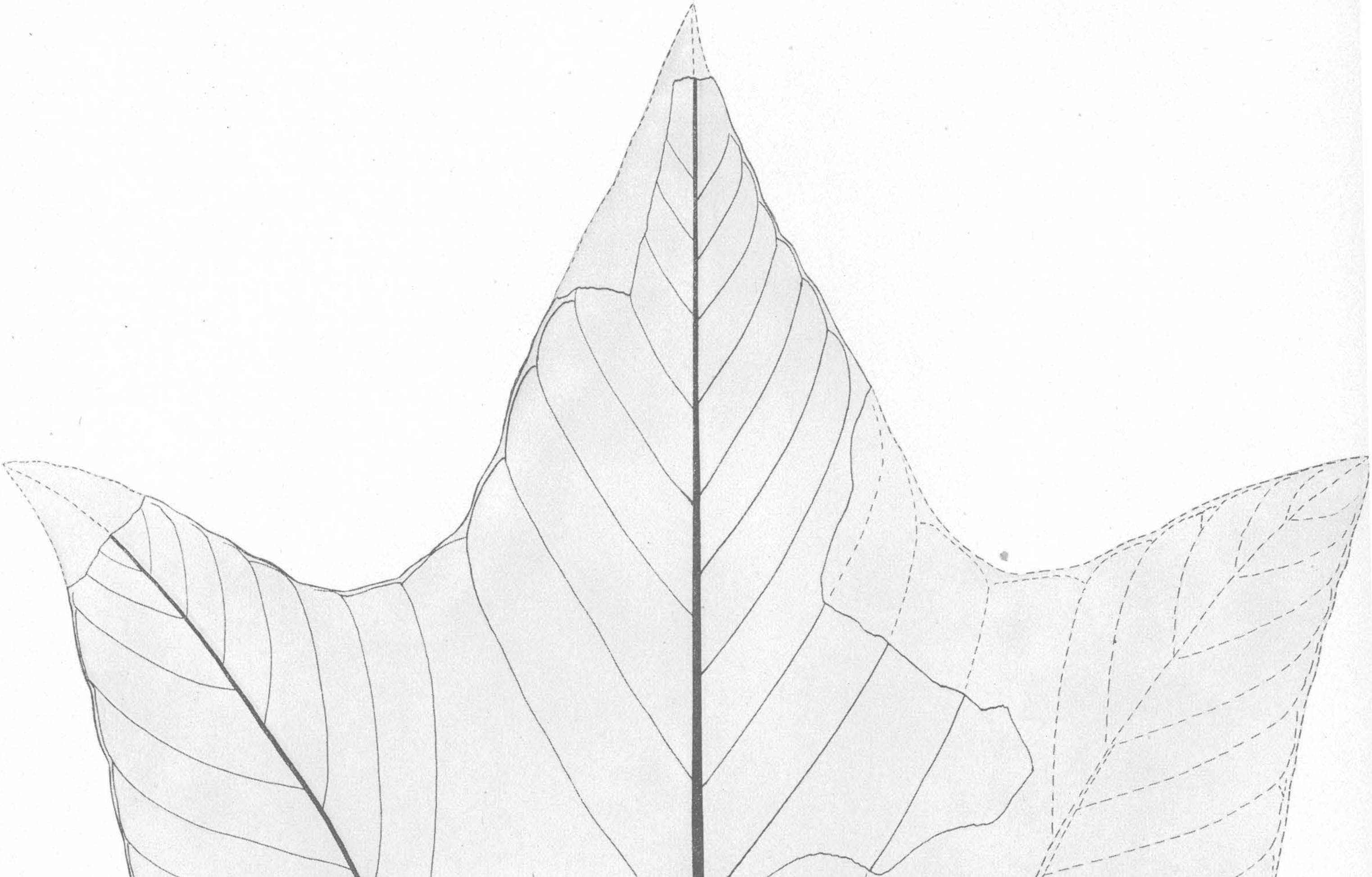
PLATE I.

1



2

FOSSIL PLANTS FROM THE MIDWAY (?) FORMATION OF EARLE, TEX.

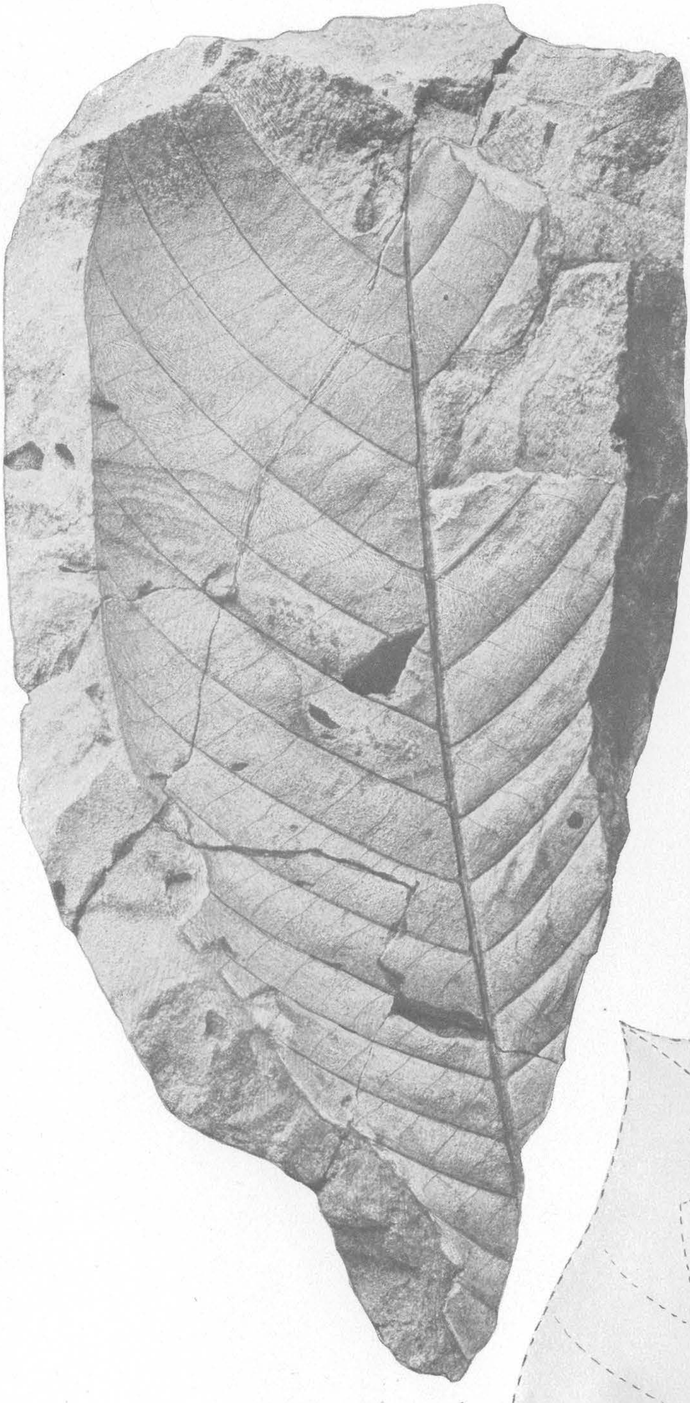


FOSSIL PLANT FROM THE MIDWAY (?) FORMATION OF EARLE, TEX.

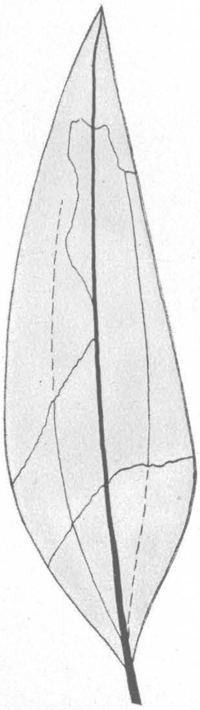
PLATE II.

PLATE III.

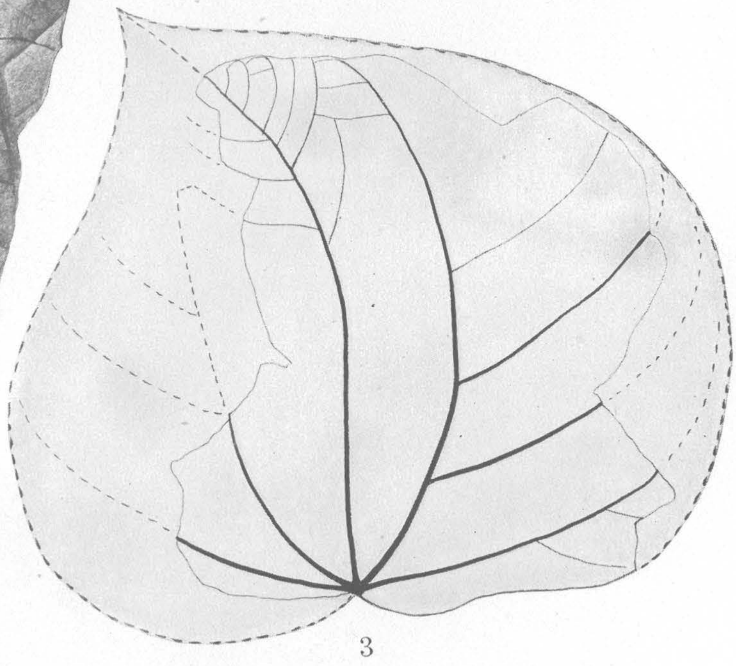
All the specimens are from the Midway (?) formation at Earle, Tex.



1



2



3

FOSSIL PLANTS FROM THE MIDWAY (?) FORMATION OF EARLE, TEX.

THE WILCOX FLORA.

WILCOX GROUP.

STUDY OF THE STRATIGRAPHY.

The complete history of the study of the deposits which are now comprised in the Wilcox group is not within the scope of this report. Only definite contributions to the paleobotanic history of the Wilcox time interval are here discussed.

Nearly every geologist who has published anything regarding the Wilcox area mentions lignite and impressions of leaves, but it would not be worth while enumerating these references in the literature. The paleobotanist engaged in relocating all the old localities in order to collect material for study should keep clearly in mind the fact that the phrase "abundant leaf impressions" may mean a really important outcrop, but more often it refers simply to films of comminuted lignite along sand laminæ in the clays, or leaf fragments so finely divided as to be entirely worthless, or even nothing more than carbonaceous clays.

The earliest significant contribution to the paleobotany of the deposits of Wilcox age is a paper published by Lesquereux[2] in 1859, based on materials collected by J. M. Safford, then State geologist of Tennessee, just south of Somerville in Fayette County, Tenn. These consisted of leaf impressions preserved in clay ironstone from a low exposure in a railroad cut about a mile south of the town. This contribution recorded the species given in the list below. This list and similar lists that follow show the original names and also the disposition that has been made of these early described forms in the present work.

Lesquereux.	Present work.
Laurus caroliniensis Michaux	Nectandra lancifolia.
Prunus caroliniana (Michaux)	Inga mississippiensis.
Quercus myrtifolia (Willdenow)	Sophora lesquereuxi.
Fagus ferruginea (Michaux)	(?).
Quercus! crassinervis? (Unger)	Dryophyllum tennesseensis.
Quercus saffordi (Lesquereux)	Banksia saffordi.
Andromeda dubia (Lesquereux)	Diospyros brachysepala.
Andromeda vaccinifoliæ affinis Lesquereux	Cassia glenni.
Elæagnus inæqualis Lesquereux	Chrysobalanus inæqualis.

This outcrop was stated to be of Pliocene age by Lesquereux, and, as will be noted from the foregoing list, several of the forms were identified with still existing species. Later he regarded these deposits as "most intimately related to the Miocene of Europe." Safford[1] considered the Orange sand, as he then termed the deposits that included the Somerville outcrop, to be of Eocene age, and Lesquereux apparently accepted this opinion to the extent of including them in his paper on the Mississippi plants collected by Hilgard, in which they were all referred to the "Lignitic" [Wilcox], although he still maintained their Miocene age. This outcrop is near the top of the Wilcox; similar ironstones carrying a few upper Wilcox plants occur at about this same horizon southwest of Trenton in Gibson County, Tenn.

Very few facts worth recording at the time were overlooked in Hilgard's work in Mississippi, which partly culminated in his "Report on the geology and agriculture of Mississippi," published in 1861. In this classic, which marks an epoch in the study of the Southern Coastal Plain, there are frequent references to plant fossils, several of which are worth mentioning. In his general section of the Tertiary of Mississippi[3] he gives several lists of species based on the preliminary studies of Lesquereux.

[1] Safford, J. M., Geology of Tennessee, 1869.

[2] Lesquereux, Leo, Am. Jour. Sci., 2d ser., vol. 27, pp. 363, 364, 1859.

[3] Hilgard, E. W., Report on the geology and agriculture of Mississippi, p. 108, 1861.

From the red shale of Tippah County the following are recorded:

Quercus.
Carya n. sp.
Populus rhomboidea.
Populus n. sp.
Morus?.
Laurus n. sp.
Persea n. sp.
Cornus sericea?.
Olea americana!.
Rhamnus n. sp.
Terminalia 2 n. sp.
Magnolia rotundifolia Lesquereux!.
Magnolia acuminata Michaux!.
Rhus.

This refers to the locality cited in the present work as Hurleys, which by the establishment of new counties is now in Benton County. In Hilgard's local section of this outcrop [1] the foregoing list is repeated with the addition of Salisburia, the latter really a Lygodium, *L. binervatum* (Lesquereux) Berry.

The next member in the general section consists of the gray clays of Lafayette and Calhoun counties carrying "Sabal, Cinnamomum, Quercus, Ficus, and Smilax?." The third member comprises the gray clays and sands of Winston County with Cycas [2] and Smilax?. The outcrop along Raglands Branch is described in detail by Hilgard.[3]

In 1860 Lesquereux [4] described and figured the following three Wilcox species, the first two from Hilgard's Mississippi collections and the third from material collected by Safford at La Grange, Tenn.:

Lesquereux.	Present work.
Magnolia hilgardiana	Terminalia hilgardiana.
Rhamnus marginatus	Rhamnus marginatus.
Quercus saffordi	Banksia saffordi.

A paper of considerable merit and the only real systematic contribution to the early study of the Wilcox flora is Lesquereux's paper [5] read before the American Philosophical Society and published in 1869. It is based for the most part on collections made about ten years earlier by E. W. Hilgard, whose paleobotanic comments on them are given in his "Report on the geology and agriculture of Mississippi." The following species were described and figured by Lesquereux in this report:

Lesquereux.	Present work.
Calamopsis danai (type)	Chamædorea danai.
Sabal grayana (type)	Sabalites grayanus.
Salisburia binervata (type)	Lygodium binervatum.
Populus monodon (type)	Ficus monodon.
Populus mutabilis var. repando-crenata Heer	(?).
Salix worthenii (type)	Myrcia worthenii.
Salix tabellaris (type)	Apocynophyllum tabellarum.
Quercus moorii (type)	Dryophyllum moorii.
Quercus lyellii Heer	Nectandra lancifolia and Terminalia hilgardiana.
Quercus retracta (type)	Myrcia bentonensis.
Quercus chlorophylla Unger	Mimusops eolignitica and Pisonia chlorophylloides.
Celtis brevifolia (type)	Ficus schimperi?
Ficus schimperi (type)	Ficus schimperi.
Ficus cinnamomoides (type)	Ficus cinnamomoides.
Laurus pedatus	Osmanthus pedatus.
Cinnamomum mississippiensis Lesquereux	Cinnamomum mississippiensis.
Banksia helvetica Heer	Bumelia pseudotenax.
Persea lancifolia (type)	Nectandra lancifolia.
Ceanothus meigsii (type)	Zizyphus meigsii.
Sapindus undulatus Alexander Braun	Eugenia hilgardiana.
Rhamnus marginatus Lesquereux	Rhamnus marginatus.
Juglans appressa (type)	Not recognized.

[1] Hilgard, E. W., op. cit., p. 113.
[2] *Chamædorea danai* of present report.
[3] Op. cit., pp. 115, 116. The species enumerated are repeated, as are also those from the third member, on p. 117.
[4] Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, pp. 317-319, pl. 6, 1860.
[5] Lesquereux, Leo, Am. Philos. Soc. Trans., new ser., vol. 13, pp. 411-430, pl. 14-22, 1869.

Lesquereux.	Present work.
Juglans saffordiana (type)	Juglans saffordiana.
Magnolia hilgardiana Lesquereux Magnolia laurifolia (type)	Terminalia hilgardiana.
Magnolia lesleyana (type)	Terminalia lesleyana.
Magnolia ovalis (type) Magnolia cordifolia (type)	Combretum ovalis.
Asimina leiocarpa (type)	Asimina leiocarpa.
Phyllites truncatus (type)	Mimusops eolignitica.

These species he regarded as most intimately related to the Miocene flora of Europe, although Hilgard had clearly recognized their position in the Eocene section of Mississippi.

The same year that Lesquereux's report was published saw the publication of Safford's "Geology of Tennessee." Lesquereux's article of 1859 on the plants from Somerville, which had not been illustrated, was reproduced and illustrated,[1] and three species were described but not figured from La Grange, Tenn. The following forms were listed:

Lesquereux.	Present work.
Laurus carolinensis Michaux	Nectandra lancifolia.
Prunus caroliniana (Michaux)	Inga mississippiensis.
Quercus myrtifolia (Michaux)	Sophora lesquereuxi.
Fagus ferruginea (Michaux)	(?).
Salix densinervis (Lesquereux)	Eugenia densinervia.
Quercus crassinervis (Unger)	Dryophyllum tennesseensis.
Quercus saffordi (Lesquereux)	Banksia saffordi.
Andromeda dubia (Lesquereux)	Diospyros brachysepala.
Andromeda vaccinifoliæ affinis (Lesquereux)	Cassia glenni.
Elæagnus inæqualis (Lesquereux)	Chrysobalanus inæqualis.
Sapotacites americanus (Lesquereux)	Bumelia americana.
Salix wortheni Lesquereux	Myrcia wortheni.
Ceanothus meigsii Lesquereux	Zizyphus meigsii.
Juglans saffordiana Lesquereux	Juglans saffordiana.

R. H. Loughridge, in his report on the Jackson purchase region,[2] reproduced Lesquereux's list from Safford's "Geology of Tennessee," with copies of the figures, poorly done and somewhat reduced. This list is as follows:

Lesquereux.	Present work.
Quercus crassinervis	Dryophyllum tennesseensis.
Quercus saffordii	Banksia saffordi.
Quercus myrtifolia	Sophora lesquereuxi.
Andromeda vaccinifoliæ affinis	Cassia glenni.
Andromeda dubia	Diospyros brachysepala.
Prunus caroliniana	Inga mississippiensis.
Elæagnus inæqualis	Chrysobalanus inæqualis.
Sapotacites americanus	Bumelia americana.
Salix? densinervis	Eugenia densinervia.
Quercus lyellii	Nectandra lancifolia.
Fagus ferruginea (fruit)	(?).

Loughridge also listed[3] the following forms from Wickliffe in Ballard County and Boaz in Graves County, Ky. These were based on his collections and the determinations were made by Lesquereux.

Lesquereux.	Present work.
Wickliffe, Ballard County, Ky.:	
Myrica elænoides	Myrica elæanoides.[4]
Myrica copeana	Cupanites loughridgii.
Ficus multinervis	Ficus myrtifolius.
Sapindus falcifolius	Ficus wilcoxensis.

[1] Safford, J. M., Geology of Tennessee, pp. 425–428, pl. K, 1869.
[2] Loughridge, R. H., Report on the geological and economic features of the Jackson's purchase region, pp. 196–198, Kentucky Geol. Survey, 1888.
[3] Op. cit., p. 198.
[4] This specimen comes from Boaz and not from Wickliffe, as Loughridge states.

Lesquereux.	Present work.
Wickliffe, Ballard County, Ky.—Continued.	
Sapindus dubius	Mixed forms bearing this label and number represent Engelhardtia ettingshauseni, Exostema pseudocaribæum, Banisteria wilcoxiana, Ficus wilcoxensis, and Carapa eolignitica.
Sapindus angustifolius	Sapindus mississippiensis.
Laurus californica?	Mespilodaphne pseudoglauca.
Quercus saffordii	Banksia saffordi.
Juglans rugosa	Juglans schimperi.
Salix angusta	Sapindus linearifolius.
Salix media	Not recognized.
Ailanthus leaf fragment	Not afterward referred to and specimen lost.
Boaz, Graves County, Ky.:	
Sapindus falcifolius	Ficus wilcoxensis.
Quercus nervifolia	Banksia saffordi.
Quercus cuspidata	Dryophyllum tennesseensis.
Quercus californica	Mespilodaphne pseudoglauca.
Ficus multinervis	Ficus myrtifolius.

In 1888 a large number of determinations made by Lesquereux were arranged by F. H. Knowlton for publication in the Proceedings of the United States National Museum.[1] The Loughridge collections are briefly described, but only the new forms are figured.

The Wickliffe list was given as follows:

Lesquereux.	Present work.
Myrica elæanoides n. sp	Myrica elæanoides.[2]
Sapindus angustifolia Lesquereux	Sapindus mississippiensis.
Sapindus dubius Unger	Specimens bearing this label and number represent Engelhardtia ettingshauseni, Exostema pseudocaribæum, Banisteria wilcoxiana, Ficus wilcoxensis, and Carapa eolignitica.
Myrica copeana Lesquereux	Cupanites loughridgii.
Juglans rugosa Lesquereux (No. 2490)	Juglans schimperi.
Salix angusta Alexander Braun	Sapindus linearifolius.
Salix media Heer (No. 2593)	Not recognized.
Quercus saffordii Lesquereux	Banksia saffordi.
Porana sp	Not a fossil but a ferruginous stain.

The Boaz list now included the following species:

Lesquereux.	Present work.
Ficus multinervis	Ficus myrtifolius.
Laurus californica	Mespilodaphne pseudoglauca.
Sapindus falcifolius Alexander Braun	Ficus wilcoxènsis.
Quercus cf. Q. cuspidata (Rossmässler) Unger (No. 2573).	Dryophyllum tennesseensis.
Quercus neriifolia Alexander Braun	Banksia saffordi.

In the late eighties and early nineties Mr. L. C. Johnson made several collecting trips through Tennessee, Mississippi, and Louisiana and sent in some fossil plant material from the following localities: Hatchie River, near Shandy, in Hardeman County, Tenn.; Baughs Bridge, Wolf River, Fayette County, Tenn.; Vaughans, near Lamar, Benton County, Miss.; Waterford and Early Grove, Marshall County, Miss.; McLees, near Mansfield, De Soto Parish, La.; and Campbell's quarry on Cross Bayou, Caddo Parish, La.

Only the material from the last two localities seems to have been studied by Lesquereux. The rest remained untouched in the National Museum until I took up the elaboration of these floras.

Lesquereux's notes on the plants from McLees and Campbell's quarry were also arranged for publication by F. H. Knowlton and appeared in volume 11 of the Proceedings of the United States National Museum.

The plants from McLees, which is 2 miles north of Mansfield, La., are few in number and poorly preserved in a lithified ferruginous sandstone. Lesquereux[3] identified the following forms:

[1] U. S. Nat. Mus. Proc., vol. 11, pp. 11-13, 1888.

[2] This specimen is from Boaz.

[3] U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Lesquereux.	Present work.
Magnolia laurifolia	Aralia notata (No. 804). Terminalia hilgardiana (No. 805).
Ficus spectabilis	Ficus denveriana.
Aralia fragment	Aralia notata.
Platanus guillelmæ	Not numbered in report nor contained in the National Museum collection.

From Campbell's quarry, Cross Lake, Caddo Parish, La., he gives the following list:[1]

Lesquereux.	Present work.
Sapindus angustifolius Lesquereux	Sapindus formosus.
Sapindus caudatus Lesquereux No. 2601	(?).
Sapindus coriaceus Lesquereux No. 2602	(?).
Magnolia laurifolia Lesquereux	Terminalia hilgardiana.
Laurus socialis Lesquereux	Mespilodaphne pseudoglauca.
Laurus utahensis Lesquereux	Ficus denveriana.
Rhamnus cleburni Lesquereux	Rhamnus cleburni.
Rhamnus eridani Unger	Nectandra lancifolia.
Carya antiqua Newberry	Hicoria antiquorum.
Quercus angustiloba Alexander Braun	Not determinable.
Quercus moorii? Lesquereux	(?).
Ficus goldiana Lesquereux	Ficus denveriana.
Ficus goldiana var	Ficus harrisiana.
Ficus spectabilis Lesquereux	Ficus denveriana.
Phragmites œningensis Alexander Braun	Not determinable.

In Knowlton's account[2] of the fossil woods collected by the Arkansas Geological Survey two of the new species, *Cupressinoxylon calli* and *Laurinoxylon branneri*, appear to have come from the Wilcox of Crowleys Ridge in the northeastern part of the State, although its exact stratigraphic position was not determined at that time.

In 1894 Harris[3] mentions the following plants from Benton, Saline County, Ark., from determinations by F. H. Knowlton:

Magnolia laurifolia Lesquereux.
Quercus retracta Lesquereux.
Quercus moorei Lesquereux.

I have not been able to find these specimens and so have omitted them from future consideration. They came from Henderson's clay pit at Benton, Saline County, Ark., and were collected by R. E. Call in 1891. Call also made collections from Hicks's pit at this place, but they were not studied at the time (U. S. Geol. Survey localities 582, 583). He also made collections in 1891 from Atchison's clay pit at Perla, near Malvern, Hot Springs County, which were also not studied at that time (U. S. Geol. Survey locality 584).

In 1895 T. W. Vaughan[4] published an article on the geology of eastern Texas, for which Knowlton furnished a list of plants determined from collections made by Vaughan from ferruginous materials at Old Port Caddo Landing on Little Cypress Bayou in Harrison County, Tex.:

The following species were listed:

Knowlton.	Present work.
Salix tabellaris Lesquereux (a single doubtful leaf)	Apocynophyllum tabellarum.
Magnolia laurifolia Lesquereux (a fragment)	Terminalia hilgardiana.
Magnolia ovalis Lesquereux	Combretum ovalis.
Juglans appressa Lesquereux	(?).
Ficus schimperi Lesquereux	Ficus schimperi.
Ficus sp. nov. Nos. 1 and 2	Ficus vaughani and planicostata maxima.
Cinnamomum affine Lesquereux (common) Cinnamomum mississippiensis Lesquereux	Cinnamomum affine.
Laurus or Litsea sp. nov	Oreodaphne obtusifolia.
Juglans (?) sp. nov	Persea longipetiolatum.

[1] Lesquereux, Leo, op. cit., pp. 24, 25, 1888.
[2] Knowlton, F. H., Arkansas Geol. Survey Ann. Rept. for 1889, pp. 249-260, pls. 9-11, 1891.
[3] Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 56, 1894.
[4] Vaughan, T. W., Am. Geologist, vol. 16, pp. 304-309, 1895.

Vaughan correctly referred these deposits to the "Lignitic" (=Wilcox), and Knowlton stated that they were probably of the same age as the Denver formation of Colorado. Harris and Veatch in their subsequent publications also referred them to the "Lignitic or Sabine" (=Wilcox).

The field work of G. D. Harris and A. C. Veatch in Louisiana resulted in a large collection of fossil plants from the ferruginous concretions exposed on Red River near Coushatta, Red River Parish, La., and smaller collections from several localities in the immediate vicinity of Shreveport in Caddo Parish, La. These were sent to Arthur Hollick,[2] who contributed an illustrated paper to the preliminary report on the geology of Louisiana by Harris and Veatch.

The largest and most interesting collection was from Coushatta and included the following forms:

Hollick.	Present work.
Andromeda delicatula Lesquereux	Mespilodaphne coushatta.
Andromeda eolignitica Hollick	Mespilodaphne eolignitica.
Apocynophyllum sapindifolium Hollick	Apocynophyllum sapindifolium.
Artocarpus dubia Hollick	Artocarpus dubia.
Artocarpus lessigiana (Lesquereux) Knowlton	Artocarpus lessigiana.
Celastrus veatchi Hollick	Celastrus veatchi.
Celastrus taurinensis Ward?	Celastrus taurinensis.
Cinnamomum buchii Heer	Cinnamomum buchi.
Cornus studeri Heer?	Cornus studeri?.
Cryptocarya eolignitica Hollick	Cryptocarya eolignitica.
Ficus artocarpoides Lesquereux?	Ficus artocarpoides?.
Fraxinus johnstrupi Heer?	Fraxinus johnstrupi?.
Ilex? affinis Lesquereux?	Ilex? affinis.
Juglans rugosa Lesquereux	Sapindus coushatta and Juglans berryi.
Juglans schimperi Lesquereux	Juglans schimperi.
Laurus primigenia Unger	Oreodaphne mississippiensis and Nectandra pseudocoriacea.
Magnolia hilgardiana Lesquereux	Terminalia hilgardiana.
Magnolia lanceolata Lesquereux	Magnolia angustifolia.
Persea speciosa Heer	Persea longipetiolatum.
Quercus microdentata Hollick	Dillenites microdentatus.
Rhamnus cleburni Lesquereux	Rhamnus coushatta.
Sapotacites americanus Lesquereux	Not determinable.
Tetranthera præcursoria Lesquereux	Oreodaphne coushatta.
Toxylon longipetiolatum Hollick	Persea longipetiolatum.
Ulmus tenuinervis Lesquereux	Dillenites ovatus.

From clay concretions at Vineyard Bluff on Cross Bayou, Caddo Parish, La., the following forms were recorded:

Hollick.	Present work.
Pteris pseudopinnæformis Lesquereux	Pteris pseudopinnæformis.
Artocarpus lessigiana (Lesquereux) Knowlton	Artocarpus lessigiana.
Ficus harrisiana Hollick	Ficus harrisiana.
Cinnamomum sezannense Watelet	Oreodaphne obtusifolia.
Daphnogene kanni Heer?	Cinnamomum postnewberryi.

Hilgard,[1] in 1887, mentioned well-preserved leaves and fruits which he had collected on the upper Red River in 1869 and deposited at the University of Mississippi at Oxford. These collections were never studied and have since been lost. They may have come from Coushatta or from some similar outcrop between Coushatta and Shreveport subsequently destroyed by the cutting of the Red River, which in the last 15 years has practically removed the plant-bearing beds at Coushatta.

From clay beds at Slaughter Pen Bluff, one-half mile below Vineyard Bluff, the following were recorded:

[1] Science, vol. 9, pp. 535–536, 1887.

[2] Hollick, Arthur, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, pp. 276–288, pls. 32–48, 1899.

Hollick.	Present work.
Poacites sp. Hollick	Poacites sp.
Cyperites sp. Hollick	Cyperites sp.
Ficus planicostata Lesquereux	Ficus planicostata maxima.
Cinnamomum scheuchzeri Heer ?	Cinnamomum postnewberryi.
Ilex sp. Hollick	Ilex sp.

From a gray sandstone, similar to that at Campbell's quarry on Cross Bayou, exposed in a cut on the Kansas City Southern Railway (Kansas City, Pittsburg & Gulf Railroad), 1 mile west of Shreveport, the following species was identified:

Hollick.	Present work.
Sapindus angustifolius Lesquereux	Sapindus mississippiensis.

At this time Harris and Veatch were still in doubt regarding the exact age of these outcrops and were inclined to consider them "Lower Claiborne." Hollick made no determination of their age beyond the opinion that they were early Tertiary.

In 1906 L. C. Glenn published a paper on the underground waters of Tennessee and Kentucky west of Tennessee River [1] which contained valuable contributions to the geology of that region. During the progress of the field work for this report several plant localities were discovered that have since yielded a large amount of important material. Small collections of fossil plants were made from four localities, only two of which prove to be of Wilcox age. These received a preliminary study by F. H. Knowlton,[2] who furnished the following lists of determinations:

The present collection embraces fossils from four localities, as follows:

1. Columbus, Ky. This material, a white sandy clay, contains two species of Quercus and apparently a single species of Salix, none of them, so far as I can make out, being identical with the forms mentioned by Lesquereux from this locality. Probably a more extended search among living species would show affinities with these, but this I have not been able to give at this time.[3]

2. Hickman, Ky. This is also a sandy clay, and embraces three forms—a single leaf each of a Salix? and *Menispermum canadense* Linné and the balance a compound leaf of what appears to be *Tecoma radicans* Linné or something near it.[3]

3. Wickliffe, Ky. The largest and best lot, affording the following forms:

Knowlton.	Present work.
Salix angusta Alexander Braun	Sapindus linearifolius.
Salix sp	Sapindus linearifolius.
Quercus saffordi Lesquereux	Banksia saffordi.
Quercus neriifolia Alexander Braun	Banksia saffordi.
Quercus moorii Lesquereux	Dryophyllum moorii.
Quercus n. sp	Dryophyllum tennesseensis.
Myrica copeana Lesquereux	Cupanites loughridgii.
Eucalyptus n. sp	Sapindus eoligniticus.
Sapindus angustifolius Lesquereux	Sapindus formosus.
Sapindus dubius? Unger	Sapindus formosus.

4. Near Grand Junction, Tenn. The same kind of material as the last, containing the following:

Knowlton.	Present work.
Monocotyledonous plant (fragments)	Sabalites sp.
Salix angusta Alexander Braun	Myrcia bentonensis.
Quercus (2 species)	Banksia saffordi.
Juglans saffordiana? Lesquereux	Cassia glenni.
Sapindus angustifolia? Lesquereux	Myrcia bentonensis.
Sapindus sp	(?).
Cinnamomum? sp	Melastomites americanus
Ceanothus meigsii Lesquereux	Zizyphus meigsii.
Acacia sp. (nov.?)	Mimosites variabilis.

[1] Glenn, L. C., U. S. Geol. Survey Water-Supply Paper 164, 1906.

[2] Knowlton, F. H., in Glenn, L. C., op. cit., pp. 38, 39.

[3] These outcrops have recently been shown to be of early Pleistocene age. See Berry, E. W., U. S. Nat. Mus. Proc., vol. 48, pp. 293-303, pls. 12, 13, 1915.

In addition to the localities and collections already mentioned, small lots, consisting of only one or two specimens, have been received from other sources but have heretofore remained unstudied. They comprise the following materials:

Three or four specimens were sent to the United States National Museum by T. O. Mabry, who collected them about twenty years ago from the plant-bearing exposures in the railroad cut just north of Oxford depot, Lafayette County, Miss.

Two or three specimens were sent to the United States National Museum in 1896 by C. T. Simpson from Frierson Mill, De Soto Parish, La.

A few specimens in clay ironstone were received at the United States National Museum in 1889 from J. W. Kelsey, who collected them at Kelseys Bluff east of Early Grove, Miss.

A small collection made by A. C. Veatch between 3 and 4 miles below Hamilton on Sabine River, Sabine County, Tex., was deposited at the New York Botanical Garden.

A small collection was sent to the United States National Museum in 1889 by J. C. Branner, at that time State geologist of Arkansas. This included a determinable specimen from a well near Texarkana (U. S. Nat. Mus. No. 8608, collected by Prof. Moseley); a specimen from sec. 28, T. 2 S., R. 14 W. (U. S. Nat. Mus. No. 8610, collected by R. I. Ailly); several specimens from Hardys Mill near Gainesville, Greene County (U. S. Nat. Mus. Nos. 8605, 8606, 8609, collected by J. C. Branner); and a specimen from Scarboroughs in the vicinity of the Hardys Mill locality (U. S. Nat. Mus. No. 8607). These were examined by Lester F. Ward, who mentions "Magnolia and an ericaceous leaf" in a letter quoted in part by Call[1] in his geology of Crowleys Ridge.

During 1911 and 1914 Berry published several preliminary papers based on the field work which has resulted in the present report. The first[2] showed that the type exposures of the Lafayette formation in Lafayette County, Miss., were of Wilcox age. The second[3] was devoted to a description of a new species of Engelhardtia fruit from Early Grove, Miss., the first authentic record of this genus from the Tertiary strata of North America. The third[4] included a brief general account of the Wilcox flora, enumerating numerous genera that were represented and giving a clear indication of its wonderful diversity and richness. The fourth[5] described the occurrence of fruits of the Nipa palm in the Grenada formation, the upper formation of the Wilcox group, of Grenada, Miss. It is the first and only known occurrence in the Western Hemisphere of the genus Nipadites, which is common in the Eocene of the Old World.

A preliminary sketch[6] which formed the basis for the treatment of the ecology and distribution in this work was read before the American Philosophical Society in 1914.

The following forms that are given in the lists on the preceding pages must be dropped from the literature, as they are based on fragmentary and not certainly determinable material that was subsequently lost or else on absolutely undeterminable remains. One specimen is not even of an organic nature.

Fagus ferruginea Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 363, 1859. Recorded from Somerville, Tenn., and specimen lost. Obviously not a Fagus.

Juglans appressa Lesquereux, Am. Philos. Soc. Trans., new ser., vol. 13, p. 420, pl. 20, fig. 6, 1869. Recorded from Hurleys, Miss., and specimen lost. Not determinable. The same remark applies to the identification of this species by Knowlton (Am. Geologist, vol. 16, p. 308, 1895) from Old Port Caddo Landing, Tex.

Magnolia laurifolia Harris, Arkansas Geol. Survey Ann. Rept. for 1892, p. 56, 1894. Recorded from Benton, Ark., and specimen lost.

Phragmites œningensis Alexander Braun. Determined from Cross Bayou by Lesquereux (specimen No. 2532). Based on a fragment of a palm ray. (Not determinable.)

Platanus guillelmæ Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888. Recorded from McLees, near Mansfield, La. Not numbered in the text or present in the collection.

Populus mutabilis var. *repando-crenata* Lesquereux, Am. Philos. Soc. Trans., new ser., vol. 13, p. 413, pl. 18, figs. 4–6, 1869. Based on undeterminable fragments recorded from Hurleys, Miss.

Porana sp. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888. Based on a ferruginous stain.

Quercus angustiloba Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888. Based on an undeterminable fragment from Cross Bayou, La.

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[1] Call, R. E., Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, pp. 96, 97, 1891.

[2] Berry, E. W., Jour. Geology, vol. 19, pp. 249–256, figs. 1–4, 1911.

[3] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 31, pp. 491–496, figs. 1, 2, 1911.

[4] Berry, E. W., Am. Philos. Soc. Proc., vol. 50, No. 199, pp. 301–315, 1911.

[5] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 37, pp. 57–60, 1914.

[6] Berry, E. W., Am. Philos. Soc. Proc., vol. 53, pp. 129–250, 1914.

Quercus chlorophylla Lesquereux, Am. Philos. Soc. Trans., new ser., vol. 13, p. 416, pl. 17, fig. 5. Figure 5 does not represent this species nor is it determinable. The specimens shown in figures 6 and 7 are referred by me to Mimusops and Pisonia respectively.

Quercus retracta Lesquereux, idem, p. 416, pl. 16, fig. 5. This fragment is undeterminable. The specimen shown in figure 4 has been referred to *Myrcia bentonensis* The record from Benton, Ark., given by Harris (op. cit.) is based on material since lost.

Salix media Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888. Recorded from Wickliffe, Ky. Specimen lost.

Sapindus caudatus Lesquereux, idem, p. 24. Recorded from Cross Bayou, La. Not determinable.

Sapindus coriaceus Lesquereux, idem. Recorded from Cross Bayou, La. Not determinable.

NOMENCLATURE.

The terminology which sanctions the name Wilcox for this group of formations is not of long standing, the various included deposits, either individually or collectively having received many names, both lithologic and geographic, of differing shades of meaning. As is usually and of necessity the case in geologic studies, most of the earlier names were loosely applied, without precisely defined limits or adequate lithologic or paleontologic characteristics. It is unnecessary for the purposes of this study to go back farther than 1860, the date of publication of Hilgard's "Report on the geology and agriculture of Mississippi." In this work the Wilcox and underlying deposits of the Midway formation in the Mississippi area are termed the "Northern Lignitic group," usually shortened to simply "Lignitic."[1] Not only because it is a lithologic term, based on an area where marine faunas are in general absent, but also because it included younger deposits it has been abandoned in more recent years. It was adopted by Smith[2] for the Alabama area and well characterized in 1887 with various subdivisions, largely paleontologic, named, in order from the top downward, Hatchetigbee, Bashi, Tuscahoma, and Nanafalia. In this usage it also included the underlying Midway. Harris[3] in 1894 used "Lignitic" but gave it the restricted paleontologic basis of the Wilcox as used at the present time. Meanwhile Safford[4] in 1856 and later, as a result of his studies in western Tennessee, had proposed the term "Orange sand or La Grange group."

The term "Orange sand" was afterward used by Hilgard for the deposits in Mississippi subsequently referred to the Lafayette formation and not in the sense of the original proposer of the name, who used it in the sense in which Hilgard used "Lignitic." The fact that much if not all of Hilgard's Orange sand or Lafayette in Mississippi is really of Wilcox age further complicates a difficult question of taxonomy. Safford's term "Orange sand or La Grange group" is objectionable, because it included surficial deposits of the so-called Lafayette,[5] some Cretaceous materials, and the younger sands and clays of west Tennessee, which are probably of lower Jackson age. This was in 1864. In 1869 Hilgard[6] proposed the name "Mansfield group" for the Wilcox of northwestern Louisiana. This unit was, however, without a paleontologic basis and of less extent than the Wilcox as now defined. The "Camden series," proposed by Hill[7] in 1888, included not only Hilgard's Mansfield but Cretaceous and Jackson deposits. Meanwhile Heilprin[8] had proposed the term "Eolignitic," which is open to the same objections as the term "Lignitic," and, unlike that term, has never been accorded a very extensive usage. Dall[9] in 1898 adopted the term "Chickasaw or Chickasawan stage," proposed by Hilgard[10] in 1871 as the equivalent of his "Northern Lignitic," assuming that the "Lignitic" as defined by Hilgard was the exact equivalent of the "Lignitic" of southern Alabama. As it embraces younger Eocene deposits, especially at the supposed type locality of the Chickasaw Bluffs, and is thus historically inappropriate, it also has been abandoned.

In 1906 Veatch[11] proposed the name "Sabine," because of the development of a marine fossiliferous series of outcrops along Sabine

[1] Hilgard, E. W., Report on the geology and agriculture of Mississippi, pp. 110-123, 1860.

[2] Smith, E. A., and Johnson, L. C., U. S. Geol. Survey Bull. 43, pp. 18, 38, 1887, and many subsequent publications of the Alabama Geological Survey.

[3] Harris, G. D., Am. Jour. Sci., 3d ser., vol. 47, p. 304, 1894; Bull. Am. Paleontology, vol. 2, No. 9, 1897.

[4] Safford, J. M., Am. Jour. Sci., 2d ser., vol. 37, pp. 369-370, 1864.

[5] Hilgard, E. W., and Safford, J. M.. communication in Am. Geologist, vol. 8, pp. 129-131, 1891.

[6] Hilgard, E. W., Am. Jour. Sci., 2d ser., vol. 48, p. 340, 1869.

[7] Hill, R. T., Arkansas Geol. Survey Rept. for 1888, vol. 2, pp. 49-53, 1888.

[8] Heilprin, Angelo, Contributions to the Tertiary geology and paleontology of the United States, Philadelphia, 1884.

[9] Dall, W. H., U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, table opp. p. 334, 1898.

[10] Hilgard, E. W., Am. Jour. Sci., 3d ser., vol. 2, pp. 394-396, 1871.

[11] Veatch, A. C., U. S. Geol. Survey Prof. Paper 46, pp. 34-36, 1906.

River in Sabine County, Tex., and Sabine Parish, La. These outcrops also represent but a part of the Wilcox as at present delimited. "Sabine River or Timber belt beds" had also been previously used by Penrose in 1890 for deposits in eastern Texas that included materials of Claiborne and Jackson as well as Wilcox age. The same year the term Wilcox was used in a paper by Crider and Johnson[1] on the underground waters of Mississippi. Since that date the more consistent supervision of the committee on geologic names of the United States Geological Survey has caused the general adoption of the term Wilcox for this group of deposits, from their fullest and most varied development in Wilcox County, Ala.

FAUNAS.

The Wilcox marine faunas are known only from the seaward deposits of this age in southern Alabama, in the eastern Gulf area, and in northwestern Louisiana and along Sabine River, in the western Gulf area.[2] The following brief account of the general character of these faunas and their relation to the sediments is based on the Alabama section and is followed by a brief synopsis of the animal remains found in the upper embayment region. The paleozoologic data relating to the Alabama section were compiled and interpreted by Dr. J. A. Gardner, of Johns Hopkins University.

The Wilcox molluscan fauna is rather monotonous in general aspect, in spite of the four faunules that have been differentiated. Probably the most important factor in determining the general character of the marine molluscan life in an area where long time intervals, range in latitude, and marked climatic changes are eliminated is the depth of the water. The Wilcox sea seems to have been quite uniformly shallow from its opening to its close. At no time is it at all probable that the depth exceeded 25 fathoms. The minimum depth is indicated by the constant presence of Cancellaria, Ostrea, Corbula, Pholas, and the like, the maximum depth by the relative abundance through the whole Wilcox interval of the larger univalves chiefly characteristic of the sublittoral zone. There is no evidence that the slight change in the character of the sediments during Bashi time involved any perceptible deepening of the waters, and it is much more probable that changes on the land were the determining factors. The Hatchetigbee check lists, indeed, offer the only evidence of any modification of the depth sufficiently pronounced to be reflected in the fauna. The littoral facies is so much more prominent, relatively, in this final epoch of Wilcox time and the sublittoral facies so much less prominent that a considerable shallowing may be safely postulated.

The later faunal studies of the Wilcox as a rule have been desultory or little more than compilations from the work of the earlier investigators, particularly from Conrad and Lea. Harris, in his "Lignitic stage,"[3] makes the most ambitious attempt at a monographic study. His paper bears many of the marks of rather hurried and superficial work, but he does bring together in a fairly satisfactory manner the results already obtained, and his mistakes, though rather numerous, are so obvious that they are not misleading. Aldrich has added very materially to the knowledge of the fauna in numerous short articles published from time to time.[4] In one of his longer papers[5] he gives some check lists which, though published in 1886, include the majority of the species thus far described. The work on the underlying Midway and overlying Claiborne faunas is even more fragmentary and unsatisfactory, so that although the Wilcox is recognized by both the paleozoologist and the stratigrapher as a clearly differentiated group, comparative figures would not afford satisfactory evidence of the differentiation, as their percentage of error would be too high. The literature of the formational faunules, though meager, is, however, consistently meager, and tables can be drawn up and computations made which, though far from being entirely accurate, yet convey a general impression which is on the whole not misleading.

The Nanafalia Mollusca recorded in the literature constitute an ill-defined group of about forty species, the denizens apparently

[1] Crider, A. F., and Johnson, L. C., U. S. Geol. Survey Water-Supply Paper 159, p. 9, 1906.

[2] A small faunule has recently been discovered in Mississippi by E. N. Lowe.

[3] Harris, G. D., Bull. Am. Paleontology, vol. 2, pp. 195–294, 1897; idem, vol. 3, pp. 3–128, 1899.

[4] Aldrich, T. H., Cincinnati Soc. Nat. Hist. Jour., vol. 8, pp. 145–153, 1885; Bull. Am. Paleontology, vol. 1, pp. 55–84, 1895; idem, vol. 2, pp. 169–192, 1897; idem, vol. 5, pp. 1–24, 1911; Nautilus, vol. 11, p. 27, 1897; idem, vol. 11, pp. 97–98, 1898; idem, vol. 17, p. 19, 1903; idem, vol. 21, pp. 8–11, 1907; idem, vol. 22, pp. 74–76, 1908.

[5] Alabama Geol. Survey Bull. 1, pp. 7–60, 1886.

of waters not exceeding 15 to 25 fathoms in depth. The characteristic features of the make-up of the fauna are probably due, quite as much to the reconnaissance nature of the work done upon it as to the actual facies. Early collections include as a rule only those forms conspicuous either for their large size or their great abundance, so that the notably meager representation in the Nanafalia check lists of all the genera of lesser dimensions suggests that they formed an inconspicuous factor in the original fauna. Fully 70 per cent of the species recorded are univalves of medium or large size—fulguroids, fusoids, buccinoids, Pseudoliva, Turritella, and the like—genera mostly characteristic of the laminarian and the sublittoral zones. The pelecypods number less than a dozen species, but one of them, the *Ostrea thirsæ* of Gabb, is so conspicuously prolific that the horizon is commonly known as the *Ostrea thirsæ* bed. The abundance of this oyster not only conclusively establishes the inshore character of the deposits but also serves as a fairly accurate Nanafalia horizon marker. The affinities of the fauna as a whole are vague and generalized. Of the 40 or 41 species and varieties only 1 species and 1 variety are restricted to the Nanafalia formation. Of the 39 remaining forms, 9, or approximately 25 per cent, range from the Midway to the upper Wilcox or higher and have no significance in close correlation; of the 30 Nanafalia species occurring at not more than two horizons only 4, or 13 per cent, are restricted to the Midway and Nanafalia; the other 26, or approximately 87 per cent, run from the Nanafalia up to a higher horizon, of which 5, roughly 19 per cent, are not known except in the Nanafalia and Tuscahoma formations. The fauna is, therefore, obviously Wilcox in its affinities and marks the initiation of many of the most characteristic Wilcox univalves but exhibits no peculiarly close relationship with any one of the later horizons.

The Tuscahoma is generally rather barren, but at Bells Landing and Greggs Landing, on Alabama River, and at Tuscahoma, on Tombigbee River, extensive collections have been made and worked up by Aldrich, Harris, and others. The check lists consulted record 168 species. Of these species 121, or approximately two-thirds, are univalves. The fauna is well diversified, includes both herbivorous and carnivorous gastropods, and indicates rather warm, shallow waters, not exceeding 40 fathoms, abounding in plant and animal life. The unusually large size attained by the individuals collected at Bells Landing [1] suggests a peculiarly favorable environment, in which the inhabitants existed under optimum conditions. The best represented genera are among the larger univalves, notably the fusoids, fulguroids, tritons, and Cassidæ. Among the bivalves the taxodonts are relatively rather numerous. Corbula also occurs in considerable numbers along with the ubiquitous Venericardia. The Tuscahoma, unlike the Nanafalia, is clearly differentiated from the formations above and below. Of the 165 species recorded 79, or nearly 50 per cent, are restricted to the Tuscahoma. Of the remaining 85 forms 35 range both above and below the horizon and may be disregarded by the stratigrapher, leaving 49 species to be considered. The Tuscahoma marks the lower limit of range of 33 of these and the upper limit of range of 16. These figures may appear more significant than they really are, for the Bashi fauna, which succeeds the Tuscahoma, has been studied in much greater detail than the Nanafalia below it. However, the critical work that has been done on the Bashi makes all the more notable the fact that almost half of the species recorded from the Tuscahoma are peculiar to it.

The Bashi formation ("Woods Bluff") presents the largest and most diversified fauna [2] known from the Wilcox, notwithstanding the entire lack of evidence of any appreciable increase in the depth of the water. On the contrary, the larger univalves, the fusoids, tritons, and Cassidæ are relatively less numerous than in the lower Wilcox. Many of the smaller genera, however, abundantly represented in the littoral and laminarian zones of our recent seas occur in very considerable numbers. For example, 20 species of pleurotomids, 3 of Cancellaria, 2 of Nassa, 2 of Cerithium, and 3 of Corbula. The decrease in the number of the genera peculiarly characteristic of the sublittoral zone is, however, merely relative, for 8 species of Fusus, 4 of Acteon, and 4 of Volutidæ have been recorded. The change in the character of the fauna is probably due not to any marked change in the depth of the

[1] Aldrich, T. H., Alabama Geol. Survey Bull. 1, pp. 54-55, 1886.

[2] This fauna has recently been discovered in east-central Mississippi by E. N. Rose.

water but to the finer sediments then in process of deposition, which afforded a more favorable habitat to the mud-loving faunas than had either the Tuscahoma or Nanafalia. The Bashi fauna recorded in the available check lists numbers approximately 200 species. Of these species 107, or more than 50 per cent, are peculiar to the formation, 42 of them range both above and below it and so lose their value for close correlations, and of the 42 remaining forms 25 range upward to the Bashi from older beds and 17 range upward into younger deposits, thus implying that the affinities with the Tuscahoma fauna are closer than with the Hatchetigbee.

The Hatchetigbee fauna is the most obviously shallow-water fauna recorded from the Wilcox. A few new forms are introduced, which later become prolific, but it chiefly represents the reduced remnant of an earlier life. The capuloids, Trochidæ, and Naticidæ are relatively a little more abundant, and Ostrea is represented by 5 species instead of only one or two, as at the earlier horizons. The known Hatchetigbee mollusks number approximately 84 species, of which 27, or a little less than one-third, seem to be peculiar to the horizon; 19 of the remaining forms occur in the overlying Claiborne group and at some lower horizon in the Wilcox; 33 of the 38 remaining species limited in range to the Hatchetigbee are not known from sediments later than the Wilcox, and only 5 of the 38 range from the Hatchetigbee upward into the higher formations of the Eocene.

West of Mississippi River the studies of Harris and Veatch have demonstrated the presence of marine fossiliferous Wilcox in Louisiana and along the Texas bank of Sabine River. Harris[1] in 1899 listed 16 species of Pelecypoda and 25 species of Gastropoda from these deposits. Some of the outcrops—for example, those at Marthasville, La., and at Pendleton, Tex.—are regarded by Harris as lower Wilcox; that at Sabinetown is correlated with the Bashi formation of the Alabama section. As has already been suggested, the insufficient character of the work thus far done on the paleozoology of the Alabama Wilcox makes it impossible to determine the actual range of the species and to what extent their recorded occurrences are the result of environmental conditions and not of chronologic value. The range of the forms found west of the Mississippi and the mingling of lower Wilcox or even Midway forms with upper Wilcox forms renders it almost certain that the Alabama faunules as at present known are individually of slight stratigraphic significance. There is thus no satisfactory paleozoologic evidence for questioning the correlations based on the far more satisfactory data furnished by the fossil plants.

The large area of Wilcox in Mississippi,[2] Arkansas, and Texas, and the deposits of Wilcox age in Tennessee and Kentucky, have not furnished any marine fossiliferous outcrops. The absence of animal fossils over this vast area has always been a source of wonder. It might at least be expected that the remains of insects would be found associated with the leaves in the fine-textured clays, but no remains of this sort have been found in any of the Coastal Plain formations earlier than the Pleistocene. It is not difficult to account for their great variety in a deposit like that at Florissant, Colo., where the bulk of the sediments are volcanic ash and where solfataric vents existed in the immediate vicinity of Florissant Lake, but their entire absence in the clays of the Wilcox is certainly remarkable. To be sure they may eventually be discovered, but the area of outcrop has now been carefully examined over many square miles without success. The Wilcox flora indicates climatic conditions from which a large insect fauna can be postulated, as all the insect orders except the Lepidoptera are recorded from pre-Tertiary deposits.

The following obscure traces of insects are all that the Wilcox deposits have afforded up to the present time. The commonest type of fossil indicating the former presence of insects is furnished by the galleries constructed by the larvæ of the Tineidæ (Lepidoptera) in the leaves of several species. These markings are shown on the leaves of the following species: *Anona ampla*, *Carapa eolignitica*, *Coccolobis eolignitica* and *C. uviferafolia*, *Combretum ovalis*, *Dryophyllum moorei* and *D. tennesseensis*, *Ficus schimperi* and *F. vaughani*, *Terminalia hilgardiana*, *Zizyphus falcatus* and *Z. meigsii*. (See

[1] Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, pp. 290–291, 1899.

[2] A small faunule has recently been discovered in Mississippi by E. N. Lowe.

Pls. XXIII, XXXI, XXXVIII, XXXIX, and XCII.)

A specimen of the so-called seed, tube, or cone galls, commonly produced by species of Cecidomyia (Diptera) and occasionally by the Aphididæ, is shown on a figured leaf of Rhamnus (Pl. CXI, fig. 1). The so-called petiole galls produced by some species of Hemiptera and more commonly by the gall flies (Hymenoptera) are represented in the illustration of *Cedrela puryearensis* (Pl. LVI, fig. 2). The figured leaf of *Icacorea prepaniculata* (Pl. CVII, fig. 5) is badly riddled in a manner suggesting the work of some Wilcox species of leaf-cutting bee (Megachilidæ of the order Hymenoptera). The uniformity in size of the holes lends support to such an interpretation, although it is possible that these are due to a brood of leaf-eating caterpillars. No traces of Coleoptera have been seen, and it is also strange that the groups with aquatic larvæ like the Odonata and Ephemerida have not left some traces of their former presence. At any rate the few obscure traces mentioned in the foregoing paragraphs show that there could have been nothing abnormal in the Wilcox insect fauna.

With the exception of teeth of *Crocodylus grypus* Cope, a Wasatch species, recently found in Texas, no traces of vertebrates except a few fish scales, as at the Puryear locality, have been discovered.

Poorly preserved Unios occur in the clays of the Holly Springs sand or middle Wilcox at Oxford, Miss., thus confirming the presence of a Wilcox estuary at this locality, indicated also by the lithology. An undeterminable Corbula(?), a genus characteristic of shallow marine or estuary muds, is present in the beds of middle Wilcox (Holly Springs) age near Grand Junction, Tenn., thus proving that the upper embayment deposits were marginal and not continental in character. The poorly preserved remains of a large myriapod or possibly an isopod are associated with the fossil plants at Holly Springs, Miss., and 1½ miles west of Grand Junction and at Holly Springs and Puryear, Tenn. Miss M. J. Rathbun is of the opinion that these remains are related to the isopod genus Ligyda Rafinesque (Ligia Fabricius) represented by the common *Ligyda baudiniana*, which lives among driftwood and seaweed in the littoral zone. Two of the best specimens are shown on Plate CXI, figures 7 and 8.

CHARACTER, SUCCESSION, AND AREAL DISTRIBUTION.

After the checkered nomenclatorial history of these deposits previously sketched in part, geologists have agreed that the term Wilcox group is their most suitable designation, as they are typically developed along Alabama River in Wilcox County, Ala. By typical is not to be understood typical in lithology, for the type of sediments of the upper embayment is much more extensive, but typical in the sense that the sections exposed along Alabama and Tombigbee rivers are the most complete, covering the whole chronologic interval of Wilcox sedimentation and sharply set off from the uppermost Midway below and from the Tallahatta buhrstone, the basal formation of the Claiborne group, above.

The Wilcox deposits in general consist of more or less extensive lenticular beds of sands and clays. The sands are commonly cross-bedded and ferruginous, and in places contain clay balls. The clays are commonly carbonaceous and their carbonaceous matter in places forms considerable beds of lignite.

In Alabama and along Sabine River in Texas the deposits assume a marine character with glauconitic sands and thin shell marls, and in Louisiana calcareous concretions are not uncommon.

Both lithologic and faunal considerations have suggested the segregation of the Wilcox deposits in Alabama that I have termed typical into the Nanafalia, Tuscahoma, Bashi, and Hatchetigbee formations.

The Nanafalia formation, termed originally the "Coal Bluff sands and lignites" by Smith, from the bluff of that name on Alabama River, receives its name from the typical section at Nanafalia Landing on Tombigbee River. It consists of sandy glauconitic beds that alternate with grayish calcareous clays, commonly fossiliferous enough to be termed shell marls, and that carry a large and distinctive fauna, of which the small *Ostrea thirsæ* is the most abundant form. These marls are extensively indurated. At the base of the formation, and immediately above the Naheola formation of the Midway group, occurs a bed of lignite 5 to 7 feet in thickness, which has been traced from Pike County, Ala., westward beyond Tombigbee River, and doubtless is represented by the uncertainly correlated lignites at the base of the Wilcox northward through the greater part of the outcrop in Mississippi.

The Nanafalia formation maintains a rather uniform thickness across Alabama of about 200 feet. The lignite bed at its base is a most important factor in the interpretation of the geologic history of Wilcox time, for it unquestionably indicates a relatively extensive emergence at the close of the Midway, an emergence marked by the withdrawal of marine waters and faunas from the neighborhood of the mouth of the Ohio southward beyond the present outcrop of the formation in southern Alabama, a distance of over 400 miles, and by the occupation of the surface by extensive swamp vegetation, as the lignite was clearly formed at the place of growth of terrestrial vegetation.

The Tuscahoma formation, formerly termed the "Bells or Greggs Landing series," consists of about 140 feet of gray or yellowish cross-bedded sands and sandy clays massive below and laminated above, generally poor in fossils except at two horizons where glauconitic shell marls carry an abundant and distinctive fauna. The lower horizon is exposed at Greggs Landing on Alabama River and the upper at Bells Landing on Alabama River and Tuscahoma on Tombigbee River.

The Bashi formation, formerly termed the "Bashi or Woods Bluff series," from Bashi Creek in Clarke County and Woods Bluff on Tombigbee River, where the glauconitic and highly fossiliferous horizons in the formation are exposed, consists of about 80 feet of calcareous glauconitic sands and sandy clays. The shallowing of the Wilcox sea in this area, first apparent in the upper part of the Tuscahoma formation, culminated in an emergence which is marked by the 2-foot bed of lignite that marks the base of the Bashi formation.

The Hatchetigbee formation, named from the bluff of that name on Tombigbee River, consists in the region of maximum thickness near the river of about 175 feet of brown, purplish, and gray laminated sandy clays, and cross-bedded, more or less glauconitic and calcareous fossiliferous sands. It thins both eastward and westward from the type locality and is overlain unconformably by the characteristic sediments of the Tallahatta buhrstone, the lowermost formation of the Claiborne group, a horizon which is well marked lithologically across Alabama and northwestward through Mississippi.

A large number of detailed local sections and lists of animal species of the Wilcox formations are given in the various reports by Dr. E. A. Smith,[1] of the Alabama Geological Survey, and his associates T. H. Aldrich, L. C. Johnson, and D. W. Langdon, jr., the major outlines of which, first published in 1887, seem destined to stand.

Along Chattahoochee River the Wilcox is represented by less than 200 feet of glauconitic fossiliferous sands and dark, laminated, commonly lignitic clay. The clay is at some places rather hard. Several possible explanations of the thinness of the Wilcox along the Chattahoochee and eastward in Georgia suggest themselves. The beds may never have attained the thickness that they did in central and western Alabama; they may have been deposited and subsequently removed by erosion, or they may be almost entirely covered by the extensive Claiborne transgression that characterized the Georgia area. That an interval of erosion was followed by one of transgression is indicated by the almost exact lithologic similarity of the deposits to those found in Alabama and Tombigbee River sections, which would not be the case if there had been a marked difference of physical conditions in the west Georgia area. In addition the extensive interval of emergence at the close of the Wilcox and a transgression of the basal Claiborne which I have claimed on general grounds finds local confirmation in the Georgia region in the admittedly great overlap of the lower Claiborne deposits and in the physical evidences of unconformity between the Wilcox and Claiborne observed by Veatch and Stephenson.[2]

From Chattahoochee River northeastward poorly fossiliferous exposures of the Wilcox are identified at intervals over a belt 5 or 6 miles in width as far as Flint and Ocmulgee rivers. If the Wilcox was ever present in eastern Georgia it is now deeply buried beneath the Claiborne overlap. Deposits carrying a small fauna suggesting the Nanafalia formation, and

[1] Smith, E. A., and Johnson, L. C., Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: U. S. Geol. Survey Bull. 43, 1887. Smith, E. A., Johnson, L. C., and Langdon, D. W., jr., Report on the geology of the Coastal Plain of Alabama, Alabama Geol. Survey, 1894.

[2] Georgia Geol. Survey Bull. 26, p. 228, 1911.

consequently referred to the Wilcox group, are represented in the Santee drainage basin of South Carolina by the Williamsburg formation, which is the easternmost known outcrop.

The Aquia formation of the middle Atlantic slope in Maryland and Virginia is unquestionably in part contemporaneous with the Wilcox of the Southern States. It represents, however, either a different geologic province or an area of sedimentation separated by a considerable eastward extension of Eocene land in the North Carolina region. Its fauna and lithology denote typically marine deposition, and as only two vague forms ascribed to Carpolithus represent the terrestrial flora, it has little interest in the present connection.[1]

West of Tombigbee River in Alabama the strike of the Wilcox formations swings around to the northwest and becomes due north in Mississippi. The formational units of Alabama lose their identity within a short distance from the Mississippi line by a gradual transition into sands and clays without marine faunas but containing an abundant representation of the terrestrial flora. The Wilcox deposits form a belt in northern Mississippi in places 50 miles wide and underlie all the State except the northeastern tier of counties. Lithologically these beds are divisible into three formations, which Lowe[2] has named the Ackerman beds (at the base), the Holly Springs sands (middle formation), and the Grenada beds (at the top).

The Ackerman formation,[3] named from the town of Ackerman in Choctaw County, is prevailingly argillaceous and consists of about 300 feet of dark-gray lignitic and ferruginous sandy clays, beds of lignite, considerable concretionary and bedded carbonate of iron, and ferruginous sandstones. A 6-foot bed of lignite occurs in southeastern Lafayette and northwestern Calhoun counties.

The Holly Springs sand, named from the town in Benton County, Miss., is prevailingly arenaceous and constitutes an important artesian horizon. The formation consists of about 350 feet of cross-bedded, mostly coarse, micaceous white to yellow, red, and purple sands, indurated in places, which contain lenses of greater or less extent of pink or white, rarely chocolate-colored, and generally siliceous clays. Most of the Wilcox plants of the eastern Gulf area have come from this formation and a number of local sections of plant-bearing outcrops are given in the chapter devoted to local sections.

The Grenada formation, named from the town and county in north-central Mississippi, is prevailingly argillaceous and consists of about 200 feet of pinkish or yellow to chocolate, sandy micaceous laminated clays and ferruginous sands, greatly resembling lithologically the Hatchetigbee formation of Alabama. It has not been found to contain any remains of invertebrates. This formation does not contain any considerable amount of lignite, and determinable fossil plants have been found only at the type locality.

In passing northward into Tennessee the outcropping strata carrying a Wilcox flora strike somewhat east of north, appearing as a broad belt from 30 to 60 miles in width. The lower (Ackerman) formation of the Wilcox group of Mississippi has not been recognized in Tennessee. The strata of Wilcox age in Tennessee form an indivisible unit that corresponds in great part, both lithologically and paleobotanically, to the middle formation (Holly Springs sand) of the Wilcox group of Mississippi. The beds consist of interbedded sands, clays, and lignites, but the lignites are much less developed than in the basal Wilcox of Mississippi and Alabama. The bedding differs greatly from place to place and numerous local unconformities are emphasized by redeposited pebbles and balls from contemporaneous clay lenses. The sands are fine to coarse and range from white to orange or red. The clays range from pure gray plastic clays to sandy lignitic clays. Most of them are high in silica and contain an abundant flora. (See pp. 40–42 for sections.) The thickness has not been determined but is probably from 500 to 600 feet. In the deep well at Memphis, 25 miles west of the western outcrop of strata of Wilcox age, these beds were reported to be between 750 and 800 feet in thickness. The heavy beds of lignite, so prominent in the upper beds of Wilcox age near the head of the embayment from Mayfield, Ky., westward, are apparently represented by the thick beds of lignite in the upper part of the strata of Wilcox age reported from numerous wells in the western parts of Haywood and Weakley counties, Tenn.

[1] Maryland Geol. Survey, Eocene, 1901.
[2] Lowe, E. N., Mississippi Geol. Survey Bull. 10, p. 23, 1913.
[3] See local section for Potts Camp on p. 42.

The strike of the beds of Wilcox age swings to the northwest a short distance within the State of Kentucky and becomes west in McCracken and Ballard counties. The landward margin of the beds crosses the southern end of Illinois, where, however, they are as a rule either entirely removed by the erosion of Ohio and Mississippi rivers or are deeply buried by alluvial deposits. Deposits correlated with the Wilcox are 325 feet thick in the well at Cairo, Ill. Lithologically the deposits of Wilcox age in Kentucky are like those of Tennessee, but several beds of lignite occur toward the top and numerous local unconformities mark oscillations in level. (See pp. 50–51 for discussion of sections.) The clays contain well-preserved plant remains at several localities, notably the classic ones at Wickliffe and Boaz. At Wickliffe well records give a thickness of 430 feet for the deposits of Wilcox age.

Little is known regarding the presence of strata of Wilcox age in southeastern Missouri because of erosion and subsequent alluvial cover. Deposits of that age are, however, reported in wells. The strike of the beds of that age is southwest across Arkansas and the deposits underlie the surface of the whole State south and east of the Cretaceous and Midway outcrops. The surface of the State of Louisiana is also underlain by these beds, except in small areas where doming or fault blocks have brought up Cretaceous or Midway deposits. The Wilcox deposits in Arkansas and Louisiana have an estimated thickness of 400 to 800 feet and are predominantly dark carbonaceous sands and brown laminated, commonly selenitic clays. In places the beds are indurated and contain transported balls of lignite and clay, especially toward the Texas border, where calcareous concretions are also common. (See Pl. V, p. 39.) In many places also they contain leaf remains, as in the vicinity of Shreveport. Leaf remains in the clays are commonly fragmentary and indeterminable. More or less sandy ferruginous segregations contain identifiable remains of plants, as at Coushatta, Frierson Mill, Naborton, and Mansfield, La., and Little Cypress Bayou across the Texas border. Brine in some places occurs in the pervious sands of the Wilcox, and they are reported to contain small quantities of oil.

A few invertebrate fossils occur from Shreveport southwestward to Sabine River, along which fossiliferous calcareous glauconitic marls are reported from several outcrops. Deposits of Wilcox age extend across Texas from the Sabine southwestward to the international boundary and on across the Rio Grande an indeterminable distance into Mexico. Westward from Sabine River, that is, landward from the Eocene sea, the complex of sands, clays, lignites, and marine fossiliferous calcareous glauconitic marls of the Sabine section merge in a short distance into practically unfossiliferous littoral deposits made up of intertonguing lenses of sands, lignitic selenitic clays with traces of leaves, and lignites. Large concretionary masses of hard sandstone are characteristically developed in some areas. These lignitic and littoral sands and clays have an estimated thickness of 500 to 600 feet. The uppermost Wilcox in northeast Texas consists of stratified white and red sands and sandy clays, entirely unfossiliferous and free from any considerable quantity of lignite. These sands constitute the Queen City beds of Kennedy.[1] West of Colorado River no detailed studies have been made, but deposits of Wilcox age are extensively developed along the Rio Grande as coarse sands overlain by fine micaceous sandstones, which are succeeded by alternating beds of shales, sandstones, and workable lignites. The whole thickness is estimated to be at least 850 feet.

These data complete a brief sketch of the lithologic character, succession, and areal distribution of the deposits of Wilcox age, from their easternmost occurrence in Georgia to the place where they cross the Rio Grande into Mexico, a distance of nearly 2,000 miles along the strike.

STRATIGRAPHIC RELATIONS.

The stratigraphic relations of the Wilcox group are relatively simple. Throughout its known extent it overlies the deposits of the Midway formation and is in turn overlain by those of the Claiborne group. These relations have always been considered to be those of conformity, but there are many indications of a long interval of erosion between the Midway and the Wilcox, and a less conclusive amount of data indicates a similar interval between the Wilcox and the Claiborne. Considering first the un-

[1] Kennedy, William, Acad. Nat. Sci. Philadelphia Proc., pp. 135–136, 1895.

conformity between the Midway and Wilcox, I am aware of only one or possibly two localities where direct physical evidence of an erosion interval is available. The first locality is in the vicinity of Fort Gaines, Ga., where numerous pothole-like depressions in limestone of the Midway formation, in places 20 feet in depth, are filled with Wilcox deposits. A second locality widely removed from the preceding is along the Rio Grande, where, however, the deposits have not been positively correlated. In southwestern Maverick County, along the Rio Grande between White Bluff and the line between Maverick and Webb counties, according to information communicated by L. W. Stephenson, marine fossiliferous beds of limestones, clays, and glauconitic sands of Midway age are separated by a marked erosional unconformity from the overlying beds provisionally regarded as of Wilcox age. The Wilcox consists of 200 to 250 feet of irregularly bedded medium to coarse grained sandstone, with subordinate thin laminated layers and laminæ of gray clay, many thick massive lenses of sand, more or less lignitic, and much fragmentary vegetable material. At one place a well-developed basal conglomerate 2 to 3 feet thick, is largely made up of pebbles of iron carbonate derived from the underlying Midway. In so vast an area, where all the studies have been of a reconnaissance nature, breaks in the sedimentation will probably not be easily recognizable in the field, particularly when the general lithologic similarity between shallow water and littoral sediments of different ages is borne in mind. Besides the faunal changes that mark the transition from Midway to Wilcox, which are considerable, and the floral changes, which are inadequately known because of the paucity of the Midway (?) flora, it may be noted that succeeding the Midway, during which time marine faunas penetrated northward at least into Tennessee, there was preserved at the base of the Nanafalia formation an extensive bed of lignite from 5 to 7 feet in thickness. That this was formed in place (autochthonous) by terrestrial vegetation and that the marine waters had withdrawn southward beyond the present outcrop is almost certainly established. It may also be noted that northward along the contact of the outcrop of the Wilcox beds with the Midway successively younger Wilcox beds rest on the Midway, so that the middle Wilcox (Holly Springs sand) of Oxford and Holly Springs, Miss., several hundred feet above the base of the Wilcox in that latitude, are the extreme basal deposits of the beds of Wilcox age in Henry County, Tenn. These horizons can be traced by the lithology and are strikingly confirmed by the distribution of the flora in the eastern Gulf area. In addition the well records available for study show that the Wilcox as a whole becomes thicker down the dip, a sure indication of either erosion or of deposition during an advance and subsequent retreat of the Gulf waters.

In the western Gulf area the floras are not sufficiently represented for exact correlation. Nevertheless, as shown in the discussion of the local sections and of correlation, all the floras across Arkansas and Louisiana westward to Wilson County, Tex., are not older than the Holly Springs sand (middle Wilcox). The deposits containing these floras commonly lie but a short distance above the top of the deposits of Midway age, as at Benton and Malvern in Arkansas or along Calaveras Creek in Wilson County, Tex. The well records in the Naborton oil field of western Louisiana show that thick beds, representing all of the lower Wilcox and most of the middle Wilcox of the eastern Gulf region, were extensively transgressed by the late middle Wilcox and nowhere reach the surface as an outcropping formation. The lignites mined in Burleson and Wood counties, Tex., probably represent the middle Wilcox. The floras preserved are sufficient to render conclusive the statement that the Wilcox deposits of the western Gulf area are either of Holly Springs (middle Wilcox) or Grenada (upper Wilcox) age. In other words, the Ackerman or lower Wilcox of the eastern Gulf area does not outcrop west of Mississippi River.

These facts clearly demand an interval of emergence and erosion between the Midway and the Wilcox, an interval of considerable duration but of not very great change in level.

The proof of a similar interval between the Wilcox and the overlying Claiborne is not so conclusive. It rests on the physical evidence of an erosional interval observed by Veatch and Stephenson [1] at several localities in western Georgia; on the littoral character of the basal beds (Tallahatta buhrstone) of the Claiborne

[1] Veatch, Otto, and Stephenson, L. W., Georgia Geol. Survey Bull. 26, p. 228, 1911.

group; on the undoubted great overlap of the lower Claiborne in Georgia; on the very great change in faunas, and especially in floras, in passing from the Wilcox to the Claiborne, for of over 300 known species of Wilcox plants less than half a dozen have been discovered in the extensive floras of the Claiborne. Evidence of the northward thinning of the Claiborne, indicating deposition during transgression and retreat of the waters is furnished by the sections along Crowleys Ridge, Ark. The section on Bolivar Creek containing Wilcox plants is discussed on page 52. A considerable bed of lignite lies at or near the base of the Claiborne at numerous localities in Arkansas, Louisiana, and Texas.[1]

The conclusion is reached that the relations of land and water in this area between the end of the Upper Cretaceous and the dawn of the Claiborne or middle Eocene were as shown in figure 1.

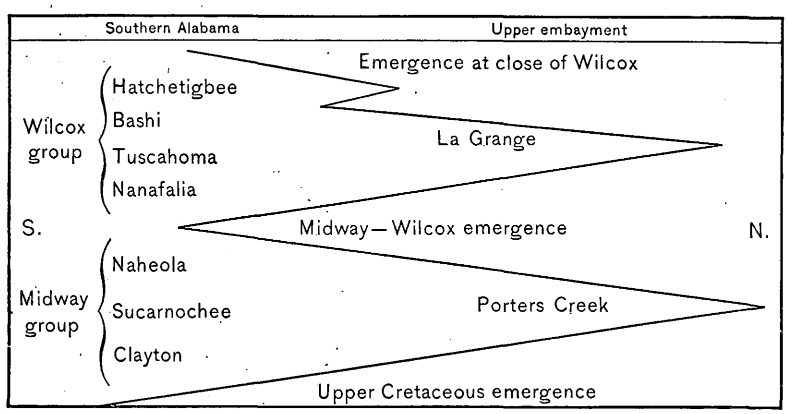


FIGURE 1.—Diagram showing oscillations of the strand line in the Mississippi embayment during earlier Eocene time.

THE PLANT-BEARING OUTCROPS.

The individual sections in the Wilcox group that are exposed to observation are nowhere of very great thickness but in many places can be augmented by well records, and as the attitude of the deposits is so uniform throughout most of the region in which they occur it is possible to trace the different horizons from place to place in spite of the very great lateral variability of the materials.

The following sections of plant-bearing outcrops are considered in geographic order from the southernmost, in Mississippi, northward around the head of the embayment and then southwestward across Arkansas, Louisiana, and Texas.

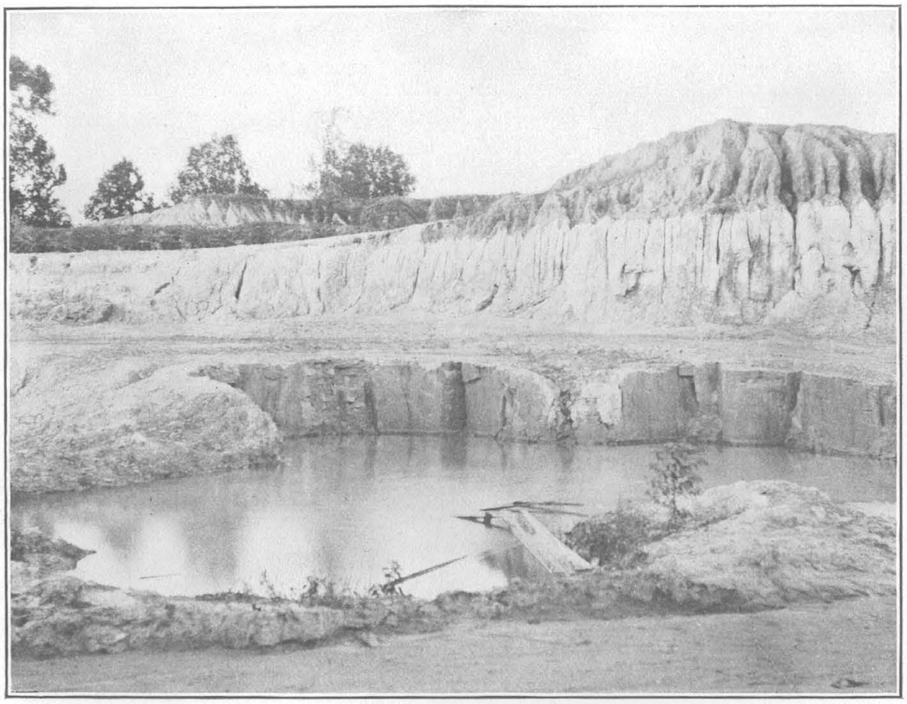
[1] See Berry, E. W., Erosion intervals in the Eocene of the Mississippi embayment: U. S. Geol. Survey Prof. Paper 95, pp. 73-82, 1915 (Prof. Paper 95-F).

SECTIONS IN MISSISSIPPI.

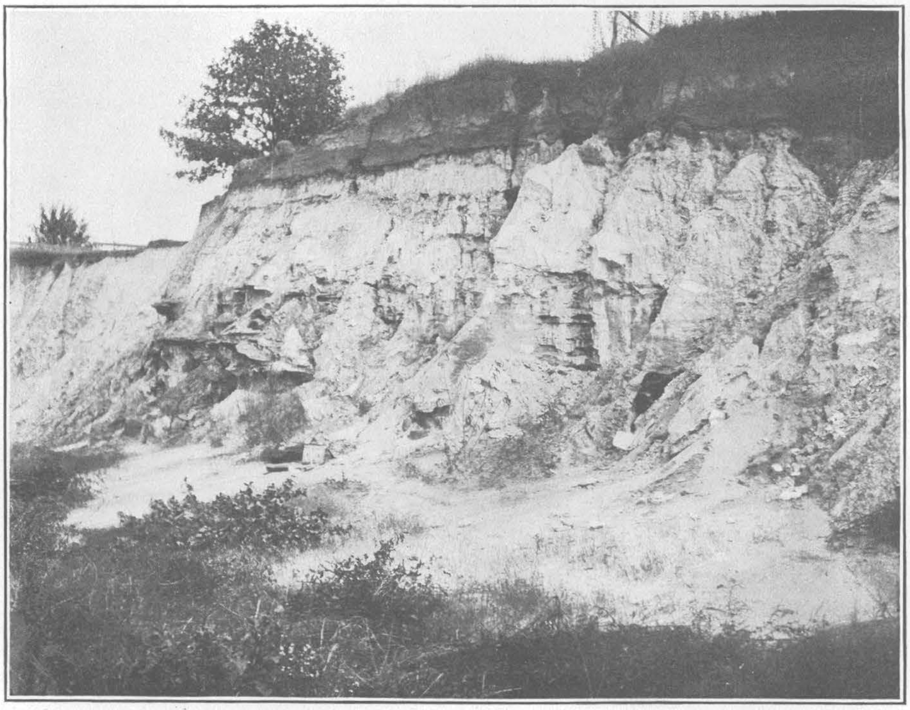
GRENADA, GRENADA COUNTY.

An abundantly fossiliferous outcrop in a bluff on the right bank of Bogue River half a mile above the wagon bridge and 1 mile east of Grenada, in Grenada County, Miss., was discovered by E. N. Lowe, State geologist of Mississippi. It is of considerable importance because of its location so far south in the embayment area and also because it is so near the top of the Wilcox group, for the overlying Claiborne outcrops within a mile or two to the west, and the plant-bearing horizon is hence within 100 feet of the contact of the Wilcox and the Claiborne. The whole section is about 150 feet in thickness, but the upper and more sandy portion is mostly concealed by slumping and vegetation. Along the river the bluff shows about 30 feet of laminated brownish, more or less indurated, siliceous clay that contains white, somewhat micaceous sand films, slightly iron stained and much less micaceous than the material around Oxford, Miss. The clays carry considerable comminuted lignite and abundant plant remains, especially about 15 feet above the base. (See Pl. VI, *A*, p. 44.) I have identified the following 63 species, which I collected from this outcrop with the assistance of Dr. E. N. Lowe:

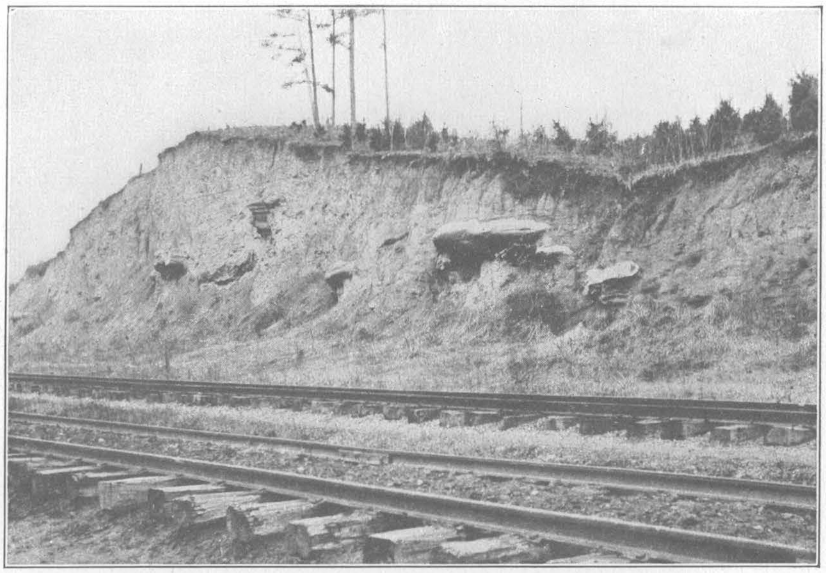
- Anacardites grevilleafolia.
- Apocynophyllum mississippiensis.
- Apocynophyllum sapindifolium.
- Aralia acerifolia.
- Aralia jorgenseni.
- Artocarpus pungens (?).
- Banksia saffordi.
- Bumelia grenadensis.
- Cænomyces pestalozzites.



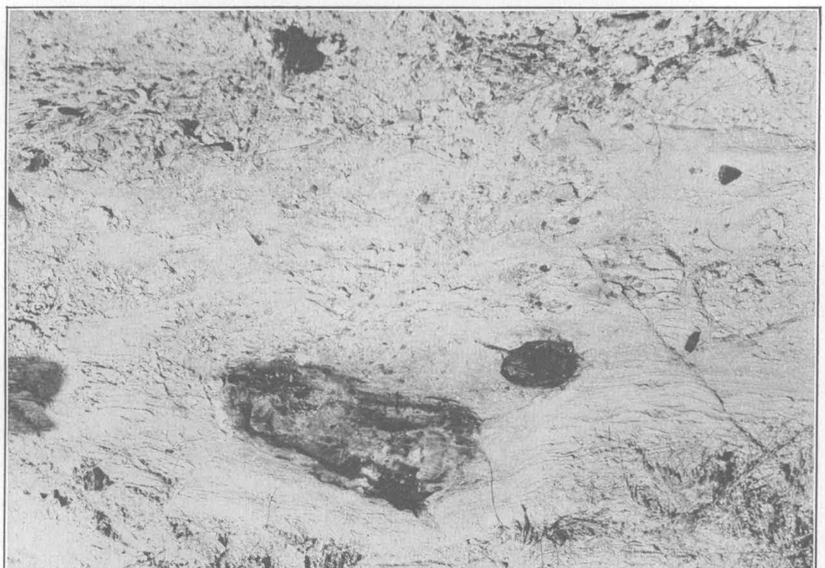
A. EXPOSURE OF FOSSILIFEROUS CLAY OF WILCOX AGE IN THE LAGRANGE FORMATION AT PURYEAR, TENN.



B. EXPOSURE OF FOSSILIFEROUS CLAY IN THE HOLLY SPRINGS SAND AT OXFORD, MISS.



A. CALCAREOUS CONCRETIONS IN SANDS OF THE WILCOX GROUP, SHREVEPORT, LA.



B. LIGNITE BALLS OR CONCRETIONS IN SANDS OF THE WILCOX GROUP AT LEIGH, TEX.

Canavalia eocenica.
Canna eocenica.
Capparis eocenica.
Carpolithus grenadensis.
Carpolithus pilocarpoides.
Carpolithus sophorites.
Cassia glenni.
Cassia lowii.
Cassia mississippiensis.
Chrysobalanus eocenica.
Chrysobalanus inæqualis.
Chrysophyllum ficifolia.
Citharexylon eoligniticum.
Dalbergites ellipticifolius.
Dalbergites ovatus.
Dillenites tetracerafolia.
Dillenites texensis.
Dryophyllum puryearensis.
Dryophyllum tennesseensis.
Engelhardtia ettingshauseni.
Eugenia grenadensis.
Ficus monodon.
Ficus puryearensis.
Fraxinus johnstrupi.
Gleditsiophyllum eocenicum.
Juglans schimperi.
Melastomites americanus.
Meniphylloides ettingshauseni.
Mespilodaphne eolignitica.
Metopium wilcoxianum.
Mimosites variabilis.
Mimusops mississippiensis.
Myrcia bentonensis.
Myrcia grenadensis.
Myrica wilcoxensis.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Nipadites burtini umbonatus.
Oreodaphne obtusifolia.
Phyllites wilcoxensis.
Planera crenata (?).
Proteoides wilcoxensis.
Pteris pseudopinnæformis.
Rhamnus cleburni.
Rhamnus coushatta.
Sabalites grayanus.
Sapindus formosus.
Sapindus mississippiensis.
Sapindus oxfordensis.
Sophora wilcoxiana.
Sterculia puryearensis.
Terminalia wilcoxiana.
Ternstrœmites lanceolatus.
Ternstrœmites ovatus.

This list represents the largest Wilcox flora from any single locality except that at Puryear, Tenn. It includes no gymnosperms. There are 1 leaf-spot fungus, 2 ferns, 4 monocotyledons, and 56 dicotyledons. There are but 10 Leguminosæ, 4 Lauraceæ, and 3 Moraceæ. Fifteen species are peculiar to this locality. They are referred to the genera Apocynophyllum, Aralia, Bumelia, Carpolithus, Cassia, Dalbergites, Eugenia, Mimusops, Myrcia, Nipadites, Phyllites, and Terminalia. None of them are generic types peculiar to the locality except Dalbergites and Nipadites. A reference to the table of distribution shows that 10 of the Grenada species, or 17 per cent, appear in the Ackerman formation or basal Wilcox, and that 33 species, or 54 per cent, are common to the Puryear locality.

OXFORD, LAFAYETTE COUNTY.

The sections in and around Oxford are of especial interest not only because of the fossil plants they contain but particularly since the so-called Lafayette formation was named from Lafayette County, Miss., and the railroad cuts at Oxford were considered the type section of this formation by Hilgard, Safford, Smith, and McGee.[1] There are no deep wells in the county which would serve to give the distance above the base of the Wilcox, but a rough estimate shows it to be between 300 and 350 feet. The littoral character of the Wilcox sediments at this horizon is well shown in the few selected sections that follow. (See Pl. IV, *B*.)

Section east of Illinois Central Railroad, one-half mile north of dépot at Oxford.

	Feet.
1. Brown loam	1– 2
2. Rather coarse brown stratified sand	4– 6
Holly Springs sand:	
3. Gray to white siliceous clay masses of greater or less size, carrying casts of Unio and abundant leaf impressions	0– 5
4. Stratified orange sand	2– 3
5. Lens of gray siliceous clay, with poorly preserved leaf impressions	0– 4
6. Coarse brown cross-bedded sands separated by ferruginous indurated bands 1 inch to 3 inches in thickness, replaced horizontally by pinkish or grayish-buff finer sands.	10–12

This section is at or near the exact outcrop that was the basis for the drawing of the "cut at Oxford" figured by Hilgard on page 6 of his "Report on the geology and agriculture of Mississippi" and reproduced by McGee in his

[1] Berry, E. W., Jour. Geology, vol. 19, pp. 249–256, figs. 1–4, 1911.

extensive paper on the Lafayette formation,[1] but there has of course been considerable erosion in the 50 years that have elapsed since Prof. Hilgard made his sketch. Some geologists, notably E. A. Smith, are inclined to see an unconformity in this section between Nos. 3 and 4, particularly because the clay outcrop is irregular and neighboring exposures show pellets or larger disconnected masses of clay. These features are due primarily to current bedding and weathering and are intraformational, as is conceded by McGee. This relation is indicated by tracing the exposure up the near-by ravine to the northeast, as shown in the following section. The strata included in the preceding section are overlain in this locality by typical leaf-bearing clays of the Wilcox.

Section in ravine at Oxford about 200 yards north of the courthouse.

	Feet.
1. Brown loam	0- 1
Holly Springs sand:	
2. Loam grading into reddish compact, rather fine sands with a few scattered pieces of limonite (probably not a primary feature); the sands become looser and are buff toward the base	9–10
3. Similar stratified sands, lighter in color and more argillaceous than material in No. 2, carrying small clay pellets at the base; about	5
4. Grayish sandy clay, more or less ferruginous stained and containing some scattered thin iron crusts	3- 4
5. Brownish stratified sand similar to that of No. 2, containing layers of gray laminated clay grading into brownish or bluish laminated clay	5- 6
6. Laminated clays passing gradually into darker, more massive, and somewhat more micaceous clays, in places very arenaceous and containing numerous leaves of plants.	20

Bed No. 6 grades horizontally into the lighter sandy laminated clays exposed along the railroad immediately south of the first section and are at the same level as the lower sands in that section. The massive argillaceous beds in the ravine are somewhat bluish in color but on drying become brownish banded ringing clays. The gray films of sand in the laminated clays contain much brownish comminuted vegetable matter, but apparently no leaves have been found in them, possibly because they do not lend themselves to exploitation. The leaf remains are not especially abundant but are rather generally distributed through the more massive clays and represent a considerable flora. Palm leaves are especially abundant and large, some being several feet in diameter, but they are very difficult to collect.

The following species occur here:

Railroad cut.

Apocynophyllum tabellarum.
Ficus vaughani.
Oreopanax oxfordensis.
Sabalites grayanus.
Sapindus oxfordensis.

Ravine.

Acacia wilcoxensis.
Apocynophyllum wilcoxense.
Cænomyces laurinea.
Cænomyces myrtæ.
Cænomyces pestalozzites.
Cænomyces sapotæ.
Canna eocenica.
Cinnamomum mississippiensis.
Cinnamomum vera.
Dryophyllum tennesseensis.
Ficus cinnamomoides.
Glyptostrobus europæus.
Myrcia bentonensis.
Myrcia vera.
Nectandra lowii.
Nectandra pseudocoriacea.
Oreopanax oxfordensis.
Palæodendron americanum.
Pithecolobium oxfordensis.
Sabalites grayanus.
Zizyphus meigsii.

This horizon is comparable to the buff clays carrying Sabalites which underlie the clay lens at Puryear in Henry County, Tenn., and which have furnished the very large flora described from that locality.

I give only one other section at Oxford, one that shows even more conclusively than the preceding section that the Wilcox in this county is indivisible and that there is nothing corresponding to a Lafayette formation in Lafayette County.

Section of Holly Springs sand in cut of Illinois Central Railroad 1 mile north of Oxford depot.

	Feet.
1. Yellowish argillaceous stratified sand, grading downward into No. 2; about	10
2. Grayish and pinkish sands, much cross-bedded, with clay laminæ	10
3. Medium coarse, much cross-bedded micaceous sands alternating in 2 to 4 foot beds with 2 to 3 foot beds of very thinly laminated greenish or pinkish gray clay containing fine sand films, the whole about	25

[1] McGee, W J, U. S. Geol. Survey Twelfth Ann. Rept., pt. 1, p. 457, fig. 58. 1891.

Deep wells are lacking throughout Lafayette County. The only record that I can find is that of the city well at Oxford, given by Crider and Johnson [1] on the authority of W. N. Logan and W. R. Perkins. It furnishes a welcome addition to the surface exposures in this vicinity, and shows that the Wilcox has a minimum thickness of at least 300 feet at this point. The record is as follows:

Record of city well at Oxford, Miss.

	Feet.
Clay and sand	90
Sand	15
Clay	67
Soapstone (clay)	78
Hard sandstone	50

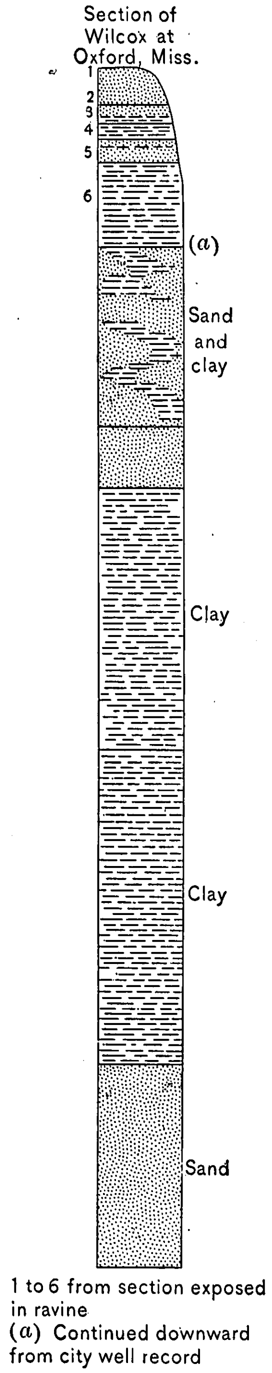


FIGURE 2.—Section of Wilcox deposits at Oxford, Miss.

In figure 2 is given a diagram of the section as measured in the ravine north of the courthouse, together with the downward continuation of the beds as shown in the record of the city well.

HOLLY SPRINGS, MARSHALL COUNTY.

Both the potteries at Holly Springs obtain their clay from near-by exposures in the same hill about 1½ miles east of the town. The small opening on the south slope of this hill shows the following sequence of materials:

Section of Holly Springs sand at Holly Springs, Miss.

	Feet.
1. Brownish sandy loam; about	5
2. Gray sandy clay becoming purer, more distinctly bedded, and darker toward the base, where it carries finely preserved impressions of leaves; exposed	10

The leaf-bearing portion is 1 to 2 feet thick and is underlain by more sandy materials. The following species occur here:

Anacardites marshallensis.
Bumelia lanuginosafolia.
Cæsalpinia wilcoxiana.
Cæsalpinites mississippiensis.
Canavalia eocenica.
Capparis eocenica.
Cassia emarginata.
Cassia fayettensis.
Cassia wilcoxiana.
Cedrela wilcoxiana.
Cinnamomum obovatus.
Cinnamomum vera.
Citharexylon eoligniticum.
Dillenites serratus.
Dryophyllum tennesseensis.
Drypetes prelateriflora.
Engelhardtia ettingshauseni.
Ficus sp.
Ficus myrtifolius.
Gleditsiophyllum entadaformis.
Gleditsiophyllum fructuosum.
Guettarda ellipticifolia.
Laguncularia preracemosa.
Nectandra pseudocoriacea.
Oreodaphne mississippiensis.
Oreodaphne obtusifolia.

[1] Crider, A. F., and Johnson, L. C., U. S. Geol. Survey Water-Supply Paper 159, p. 65, 1906.

Paliurus angustus.
Paliurus mississippiensis.
Reynosia prænuntia.
Sabalites grayanus.
Sapindus formosus.
Sapindus linearifolius.
Solanites saportana.
Sophora wilcoxiana.

The larger opening on the north slope shows 3 to 5 feet of brownish argillaceous sand, underlain by about 20 feet of gray stratified clay in beds that are alternately of different degrees of purity or sandiness. At the base of the exposure in a near-by ravine the following species were collected:

Cassia emarginata.
Cedrela wilcoxiana.
Celastrus bruckmannifolia.
Celastrus minor.
Cinnamomum vera.
Dodonæa wilcoxiana.
Dryophyllum tennesseensis
Ilex eolignitica.
Paliurus angustus.

EARLY GROVE, MARSHALL COUNTY.

Early Grove is situated in northeastern Marshall County, Miss., at an elevation between 450 and 500 feet, less than 15 miles directly along the strike north of the plant locality at Holly Springs. The exact locality is at Wellborns, about 1 mile southeast of the town and just east of the public road, where extensive gullies have been eroded in the upland. The following section is exposed:

Section of Holly Springs sand at Early Grove, Miss.

	Feet.
1. Orange, brown, yellow, and gray compact coarse cross-bedded sand, grading downward into No. 2	15
2. Gray, more or less ferruginous stratified sand; thin iron crust at base	15
3. Gray, pinkish, and white arenaceous laminated clay, containing in places thin iron crusts and poorly preserved impressions of leaves, grading downward into No. 4	8
4. Brownish-drab, rather pure clay, thickly laminated, and containing thin films of fine light sand with well-preserved leaf impressions; exposed	4–5

A small collection was made here in 1889 by L. C. Johnson from No. 4, and three specimens from No. 3 were collected by W J McGee shortly afterward. McGee's specimens are *Cassia eolignitica* Berry, *Engelhardtia* (*Oreomunnea*) *mississippiensis* Berry, and *Sapindus mississippiensis* Berry. I visited this locality in 1910 and 1913 and collected much material from the lower member. A study of this collection and that made by Johnson furnishes the following list of species:

Antholithus marshallensis.
Avicennia nitidaformis.
Bumelia pseudotenax.
Bumelia wilcoxiana.
Cæsalpinia wilcoxiana.
Canavalia acuminata.
Capparis eocenica.
Cassia eolignitica.
Cassia glenni.
Cassia marshallensis.
Cassia tennesseensis.
Cedrela mississippiensis.
Celastrus eolignitica.
Celastrus veatchi.
Engelhardtia ettingshauseni.
Engelhardtia mississippiensis.
Euonymus splendens.
Exostema pseudocaribæum.
Ficus myrtifolius.
Glyptostrobus europæus.
Heterocalyx saportana.
Ilex vomitoriafolia.
Inga mississippiensis.
Lycododites (?) eolignitieus.
Mimosites variabilis.
Paliurus mississippiensis.
Sapindus linearifolius.
Sapindus mississippiensis.

HURLEYS, BENTON COUNTY.

This locality, known as Hurleys schoolhouse, and formerly in Tippah County but now in Benton County, was discovered by E. W. Hilgard before the Civil War, and his collection formed the basis for a number of species described by Lesquereux in 1869.

The outcrop is 4 miles west of the town of Blue Mountain, Miss., and had not been revisited until it was rediscovered by E. N. Lowe in 1912. I visited it in company with Dr. Lowe in 1913. The schoolhouse has long since disappeared, and its site, on the summit of a low hill, is occupied by Flat Rock Church. On the slopes of the hill the leaf-bearing clay ironstone outcrops as an almost concealed ledge about 20 feet below the top of the hill, overlain by brown or reddish, more or less indurated sand. The leaf-bearing layer is generally free from sand and is laminated and high in iron. Below this stratum lies an undetermined thickness of gray sandy clays of the Ackerman formation of the Wilcox group. The outcrop is probably less than 100 feet above the base of the Wilcox, as the contact with the Sucarnoochee clay of the underlying Midway group is only about 1½ miles to the east. The following species occur at this outcrop, which throughout the systematic portion of my work is referred to simply as "Hurleys:"

Asplenium hurleyensis.
Asimina leiocarpa.
Bumelia hurleyensis.
Bumelia pseudotenax.
Combretum ovalis.
Cordia (?) lowii.
Dillenites ovatus.
Dryophyllum moorii.
Eugenia hilgardiana.
Fagara hurleyensis.
Ficus monodon.
Ficus occidentalis.
Ficus puryearensis.
Ficus schimperi.
Gleditsiophyllum hilgardianum.
Lygodium binervatum.
Magnolia leei.
Mespilodaphne eolignitica.
Mimusops eolignitica.
Myrcia bentonensis.
Myrica elæanoides.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Oreodaphne obtusifolia.
Oreodaphne puryearensis.
Osmanthus pedatus.
Pisonia chlorophylloides.
Rhamnus marginatus.
Rhamnus marginatus apiculatus.
Terminalia hilgardiana.
Terminalia lesleyana.

Of these 31 species only the following 10 are peculiar to this outcrop: *Asplenium hurleyensis*, *Asimina leiocarpa*, *Bumelia hurleyensis*, *Cordia (?) lowii*, *Eugenia hilgardiana*, *Fagara hurleyensis*, *Gleditsiophyllum hilgardianum*, *Lygodium binervatum*, *Pisonia chlorophylloides*, and *Rhamnus marginatus apiculatus*. Fifteen species are common to Puryear, 1 additional to Wickliffe, and 1 additional to Boaz, making a total of 17 species that range from beds near the base to the top of the Wilcox group.

POTTS CAMP, BENTON COUNTY.

The iron ores that occur in a belt in Marshall, Benton, and Lafayette counties, Miss., in the lower part of the Wilcox group bear an intimate relation to the palustrine and lagoon character of early Wilcox physical conditions. In southern Benton County these ores are worked in a small way in a locality known as the Potts Camp district.[1] They occur in the Ackerman formation, the lowest of the three formations into which the Wilcox group of Mississippi is divided. The general character of these beds is indicated by the following section of the cut 1 mile east of Ackerman in Choctaw County, as given by Crider and Lowe:

Section of Ackerman formation 1 mile east of Ackerman, Miss.

		Feet.
1.	Sandstone and sands which have been cemented into a ferruginous mass capping the ridge; in places this sandstone is 10 to 15 feet thick	20
2.	Yellow stratified sand	10
3.	Bed of lignite, which is not continuous but changes laterally into a dark lignitic clay; more or less sand and mica throughout the mass of lignite and lignitic clay	5
4.	Dark-blue clay weathering to gray	6½
5.	Impure lignite	1
6.	Chocolate-colored joint clay	5
7.	Thin band of ferruginous sandstone	½
8.	Dark-blue clay, similar to that of No. 4	4½
9.	Laminated dark clay	6
10.	Laminated clay in which thin ferruginous bands alternate with soft chocolate clay	5
11.	Gray micaceous joint clay, weathering to white	5

In the Potts Camp area extensive exposures are lacking. Reddish sands a few feet in thickness overlie a 15-inch more or less nodular seam of brown oxide ore, which was probably deposited as carbonate. This is underlain by about 40 feet of gray, more or less lignitic clay, beneath which is a 10 to 20 inch seam of carbonate or spathic iron, underlain by an undetermined thickness of clay. This ore is of nearly theoretic purity and marks a horizon that can be traced for several miles in discontinuous exposures. It bears every indication

[1] Lowe, E. N., Preliminary report on the iron ores of Mississippi: Mississippi Geol. Survey Bull. 10, 1913.

of having been nearly if not entirely continuous at the time of formation and furnishes striking evidence of the palustrine character of the early Wilcox, the low surface of the Wilcox mainland, the absence of terrigenous materials in the Wilcox lagoons at this time, and the highly ferruginous character of the run-off, possibly derived from the glauconite of the Upper Cretaceous mainland to the east.

Iron salts in the presence of carbonic acid and certain bacterial organisms are converted into ferrous carbonate and deposited directly from solution. The ferric hydroxide formed would be reduced to ferrous hydroxide by the action of the decaying organic matter and the carbon dioxide freed in the accompanying reactions would unite with the ferrous hydroxide, forming the normal ferrous carbonate.

So far as I have observed, these iron carbonates are unfossiliferous, and they lie somewhat above the leaf-bearing ferruginous sandstone at Hurleys.

More than two levels are developed at other localities, and these levels are probably not exactly synchronous throughout northeastern Mississippi.

SECTIONS IN TENNESSEE.

GRAND JUNCTION, FAYETTE COUNTY.

The beds numbered 1 to 6 in the following section were measured about 1 mile south of Grand Junction, Fayette County, Tenn., at an elevation of about 570 feet above sea level. The rest of the section (beds numbered 7 to 9) is taken from a well record at Grand Junction given by L. C. Glenn.[1]

Section of beds of Wilcox age near Grand Junction, Fayette County, Tenn.

		Feet.
1.	Yellowish loamy stratified sand becoming coarser below, in places purplish; contains a few ferruginous sand-filled "bombs"; thickens to the east	2–15
2.	Small white clay lens	0– 2
3.	Buff to gray stratified sand	3
4.	Gray clay, more or less sandy and generally thinly laminated, with ferruginous films or a few thin iron crusts; in places a pure hard ringing white clay	15–20
5.	Iron crust not far above base of formation	$\frac{1}{12}$– $\frac{1}{6}$
6.	Coarse gray to brown sand similar to lower part of bed No. 1, with here and there argillaceous bands an inch or two in thickness	5– 6
7.	White sharp sand	20
8.	White plastic clay	2
9.	Reddish sand, coarse at top and bottom and finer in the middle, penetrated	139

Pinkish ferruginous leaf impressions are distributed throughout bed No. 4, usually between the clay laminæ, and are as a rule poorly preserved. A few better-preserved remains have furnished the following determinable species, among which *Euonymus splendens* in all sizes is by far the most abundant form:

Cercis wilcoxiana.	Grewiopsis tennesseensis.
Combretum ovalis.	Oreodaphne obtusifolia.
Euonymus splendens.	Terminalia lesleyana (?).

About 100 feet southeast of the plant-bearing section the gullies expose the section shown diagrammatically in figure 3.

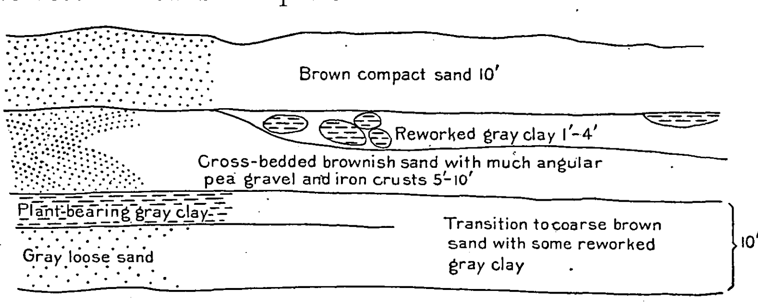
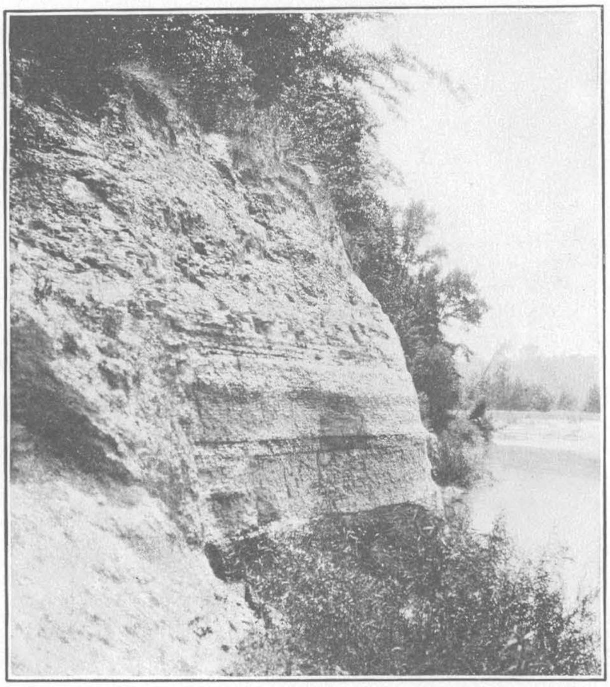


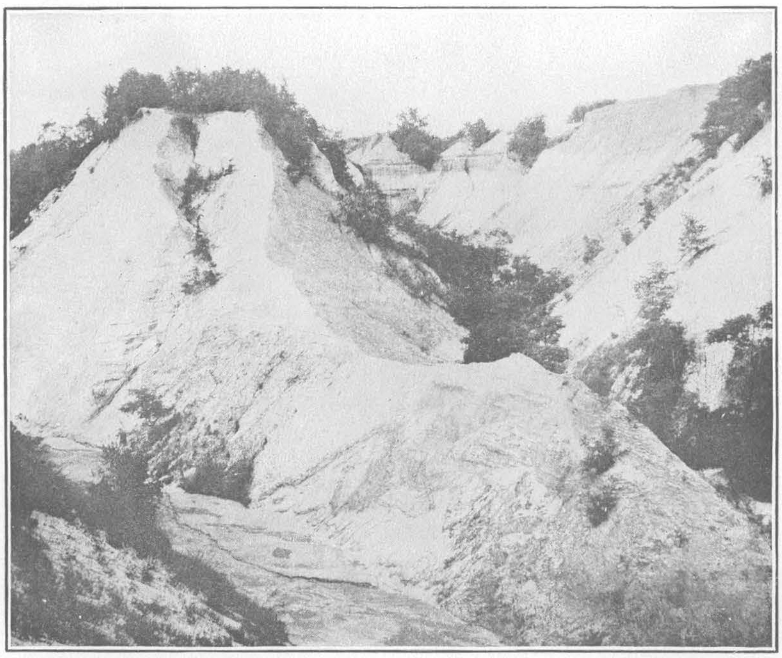
FIGURE 3.—Diagrammatic section of Wilcox deposits near Grand Junction, Tenn.

The plant-bearing clay is obviously a lens, since it thins within a short distance both to the north and to the east. There is a gradual horizontal transition to the east from this clay to brownish sand, and the sands contain transported masses of the gray clay, indicating two local unconformities at different levels in the beds of Wilcox age. Some geologists consider these reworked clays as proof that the upper part of the section represents a thin stratum of the socalled Lafayette lying unconformably upon the Wilcox. Those who are disposed to accept this interpretation are confronted in the preceding section by two Lafayette formations separated from each other by an unconformity fully as marked as that at the base.

[1] Glenn, L. C., Underground waters of Tennessee and Kentucky west of Tennessee River and of an adjacent area in Illinois: U. S. Geol. Survey Water-Supply Paper 164, p. 79, 1906.



A. FOSSILIFEROUS LAMINATED CLAY OF THE UPPER (GRENADA) FORMATION OF THE WILCOX GROUP AT GRENADA, MISS.



B. SANDS OF WILCOX AGE IN THE LAGRANGE FORMATION AT LA GRANGE, TENN.

LA GRANGE, FAYETTE COUNTY.

The uplands of both sides of Wolf River in southern Fayette County are all extensively gullied and show very similar sections. Immediately south of the town of La Grange (see Pl. VI, *B*) the following section is exposed:

Section of beds of Wilcox age south of La Grange, Tenn.

		Feet.
1.	Soft, loose light-yellow to light-gray sands, cross-bedded	15–18
2.	Layer of soil, dark with organic matter (lignitic sand)	1
3.	Massive bed of brick-red sand, case-hardened; shows very even top but very irregular lower surface and rests unconformably on the underlying sand	4–15
4.	Soft cross-bedded sands, mostly fine but in places coarse, of light colors, such as nearly white, light yellow, faint pink, and faint purplish, containing a few thin crusts and small rounded or short tubular concretions of sand ironstone in places. Near the top there is a clay lens of irregular shape 8 or 10 feet in maximum thickness	100

The lower part of the section was included by McGee in the so-called Lafayette formation, which throughout northern Mississippi and western Tennessee he considered as usually tripartite, the upper division being massive case-hardened loamy brick-red sand and the middle and lower divisions being softer brighter-colored sand, commonly carrying clay lenses or beds containing impressions of leaves. He would place the lower 100 feet of the above section in the middle and lower divisions of the Lafayette and regard the entire Lafayette at La Grange as 200 feet or more in thickness.

Glenn [1] considered that beds Nos. 1 and 2 represent the Columbia, No. 3 the Lafayette, and No. 4 the Wilcox. In my judgment only Wilcox materials are present. This was the type locality of Safford's Lagrange formation, and his early collections contained the following plants: *Banksia saffordii* (Lesquereux) Berry, *Rhamnus marginatus* Lesquereux, *Terminalia hilgardiana* (Lesquereux) Berry, and *Zizyphus meigsii* (Lesquereux) Berry. I am able to add *Euonymus splendens* Berry as a result of my visit. Impressions of leaves are as a rule scattered and poor.

About one-fourth of a mile west of the town sand is quarried from a large open pit that well illustrates the extreme lateral variation of the materials of Wilcox age. Orange sand; iron crusts; drab, somewhat lignitic sands (Glenn's "old soil layer"); and pinkish sandy clay with leaf impressions occur at all levels and replace each other within short intervals. Just west of the sand pit I obtained the following section:

Section of beds about one-fourth mile west of La Grange, Tenn.

		Feet.
1.	Brownish sand grading into next member	20
2.	Gray sand	5–8
3.	Yellow ferruginous argillaceous sand	10
4.	Gray sandy clay; about	10

[1] Glenn, L. C., op. cit., p. 36.

In some of these sections between Grand Junction and La Grange the gray sandy clay (of Wilcox age) constitutes the upper member and is underlain by the coarse, cross-bedded, and case-hardened brown sands (so-called Lafayette). In other sections these sands lie at the top and reach a maximum observed thickness of 25 to 30 feet. I fail to find any evidence in Fayette or Hardeman counties of an interval of erosion commensurate with the supposed interval representing the time intervening between the lower Eocene and the Pliocene. In fact there is no evidence of erosion except the fancied evidence common to all shallow-water deposits of this sort where clay lenses of different sizes are inclosed in sands of varying lithology and bedding.

About halfway between Grand Junction and La Grange, Tenn., near the eastern border of Fayette County, 1½ miles west of Grand Junction, a southerly sloping hillside immediately south of the public road is incised with old gullies, now almost entirely covered by a growth of scrub. The section is not well exposed but probably does not differ materially from the section at La Grange. In a small stream channel a brownish-drab laminated plastic clay carrying well-preserved impressions of leaves is exposed at intervals from 10 to 20 feet below the level of the road. This same clay lens apparently extends upward to about 8 feet above the level of the road and is overlain by 2 to 3 feet of brownish or reddish sandy loam. L. C. Glenn made a collection here in 1905 and I made several collections in 1910 and 1913. The forms identified from these collections are:

Anacardites serratus.
Aristolochia wilcoxiana.
Banisteria wilcoxiana.
Banksia saffordii.
Cænomyces annulata.
Cænomyces cassiæ.
Cassia emarginata.

Cassia eolignitica.
Cassia fayettensis.
Cassia glenni.
Cassia marshallensis.
Cassia mississippiensis.
Cassia tennesseensis.
Celastrus eolignitica.
Combretanthites eocenica.
Euonymus splendens.
Euphorbiophyllum fayettensis.
Laurophyllum florum.
Laurophyllum preflorum.
Melastomites americanus.
Mespilodaphne pseudoglauca.
Mimosites inequilateralis.
Mimosites lanceolatus.
Mimosites variabilis.
Myrcia bentonensis.
Myrica elæanoides.
Sophora palæolobifolia.
Sophora wilcoxiana.
Taxodium sp.
Zizyphus meigsii.

PINSON, MADISON COUNTY.

The following section was measured at the pits of the Pinson Pottery Co., on Bear Creek, near Pinson, Madison County, Tenn., at an elevation between 350 and 400 feet above sea level:

Section at pits of Pinson Pottery Co., on Bear Creek, near Pinson, Madison County, Tenn.

	Feet.
1. Reddish loam	1- 2
2. Gray to orange sand with some thin clay laminæ and numerous ferruginous pipes	12
3. Light-orange to brownish coarse cross-bedded sand with some fine gravel	10-12
4. Thin iron crusts	$\frac{1}{12}$- $\frac{1}{8}$
5. Gray, finely sandy clay becoming brownish below; contains scattered lignitic fragments and poorly preserved leaves at some levels	18-20

There are no well records at Pinson or other means for determining the distance of the plant-bearing horizon above the base of the beds of Wilcox age, except the unreliable evidence of the probable dip of the upper surface of the Porters Creek clay (of Midway age), which outcrops a few miles east of Pinson. The deep well at Jackson, which starts at nearly the same level as the top of the Pinson section, is of interest in this connection, since it is only 3 or 4 miles farther from the eastern margin of the beds of Wilcox age. According to Glenn[1] it furnished the following section. The geologic names used in brackets, however, are my own interpretation of the formational units to which the beds belong.

Log of deep well at Jackson, Tenn.

	Feet.
[Wilcox group]:	
Sandy red clay (Lafayette)	12
Tough blue clay	16
Coarse white sand	12
Tough white clay	6
White sand with small gravel and iron crusts	60
Light varicolored clay	43
Soft ferruginous sandstone (base of Lagrange)	11
[Porters Creek clay]:	
Lead-colored fine clay (Porters Creek)	170
Hard dark rock (limestone?) (base of Porters Creek)	5
[Ripley formation]:	
White water-bearing sand	13
White, very micaceous quicksand	28
[Selma? chalk]:	
Dark lead-colored laminated clay and lignitic micaceous pyritiferous sand	29
[Eutaw? formation]:	
Material similar to foregoing, with shark teeth at 418 feet	43
Light water-bearing sands	77

If correctly interpreted, this section shows a thickness of about 160 feet of beds of Wilcox age at Jackson, so that at the Pinson pit their thickness must be between 100 and 150 feet. This would make the horizon at which the fossil plants are found within 100 feet of the base of the beds of Wilcox age in this latitude, probably a maximum estimate. These plant remains are neither common nor well preserved, being more macerated than most of the material from the leaf-bearing horizons in the Wilcox. The following species have been identified from this locality:

Cæsalpinia wilcoxiana.
Cæsalpinites pinsonensis.
Chrysophyllum ficifolia.
Paliurus pinsonensis.
Sabalites grayanus.
Taxodium dubium.

This meager flora is of interest because three of the species have not been found at other Wilcox outcrops where the flora is much more representatively preserved, although as the stratigraphy is interpreted by me, the base of the beds of Wilcox age at Pinson lies in the abundantly leaf-bearing zone of the Holly Springs sand or middle Wilcox of northern Mississippi.

[1] Glenn, L. C., op. cit., p. 98, 1906.

HENRY COUNTY.

Henry County lies on the divide between the Tennessee and the Mississippi drainage basins. A little more than its western half is underlain by the beds of Wilcox age, which are chiefly white or gray siliceous clays. Probably more clays are worked in this county than anywhere else in the Wilcox area. The best pits are close to the eastern edge of the outcrop of the beds of Wilcox age and near the towns of Puryear, Whitlock, Paris, and Henry. The basal strata of Wilcox age in this area consist largely of sands with lenses of gray or white clay containing more or less silica in the form of rock flour, probably derived from the disintegration of the Paleozoic cherts to the eastward. These clay lenses are numerous and range from a foot or two in thickness and an acre or less in area to beds 20 feet thick that cover 5 to 10 acres. In general, these lenses are elliptical in horizontal outline, with their long axes approximately parallel to the Wilcox shore line, as interpreted by the writer. Scattered leaf impressions are not rare in these clays, but desirable specimens are scarce. Carbonaceous clays occur at various levels, but no extensive beds of lignite were observed. Only a few sections will be given to illustrate the materials and the criteria they offer for determining the conditions of sedimentation.

Section at pit 2½ miles south of Puryear, Tenn., worked by Mandle-Sant Co.

	Feet.
1. Brown loam with scattered pebbles	5
2. Gravel bed of angular chert and rounded quartz pebbles as much as 3 inches in diameter with semi-indurated ferruginous bands an inch or two thick toward the top	4
3. Coarse or fine gray or brown compact sand with iron crusts at the top; about	10
4. Laminated pinkish and buff ferruginous sandy clay	10–25
5. Lens of black to gray plastic clay, in places massive and elsewhere laminated and somewhat sandy, with scattered carbonaceous impressions of leaves	0–15
6. Gray clay, exposed	5

The upper 9 or 10 feet is probably Pleistocene, although I suppose it would be called Lafayette by some geologists. No identifiable plants were collected at this outcrop, but the section is interesting, as the lens of carbonaceous clay shown in cross section on the west wall of this extensive opening obviously represents a section across an estuary bayou or oxbow of Wilcox age. In its general features it is very similar to a number of Pleistocene or Recent sections of some of our meandering Coastal Plain rivers that I have seen. Beds Nos. 3, 4, 5, and 6 are of Wilcox age.

About one-fourth of a mile south of the depot at Puryear (elevation 612 feet) and immediately west of the Nashville, Chattanooga & St. Louis Railway is a clay pit of remarkable scientific interest. The section exposed is not extensive, but it shows the following sequence of materials. (See Pl. IV, *A*, p. 38.)

Section at Puryear, Tenn.

	Feet.
1. Yellowish coarse argillaceous sand with a few pebbles	2– 8
2. White to brown chert and flint gravel with scattered angular bowlders of sandstone, the largest 2 or 3 feet in diameter, and some well-rounded quartz pebbles	0– 6
3. Gray or buff, faintly stratified, and in places sandy hard clay that dries nearly white	10–15
4. Flat bench, plastic brown siliceous, thinly laminated clay, with abundant plant remains; dries nearly white	5– 8
5. Buff plastic clay carrying numerous leaves of *Sabalites grayanus;* about	15
6. Coarse white sand, exposed in borings.	

Beds Nos. 1 and 2 are probably of Pleistocene (so-called Lafayette) age. The whole clay lens probably covers 5 or 6 acres, but only about one-sixth has been stripped. It would be interesting to determine whether the leaf-bearing layers are as extensive as the lens itself. Beds Nos. 3, 4, 5, and 6 are of Wilcox age.

This is the most remarkable leaf-bearing clay that I have ever seen at any geologic horizon. The fossiliferous layers are practically without sand and must have been deposited in very quiet waters. They are crowded with leaves that lie horizontally, but not in matted layers. There is no evidence of seasonal accumulations such as occur in supposedly similar situations at the present time, but an evenly distributed succession of an unusual variety of forms, some of them of large size and only a few with their petioles broken or acuminate forms with their tips missing. The plants must have grown near at hand, for they could not have withstood much transportation. Indeed most of the forms are evidently coastal types.

I picture the Wilcox conditions here as an area at the mouth of a Wilcox stream of low gradient, carrying only the finest sediment, that emptied into a lagoon lined on the landward side by a sand beach supporting a typical subtropical strand vegetation and separated by a considerable barrier beach from the main body of embayment waters. That it was not an estuary or bayou seems to be indicated by the lack of carbonaceous muds and the presence of a few gypsum crystals. The contact with the underlying beds of Midway age can not be far below the base of the section, because beds of that age outcrop a few miles to the eastward. Driven wells, which obtain abundant water at depths of 100 to 115 feet, must tap the basal sands of Wilcox age. Though this flora is within 100 feet of the beds of Midway age in this latitude, and practically the lowest horizon with respect to the adjacent shore line of what I regard as the Wilcox embayment at which fossil plants have been found, it by no means follows that it is near the base of the Wilcox group as a whole or as compared with localities to the south.

The Wilcox transgression may have been relatively rapid, but I would not expect deposition to have as yet commenced in northern Tennessee during the time of the deposition of the Nanafolia formation of the Alabama section. Certainly the flora found at Puryear and farther northward at Wickliffe, Ky., contains some elements not found in the Holly Springs sand (middle Wilcox) at localities in northern Mississippi and in contemporaneous beds in southern Tennessee, and some of these elements may be legitimately considered as later, since they resemble forms from the flora of the Yegua or "Cockfield" Claiborne. A list of the Wilcox species identified in the Puryear collections follows:

Anacardites metopifolia.
Anacardites minor.
Anacardites falcatus.
Anacardites grevilleafolia.
Anacardites puryearensis.
Aneimia eocenica.
Anona ampla.
Anona eolignitica.
Anona wilcoxiana.
Antholithus arundites.
Apocynophyllum sapindifolium.
Apocynophyllum tabellarum.
Apocynophyllum wilcoxense.
Arthrotaxis (?) eolignitica.
Artocarpoides wilcoxensis.
Avicennia eocenica.
Banisteria fructuosa.
Banisteria pseudolaurifolia.
Banisteria repandifolia.
Banksia puryearensis.
Banksia saffordi.
Banksia tenuifolia.
Bombacites formosus.
Bombacites wilcoxianus.
Bumelia pseudohorrida.
Bumelia wilcoxiana.
Cæsalpinia wilcoxiana.
Cæsalpinites aculeatafolia.
Calycites davillaformis.
Calyptranthes eocenica.
Canavalia acuminata.
Canavalia eocenica.
Capparis eocenica.
Carapa eolignitica.
Carpolithus dictyolomoides.
Carpolithus henryensis.
Carpolithus hyoseritiformis.
Carpolithus prangosoides.
Carpolithus proteoides.
Carpolithus puryearensis.
Cassia eolignitica.
Cassia fayettensis.
Cassia glenni major.
Cassia odoratifolia.
Cassia puryearensis.
Cedrela puryearensis.
Cedrela wilcoxiana.
Chrysobalanus eocenica.
Chrysobalanus inæqualis.
Cinnamomum oblongatum.
Cinnamomum vera.
Citrophyllum wilcoxianum.
Coccolobis eolignitica.
Coccolobis uviferafolia.
Combretum obovalis.
Combretum wilcoxensis.
Conocarpus eolignitieus.
Cordia eocenica.
Crotonophyllum appendiculatum.
Crotonophyllum eocenicum.
Cupanites eolignitieus.
Dalbergia eocenica.
Dalbergia monospermoides.

Dalbergia tennesseensis.
Dalbergia wilcoxiana.
Dillenites tetracerafolia.
Diospyros brachysepala.
Diospyros wilcoxiana.
Dodonæa knowltoni.
Dryophyllum anomalum.
Dryophyllum puryearensis.
Dryophyllum tennesseensis.
Drypetes prekeyensis.
Echitonium lanceolatum.
Engelhardtia ettingshauseni.
Engelhardtia puryearensis.
Eugenia puryearensis.
Euonymus splendens.
Fagara eocenica.
Fagara puryearensis.
Ficus monodon.
Ficus planicostata maxima.
Ficus pseudolmediafolia.
Ficus pseudopopulus.
Ficus pseudocuspidata.
Ficus puryearensis.
Ficus puryearensis elongata.
Ficus schimperi.
Ficus vaughani.
Ficus wilcoxensis.
Fraxinus johnstrupi.
Fraxinus wilcoxiana.
Gleditsiophyllum constrictum.
Gleditsiophyllum ellipticum.
Gleditsiophyllum eocenicum.
Gleditsiophyllum minor.
Gleditsiophyllum ovatum.
Guettarda ellipticifolia.
Hiræa wilcoxiana.
Icacorea prepaniculata.
Inga puryearensis.
Juglans schimperi.
Knightiophyllum wilcoxianum.
Laguncularia preracemosa.
Laurophyllum juvenalis.
Leguminosites prefoliatus.
Leguminosites reniformis.
Leguminosites subovatus.
Magnolia angustifolia.
Magnolia leei.
Maytenus puryearensis.
Melastomites americanus.
Mespilodaphne coushatta.
Mespilodaphne elegans.
Mespilodaphne eolignitica.
Mespilodaphne pseudoglauca.
Mespilodaphne puryearensis.
Metopium wilcoxianum.
Mimosites acaciafolius.
Mimosites variabilis.
Mimusops eolignitica.
Mimusops sieberifolia.
Myrcia bentonensis.
Myrcia parvifolia.
Myrcia puryearensis.
Myrcia vera.
Myrcia worthenii.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Nectandra puryearensis.
Nectandra sp.
Nyssa eolignitica.
Nyssa wilcoxiana.
Oreodaphne obtusifolia.
Oreodaphne pseudoguianensis.
Oreodaphne puryearensis.
Oreodaphne wilcoxensis.
Oreopanax minor.
Osmanthus pedatus.
Paraengelhardtia eocenica.
Persea longipetiolatum.
Pisonia eolignitica.
Pisonia puryearensis.
Pithecolobium eocenicum.
Proteoides wilcoxensis.
Pseudolmedia eocenica.
Psychotria grandifolia.
Reynosia prænuntia.
Reynosia wilcoxiana.
Rhamnus eolignitićus.
Rhamnus marginatus.
Rhamnus puryearensis.
Sabalites grayanus.
Sapindus eolignitićus.
Sapindus formosus.
Sapindus knowltoni.
Sapindus linearifolius.
Sapindus mississippiensis.
Sapindus pseudaffinis.
Sideroxylon ellipticus.
Sideroxylon premastichodendron.
Simaruba eocenica.
Sophora henryensis.
Sophora mucronata.
Sophora puryearensis.
Sophora repandifolia.
Sophora wilcoxiana.
Sterculia puryearensis.
Sterculiocarpus sezannelloides.
Terminalia hilgardiana.
Terminalia lesleyana.
Ternstrœmites eolignitićus.
Ternstrœmites lanceolatus.
Ternstrœmites ovatus.
Ternstrœmites preclaibornensis.
Trapa wilcoxensis.
Vantanea wilcoxiana.
Zizyphus falcatus.
Zizyphus meigsii.

The list includes 181 species, an almost unprecedented number from a single horizon at a single locality, and moreover most of these species are represented by numerous specimens.

There is only 1 species of fern (Aneimia), 1 gymnosperm (Arthrotaxis ?) and 1 monocotyledon, a palm (Sabalites), which is, however, very abundant in the basal part of the section. Among the 176 species of dicotyledons the most abundant genus is Ficus with 10 species. There are 27 species of Leguminosæ, the largest genera being Sophora and Gleditsiophyllum, each with 5 species, and Dalbergia and Cassia, each with 4 species. In individual abundance species of Sophora and Gleditsiophyllum outnumber all the other Leguminosæ. The family Lauraceæ has 17 species, 4 in Nectandra, 4 in Oreodaphne, and 5 in Mespilodaphne. *Oreodaphne obtusifolia* is the most abundant lauraceous form. There are 8 species of Sapindaceæ and 6 species each of Anacardiaceæ, Sapotaceæ, Myrtaceæ, Rhamnaceæ, and Combretaceæ. Of the Ackerman or lower Wilcox flora, as represented by the 31 species identified from Hurleys, 15 are found at Puryear. The Holly Springs or middle Wilcox flora of northern Mississippi, as represented by the localities from Oxford, Miss., northward to Grand Junction, Tenn., has 37 species common to Puryear; the latest known Wilcox flora (that from the Grenada formation), represented by the 63 species from Grenada, Miss., has 32 forms common to Puryear. The relative abundance and botanic character of these common species show clearly that the base of the beds of Wilcox age in northern Tennessee is of the same age as or is slightly younger than the Holly Springs sand or middle Wilcox of northern Mississippi.

Section at Breedlove pit, 1 mile southwest of Henry, Tenn.

	Feet.
1. Alternating beds of brown and white argillaceous sand	8–10
2. White sand	2– 4
3. Cross-bedded ferruginous sand with some iron crusts at base	4– 5
4. Lens of gray plastic clay with faint impressions of leaves; exposed (in places shown by boring to be 16 feet thick)	4–10
5. Coarse gray quartz sand at east end of pit; exposed	4

The whole section is probably of Wilcox age. The leaf remains are complete but very faint, since the leaf substance has neither been preserved nor replaced nor even stained by ulmic or ferric precipitates. Their condition suggests that scattered leaves may have been present throughout many of these gray clays of Wilcox age and have failed to leave tangible evidence of their former presence.

The following species were identified from bed No. 4 at this outcrop:

Dryophyllum tennesseensis.
Nectandra lancifolia.
Sabalites grayanus.

SECTIONS IN KENTUCKY.

MAYFIELD, GRAVES COUNTY.

About 3½ miles southwest of Mayfield, between the Illinois Central Railroad and Mayfield Creek, in Graves County, Ky., are the extensive clay pits of the Kentucky Construction & Improvement Co. The section exposed is as follows:

Section of clay pits 3½ miles southwest of Mayfield, Ky.

	Feet.
1. Buff to reddish sandy loam	4– 8
2. Buff gravel	5–10
3. Light-buff cross-bedded sand	8–10
4. Black compact, somewhat argillaceous lignite	3–12
5. Drab plastic clay with four very carbonaceous layers; about	22
6. Light plastic, somewhat sandy clay; exposed	6

This is an exceedingly interesting section, but it is difficult to correlate in the absence of fossil plants. There is a great variety of macerated plant débris in the section, but I found no identifiable remains. I was told on good authority that at times in small areas of certain layers of bed No. 5 the workmen uncovered leaf impressions, but unfortunately none were exposed at the time of my visit and no specimens had ever been saved. This section was studied by Glenn in 1905, but not described, although he gives a photograph of it.[1] He refers the upper part to the Columbia, the middle part to the Lafayette, and the basal part to the Wilcox. I see no reason to doubt the Wilcox age of beds Nos. 4 to 6. Beds Nos. 1 and 2 are undoubtedly of Pleistocene age. Bed No. 3 is unconformable with both the underlying and overlying beds. It is lithologically like so many light-colored cross-bedded sands throughout the Wilcox area that have been called Lafayette that I am inclined to refer it to the Wilcox.

At the town of Mayfield (elevation 480 feet) a well furnishes additional data bearing on this section. The driller's record is as follows:[2]

Record of well at Mayfield, Ky.

	Feet.
Claylike loess	12
Orange sand and gravel	278
Thin parting of pipe clay.	
White water-bearing sand	50

[1] Glenn, L. C., op. cit., pl. 7, *B*.
[2] Idem, p. 136.

Apparently there is no trace of the lignitic materials and clay lenses of the preceding section, which is less than 4 miles distant. These clay lenses shed an interesting light on the local conditions of sedimentation during Wilcox time and show that after a considerable thickness of littoral sands were deposited the waters became wholly or partly ponded, forming a lagoon where clays were deposited. Swamp vegetation characterized the upward fluctuation of level and is marked by the carbonaceous beds of the section, which show five slight upward movements separated by five slight subsidences and followed by a sixth upward movement, marking a retransgression of littoral sands. The area has been above water since early Eocene time, except for the Pleistocene depressions, and has been greatly eroded.

WICKLIFFE, BALLARD COUNTY.

Fossil plants were discovered at Wickliffe by R. H. Loughridge, and in his report on the Jackson's Purchase region, published in 1888, 12 species were recorded on the authority of Lesquereux. The geology was discussed at considerable length. The plants occur in a clay stone in low exposures in branch bottoms in the southern part of the town, and the section is so thin that it has no significance in the present connection. The cuts along the Illinois Central Railroad, however, furnish more extensive exposures of deposits of Wilcox age in this region. In the east side of the cut that is south of the town and immediately north of milepost 371–59 the following section is exposed:

Section of beds exposed in Illinois Central Railroad cut near Wickliffe, Ky.

	Feet.
1. Heavy gravel of all sizes, prevailingly coarse, pebbles averaging 1 inch in diameter, in matrix of coarse ferruginous sand carrying a few bowlders, the whole more or less lithified; about.	10
2. Fine to coarse yellowish or reddish ferruginous sand, the upper 3 feet forming a lens of fine and very argillaceous sand, underlain by buckshot sand more or less lithified into sandstone bowlders	8–13
Iron crusts and water-bearing horizon.	
3. Gray plastic clay with scattered lignite	12
4. Compact brown argillaceous lignite with scattered and mostly undeterminable plant remains; *Leguminosites wickliffensis* Berry occurs at this level; about	4
5. Concealed to track level	7
Basal beds pass horizontally into reddish-stained gray clay and from that into a fine, almost white loose sand.	

One hundred yards north of the preceding section the following section is exposed:

Section 100 yards north of preceding section.

	Feet.
1. Mostly concealed, probably entirely loamy loess; about	25
2. Gravel and sand as in preceding section; about	20
3. Bed of argillaceous lignite; about	4
4. Clay or sand	8
5. Lignite bed of preceding section; about	4
6. Clay or sand; about	10

Loughridge [1] discussed sections in this same ridge which were situated somewhat west of those just given. At that time the railroad ran along the river bank, which is now much washed and overgrown. The new right of way skirts the eastern instead of the western edge of the ridge. Glenn [2] gives well records (quoted from drillers' recollections) from which it appears that the beds of Wilcox age are about 430 feet thick at Wickliffe. Their upper surface is about 1,050 feet above the crystalline floor of the embayment.

The lignite beds are doubtless to be correlated with those exposed near Mayfield, Ky. According to Loughridge [3] they occur 7 miles east of Wickliffe, at Blandville, and on Panther Creek, 6 miles east of Mayfield, which indicates the extensive oscillations of level at the head of the embayment during the early Eocene.

From the collections made from the low exposure of clay stone I have determined the following species:

Anacardites metopifolia.
Banisteria pseudolaurifolia.
Banisteria wilcoxiana.
Banksia saffordi.
Banksia tenuifolia.
Carapa eolignitica.

[1] Loughridge, R. H., Report on the geological and economic features of the Jackson's purchase region: Kentucky Geol. Survey, pp. 47, 48, 233, 1888.

[2] U. S. Geol. Survey Water-Supply Paper 164, pp. 125–126, 1906.

[3] Op. cit., p. 42.

Cassia fayettensis.
Cassia glenni.
Cassia marshallensis.
Cupanites eoligniticus.
Cupanites loughridgii.
Dryophyllum moorii.
Dryophyllum puryearensis.
Dryophyllum tennesseensis.
Engelhardtia ettingshauseni.
Exostema pseudocaribæum.
Ficus denveriana.
Ficus myrtifolius.
Ficus wilcoxensis.
Inga wickliffensis.
Juglans berryi.
Juglans schimperi.
Mespilodaphne pseudoglauca.
Mimosites variabilis.
Sapindus eoligniticus.
Sapindus formosus.
Sapindus linearifolius.
Sapindus mississippiensis.

These species indicate a stratigraphic position at about the boundary between the Holly Springs sand or middle Wilcox and the Grenada formation or upper Wilcox of the northern Mississippi section, or slightly higher (younger).

SECTIONS IN ARKANSAS.

CROWLEYS RIDGE, CLAY, GREENE, AND POINSETT COUNTIES.

The age of the light quartzitic sandstone which outcrops as a series of ledges at so many points along the western side of Crowleys Ridge, in northeastern Arkansas, has been a puzzle to geologists since the days of Owen, who in his first report compared them with the Potsdam of the early Paleozoic. Many sections are given by R. E. Call in his report on Crowleys Ridge,[1] where they are correctly referred to the Eocene. He collected a few leaves from one of these outcrops in 1889 at Hardys Mill, near Gainesville in Greene County.[2] I have determined the following forms from this locality:

Anona ampla.
Aralia notata.
Asplenium eolignitica.
Cinnamomum postnewberryi.
Ficus eolignitica.
Ficus vaughani.
Mespilodaphne coushatta.

At the classic locality on the Lane place, described originally by Owen and subsequently by Call, the fragments of the quartzite in the bed of the gully contain fragments of dicotyledonous leaves and of a fan palm (presumably *Sabalites grayanus* Lesquereux) as well as fossil rootlets (rhizomorphs).

Farther to the north along the west escarpment of the ridge in Clay County, about 4 miles southwest of Boydsville, a small exposure, only about 6 feet in thickness and 10 to 15 feet in horizontal extent, occurs on the heavily wooded slope at the head of a branch that is usually dry. This outcrop was discovered by L. W. Stephenson and visited by me in 1910. The materials are stratified and more or less indurated, medium fine gray sands somewhat stained with iron. Impressions of leaves are common, but the variety of forms is not great. The following species have been determined:

Aneimia eocenica.
Apocynophyllum tabellarum.
Banksia tenuifolia.
Dryophyllum tennesseensis.
Ficus denveriana.
Nectandra lowii.
Nectandra pseudocoriacea.
Sabalites grayanus.
Sapindus linearifolius.

These forms in conjunction with the similar leaf-bearing materials from Hardys Mills effectually settle the Wilcox age of these sandstones of Crowleys Ridge. Though the flora found along Crowleys Ridge is too limited for exact correlation within the Wilcox it falls in the upper instead of the lower half of the group.

The southernmost locality on Crowleys Ridge at which the Wilcox has been identified paleobotanically lies on the west side of the ridge along Bolivar Creek, the main affluent of L'Anguille River. This section is discussed at length in Call's report.[3] The following section taken by Stephenson [4] in 1912 is not composite like that described by Call:

Section on Bolivar Creek, Ark.

	Feet.
Pleistocene (loess):	
1. Loam, probably creep from a higher level, brownish color	1
Pliocene (?) (Lafayette formation):	
2. Gravel, probably creep from a higher level	4
Eocene (Claiborne (?) formation):	
3. Weathered brown fine argillaceous sand	3
4. Fine light-gray, faintly laminated argillaceous sand	11
5. Fine light-gray massive sand	4½
6. Fine chocolate-colored argillaceous, faintly laminated sand	4½
7. Dark-colored, very fine, very argillaceous sand	4

[1] Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, 1891.
[2] Idem, pp. 95, 96.
[3] Call, R. E., The geology of Crowleys Ridge: Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, pp. 80-83, 1891.
[4] Stephenson, L. W., unpublished report.

Eocene (Wilcox group):	Feet.
8. Dark-brown to black lignite	5
9. Brown argillaceous lignitic sand	1
10. Dark chocolate-colored tough clay, lignitic in upper portion; in places in the upper 2 feet contains numerous poorly preserved lignitized leaves and impressions of leaves	3
11. Very tough, light greenish-gray clay	2

The lignitic bed (No. 8) and beds Nos. 10 and 11 are somewhat irregularly bedded and differ in thickness along the bluff. In places the upper lignitic portion of bed No. 10 becomes a bed of true lignite 1 to 2 feet thick. A few lignitized logs and fragmental remains of lignitized stumps were seen in this layer.

Call[1] recorded several large upright lignitized trunks with radiating roots in beds Nos. 9 and 10. A specimen of silicified wood from this locality (not in place, probably from bed No. 2) was identified by Knowlton[2] as *Laurinoxylon branneri*, a species originally based on more complete material from the upper Claiborne or lower Jackson of St. Francis County, but it has no weight in correlation, since it was obviously reworked in the upper part of the section. From bed No. 4 Stephenson collected the following plants:

Ficus pseudolmediafolia.
Juglans schimperi.
Palæodendron americanum.
Sapindus mississippiensis.
Sophora wilcoxiana.

Although the material is very poor, several of the identifications are satisfactory, and as none of the forms are known above the Wilcox it seems reasonably certain that this is the age of the lower part of the section. The lignite bed clearly represents a local emergence, and beds Nos. 3 to 7 may be of Claiborne age.

BENTON, SALINE COUNTY.

Several interesting but generally poor sections are exposed in the vicinity of Benton, Saline County, Ark.

About one-half mile northwest of the town along the military road a local working (known as the McDonald pit in 1910) shows the following section:

Section at McDonald pit, about one-half mile northwest of Benton, Ark.

	Feet.
1. Heavy gravel	0–8
2. Stratified, brick-red, case-hardened, coarse sand or fine gravel, with undulating upper and lower surface	0–5
3. Thinly laminated gray sandy clay, with red and yellow mottling, current bedded and containing thin layers of gravel	0–6
4. Plastic gray to brownish, heavily bedded clay	2–6
5. Slightly ferruginous sharp gray sand	4–6

Mr. W. H. McDonald, who is in charge of the Government experiment farm across the road, says that borings show several feet of sand below the level of bed No. 5, followed by shell fragments, which seems to indicate the presence of fossiliferous Midway deposits at no great distance below the surface, since fossiliferous Midway occurs a few miles to the west. No determinable plant remains were found at this outcrop.

A small exposure on the property of the Eagle Pottery Co., one-half mile west of the preceding section, shows just south of the road a few feet of brownish sandy clay grading upward into grayish and pinkish clays. The brown clays are packed with poorly preserved leaves, and some of the material occurs in matted layers. The most abundant form is *Artocarpus pungens* (Lesquereux), in addition to which the following species have been identified: *Cassia bentonensis* Berry, *Oreodaphne salinensis* Berry, and *Sabalites grayanus* Lesquereux.

About half a mile north of the preceding outcrop, at the Leech place, on the Pine Bluff road, the following section is exposed:

Section at Leech place, near Benton, Ark.

	Feet.
1. Reddish, fine stratified sand, becoming gradually buff toward the base	6–8
2. Massive brown plastic clay with disseminated bits of lignite but no leaf impressions; exposed	6

The old Henderson pit, from which fossil plants were collected by the Arkansas Geological Survey a score of years ago, has not been worked in recent years and is much masked by slumping. It is somewhat less than half a mile northwest of Benton on the Pine Bluff road. The following section is exposed there:

[1] Call, R. E., The geology of Crowley's Ridge: Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, pp. 80–83, 1891.
[2] Idem, p. 256.

Section at Henderson pit, one-half mile northwest of Benton, Ark.

		Feet.
1.	Brownish loam carrying coarse gravel	1–3
2.	Very irregularly bedded, brick-red, case-hardened sand, with clay laminæ, grading into No. 3.	4–8
3.	Gray to buff, very argillaceous sand or arenaceous clay, in places grading into No. 4	4–8
4.	Massively bedded, bluish to brown plastic clay with numerous leaf impressions; exposed	4

This locality is on the strike a short distance north of the section from the McDonald pit described on page 53. Bed No. 4 has yielded the following plants:

Apocynophyllum constrictum.
Apocynophyllum sapindifolium.
Cæsalpinites bentonensis.
Cassia bentonensis.
Cassia fayettensis.
Chamædorea danai.
Engelhardtia ettingshauseni.
Myrcia bentonensis.
Nectandra pseudocoriacea.
Oreodaphne salinensis.
Oreopanax oxfordensis.
Sabalites grayanus.
Sapindus bentonensis.
Sapindus knowltoni.

Compared with the eastern Gulf area the flora from Benton contains 5 species of unknown position, 2 species that range from the base to the top of the Wilcox, 1 species confined to the Ackerman formation or lower Wilcox, 2 species confined to the Holly Springs sand or middle Wilcox, 4 species confined to the Holly Springs sand and Grenada formation or upper Wilcox, and 1 species confined to the Grenada formation. It is therefore not older than the leaf-bearing outcrops of Henry County, Tenn., which are in turn slightly younger than those of the Holly Springs sand or middle Wilcox of northern Mississippi.

MALVERN, HOT SPRING COUNTY.

Fossil plants were collected by the Arkansas Geological Survey a score of years ago from the Atchison clay pit, about half a mile east of the St. Louis, Iron Mountain & Southern Railway, between Perla and Malvern in Hot Spring County.

In this part of the State the clay lenses of the Wilcox are small and are embedded in the sands. They make the cores of the small hills. When one is worked out another is opened, so that the original locality was not exposed at the time of my visit. The workings in 1910 showed the following section:

Section at Atchison clay pit near Malvern, Ark.

		Feet.
1.	Gray to drab, somewhat sandy clay, becoming brownish and lignitic at the base	0–6
2.	Buff to gray plastic clay	2–8
3.	Gray to buff sand	0–5

Unidentifiable leaf fragments occur near the base of bed No. 1. The old collections, not previously studied, have furnished specimens of *Oreodaphne salinensis* Berry and *Sophora wilcoxiana* Berry.

OUACHITA COUNTY.

Owen,[1] in his second report, gives special attention to the ligni e of the Camden Coal Mining Co. in Ouachita County (sec. 12, T. 12 S., R. 18 W.). He gives the following section:

Section at mine of Camden Coal Mining Co., Ouachita County, Ark.

	Feet.
Sand and ferruginous sandstone	20–30
Ash-colored clay	6– 7
Lignite	6
Pipe clay with segregations of limonite.	
Light-gray sandy clay, somewhat ferruginous	10–18

Harris,[2] who revisited this locality, records the following section exposed at the time of his visit:

Section at mine of Camden Coal Mining Co., Ouachita County, Ark.

	Feet.
Arenaceous materials, poorly exposed.	
Light-pinkish clay	6
White sand	6
Bluish clay	8
Lignite	6

The lignite is reported to be without sand or clay and evidently represents an interval of emergence. Impressions of leaves are said to occur in the vicinity (sec. 14, T. 12 S., R. 18 W.) in a sandy ferruginous indurated matrix, but I have seen nothing identifiable from this region, either in the field or in the National Museum collections.

SECTIONS IN LOUISIANA.

SHREVEPORT, CADDO PARISH.

A section at Slaughter Pen Bluff, near Shreveport, La., has been discussed by Johnson,[3] Lerch,[4] Vaughan,[5] Veatch,[6] and Harris.[7]

[1] Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, pp. 128–133, 1860.
[2] Harris, G. D., Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 65, 1894.
[3] Johnson, L. C., Report on the iron regions of northern Louisiana and eastern Texas: H. Ex. Doc. No. 195, 50th Cong., 1st sess., p. 18, 1888.
[4] Lerch, Otto, Louisiana Exper. Sta. Bull., 1892.
[5] Vaughan, T. W., Am. Geologist, vol. 15, p. 205, 1895.
[6] Veatch, A. C., Louisiana Geol. Survey Rept. for 1899, p. 196, 1900.
[7] Harris, G. D., U. S. Geol. Survey Bull. 429, 1910.

Johnson referred it to Hilgard's "Mansfield series" (Wilcox formation); Lerch to his "Lower Lignitic," which is partly Wilcox and partly Claiborne (St. Maurice formation); Vaughan referred it to the "Lignitic"; Veatch and also Harris were inclined to consider it "Lower Claiborne"; but recently Harris has considered it as Wilcox, which is undoubtedly its correct age. (See Pl. V, *A*, p. 39.) The section is as follows:

Section at Slaughter Pen Bluff, Shreveport, La.

	Feet.
1. Reddish loam, grading down into yellowish argillaceous and somewhat calcareous sand	8
2. Buff sandy clay with a few small bivalves (Leda, Mactra, and the like) and scattered leaf impressions	5
3. Laminated brown clay and buff sand with ferruginous concretions toward the top	10
4. Dark lignitic clay	2
5. Lignite	2
6. Gray and buff laminated sands and thin laminæ of bluish clay with a few leaf impressions and more or less comminuted vegetable matter, exposed about	17

Few fossil plants occur in this section, and these as a rule are poorly preserved, as seems to be the case with all the remains of this sort around Cross Bayou. A small collection made by Veatch was reported on by Hollick [1] in 1900. I visited this and neighboring outcrops in 1911, but saw no fossils worth collecting. I have had access to the original collections made by Johnson and determined by Lesquereux,[2] which are now in the United States National Museum, as well as the Harris and Veatch collection, preserved at the New York Botanical Garden.

The following is a revised list of the species from this outcrop:

Cinnamomum postnewberryi.
Cyperites sp.
Ficus planicostata maxima.
Ilex sp.
Poacites sp.

Vineyard Bluff, about half a mile above Slaughter Pen Bluff to the west, on Cross Bayou, is an outcrop similar in lithology and stratigraphic position. A collection of fossil plants procured from this outcrop by Harris and Veatch is now at the New York Botanical Garden. The following species are represented:

Artocarpus lessigiana.
Cinnamomum postnewberryi.
Ficus harrisiana.
Oreodaphne obtusifolia.
Pteris pseudopinnæformis.

There are several deep wells at Shreveport whose records are incomplete, though they are discussed by Harris in connection with the numerous deep-well records from the near-by Caddo oil field. They show a thickness of Wilcox sediments in northwestern Louisiana of about 450 feet.

The Johnson collections from Cross Bayou came from an old quarry known as Campbells quarry. The matrix is a well-lithified gray sandstone. These forms were tentatively determined by Lesquereux and their critical revision furnishes the following list of species:

Ficus denveriana.
Ficus harrisiana.
Hicoria antiquorum.
Mespilodaphne pseudoglauca.
Nectandra lancifolia.
Rhamnus cleburni.
Sapindus formosus.
Terminalia hilgardiana.

A similar gray sandstone is exposed in a cut of the Kansas City Southern Railway 1 mile west of Shreveport and only a short distance south of Cross Bayou. It contains much fragmentary leaf material, among which *Sapindus mississippiensis* Berry has been recognized.

COUSHATTA, RED RIVER PARISH.

Red River has impinged on the Eocene beds at Coushatta, where they are exposed in low bluffs along the left (east) bank from a point below the town to Coushatta Bayou, three-eighths of a mile above the town. The following section is taken from Veatch and represents the condition in 1898, when the bulk of the fossil plants were collected. The river is rapidly eroding these cliffs, and they are said to have receded about one-fourth of a mile between Veatch's visit in 1898 and my visit in 1911. The section exposed at present is substantially that as quoted below, except that the iron concretions are much poorer in plant remains. I split open all that were exposed without obtaining anything noteworthy. The section is as follows: [3]

[1] Hollick, Arthur, Louisiana Geol. Survey Rept. for 1899, pp. 276-288, pls. 32-48, 1900.
[2] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 11, pp. 24-25, 1888.
[3] Veatch, A. C., op. cit., p. 200.

Section exposed on Red River near Coushatta, La.

	Feet.
1. Soil grading into orange, buff, or gray sand, stratified and more or less cross-bedded, with scattered clay pellets and laminæ	20
2. Brown laminated clay with thin gray sand partings, becoming nearly black below and containing poor casts of Leda, Nucula, Lucina, and Venericardia near the base	10
3. Brown laminated clay with two or three courses of iron concretions, many of them large and containing impressions of leaves	20
4. Black laminated clay with gypsum crystals	6
5. Dark sand with a few thin layers of black clay	3
6. Black laminated sandy clay with gypsum crystals, exposed	3

The fossil plants come from bed No. 3 and, as previously stated, were not abundant at the time of my visit, but Veatch made some remarkably fine collections from these concretions in 1898, which are preserved at the New York Botanical Garden. These were reported on by Hollick[1] in 1900. I have restudied these collections, and the following is a revised list of the 31 determinable species:

Apocynophyllum sapindifolium.
Artocarpus dubia.
Artocarpus lessigiana.
Artocarpus pungens.
Celastrus taurinensis.
Celastrus veatchi.
Cinnamomum buchii.
Cornus studeri.
Cryptocarya eolignitica.
Dillenites microdentatus.
Dillenites ovatus.
Euonymus splendens.
Ficus artocarpoides (?).
Ficus denveriana.
Ficus schimperi.
Fraxinus johnstrupi.
Ilex (?) affinis.
Inga laurinafolia.
Juglans berryi.
Juglans schimperi.
Magnolia angustifolia.
Mespilodaphne coushatta.
Mespilodaphne eolignitica.
Nectandra pseudocoriacea.
Oreodaphne coushatta.
Oreodaphne mississippiensis.
Oreodaphne pseudoguianensis.
Persea longipetiolatum.
Rhamnus coushatta.
Sapindus coushatta.
Terminalia hilgardiana.

NABORTON, DE SOTO PARISH.

Extensive oil developments in De Soto Parish, in western Louisiana, begun since the bulk of this manuscript was prepared, have resulted in large collections of fossil plants. These plants were collected by G. C. Matson, O. B. Hopkins, L. C. Chapman, and E. H. Finch from a large number of localities within a few miles of the town of Naborton. According to these geologists the plants were found in the upper part of the section of the Wilcox of western Louisiana and their determination of the geologic horizon is strikingly confirmed by a study of the flora. I am indebted to Messrs. Matson and Hopkins for the following composite section:

[1] Hollick, Arthur, op. cit.

Composite section of Wilcox formation near Naborton, De Soto Parish, La.

Section 1 mile southwest of Zion Hill.

	Feet.
Sand, medium grain, varying in color from orange through yellow to gray	22
Sand, medium grain, pure, orange colored	17
Sand, same as below, with small pebbles of light-gray shale	13
Sand, medium grain, pure, orange to yellow	5
Lignite and bone	1
Sand	10
Clay, red	2
Sand	5
Shale, arenaceous, gray, weathering to red clay	7
Sandstone, concretionary, forms prominent hard layers	1
Shale, arenaceous or laminated sandy clay; weathers to fine sandy sticky, deep red clay	20
Concretionary layer, calcareous sandy, persistent	1
Shale, arenaceous, grading upward into clay and carbonaceous clay and laminated sandy clay, containing fossil leaves at top	24

Section 1 mile southeast of Naborton.

Sandstone, hard, ferruginous, with fossil leaves	1
Clay, stiff, red, granular	25
Lignite and carbonaceous shale	2
Shale, arenaceous, weathering to red clay	10
Shale, gray, arenaceous, some with carbonaceous layers below	13
Sand, hard, medium grain, yellow	8
Sandstone, hard, ferruginous	2
Shale, arenaceous, or laminated gray clay, with large concretions and carbonaceous below	15
Shale	2
Sandstone, hard, ferruginous	2½
Sandstone, soft, grading into arenaceous shale below	9½

	Feet.
Shale, dark gray, with sandy layers	6
Shale, arenaceous, gray	2
Sandstone and shale, ferruginous pebbles and concretions	5
Sandstone, medium grain, soft, yellow	3
Shale, sandy, fine grained, gray	6

Part of the log of a well near Naborton.

Gumbo	18
Sand and bowlders	4
Gumbo	7
Shale and rocks	123
Shale, gumbo, and rock	259
Gumbo and bowlders	45
Base of Wilcox (?).	
	696

The top of the Wilcox is not shown in this section, but it is exposed, and the overlying Claiborne has been recognized farther south, near Natchitoches. The whole Wilcox in this vicinity is about 800 feet thick, and the fossil plants around Naborton are found in a zone commencing at a horizon 542 feet above the base of the Wilcox and extending about 120 feet upward.

The following forms have been identified:

Anona ampla.
Anona eolignitica.
Anona wilcoxiana.
Apocynophyllum tabellarum.
Apocynophyllum wilcoxense.
Araceæites friteli.
Artocarpus dubia.
Artocarpus pungens.
Bombacites wilcoxianus
Cinnamomum affine.
Cinnamomum oblongatum.
Conocarpus eolignitieus.
Cornus studeri.
Cupanites eolignitieus.
Dillenites microdentatus.
Dryophyllum amplum.
Dryophyllum tennesseensis.
Ficus harrisiana.
Ficus neoplanicostata.
Ficus planicostata maxima.
Ficus pseudopopulus.
Juglans schimperi.
Lygodium binervatum.
Magnolia angustifolia.
Meniphylloides ettingshauseni.
Menispermites wilcoxensis.
Mespilodaphne pseudoglauca.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Nectandra puryearensis.
Nectandra sp.
Nyssa wilcoxiana.
Oreodaphne coushatta.
Oreodaphne mississippiensis.
Oreodaphne obtusifolia.
Persea longipetiolatum.
Pistia wilcoxensis.
Proteoides wilcoxensis.
Prunus nabortensis.
Pteris pseudopinnæformis.
Rhamnus coushatta.
Rhamnus eolignitieus.
Sabalites grayanus.
Sapindus formosus.
Sapindus linearifolius.
Sophora wilcoxiana.
Sterculia puryearensis.
Sterculiocarpus eocenicus.
Terminalia hilgardiana.
Terminalia lesleyana.
Ternstrœmites ovatus.
Vantanea wilcoxiana.
Zamia (?) wilcoxensis.

Fifty-three species are enumerated in the foregoing list. Eight are peculiar to this area and three range from the base to the summit of the Wilcox. The only form characteristic of the lower Wilcox is the doubtfully determined Lygodium. There are 3 species which in the eastern Gulf area are confined to the lower and middle Wilcox, 16 which are confined to the middle Wilcox, and 12 which are confined to the upper Wilcox. It is obvious that the horizon is very near that of Puryear, Tenn., namely, at the top of the middle Wilcox. The flora shows an almost entire absence of Leguminosæ and a surprising number of Lauraceæ.

The section derives its chief importance from the fact that the stratigraphic interpretation and the paleobotanic evidence corroborate each other in showing that in this part of the western Gulf area approximately 500 feet of earlier Wilcox sediments are transgressed by later Wilcox deposits, thus corroborating the interpretation of the geologic history presented elsewhere (pp. 36–38).

SECTIONS IN TEXAS.

OLD PORT CADDO LANDING, HARRISON COUNTY.

The following section at Old Port Caddo Landing, in Harrison County, Tex., is given by Vaughan:[1]

[1] Vaughan, T. W., Am. Geologist, vol. 16, pp. 304, 305, 1895.

Section at Old Port Caddo Landing, Harrison County, Tex.

	Feet.
1. Irregularly stratified sands and clay; about	10
2. Reddish, more or less cross-bedded sands with limonitic geodes and silicified wood	50
3. Sands with bowlders and more or less contorted masses of clay	10–15
4. Interbedded grayish sands and bluish clays with small seam of lignite	55–60
5. Impure lignite bed, commonly replaced by iron carbonate, ironstone, or impure limestone, and containing plant remains	2
6. Thinly laminated, bluish clay and sand; exposed	13

A collection was made by Vaughan from bed No. 5, which was tentatively identified by Knowlton.[1] His list has already been reproduced. As revised in the light of the present extensive Wilcox collections it furnishes the following forms:

Apocynophyllum tabellarum (?).
Asplenium eolignitica.
Canna eocenica.
Cinnamomum affine.
Combretum ovalis.
Dryophyllum moori.
Ficus planicostata maxima.
Ficus schimperi.
Ficus vaughani.
Grewiopsis tennesseensis.
Meniphylloides ettingshauseni.
Metopium wilcoxianum.
Nectandra lancifolia.
Nectandra sp.
Oreodaphne obtusifolia.
Persea longipetiolatum.
Sabalites grayanus.
Terminalia hilgardiana.

None of these are species peculiar to the Ackerman formation or lower Wilcox of the eastern Gulf region; 3 occur in the Ackerman formation and the Holly Springs sand; 2 are known only from the Holly Springs sand; 1 is found in the Ackerman formation and Holly Springs sand as well as in post-Wilcox deposits; 1, the characteristic *Meniphylloides ettingshauseni*, is peculiar to the Grenada formation or uppermost Wilcox. The conclusion is inevitable that the deposits at Port Caddo are of late Wilcox age.

SABINE RIVER, SABINE COUNTY.

The section of the Wilcox strata exposed along Sabine River from the vicinity of Rock Bluff to a point below Sabinetown is of considerable interest, because it may be taken as typical of the Wilcox in the western Gulf region. The details were described in 1902 by Veatch.[2] Leaf remains are reported from calcareous concretions just below Harts Bluff on the Louisiana bank. A short distance below Hamilton and just above Chambers Ferry similar materials carry leaf impressions, and a small amount of rather poor material was collected. This was deposited at the New York Botanical Garden, where I have studied it. The only identifiable forms are *Grewiopsis tennesseensis* Berry, which also occurs south of Grand Junction, Tenn., and *Leguminosites? arachioides* Lesquereux of the Denver and Fort Union formations of the Rocky Mountain province. The section as given by Veatch[3] shows a bluff about 125 feet high, the upper 70 feet of which was concealed. The lower 56 feet consist of gray and light-yellow, slightly cross-bedded sands carrying large calcareous concretions that contain scattered fragments and more or less distorted leaves. This outcrop is 7 or 8 miles along the dip above Sabinetown, where, according to Harris, the marine fossils indicate the Bashi formation. The fossil plants, though too few for precise correlation, indicate a horizon not older and probably younger than the Holly Springs sand or middle Wilcox of Mississippi.

CALAVERAS CREEK, WILSON COUNTY.

Alexander Deussen discovered an outcrop containing Wilcox plants on Calaveras Creek about 500 yards east of the San Antonio & Aransas Pass Railway in Wilson County, Tex. The section shows the following sequence of materials:

[1] Vaughan, T. W., op. cit., p. 308.

[2] Veatch, A. C., The geography and geology of the Sabine River, La.: Louisiana Geol. Survey, pt. 6, pp. 107-127, 1902.

[3] Op. cit., p. 123.

Section on Calaveras Creek, Tex.

	Feet.
Pleistocene:	
Yellow loam	5
Covered	4
Deposits regarded by the author as belonging to the Wilcox group:	
Gravel	5
Yellow stratified sand	4–10
Compact laminated, brown to gray clay with fossil plants	0– 6

The small clay lens at the base of the section contains much comminuted vegetable matter and rather poorly preserved impressions of leaves, among which the following are recognizable:

- Bumelia pseudotenax (?).
- Calycites ostryaformis.
- Cassia bentonensis.
- Diospyros brachysepala (?).
- Ficus vaughani.
- Gleditsiophyllum eocenicum.
- Mespilodaphne eolignitica.
- Rhamnites berchemiaformis.
- Sabalites grayanus.
- Sapindus bentonensis.
- Sapindus linearifolius.
- Terminalia lesleyana (?).

Of these 12 species 2 are new and therefore without stratigraphic significance. In comparison with the floras of the Wilcox of the eastern Gulf area it may be noted that none of the species from Calaveras Creek are confined to the Ackerman formation or lower Wilcox. Three species are confined to the Ackerman formation and Holly Springs sand; 1 to the Holly Springs sand; and 6 to the Holly Springs sand and Grenada formation. It seems evident that the outcrop is of about the same age as those at Benton and Malvern in Arkansas, or somewhat younger, and is certainly not older than the Holly Springs sand or middle Wilcox of Mississippi. This conclusion receives confirmation from the single species *Dillenites texensis* Berry, described from near Pope Bend on Colorado River in Bastrop County, which occurs elsewhere only at the top of the Wilcox at Grenada, Miss.

LOCAL DISTRIBUTION OF THE WILCOX FLORA.

The following table shows the local distribution of the species described in this work that comprise the Wilcox flora:

Distribution of the Wilcox flora.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois	Arkansas.						Louisiana.					Texas.			
	Grenada formation, Grenada.	Ackerman formation, Colemans Mill.	Ackerman formation, De Kalb-Herbert road.	Holly Springs sand, Oxford.	Holly Springs sand, Lamar.	Ackerman formation, Hurleys.	Holly Springs sand, Holly Springs.	Holly Springs sand, Early Grove.	Grand Junction.	La Grange.	Baughs Bridge.	Somerville.	Shandy.	Pinson.	Henry.	Puryear.	Lagrange formation, Boaz.	Lagrange formation, Wickliffe.	Lagrange formation, Mound City.	Boydsville.	Gainesville.	Hardys Mill.	Bolivar Creek.	Benton.	Malvern.	Shreveport.	Friersons Mill.	Coushatta.	Mansfield.	Naborton.	Old Port Caddo Landing.	Sabine River.	Colorado River.	Calaveras Creek.
Phylum Thallophyta. **Class Fungi.** **Order Pyrenomycetes (?).**																																		
Cænomyces laurinea				×																														
sapotæ				×																														
pestalozzites	×			×																														
annulata									×																									
cassiæ									×																									
myrtæ				×																														
Phylum Pteridophyta. **Class Lepidophyta.** **Order Lycopodiales.** **Family Lycopodiaceæ.**																																		
Lycopodites (?) eolignitius								×																										
Class Filices. **Order Filicales.** **Family Schizæaceæ.**																																		
Aneimia eocenica																×				×									×					
Lygodium binervatum						×																								?				
Family Polypodiaceæ.																																		
Meniphylloides ettingshauseni	×																													×	×			
Asplenium eolignitica			×																			×									×			
hurleyensis						×																												
Pteris pseudopinnæformis	×																									×			×	×				
Phylum Spermatophyta. **Class Gymnospermæ.** **Order Cycadales.** **Family Cycadaceæ.**																																		
Zamia (?) wilcoxensis																														×				

Order Coniferales. Family Pinaceæ.																																		
Glyptostrobus europæus				×				×																										
Taxodium dubium														×																				
Taxodium sp									×																									
Arthrotaxis (?) eolignitica																×																		
Cupressinoxylon calli																					×													
Class Angiospermæ. Subclass Monocotyledonæ. Order Graminales. Family Poaceæ.																																		
Poacites sp																										×								
Family Cyperaceæ.																																		
Cyperites sp																										×								
Order Arales. Family Araceæ.																																		
Pistia wilcoxensis																														×				
Araceæites friteli																														×				
Order Arecales. Family Arecaceæ.																																		
Chamædorea danai		×																						×										
Sabalites grayanus	×			×			×				×			×	×	×				×				×		×				×	×			×
Nipadites burtini umbonatus	×																																	
Order Scitaminales. Family Cannaceæ.																																		
Canna eocenica	×			×																											×			
Incertæ sedis.																																		
Phyllites wilcoxensis	×																																	
Subclass Dicotyledonæ. Superorder Choripetalæ. Order Juglandales. Family Juglandaceæ.																																		
Juglans schimperi	×															×		×					×					×		×				
berryi																		×										×						
saffordiana										×																								
Hicoria antiquorum																										×								
Paraengelhardtia eocenica																×																		
Engelhardtia mississippiensis								×																										
puryearensis																×																		
ettingshauseni	×						×	×								×		×						×										
Order Myricales. Family Myricaceæ.																																		
Myrica elæanoides						×			×								×																	
wilcoxensis	×																																	

Distribution of the Wilcox flora—Continued.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois	Arkansas.						Louisiana.					Texas.			
	Grenada formation, Grenada.	Ackerman formation, Colemans Mill.	Ackerman formation, De Kalb-Herbert road.	Holly Springs sand, Oxford.	Holly Springs sand, Lamar.	Ackerman formation, Hurleys.	Holly Springs sand, Holly Springs.	Holly Springs sand, Early Grove.	Grand Junction.	La Grange.	Baughs Bridge.	Somerville.	Shandy.	Pinson.	Henry.	Puryear.	Lagrange formation, Boaz.	Lagrange formation, Wickliffe.	Lagrange formation, Mound City.	Boydsville.	Gainesville.	Hardys Mill.	Bolivar Creek.	Benton.	Malvern.	Shreveport.	Friersons Mill.	Coushatta.	Mansfield.	Naborton.	Old Port Caddo Landing.	Sabine River.	Colorado River.	Calaveras Creek.
Order Fagales. Family Fagaceæ.																																		
Dryophyllum anomalum																×																		
moorii						×												×													×			
tennesseensis	×			×			×					×			×	×	×	×		×										×				
puryearensis	×															×		×																
amplum																														×				
Order Urticales. Family Ulmaceæ.																																		
Planera crenata (?)	×																																	
Family Moraceæ.																																		
Artocarpus lessigiana																										×		×						
pungens	×																							×				×		×				
dubia																										×		×		×				
Artocarpoides wilcoxensis																×																		
Pseudolmedia eocenica																×																		
Ficus pseudolmediafolia																×							×											
puryearensis	×					×										×																		
puryearensis elongata																×																		
wilcoxensis																×	×	×																
myrtifolius							×	×									×	×																
schimperi						×					×					×												×			×			
eolignitica																						×												
vaughani				×												×						×									×			×
monodon	×					×										×																		
harrisiana																										×				×				
occidentalis						×																												
cinnamomoides				×																														
denveriana																		×		×						×		×	×					
pseudopopulus													×			×													×	×				
artocarpoides (?)																												×						
planicostata maxima																×										×				×	×			
planicostata latifolia																										×								
pseudocuspidata																×																		
neoplanicostata																														×				
sp							×																											

Order Proteales. Family Proteaceæ.																																		
Palæodendron americanum				X																			X											
Banksia saffordi	X								X			X				X	X	X																
tenuifolia																X		X		X														
puryearensis																X																		
Proteoides wilcoxensis	X															X														X				
Knightiophyllum wilcoxianum																X																		
Order Aristolochiales. Family Aristolochiaceæ.																																		
Aristolochia wilcoxiana									X																									
Order Polygonales. Family Polygonaceæ.																																		
Coccolobis eolignitica																X																		
uviferafolia																X																		
Order Chenopodiales. Family Nyctaginaceæ.																																		
Pisonia eolignitica																X																		
chlorophylloides						X																												
puryearensis																X																		
Order Ranales. Family Magnoliaceæ.																																		
Magnolia angustifolia																X												X		X				
leei						X										X																		
Family Anonaceæ.																																		
Anona wilcoxiana[a]																X														X				
ampla																X						X				X				X				
eolignitica																X														X				
Asimina leiocarpa						X																												
Family Menispermaceæ.																																		
Menispermites wilcoxensis																														X				
Order Papaverales. Family Capparidaceæ.																																		
Capparis eocenica	X						X	X								X																		
Order Rosales. Family Hamamelidaceæ.																																		
Parrotia cuneata													X																					
Family Rosaceæ.																																		
Chrysobalanus inæqualis	X											X				X																		
eocenica	X															X																		
Prunus nabortensis																														X				
Family Mimosaceæ.																																		
Acacia wilcoxensis				X																														
Inga mississippiensis								X				X																						
laurinafolia																												X						

[a] Occurs near Trenton, Tenn.

Distribution of the Wilcox flora—Continued.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois.		Arkansas.					Louisiana.					Texas.			
	Grenada formation, Grenada.	Ackerman formation, Colemans Mill.	Ackerman formation, De Kalb-Herbert road.	Holly Springs sand, Oxford.	Holly Springs sand, Lamar.	Ackerman formation, Hurleys.	Holly Springs sand, Holly Springs.	Holly Springs sand, Early Grove.	Grand Junction.	La Grange.	Baughs Bridge.	Somerville.	Shandy.	Pinson.	Henry.	Puryear.	Lagrange formation, Boaz.	Lagrange formation, Wickliffe.	Lagrange formation, Mound City.	Boydsville.	Gainesville.	Hardys Mill.	Bolivar Creek.	Benton.	Malvern.	Shreveport.	Friersons Mill.	Coushatta.	Mansfield.	Naborton.	Old Port Caddo Landing.	Sabine River.	Colorado River.	Calaveras Creek.
Family Mimosaceæ—Continued.																																		
Inga puryearensis																×																		
wickliffensis																		×																
Pithecolobium eocenicum																×																		
oxfordensis				×																														
Mimosites inæquilateralis									×																									
lanceolatus									×																									
acaciafolius																×																		
variabilis	×							×	×							×		×																
Family Cæsalpiniaceæ.																																		
Cercis wilcoxiana					×				×																									
Cassia eolignitica								×	×							×													×					
glenni [a]							×	×	×			×						×																
glenni major																×																		
puryearensis																×																		
tennesseensis								×	×																									
lowii	×																																	
mississippiensis	×								×																									
fayettensis					×		×		×							×		×						×										
bentonensis																								×										×
wilcoxiana							×																											
marshallensis								×	×									×																
emarginata							×		×																									
Cæsalpinia wilcoxiana							×	×						×		×																		
Cæsalpinites bentonensis																								×										
mississippiensis							×																											
aculeatafolia																×																		
pinsonensis														×																				
Gleditsiophyllum eocenicum	×															×													×					×
hilgardianum						×																												
fructuosum							×																											
minor																×																		
entadaformis							×																											
ovatum																×																		
constrictum																×																		
ellipticum																×																		

Family Papilionaceæ.																																		
Sophora henryensis																X																		
wilcoxiana	X						X		X							X							X		X					X				
palæolobifolia									X																									
repandifolia																X																		
puryearensis																X																		
lesquereuxi	[a]											X																						
mucronata																X																		
Dalbergia eocenica																X																		
wilcoxiana																X																		
tennesseensis																X																		
monospermoides																X																		
Dalbergites ovatus	X																																	
ellipticifolius	X																																	
Canavalia eocenica	X						X									X																		
acuminata								X								X																		
Leguminosites prefoliatus																X																		
arachioides																													X			X		
wickliffensis																		X																
subovatus																X																		
reniformis																X																		
Order Geraniales. **Family Rutaceæ.**																																		
Fagara eocenica																X																		
puryearensis																X																		
hurleyensis						X																												
Citrophyllum wilcoxianum																X																		
Family Simarubaceæ.																																		
Simaruba eocenica																X																		
Family Meliaceæ.																																		
Carapa eolignitica																X		X																
Cedrela puryearensis																X																		
odoratifolia																X																		
mississippiensis								X																										
wilcoxiana							X									X																		
Family Humiriaceæ.																																		
Vantanea wilcoxiana																X														X				
Family Malpighiaceæ.																																		
Hiræa wilcoxiana																X																		
Banisteria repandifolia																X																		
pseudolaurifolia																X		X																
wilcoxiana									X									X																
fructuosa																X																		

[a] Occurs near Trenton, Tenn.

50243°—16——5

Distribution of the Wilcox flora—Continued.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois	Arkansas.						Louisiana.					Texas.			
	Grenada formation, Grenada.	Ackerman formation, Colemans Mill.	Ackerman formation, De Kalb-Herbert road.	Holly Springs sand, Oxford.	Holly Springs sand, Lamar.	Ackerman formation, Hurleys.	Holly Springs sand, Holly Springs.	Holly Springs sand, Early Grove.	Grand Junction.	La Grange.	Baughs Bridge.	Somerville.	Shandy.	Pinson.	Henry.	Puryear.	Lagrange formation, Boaz.	Lagrange formation, Wickliffe.	Lagrange formation, Mound City.	Boydsville.	Gainesville.	Hardys Mill.	Bolivar Creek.	Benton.	Malvern.	Shreveport.	Friersons Mill.	Coushatta.	Mansfield.	Naborton.	Old Port Caddo Landing.	Sabine River.	Colorado River.	Calaveras Creek.
Family Euphorbiaceæ.																																		
Crotonophyllum eocenicum																X																		
appendiculatum																X																		
Euphorbiophyllum fayettensis									X																									
Drypetes prekeyensis																X																		
prelateriflora							X																											
Order Sapindales. Family Anacardiaceæ.																																		
Metopium wilcoxianum	X															X															X			
Anacardites metopifolia					X		X									X		X																
falcatus																X																		
serratus									X																									
minor																X																		
puryearensis																X																		
marshallensis							X																											
grevilleafolia	X															X																		
Heterocalyx saportana								X																										
Family Ilicaceæ.																																		
Ilex eolignitica							X																											
vomitoriafolia								X																										
affinis (?)																												X						
sp.																										X								
Family Celastraceæ.																																		
Maytenus puryearensis																X																		
Celastrus eolignitica								X	X																									
minor							X																											
taurinensis																												X						
bruckmannifolia							X																											
veatchi[a]								X																				X						
Euonymus splendens					X			X	X				X			X												X					X	
Family Sapindaceæ.																																		
Cupanites eolignitícus																X														X				
loughridgii																		X																
Sapindus pseudaffinis																X																		

oxfordensis	X			X																														
bentonensis																								X										X
mississippiensis	X							X								X		X					X			X								
linearifolius							X	X								X		X		X									X	X				X
formosus	X						X									X		X								X				X				
eoligniticus																X		X																
knowltoni																X								X										
coushatta																												X						
Dodonæa wilcoxiana							X																											
knowltoni																X																		
Order Rhamnales. Family Rhamnaceæ.																																		
Zizyphus falcatus																X																		
meigsii		X		X					X	X						X																		
Paliurus mississippiensis							X	X																										
pinsonensis														X																				
angustus							X																											
Reynosia wilcoxiana																X																		
prænuntia							X									X																		
Rhamnus cleburni	X																									X								
coushatta	X																											X		X				
puryearensis																X																		
eoligniticus													X			X														X				
marginatus						X										X																		
marginatus apiculatus						X																												
Rhamnites berchemiaformis																																		X
Order Malvales. Family Tiliaceæ.																																		
Grewiopsis tennesseensis									X																						X	X		
Family Sterculiaceæ.																																		
Sterculia puryearensis	X															X														X				
Sterculiocarpus eocenicus																											X			X				
sezannelloides																X																		
Family Bombacaceæ.																																		
Bombacites formosus																X																		
wilcoxianus																X														X				
Order Parietales. Family Dilleniaceæ.																																		
Dillenites serratus							X																											
tetracerafolia	X															X																		
ovatus						X																						X						
texensis	X																																X	
microdentatus																												X	X	X				
Family Ternstrœmiaceæ.																																		
Ternstrœmites ovatus	X															X														X				
lanceolatus	X															X																		
eoligniticus																X																		
preclaibornensis																X													X					

[a] Occurs near Trenton, Tenn.

Distribution of the Wilcox flora—Continued.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois	Arkansas.						Louisiana.					Texas.			
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Order Thymeleales. Family Lauraceæ.																																		
Cinnamomum obovatus							×																											
postnewberryi																						×				×								
mississippiensis		×		×																														
affine																													×	×	×			
oblongatum																×														×				
vera				×			×									×																		
buchii																												×						
Persea wilcoxiana																											×							
longipetiolatum																×												×		×	×			
Oreodaphne salinensis																								×	×					×				
mississippiensis [a]							×																		(b)	×		×		×				
coushatta																												×						
pseudoguianensis																×												×						
puryearensis						×										×																		
wilcoxensis																×																		
obtusifolia	×					×	×		×							×										×			×	×	×			
Mespilodaphne puryearensis																×																		
pseudoglauca					×				×							×	×	×								×				×				
eolignitica	×					×					×		×			×										×		×		×				×
coushatta																×						×				×		×	×					
Nectandra glenni									×																									
lancifolia	×	×				×				×	×	×				×										×			×	×	×			
pseudocoriacea	×			×	×	×	×		×		×					×				×				×				×		×				
lowii				×							×									×									×					
puryearensis																×														×				
sp																×														×	×			
Cryptocarya eolignitica																												×						
Laurinoxylon branneri																							×											
Laurophyllum juvenalis																×																		
florum									×																									
preflorum									×																									
Order Myrtales. Family Myrtaceæ.																																		
Myrcia vera				×												×																		
wortheni										×						×			×															
parvifolia																×																		

bentonensis	×			×		×			×							×								×										
puryearensis																×																		
grenadensis	×																																	
Calyptranthes eocenica																×																		
Eugenia hilgardiana						×																												
densinervia												×																						
grenadensis	×																																	
puryearensis																×																		
Family Combretaceæ.																																		
Laguncularia preracemosa							×									×																		
Combretum ovalis						×			×																						×			
obovalis																×													×					
wilcoxensis																×																		
Combretanthites eocenica									×																									
Terminalia lesleyana						×			×							×														×				×
wilcoxiana	×																																	
hilgardiana						×										×										×		×	×	×	×			
Conocarpus eoligniticus																×														×				
Family Hydrocaryaceæ.																																		
Trapa wilcoxensis																×																		
Family Melastomataceæ.																																		
Melastomites americanus	×								×							×													×					
Order Umbellales. Family Araliaceæ.																																		
Aralia notata																					×								×					
acerifolia	×																																	
jorgenseni	×																																	
Oreopanax minor																×																		
oxfordensis				×																				×										
Family Cornaceæ.																																		
Cornus studeri																												×		×				
Nyssa eolignitica																×																		
wilcoxiana																×														×				
Superorder Gamopetalæ. Order Primulales. Family Myrsinaceæ.																																		
Icacorea prepaniculata																×																		
Order Ebenales. Family Sapotaceæ.																																		
Sideroxylon ellipticus																×																		
premastichodendron																×																		
Chrysophyllum ficifolia	×													×																				
Bumelia pseudohorrida																×																		
pseudotenax						×		×																										?
wilcoxiana								×								×																		

[a] Occurs near Lockhart, Miss.

[b] Also obtained from a well near Texarkana.

Distribution of Wilcox flora—Continued.

	Mississippi.								Tennessee (Lagrange formation).								Kentucky.		Illinois	Arkansas.						Louisiana.					Texas.			
	Grenada formation, Grenada.	Ackerman formation, Colemans Mill.	Ackerman formation, De Kalb-Herbert road.	Holly Springs sand, Oxford.	Holly Springs sand, Lamar.	Ackerman formation, Hurleys.	Holly Springs sand, Holly Springs.	Holly Springs sand, Early Grove.	Grand Junction.	La Grange.	Baughs Bridge.	Somerville.	Shandy.	Pinson.	Henry.	Puryear.	Lagrange formation, Boaz.	Lagrange formation, Wickliffe.	Lagrange formation, Mound City.	Boydsville.	Gainesville.	Hardys Mill.	Bolivar Creek.	Benton.	Malvern.	Shreveport.	Friersons Mill.	Coushatta.	Mansfield.	Naborton.	Old Port Caddo Landing.	Sabine River.	Colorado River.	Calaveras Creek.
Family Sapotaceæ—Continued.																																		
Bumelia americana												×				×																		
grenadensis	×																																	
hurleyensis						×																												
Mimusops sieberifolia																×																		
mississippiensis	×																																	
eolignitica						×										×																		
Family Ebenaceæ.																																		
Diospyros wilcoxiana																×																		
brachysepala												×				×																		×
Order Gentianales. Family Oleaceæ.																																		
Fraxinus johnstrupi	×															×												×						
wilcoxiana																×																		
Osmanthus pedatus						×										×																		
Family Apocynaceæ.																																		
Echitonium lanceolatum																×																		
Apocynophyllum sapindifolium	×															×								×				×						
tabellarum				×	×											×				×										×	?			
constrictum																								×										
wilcoxense				×												×													×	×				
mississippiensis	×																												×					
Order Polemoniales. Family Boraginaceæ.																																		
Cordia eocenica																×																		
?lowii						×																												
Order Personales. Family Verbenaceæ.																																		
Citharexylon eolignitcum	×						×																											
Avicennia eocenica																×																		
nitidaformis								×																										

Family Solanaceæ.																																		
Solanites saportana							×																											
Order Rubiales. Family Rubiaceæ.																																		
Exostema pseudocaribæum								×										×																
Psychotria grandifolia																×																		
Guettarda ellipticifolia							×									×																		
Incertæ sedis.																																		
Calycites davillaformis																×																		
ostryaformis																																		×
Antholithus arundites																×																		
marshallensis								×																										
Carpolithus puryearensis																×																		
prangosoides																×																		
henryensis																×																		
grenadensis	×																																	
tennesseensis																×																		
sophorites	×																																	
dictyolomoides																×																		
hyoseritiformis																×																		
proteoides																×																		
pilocarpoides	×																																	

CHARACTER AND ECOLOGY.

COMPOSITION OF THE FLORA.

It is of vital importance that the determinations made in the present study rest on real and not fanciful affinities, for the conclusions presented as to climatic and other physical conditions are largely dependent on the correctness of the identifications. I fully realize that the statistics given under this heading are by no means complete, but I believe that even the imperfect survey here given will be of value not only to paleobotanists and geologists, but to botanists and others interested in the history and the geographic distribution of the higher plants. The problem is not so intricate or so insoluble as it might seem to a student who is strongly impressed by the thousands of living and extinct genera. De Candolle estimated that the living flowering plants included about 250,000 species, and if to this number be added the herbaceous species living in recent geologic times the number would be enormously increased. The ratio of arborescent to herbaceous types was much greater in the Tertiary period than it is now and the trees were probably more abundant and varied than in the existing flora. They certainly were in all Tertiary floras outside the Torrid Zone, as is shown by the Eocene floras of North America, the Miocene floras of Europe, or, to cite an extreme case, the Tertiary floras of the Arctic and Antarctic regions.

Though the arborescent flora of the Temperate Zone is relatively meager the number of species of trees increases toward the Equator. Maryland presents a cross section of the Coastal Plain, Piedmont Plateau, and Allegheny Mountains, regions which exhibit great differences in climate, topography, and soils, and is the meeting ground for plants of northern and southern range, yet it contains only about 150 species of trees. On the other hand, Small's "Trees of Florida" (published in 1913) lists 366 native and naturalized arborescent forms, and if Florida exhibited greater variation in altitude the number would be much larger. The trees of the Philippine Islands, where the range in altitude is much greater, include 665 native species and many additional introduced forms, or more than 10 per cent of the estimated total number of species of flowering plants in the Philippine flora. Even remote oceanic islands, if sufficiently large and sheltered by topographic features from the adverse action of winds, have a large arborescent flora. Thus the Hawaiian Islands have 225 native species of trees, distributed among 45 families, those having the greater number of species being the Rutaceæ (32 species), Rubiaceæ (31 species), Campanulaceæ (15 species), Araliaceæ (14 species), Pittosporaceæ (12 species), Palmaceæ (11 species), Myrsinaceæ (11 species), and Malvaceæ (10 species).[1]

Koorders collected 700 species of trees in the Celebes during a visit of four months. He also says that he has specimens of about 1,200 arborescent species indigenous to the island of Java, or about 25 per cent of the total number of flowering plants in the flora of that island. In an area of only 3 square kilometers on the small island of Kambangan, off the Javan coast, Koorders collected 600 species of trees that illustrate not only the wonderful abundance of arborescent forms in the Tropics but the manner in which unrelated species are mixed, so that pure stands, such as we see in the coniferous forests of the Temperate Zone and also in part in the deciduous forests, are unknown in those regions.

The general physical conditions of a remote geologic epoch may be more or less completely deduced from the character of the sediments. The approximate run-off from the land and consequently the attitude of the land and the probable rainfall, as well as any periodicity in these conditions, are all reflected in the sediments. Work like that of Vaughan[2] on the deposits of the Florida keys or that of Drew[3] on the part played by denitrifying bacteria in the formation of limestones enable a careful paleobotanist to determine in a measure the character of the flora that clothed the marginal lands. In work on deposits that teem with the remains of marine life, as do many of the Tertiary formations of southeastern North America, it is possible to arrive at very close approximations of the temperatures of the coastal waters. It may be safely assumed that boreal or temperate floras did not flourish in proximity to tropical marine faunas and that plants reflected their environment in the past as in the present.

[1] Rock, J. F., The indigenous trees of the Hawaiian Islands, Honolulu, 1913.
[2] Vaughan, T. W., Carnegie Inst. Washington Pub. 133, 1910.
[3] Drew, G. H., Carnegie Inst. Washington Year Book 10, 1911

Many botanists love to dwell on the temerity of the paleobotanists in determining species from impressions of leaves. I admit at the outset that some identifications based on fragmentary materials are altogether too uncertain. There is more or less convergence in foliar characters in unrelated or remotely related families and there may also be considerable variation in the leaves of a single species, but foliar characters in general are more fixed than those of almost any other organs of plants. They are subjected to less complex environmental factors and always have been.

It should be remembered that characters which are less essential to the vital activities of plants, such as the form of the leaf, when once acquired may continue practically unchanged for thousands of years and afford a surer clue to relationship than characters more immediately within the field of action of natural selection. This is shown by the persistence of fern fronds on the Paleozoic pteridosperms, by the uniformity of cycad-like fronds from the Permian to the Cretaceous, and by the striking persistence of dicotyledonous foliar types from the middle Cretaceous to the present. This persistence of type in plants is parallel with the persistence of superficial and ornamental shell characters in the Mollusca from the Cretaceous to the Recent, as noted by Dall.

In the Tropics, where flowers and fruits are often unobtainable or beyond reach, it is easy to learn to recognize most trees by their habit and foliage, but most botanists, systematic or otherwise, give little attention to anything beyond floral structure.

It is reasonable to conclude that palms and tree ferns are not boreal plants that were in the course of ages restricted to the Tropics, as Naumayr once suggested, in an effort to explain their presence within the Arctic Circle on other than climatic grounds. Uniformity of cause and effect is the foundation upon which rests the whole fabric of our knowledge of past events, and it is just as unscientific to assume that the carrying power of water was not conditioned by its velocity during the Tertiary period as it is to assume that insolation, humidity, rainfall, winds, and all the other factors that constitute the environment of the vegetation had effects on the flora of past ages different in kind from their effects on the living flora.

In a study like this the chief emphasis should be based on comparisons with the existing relatives of the fossil forms and not on the study of previously described forms, many of them from remote regions, in the search for species that appear to be similar. Correlation with previously described paleobotanic forms should not be neglected, however, and no descriptions are complete unless they include a discussion of the resemblances and differences of fossil forms that show similarities together with their geologic and geographic distribution. Even the most trivial characters of the fossil should be carefully noted, for all these characters are valuable in future studies. The living representatives, their habitat, range, and variation are of the greatest importance in determining what may be called paleoecology.

It may be assumed that strand plants and upland plants will not be found in association without clear evidence of transportation, and if such seems to be the case additional study may reveal the errors of determination.

The facts that all floras are dynamic and not static, that all their elements are more or less plastic in their reactions to the infinite complexity of their environment, raise some doubt with regard to the methods and results of paleoecology, especially as so little is known regarding the precise relations between existing plants and their environment. At the same time the method used is the only one available and it must be considered to be a legitimate method until negatived in human experience. If it be assumed incorrect, there is no limit to idle speculations as futile as those of medieval times.

The Wilcox flora as described in the present study comprises considerably more than 300 species; the exact number is without significance, since it is so largely dependent on accidents of preservation and discovery and since it is also considerably influenced by the evaluation of specific characters. The number might readily be increased to 400 if fragments of new forms were considered the basis for the description of species.

This flora is therefore one of the largest floras yet known from a single geologic horizon in a single area, although it is considerably smaller than the so-called Fort Union flora of the Rocky Mountain province, which, however, covers a greater geographic area and a longer interval of time.

In comparison with foreign Eocene floras of similar age it may be noted that Ettingshausen enumerated 72 genera and 200 species from the London clay of the Isle of Sheppey[1] and 116 genera and 274 species from Alum Bay, on the Isle of Wight.[2] I mention these two English floras specifically, because though never adequately described they are at least partly contemporaneous with that of the Wilcox, as I hope to show in the chapter on correlation, and they therefore offer interesting details for comparison, as will subsequently appear.

The Wilcox flora comprises 134 genera in 63 families and 37 orders. The Thallophyta are represented by a few species of leaf-spot fungi, but if the student were to follow the fashion set by the older European paleobotanists the so-called species of spot fungi could be increased many fold, for I have only picked out for enumeration certain conspicuous or characteristic types. The Bryophyta, as is the rule in fossil floras, are entirely unrepresented, although the sediments in many places would have preserved them in perfection if they had been present, and the assumption is logical that they were either confined to more northern latitudes at this time or were an exceedingly minor element in the flora. The Pteridophyta, which are such a preponderating element in all fossil floras up to the middle Cretaceous, are represented by a doubtfully determined lycopod and six species of ferns.

Of the vascular plants in the flora of tropical America, ferns are among the most abundant in specific differentiation, those of the island of Jamaica being especially numerous. Grisebach enumerated 340 species of ferns in his "Flora of the British West Indies," published in 1864. In Urban's more recent work 182 species of the Polypodiaceæ alone are recorded from Porto Rico. The five genera Aneimia, Lygodium, Asplenium, Pteris, and Meniphylloides have been recognized in the Wilcox, each represented by a single species, except the genus Asplenium which has two species. Though six species seems a small number of ferns in a subtropical flora like that of the Wilcox, it is just twice as many as have been found in the contemporaneous deposits of Alum Bay on the Isle of Wight, where the remains of an extensive flora are preserved in the pipe clays. The explanation of this seeming disparity between the abundance of the ferns in the lower Eocene and in the modern floras is readily formulated and it also indicates the reasons for thinking that the Wilcox fern flora if it were available for study would be rich and varied, comparable at least with the existing fern flora of the lowlands of subtropical America.

The known Wilcox flora is almost entirely a coastal flora, made up very largely of strand types. Very few elements in it can be properly considered as derived from inland areas by stream transportation. In fact the condition of preservation of most of the plants proves that they grew in the immediate vicinity of the places where they are now found as fossils. With a few striking exceptions the existing tropical and subtropical fern floras are floras of humid inland or upland habitats. For example, most of the Jamaican ferns are found on the Blue Mountains. The most striking exception to this statement is the genus Acrostichum, which strangely enough has not yet been positively recognized in the Wilcox flora, although it was widespread along the shores of the Mississippi Gulf in the succeeding middle Eocene (Claiborne) and lower Oligocene (Vicksburg) floras, as abundant apparently as it is in the existing flora of tropical tidal marshes in both the Eastern and the Western hemispheres. Another fern type likely to appear in coastal thickets is the genus Lygodium, of scandent habit, and this genus is represented in the Wilcox flora by both sterile and fertile fronds. It is likewise common in the Claiborne and Vicksburg floras and in Tertiary floras generally. Beside Lygodium the family Schizæaceæ is represented by a species of Aneimia, which must also be considered to have been a coastal type in the early Eocene as are some of its species at the present time, since very similar species of Aneimia are found in a large number of Eocene coastal deposits both in this country and abroad.

The remaining four species of Wilcox ferns are all referable to the family Polypodiaceæ, which is the dominant existing family of the fern phylum. The two species of Asplenium are types readily matched by existing Central American species. The Pteris, not certainly identified as a true species of this common

[1] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 29, pp. 388-396, 1879.

[2] Ettingshausen, C. von, idem, vol. 30, pp. 228-236, 1880.

cosmopolitan type, had stout coriaceous fronds and may have been transported, since it occurs at only two localities in the Wilcox, and at one of these it is in a fragmentary condition. This supposition receives some support from its presence in the basal Eocene of the Rocky Mountain province after the sea had withdrawn from that area and after there had been a large amount of volcanic activity and more or less uplift. The genus Meniphylloides is a unique type, as yet peculiar to the Wilcox flora, although it is closely related to the similarly unique genus Meniphyllum Ettingshausen and Gardner, from the middle Eocene (Lutetian) of England, and both are closely related to and possibly the progenitors of the existing genus Meniscium, which has at least one species that is close to the Wilcox form. Meniphylloides is found at only three localities near the top of the Wilcox and its probable habitat is not known. The remains are broken but are associated with a typical strand flora.

It will be seen that of the Wilcox ferns whose habitats can be surmised all are coastal types, and when we recall that the mainland was relatively low throughout Wilcox time it is not surprising that the ferns are scarce. By a specialization of habitat in modern equatorial regions a large part of the flora becomes epiphytic, the smaller ferns being commonly so. None of the members of the extensive Wilcox flora can be regarded as epiphytes with the possible exception of *Lycopodites? eoligniticus*, which is such a rare and poorly represented form that it is without significance. Apparently epiphytes were not conspicuous in the Wilcox coastal floras, so that this possible source of additional fern species is also eliminated.

The Gymnospermæ, so conspicuous in Mesozoic floras, are relatively unimportant, both in species and individuals, in the Wilcox flora, a feature due to their general relative unimportance in Cenozoic floras and to their intolerance of the habitats and climatic conditions indicated by the Wilcox flora as a whole. Four Wilcox gymnosperms are referred to the relatively modern family Pinaceæ and none of the genera are especially close to Mesozoic types.

These Pinaceæ include the following: Somewhat poorly defined petrified wood which does not merit especial comment, representing the genus Cupressinoxylon of Göppert. The genus Glyptostrobus, which contains but two surviving species in the river bottoms of eastern Asia, is represented by foliage and seeds referred to *Glyptostrobus europæus* (Brongniart) Heer. This species is exceedingly common at a large number of localities and horizons in the northern hemisphere throughout the Tertiary period. In North America it is represented from the basal Eocene to the Pliocene, and though it probably includes more than one botanic species no basis for its segregation except by geographic or geologic divisions is discernible. The genus Taxodium is sparingly represented by foliage and seeds. The leaves are referred to *Taxodium dubium* (Sternberg) Heer, a species whose distribution and geologic range are as wide as that of *Glyptostrobus europæus*. It is found in North America from the base of the Eocene to the Miocene Chesapeake group and in the Pliocene of the Gulf coast it passes insensibly into the Pleistocene and still existing bald cypress. Arthrotaxis, still living in the mesophytic areas of Tasmania, is represented by cone scales. No traces of the genera Sequoia or Podocarpus have been discovered.

Though gymnosperms are so poorly represented in the lower Eocene of the embayment area they are not without significance.[1] The fact that they are so uncommon there, whereas in more northern Eocene floras they are so abundant, seems to show that the Wilcox climate was unfavorable. The only possible adverse condition which the flora of the Wilcox as a whole indicates is too warm a temperature, which, if correctly interpreted, indicates at least some development of climatic zones in the lower Eocene. The habitats of Glyptostrobus and Taxodium in the lower Eocene were apparently the same as those of the existing species, and they thus confirm the predicated character of the physical conditions in Wilcox time. Both genera are only known from the Holly Springs sand or middle Wilcox, which was deposited at a time when the coastal region stood at about sea level and was traversed by sluggish meandering streams. The Glyptostrobus twigs are found in the estuary of a middle Wilcox river, associated with unios and thickets of Sabalites. The Taxodium

[1] The petrified woods from the Wilcox were not sectioned in time to be described in this report. A number are coniferous, and that conifers were more abundant during Wilcox time than their foliage remains have indicated is also shown by the canneloid lignite from Lester, Ark., described by White (Bur. Mines Bull. 38, p. 19, 1913), which is largely made up of resin concentrated by the decay of coniferous woods. Pollen exines of conifers are also reported from the Wilcox lignites at Lester by Thiessen (idem, p. 234).

occurs in a region of bayous and lagoons, as shown by the sediments.

The Cycadaceæ, which were practically cosmopolitan during the Mesozoic era, are almost unknown in the Tertiary period, despite the fact that there are 9 still existing genera together containing over 100 species. The Tertiary records include a doubtfully determined Zamites from the Heersian of Belgium, an Oligocene species from southeastern France, an early Tertiary species from Chile, a late Oligocene Encephalartos-like form from Greece, and two poorly defined species from the Miocene of Switzerland. The Wilcox land would seem to have furnished ideal conditions for Zamia-like forms, but material of this sort is very rare and is confined to the later Wilcox of the western embayment area. This scanty material is very similar to the existing *Zamia pumila* Linné, a small species with an underground stem common in the hammocks of the east coast of Florida. The genus contains about 30 existing species confined to the tropic and subtropic regions of America.

The Angiospermæ, decidedly the dominant class in existing floras, was as clearly dominant in Wilcox time, since to it belongs more than 94 per cent of the known Wilcox flora. Of these numerous angiosperms only nine are referable to the Monocotyledonæ. It is true that the number of monocotyledons might have been increased by describing the various sedge or grasslike fragments that are not uncommon at certain localities. However, none of these fragments have been dignified by names except a single form each of Poacites and Cyperites, which were retained only because they were already in the literature. That only three species of palms have been recognized is remarkable, for palms were well differentiated at this time and genera such as Phœnicites, Thrinax, Geonoma, Bactrites, and Manicaria are recognized in the later Tertiary deposits. Of the 30 monocotyledons named by Ettingshausen[1] in the contemporaneous deposits of Sheppey 22 species are palms. On the other hand, the contemporaneous Alum Bay flora, which comes from a locality not far distant from that of the Sheppey deposits, furnishes only 6 monocotyledons. This contrast indicates that the fruits which accumulated at Sheppey in the delta of an Eocene river system contain interior forms not present in the coastal region, represented by the Alum Bay clays, and that inland from the Wilcox coast monocotyledons suitable to the Wilcox environment flourished but were not preserved as fossils.

Since the early Eocene floras of Europe are so much like those of southeastern North America an enumeration of the Sheppey palms is of considerable interest. They include the genera Nipa, Œnocarpus, Areca, Iriartea, Livistona, Sabal, Chamærops, Thrinax, Bactris, Asterocaryum, and Elæis. Of these Nipa and Sabal are represented in the Wilcox and Thrinax and Bactrites are present in the embayment area in the middle Eocene (Claiborne). The order Palmales, or more properly Arecales, has a single existing family, the Arecaceæ (Palmæ), with about 150 genera and considerably more than a thousand existing species, about equally divided between the oriental and occidental tropics. There are no temperate outliers, although some species extend far into the Temperate Zone, as for example *Sabal adansonii*, which ranges northward along the Atlantic coast as far as North Carolina. The present distribution of the palms is a good illustration of modern continental floral diversities succeeding a Tertiary cosmopolitanism of floras, and it shows further the part played by isolation in evolution, which is also indicated by the abundance of monotypic genera in the Orient, where the tropical area is so much broken. Not a single species or genus is common to the two hemispheres and even the tribes are almost all either oriental or occidental.

Most students regard the Pandanaceæ (screw pines) as the probable ancestral stock of the palms, and though the screw pines are entirely oriental now, they were not so in the Tertiary, and it is perhaps significant that the existing genus Phytelephas, which is regarded as intermediate between the Pandanaceæ and the Arecaceæ is exclusively American, and that genera now exclusively oriental are represented in the American Tertiary, Nipa in the Wilcox and Phœnix in the Vicksburg. There is no warrant for the assertion that palms are of occidental origin, but their oriental origin is equally difficult of proof, and what we know of their geologic history clearly shows that their existing distribution throws little light on their phylogeny.

[1] Roy. Soc. London Proc., vol. 29, p. 393, 1879.

The three Wilcox species of palms comprise a fan palm and two feather palms. The Chamædorea leaves represent a small palm whose numerous modern allies are confined to America. Most of its species are found in the humid mountainous regions of Central America, though it is also present in coastal floras, as along the Atlantic coast of the Isthmus of Panama. It is not, however, a strictly coastal form and is not found in association with the typical Wilcox strand flora, for it occurs only in the basal Wilcox (Ackerman formation) of Choctaw County, Miss., and at the base of the transgressing upper Wilcox deposits in Saline County, Ark. Its rarity and occurrence in basal beds indicates that its area of growth was inland and only reached in these two localities by the landward migration of the strand line. The Sabalites, which I have compared with the existing *Sabal palmetto*, is common everywhere from the base to the top of the Wilcox. It is distinctly a coastal type, rather of the lagoons, bayous, and estuaries than of the strand. This fact is indicated by the fragmentary nature of the remains at many localities and the occurrence of innumerable complete specimens at other localities, as at Oxford, Miss., where the presence of unios and the local unconformities indicate an estuary.

The nipa palm, found in the Grenada formation or upper Wilcox, is clearly an inhabitant of muddy tidal shores, so that it would naturally be expected in the laminated clays of the upper Wilcox. Its single modern representative is tolerant of water of considerable salinity and is a member of the mangrove association of the Orient. It shows many points of affinity with the Pandanaceæ and has never before been found in the Western Hemisphere. Like so many forms which are strictly oriental in the existing flora, such as Cinnamomum, Artocarpus, and Phœnix, it enjoyed a cosmopolitan range during at least the earlier half of the Tertiary period.

A rather full account of Nipa, including a map showing its Recent and Tertiary distribution, has been recently published.[1]

The single species of Canna of the Wilcox represents a strictly hygrophilous type, which is confined to America in the existing flora. It is an inhabitant of estuary and river swamps near the coast, and that the Wilcox species inhabited a similar situation is indicated by the small area in which it is found and its association with Sabalites near the mouth of a Wilcox river, which on other grounds is known to have traversed Lafayette County, Miss.

The order Arales (Spathifloræ of Engler) is a distinct and diversified group of monocotyledons that comprises more than a thousand existing species, most of them belonging to the family Araceæ. The kindred family, Lemnaceæ, which consists of smaller forms, all aquatic, comprises but few species, which, however, have a very wide distribution. The distinctive features of the plants comprising these allied groups are the differentiation of the leaves into stalk and blade; the netted venation of the blade; certain anatomical differences; and the combination of the flowers into a spadix. The floral structure is varied, ranging from 2-merous to 4-merous, pentacyclic, syncarpous forms such as Calamus, with its bract-like spathe, to the more abundant bisporangiate forms with obsolete perianth and a much developed petaloid spathe specialized for entomophily.

The Araceæ are cosmopolitan, but most of the forms are found in the Tropics, massed in South America and the southeastern Asiatic region. There is little evidence that the main differentiation of the aroids was not relatively modern, although Pistia is found in the lower beds of the Upper Cretaceous of both North America and Europe. The only known Tertiary species are a well-marked form in the Grenada formation or upper Wilcox, evidently of estuarine habitat, and a species in the overlying Claiborne Eocene. The species in the upper Wilcox represented by a spadix, *Aracexites friteli*, is comparable with those of the existing South American genera Spathiphyllum and Monstera, and indicates the existence of swamps in the western embayment.

The Dicotyledonæ, as might be expected, are largely choripetalous forms. There are over 250 species of Choripetalæ (Archichlamydeæ) and only 34 species of Gamopetalæ (Sympetalæ). At the same time the representation of Gamopetalæ is really much larger than might be expected thus early in the Eocene, and many families often thought to be relatively more modern are represented.

The following orders of Choripetalæ are not represented in the Wilcox flora: Casuarinales, Piperales, Salicales, Balanopsidales, Leitneriales, Santalales, Sarraceniales, and Opuntiales.

[1] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 37, pp. 57-60, fig. 1, 1914.

The absence of the Balanopsidales, Sarraceniales, and Opuntiales is not remarkable, since they are all specialized types and the rather uniform habitats of the cacti and their relatively modern evolution both conspire to eliminate them from Eocene coastal floras. The presence of the primitive Casuarinales and Piperales might be expected, especially since there is a well-marked Piper-like form in the Upper Cretaceous of Alabama. The Salicales, though prevailingly temperate forms, are abundantly represented in the Upper Cretaceous floras of the embayment area, and the Santalales have also been recorded from the American Upper Cretaceous and are present in the European Tertiary.

Those alliances of Gamopetalæ which are not present in the Wilcox are mainly the great modern and Temperate Zone groups. For example, there are no Wilcox species of Ericales, Labiatæ, Convolvulaceæ, Bignoniaceæ, Scrophulariaceæ, Plantaginales, Valerianales, or Campanulales, thus proving not only the essential modernness of the evolution of the Compositæ but firmly establishing the subtropical rather than temperate character of the Wilcox flora. The fruit described as *Carpolithus hyoseritiformis* is probably referable to the Compositæ.

The larger families of the Dicotyledonæ in the Wilcox flora are the following: Lauraceæ (30 species), Cæsalpiniaceæ (26 species), Moraceæ (23 species), Papilionaceæ (22 species), Rhamnaceæ (14 species), Sapindaceæ (13 species), Sapotaceæ (12 species), Myrtaceæ and Mimosaceæ (11 species each), Combretaceæ and Anacardiaceæ (9 species each), Juglandaceæ (8 species), Celastraceæ (7 species), and the Proteaceæ and Apocynaceæ (6 species each).

The largest single genus is Ficus, which has 18 species. Cassia has 12 species; Sapindus 9; Gleditsiophyllum 8; Oreodaphne, Sophora, and Anacardites 7 each; Cinnamomum, Nectandra, Rhamnus, Myrcia, and Bumelia 6 each; and Celastrus, Dillenites, and Apocynophyllum, 5 each. Ten species are referred to the form genus Carpolithus, and this number could readily be greatly increased if all the unidentified seeds were named and described.

The amentiferous families, in accordance with their Upper Cretaceous deployment and their undoubtedly primitive and not reduced character, are represented in the Wilcox flora by 14 species, some of which are abundant. The Juglandales [1] are represented in the Wilcox by three species of Juglans, only one of which, *Juglans schimperi*, is at all common; by a doubtfully determined species of Hicoria; by three well-marked species of Engelhardtia; and by an extinct type, Paraengelhardtia, of a habit similar to that of Engelhardtia.

The genus Juglans is one of the earliest of the still-existing dicotyledonous genera to appear in the fossil record, and it is continuously represented in fossil floras from the middle Cretaceous to the present. There are about 25 Eocene species of walnut, which range during that period from the Gulf region to Alaska and Greenland, and these forms are also present in the tropical forests of the Egyptian Fayum in the early Oligocene. The accompanying sketch map (fig. 4) shows the existing distribution of Juglans and its known former range. This map, which shows the outlying existing species in the West Indies and under the Equator in South America, indicates that in spite of the northward range of the Asiatic species in Manchuria and of some of the North American species into New England and southern Ontario, the progenitors were at least subtropical types, a fact corroborated by their foliar characters, since it is well known that compound leaves indicate tropical ancestry. This is abundantly proved for Juglans by its associates in the fossil floras in which it is represented.

The genus Engelhardtia [2] is one of the most interesting Wilcox genera. In the first place the identification of its leaves is corroborated by two varieties of characteristic winged fruits. The genus was described by Leschen in 1825 and contains about 10 species in the southeastern Asiatic area, ranging from the northwestern Himalayan region, where they extend a short distance north of the Tropic of Cancer, through Farther India and Burma to Java and the Philippines. The pistillate flowers are small and are grouped in paniculate spikes. They develop into small drupelike fruits, each of which is connate at the base to a large expanded trialate involucre.

A single little-known species, rarely represented in even the larger herbaria, occurs in Central America and is the type and only species of the genus Oreomunnea of Oersted.

[1] Berry, E. W., Notes on the geological history of the walnuts and hickories: Plant World, vol. 15, pp. 225–240, 1912.

[2] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 31, pp. 491–496, 1911; Plant World, vol. 15, pp. 234–238, figs. 3, 4, 1912.

This form has a much narrower range than its kin beyond the Pacific. Oreomunnea is very close to Engelhardtia, and by the paleobotanist the two may be considered as identical,[1] for they represent slightly modified descendants of a common ancestor which was of cosmopolitan distribution during the early Tertiary. The present isolation of Oreomunnea furnishes a striking illustration of the great changes which have taken place in the flora of the world in the relatively short time, geologically speaking, that has elapsed since the dawn of the Tertiary.

When closely related forms in the existing flora of the world are restricted in range and isolated from their nearest relatives, or when other existing genera are monotypic, it is quite safe to predicate for them an interesting and extended geologic history. Engelhardtia is an illustration of this principle, for its peculiar three-winged fruits have been known in the fossil state for almost a century. They were long unrecognized, however, and the earlier students who described them compared them with the somewhat similar winged fruits of the genus Carpinus (Betulaceæ). As a result of the botanic exploration of distant lands in the early part of the nineteenth century specimens of Engelhardtia were obtained for the larger European herbaria, and Baron Ettingshausen, that most sagacious of paleobotanists, as long ago as 1851 pointed out that certain supposed species of Carpinus were really fruits of Engelhardtia. He returned to the subject in 1858 without, however, actually changing the names of any of the supposed species of Carpinus, nor does he seem to have been aware of the presence of a living species of Engelhardtia (Oreomunnea) in Central America.

Since Ettingshausen's announcement a dozen or more fossil species of Engelhardtia have been described. The oldest known European form occurs in the lower Oligocene (Sannoisian) of France and the species become increasingly abundant throughout southern Europe, especially toward the close of the Oligocene and the dawn of the Miocene. Saporta says that the slabs from the leaf beds at Armissan, in southeastern France, are thickly strewn with these peculiar fruits. Fossil forms are found in Europe throughout the Miocene and Pliocene, and specimens of late Miocene or early Pliocene age are recorded from Spain, France, Italy, Croatia, and Hungary. The Wilcox species are somewhat older than any of the European forms.

The accompanying sketch map (fig. 5) shows the present distribution of Engelhardtia in the

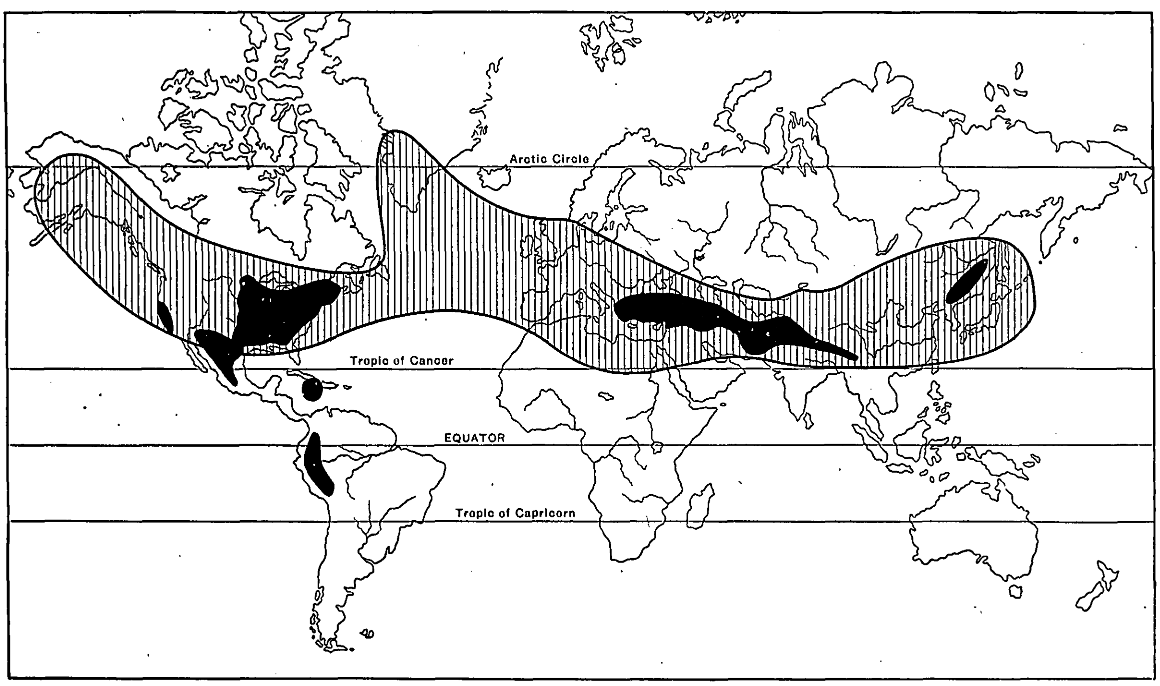

FIGURE 4.—Sketch map showing areas of distribution of recent (solid black) and fossil (lined) species of Juglans. A South American species found near Bahia, Brazil, and the existing Japanese species are not shown.

[1] Many students of recent floras, as, for example, Hemsley, in his Flora of Central America, consider Engelhardtia and Oreomunnea as one genus.

Orient and Oreomunnea in the Occident in outline. These areas are somewhat generalized and exaggerated in order to be shown on a map so small in scale. The areas where Tertiary species of Engelhardtia have been found are indicated by circles, and though the map is not as complete as might be desired, it shows very clearly that forms closely allied to the modern Engelhardtia were widespread during the Tertiary period, when the more extensive warm climate enabled them to penetrate more than halfway across the North Temperate Zone. It seems probable that they also pushed southward into the South Temperate Zone, but this can neither be verified nor disproved, for practically no fossil plants of Tertiary age have been discovered in South America or Africa. It is also probable that careful exploration will disclose living representatives of this widespread Tertiary stock in western Brazil, especially as they have survived in Central America north of the Equator.

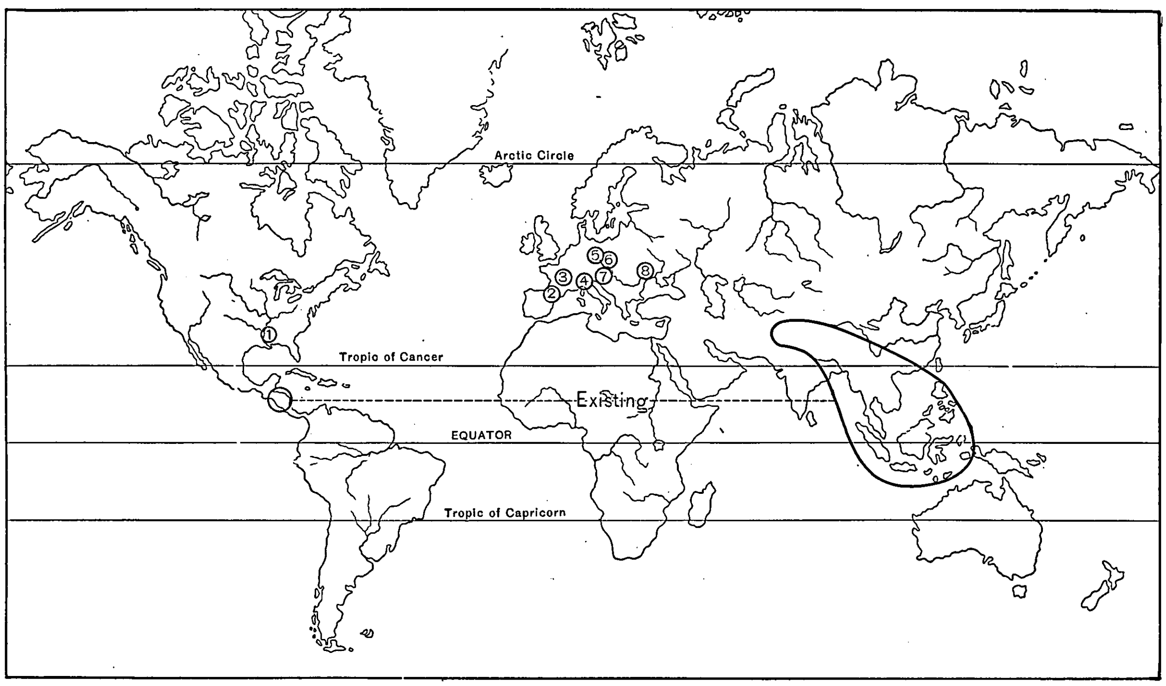

FIGURE 5.—Sketch map showing areas of distribution of recent and fossil species of Engelhardtia and Oreomunnea.

The existing Engelhardtias are upland forms, which may also have been true of the Wilcox species, although their abundance at different localities along the Wilcox coast would seem to indicate otherwise.

The genus Paraengelhardtia, which is a unique type confined to a single locality in the Wilcox, is clearly allied to Engelhardtia, as I have shown in the systematic part of this work. Probably it represents a survival of the ancestral stock from which Engelhardtia was derived, since its fruits are more primitive and indicate ancestral forms with smaller bracts, comparable with the bracts of Juglans or Hicoria, which in the course of time became accrescent and subsequently deeply trilobate. The primitive character of Paraengelhardtia and the presence of true Engelhardtias in the Wilcox so much earlier than their first occurrence in Europe suggest that America was the original home of the Engelhardtia stock, although this supposition can not be verified or disproved until a Tertiary paleobotanic record for the continent of Asia is available.

The Myricales of the Wilcox flora contain but two species of Myrica. Myrica is a very old generic type and has a large number of fossil species, ranging from the middle Cretaceous to the present. The existing species are relatively few in number, are widely scattered geographically, and represent survivors from a Tertiary cosmopolitan distribution. The allied monotypic genus Comptonia, which by some students is included in Myrica, has an extended geologic history which I discussed[1] in 1906. Myrica is much less abundant in the Wilcox than in the European Tertiary, although it

[1] Berry, E. W., Am. Naturalist, vol. 40, pp. 485–520, pls. 1–4, 1906.

was present in the embayment area in upper beds of the Upper Cretaceous (Ripley formation of Tennessee). Its meager representation in Wilcox time may be due to the more tropical climate. The modern Myricas are temperate and subtropical, and a number of the species are coastal forms of either swamps or sand dunes. *Myrica elæanoides* was evidently a coastal form and so was *Myrica wilcoxensis*, a species very similar to the existing *Myrica cerifera*, which ranges from New Jersey to Texas, and is also found on the Bermudas and Bahamas. *Myrica cerifera* is most abundant and vigorous in the sandy swamps along the South Atlantic and Gulf coasts, and its habitat may be compared with that of *Myrica wilcoxensis*, which seems to be the ancestral stock of a very similar species that occurs along the middle Eocene (Claiborne) coast of the embayment.

The order Fagales, which includes many well-known timber trees of the Temperate Zone, is comprised in the two families Betulaceæ and Fagaceæ. These families together contain about 450 existing species, about three-fourths of which belong to the Fagaceæ. Although the Betulaceæ are characteristically developed in the Upper Cretaceous of North America, they are unrepresented in the Wilcox flora, probably because the climate was too warm, and this probability may also account for the absence of true oaks, the Fagaceæ being represented in the Wilcox flora only by the genus Dryophyllum, which there includes five rather widespread and locally common species.

The genus Dryophyllum is of world-wide distribution and shows consistently uniform characters throughout many horizons of the late Cretaceous and early Eocene from the Senonian to the Ypresian stage. It especially characterizes the dawn of the Eocene and represents the ancestral stock from which the genera Castanea, Castanopsis, Pasania, and Quercus took their origin, although this origin was in the late Cretaceous. As might be expected, Dryophyllum has long since become extinct. The Wilcox species were apparently strand types, as were also the many species enumerated by Debey, the describer of the genus, from the sandy shores of the Upper Cretaceous sea of Rhenish Prussia. Dryophyllum is abundant in the Montian of Belgium and in the littoral sands of Ostricourt and Belleu in France. In the systematic chapter detailed comparisons are made between the Wilcox and the foreign species which show a striking parallelism.

The Urticales include the families Ulmaceæ, Moraceæ, and Urticaceæ, which together contain about 1,600 existing species. The Urticaceæ are largely herbaceous forms, and the Ulmaceæ are mostly extratropical.

The Ulmaceæ comprise 13 genera and about 140 existing species, widely distributed in temperate and tropical regions. A single species of Planera, described originally by Newberry from the western Eocene, is doubtfully identified from the Wilcox. The genus is monotypic in the existing flora and is confined to wet swampy situations in the warm temperate region of southeastern North America. Its geologic history goes back to the Upper Cretaceous, species having been recognized along the Atlantic coast from North Carolina northward in beds of that age. Thus there is no reason why it should not have been present in the early Tertiary of the embayment unless the climate was too warm.

The Moraceæ, by far the largest family of the order Urticales and the only one certainly represented in the Wilcox flora, contains between 900 and 1,000 existing species segregated among about 55 genera, of which the genus Ficus is by far the largest, including about 60 per cent of the existing species of the family. The Moraceæ are distinctly tropical and warm temperate types and are most abundant in the oriental tropics, although the dominant genus Ficus is widespread and the family also is largely represented in the South American tropics.

There are at least 18 monotypic genera, of which 1 is North American, 4 South American, 4 African, and 9 Australasian. No single tribe is confined to a single continental area and all show apparent anomalies of distribution due to our lack of knowledge of their geologic history. The genera Ficus, Artocarpus, and Artocarpidium go back to the base of the Upper Cretaceous and numerous other genera appear in the Eocene.

There are 23 species of Moraceæ in the Wilcox flora. The genus Artocarpus is represented by 3 well-marked species. In the existing flora the two score known species of

Artocarpus are indigenous to the southeastern Asiatic region, although some of them are cultivated in all tropical countries. The breadfruit is found throughout Oceanica and was present in Hawaii and the Marquesas, when they were first visited by Europeans. It was introduced into the West Indies in 1793. Of the tribe Euartocarpeæ, of which Artocarpus is the largest existing genus, 5 genera are confined to Central and South America, 1 genus is confined to tropical West Africa, 2 to the southeastern Asiatic region, 1 to Borneo, and 1 ranges from Japan to Australia. Though the geologic history of Artocarpus is only imperfectly known, at least 15 different fossil species have been described. The oldest is a well-marked form based on characteristic leaves and parts of the fruit which show the typical surface features. It has been fully described by Nathorst[1] and comes from the Atane beds (Cenomanian) of west Greenland. Slightly younger is a less well defined form recorded from the Emscherian of Westphalia and the somewhat doubtful genus Artocarpophyllum of Dawson from the Upper Cretaceous of Vancouver Island. Another species is recorded from the Laramie formation and the genus is widely distributed in the basal Eocene of North America. It continues in the Gulf region until the close of the Oligocene, the latest recorded occurrence being in the sands of the Alum Bluff formation at Alum Bluff on Apalachicola River. On the Pacific coast it is found in deposits in California and Oregon which are referred to the Miocene. In the European area it occurs in the Tongrian of France, the Tortonian of Baden, the Pontian of France and Italy, and the Pliocene of Italy. It is present in both the Pliocene and Pleistocene of the island of Java.

Artocarpus is said to be represented by petrified wood in the Oligocene of the island of Antigua, and it was evidently a member of the American flora from the Upper Cretaceous until late in the Tertiary, although, like the genera Cinnamomum, Nipa, Phœnix, and the like, it is not represented in post-Pleistocene American floras. An extinct genus related to Artocarpus and named Artocarpoides by Saporta, who described several species from the Paleocene of France, is represented by a single Wilcox species.

The genus Cecropia, which includes about 40 existing species confined to the Tropics of South America, has 2 species in the Aquitanian of Bohemia, and the Midway (?) and Wilcox form described as Ficus sp. is very probably a representative of this genus.

The genus Pseudolmedia, which has 5 existing species in the American Tropics, has a well-marked species in the Wilcox flora. As far as I know, it has not heretofore been recorded in the fossil state, although it is probable that some of the numerous fossil species of Ficus may represent Pseudolmedia.

The genus Ficus is represented by many species in the Wilcox flora, no less than 18 having been described, and a number of these are individually abundant. They include the narrow lanceolate forms of the *Ficus elastica* type with close-set laterals, as well as open-veined lanceolate forms and the shorter and broader palmately veined forms. None are lobate or have toothed margins. Ficus was evidently much more abundant and varied along the Wilcox coast than it is to-day throughout the West Indies and was more nearly comparable in this respect with the numerous forms of figs in the East Indies or in tropical South America.

The number of fossil forms that have been referred to Ficus are very numerous, including perhaps 300 species. None are certainly known from the Lower Cretaceous, the genus Ficophyllum[2] being entirely doubtful. In the Upper Cretaceous, however, Ficus is very widespread and abundant, being represented by characteristic fruits as well as leaves, which seemingly indicates a Lower Cretaceous ancestry as yet unknown. The Cenomanian has furnished 3 species in Greenland, 6 along the Atlantic coast, and 24 in the interior of North America, as well as 11 in Saxony, Bohemia, and Moravia. The succeeding Turonian furnishes 4 species in Bohemia and the Tyrol and several in North America (Tuscaloosa, Magothy, Black Creek, and Eutaw formations). Later Upper Cretaceous horizons have numerous species of Ficus throughout North America and Europe, as well as in Greenland, Australia, and New Zealand. This cosmopolitanism

[1] Nathorst, A. G., Kongl. Svenska Vet.-Akad. Handl., Bd. 24, No. 1, 10 pp., 1 pl., 1890.

[2] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, pp. 502–506, 1911.

continues throughout the Tertiary, there being about 50 Eocene species, about 60 Oligocene species, 90 Miocene species, and 20 Pliocene species. Africa is added to the record in the basal Oligocene and Asia in the Miocene.

The fossil records will have to be much more complete before the original center of radiation of the Moraceæ can be determined. The present brief sketch merely indicates that not only Ficus but other genera, like Artocarpus, which are entirely oriental in the present, were normal elements in North American floras from the time of the modernization of these floras at the beginning of the Upper Cretaceous. Along our east coast they apparently became restricted in their range at the dawn of the Miocene, and they apparently never after became as important in southeastern North America as they had been or as they are in the recent flora of the Orient.

The order Proteales includes the single family Proteaceæ, which has about 1,000 existing species. They include the prominent arborescent forms of Choripetalæ in the Southern Hemisphere, to which region all but the four genera Roupala, Protea, Leucospermum, and Helicia are confined. They are usually considered as Australian types, and in fact most of the genera and species are confined to that continent, yet there are 4 genera in South America which together contain more than 50 existing species; several genera are peculiar to the African flora; and the genus Helicia is predominantly Asiatic.

The geologic history of the Proteaceæ affords a most striking example of the great difference in geographic distribution in former ages from what could possibly be inferred from a study of the present geographic distribution of the members of this family, although some significant features in the distribution of the recent forms will be mentioned subsequently.

The discovery of fossil forms of Proteaceæ in the Tertiary deposits of Europe was the inspiration of a considerable literature [1] and was the occasion of a rather acrimonious controversy regarding their botanic affinity. This is well illustrated in the dissenting opinions expressed by the botanists Hooker and Bentham, who both regarded fossil leaves as undeterminable. If this be granted, it is difficult to see how they could arrive at any other conclusion. Their opinion, however, is refuted by the present distribution of certain genera. For example, the genus Roupala includes 36 species in tropical America, 2 in New Caledonia, and 1 in Queensland; the genus Embothrium 4 Andean species and 1 in Australia; the genus Lomatia 3 species in Chile, 4 in Australia, and 2 in Tasmania. It follows, unless one is prepared to subscribe to the doctrine of special creation for each continent or to the independent evolution on separate continents of different species of the same genus, that during their geologic history these genera must have ranged over intervening areas, so that if the Cretaceous and Tertiary plants of the Northern Hemisphere whose fruits and leaves resemble those of the Proteaceæ are not related to the genera which they most resemble, then forms whose leaves and fruit resemble those of other families must be fossil Proteaceæ, which certainly seems absurd. As a matter of fact, though exception may justly be taken to some determinations of Unger, Ettingshausen, and Heer, these doubtful determinations in no wise affect the main body of facts. There is so much collateral evidence, furnished for example by the geologic history of the Araucarian conifers, and the history of the Proteaceæ is so similar to that of the Myrtaceæ and Leguminosæ—the two other great families of the existing Australian flora—that it seems to be conclusive. The present distribution of some of the more significant genera of Proteaceæ is shown on the accompanying sketch map (fig. 6).

Those who follow the opinion of Hooker or Bentham will now see on turning to the fossil record how vast and substantial are the supposed illusions of the paleobotanists. In addition to the two extinct genera in the Wilcox flora I have fossil records of 32 genera of Proteaceæ, although this number is increased by the joint usage, according to taste, of names like Dryandra and Dryandroides, Banksia and Banksites. A brief consideration of these genera with fossil representatives will prove useful. The list is not complete, but is sufficiently so for the purpose of this discussion.

The genus Protea Linné, from which the family takes its name, includes about 60 existing species which occupy disconnected areas in central and South Africa. To it have been referred a middle Cretaceous species from

[1] See the writings of Unger, Heer, Ettingshausen, Schimper, Schenk, and Saporta.

Saxony; 3 Aquitanian species from Prussia, Bohemia, and Greece; 1 species from the Burdigalian of Italy; 1 from the Helvetian of Switzerland, and 1 from the Messinian of Italy. Allied to Protea but possibly more generalized is the genus Proteoides of Heer, which includes several Tertiary species and 15 Upper Cretaceous species. There are 2 species each in the Cenomanian of Bohemia and Lesina, 2 in the Atane beds of Greenland, 3 in the Dakota sandstone of North America, 1 in the Tuscaloosa formation of Alabama, 1 in the Middendorf arkose member of the Black Creek formation of South Carolina, 1 in the Cretaceous of Australia, 2 in the Vancouver Island Cretaceous, and 1 in the Senonian of Saxony.

The genus Proteophyllum Velenovsky,[1] a still more generalized proteaceous type, includes 7 species (Saporta, 1894) in the Albian (Vraconian) of Portugal and 8 species in the Perucer beds (Cenomanian) of Bohemia. Another generalized type is Proteopsis Velenovsky, which is represented by a single species in the Cenomanian of Bohemia. The genus Proteæphyllum of Fontaine, containing 2 species in the Patuxent formation (Neocomian) of Virginia, I regard as entirely worthless.[2] The genus Cenarrhenes Labill, which includes 1 existing species in Tasmania, contains a single species represented by both foliage and fruit in the Miocene of Carniola, based on a determination by Ettingshausen, which may well be viewed with suspicion. The genus Conospermum Smith, which contains about 33 existing species in Australia, includes 2 fossil species in the Oligocene of Styria and 1 in the Miocene of Carniola. The somewhat less definite genus Conospermites (Ettingshausen, 1867) is represented by a fossil species in the Upper Cretaceous of Australia and another in the Cenomanian of Saxony and Bohemia. Fontaine's determination of a species of Conospermites in the Lower Cretaceous of Virginia I regard as worthless.

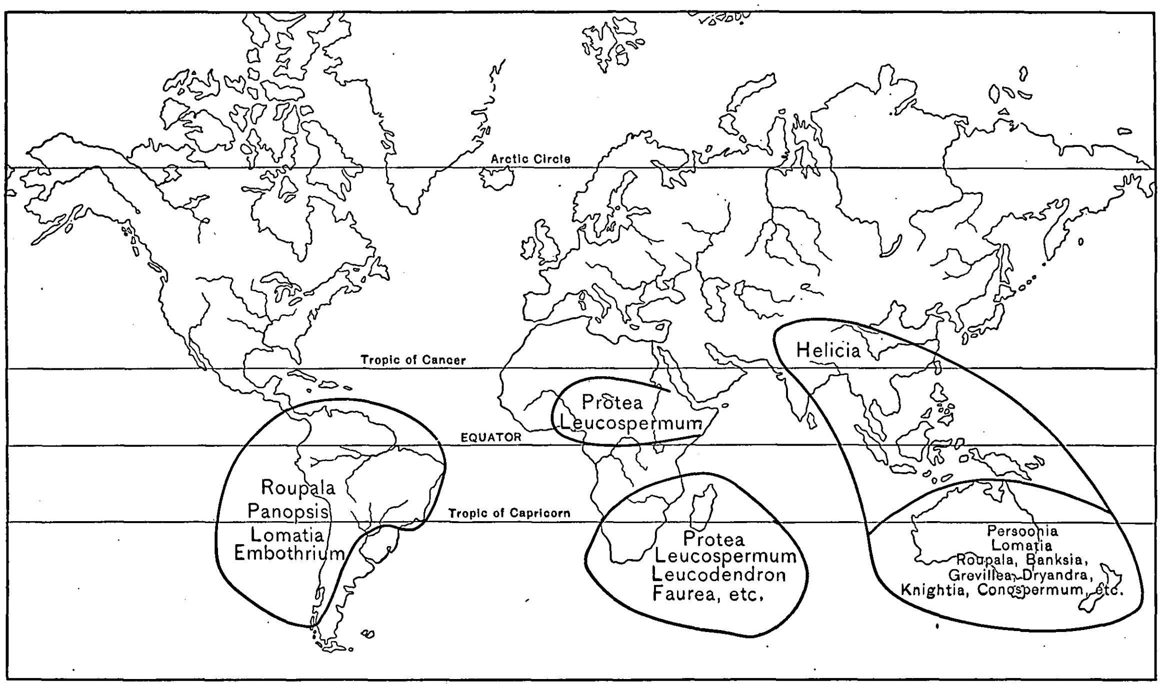

FIGURE 6.—Sketch map showing the present area of distribution of the more important genera of Proteaceæ.

The genus Helicia Loureiro is of especial interest, since it is found farther north in the existing flora than any member of the family. There are about 25 modern forms, mostly Indo-Malayan, as shown on the map (fig. 6), but a few still survive in Australia, or have recently spread to that continent. The fossil record includes a species in the Oligocene of Styria and another in the Pliocene of Italy. The genus Lambertia Smith, which includes 8 existing Australian species, contains a single fossil species in the Miocene of Carniola. The genus Hakea Schrader, which contains 100

[1] Velenovsky, J., Květena českého cenomanu, p. 18, 1889.

[2] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, pp. 494–499, 1911.

recent Australian species, is represented by 11 fossil species in the Oligocene of Europe, in France, the Tyrol, Saxony, and Greece, and by no less than 17 species in the Miocene of France, Italy, Switzerland, Baden, Hesse, Prussia, Bohemia, Austria, Styria, Croatia, and Hungary.

The genus Knightia R. Brown, which includes a modern species in Australia and 2 in New Caledonia, includes a fossil form in the Oligocene of Australia and another in Graham Land (Antarctic Continent)[1] in beds which are regarded as Oligocene. The allied genus Knightites Saporta contains 2 species from the Sannoisian of France.

The remarkable genus Lomatia, previously mentioned, is represented by 4 existing species in Australia, 2 in Tasmania, and 3 in Chile. As might be expected from these modern isolated occurrences, there are over 30 fossil species, some of them based on associated leaves and fruits. The oldest of these species are 2 (perhaps wrongly identified) in the Dakota sandstone. Eocene forms include species from the Green River formation of North America, an Ypresian species from the south of England, and an Italian species. There are about 18 Oligocene spécies, some of which are very characteristic. They occur in the Tyrol, Saxony, Baltic Prussia, Styria, Australia, and Tasmania, and the relatively large number of 4 are recorded by Dusén from Graham Land. The Australian and Tasmanian forms may be Miocene instead of Oligocene. About a dozen Miocene species have also been recorded from such widely separated areas as Colorado, Switzerland, and Carniola. The characteristic details seen in the wonderfully preserved leaves in the volcanic ash beds at Florissant, Colo., from which 7 forms of Lomatia have been described, leave no doubt as to the validity of the generic identification.

The allied genus Lomatites Saporta is represented by a Cenomanian species in Saxony and 5 or 6 Oligocene species in France. The genus Stenocarpus R. Brown, of which 11 existing species have been found in New Caledonia and 3 additional species at other places, ranging from North Australia to New South Wales, has a single fossil species in the Oligocene of Saxony.

The genus Persoonia Smith contains 60 existing species in Australia and 1 in New Zealand. The fossil record includes 2 widely distributed species in the Upper Cretaceous of North America; 1 in the Eocene of England; 4 in the Oligocene of Tyrol, Saxony, Styria, and Greece, and 10 in the Miocene of France, Italy, Switzerland, Baden, Bohemia, Styria, Croatia, Carniola, and Slavonia. Deane records a Tertiary species from New South Wales. A large number of these fossil forms of Persoonia are not especially convincing, but certainly the three European species *Persoonia cuspidata*, *P. daphnes*, and *P. myrtillus* of Ettingshausen,[2] which have the leaves associated with characteristic fruits, are above suspicion.

Bowerbank, in his classic study of the pyritized fruits and seeds from the Isle of Sheppey, established a genus which he called Petrophiloides from its resemblance to the genus Petrophila R. Brown, which includes about 35 existing species in Australia, most of which are confined to West Australia. Bowerbank described several species, one of which was shown by Starkie Gardner to be an Alnus fruit, and others have been referred to Sequoia. Ettingshausen[3] in the study of the Sheppey fruits, after careful comparisons, retained three English Eocene species and the genus has also been recognized in the Sannoisian of Dalmatia and Styria.

The genus Leucadendrites was established by Saporta for a Sannoisian species of southeastern France from its resemblance to Leucadendron Hermann, which includes more than 70 existing species in South Africa.

The genus Grevillea R. Brown contains 56 existing species which are confined to Australia. The fossil record includes a Cretaceous species in Australia; 2 Cenomanian species in Bohemia (Grevilleophyllum Velenovsky); 3 Eocene species in England, France, and Italy; 12 Oligocene species, mostly in southern France but also represented in Saxony, Tyrol, Bohemia, Styria, and Greece; and 12 Miocene species in France, Switzerland, Bohemia, and Croatia.

The genus Embothrium Förster, already alluded to, includes 4 existing species in South America, which range from Chile to the Straits of Magellan, and 1 species in Australia. This

[1] Dusén, P. C. H., Wissenschaftliche Ergebnisse der Schwedischen Südpolar-Expedition, 1901-1903, Bd. 3, Lief. 3, p. 7, pl. 1, figs. 7, 9, 11, 1908.

[2] Ettingshausen, C. von, K. Akad. Wiss. Wien, Math.-Nat. Cl., Sitzungsber., Bd. 7, pp. 718-719, pl. 30, figs. 6-14, 1851.

[3] Roy. Soc. London Proc., vol. 29, p. 394, 1879.

widely isolated occurrence is explained when the fossil record is combined with the occurrences referred to Embothrites, Embothriopsis, and Embothriophyllum. To Embothrium are referred 8 Oligocene species of Styria and Greece and 4 Miocene species of Baden, Styria, Croatia, and Hungary. To Embothriopsis Hollick is referred a single species from the Long Island middle Cretaceous.

Dusén includes a single species from the supposed Oligocene of Graham Land in Embothriophyllum. The genus Embothrites Unger contains a doubtful species from the Dakota sandstone; 6 Oligocene species from France, Tyrol, Styria, Carniola, and Greece; and 3 Miocene species in Croatia and Bohemia.

The genus Dryandra R. Brown is represented by about 50 existing species in Australia. The fossil forms have caused much discussion and have been referred back and forth between this genus and Comptonia and Myrica. The forms retained in Dryandra include a Cenomanian species in Bohemia and Moravia, an Eocene species in France, 2 Oligocene or Miocene species in Australia, and an Oligocene species in Greece. The allied forms referred to the genus Dryandroides Unger include 5 Upper Cretaceous species in Europe and North America; an Oligocene or Miocene species in Tasmania; 4 Oligocene species in Italy, Tyrol, Saxony, Styria, and Greece, and a Miocene species in Bohemia.

The allied genus Banksia Linné fils, also confined to Australia in the existing flora, contains 3 Upper Cretaceous species, all restricted to the North Temperate Zone; 3 Eocene species, 1 Alaskan (?) and 2 English; 12 Oligocene species widely distributed in Europe; 16 Miocene species equally widespread in Europe, and a Pliocene species in Italy. The 7 Australian species are not older than Oligocene and they may be Miocene. Three well-marked species from the Wilcox have been referred to this genus.

The allied genus Banksites Saporta is represented by a Cenomanian species in Bohemia and by several Tertiary species from Europe hopelessly entangled in the literature with Banksia, Dryandra, and Dryandroides.

The genus Roupala Aublet (Rhopala), whose peculiarly isolated outliers in Queensland and New Caledonia have already been mentioned, is common in northern South America, extending northward to Guatemala. Fossil forms are recorded from the Cenomanian of Saxony, from the Oligocene of Australia, and from the Aquitanian of Switzerland. In addition Saporta described a Rhopalospermites from the lower Oligocene of France. A species of Rhopalophyllum has been described from the Upper Cretaceous (?) of Australia and another species from the Miocene of Styria. The genus Hakea also has been mentioned frequently in descriptions of the European Tertiary floras, and recently Clement Reid has identified characteristic follicles from the Pliocene of Holland.

The geologic history sketched here is necessarily fragmentary, but I think the fossil forms are sufficient, after doubtful determinations are excluded, to show that the Proteaceæ originated in the Northern Hemisphere, first appearing at the close of the Lower Cretaceous epoch and becoming practically cosmopolitan in Upper Cretaceous time, when they reached the Australian region from southeastern Asia. New Zealand must have already been segregated but not the land mass now represented by New Caledonia. During the early half of the Tertiary period Afiica and southern Europe were essentially a single floral province, and in the Western Hemisphere the Proteaceæ ranged from the United States through South America and an unknown distance across the Antarctic Continent. Concomitant with the continent building and the consequent climatic changes of the Miocene epoch the area of distribution commenced that shrinking which culminated during the Pleistocene epoch, leaving the stranded remnants of the stock in the present widely separated localities of the Southern Hemisphere. Not all the modern genera took part in these migrations, since the local peculiarities of poor soil and rigorous climate, combined with relative freedom from outside competition, were the factors that stimulated the evolution of forms in Australia during the Tertiary period in exactly the same manner as the peculiar Australian genera of Myrtaceæ and Leguminosæ were evolved.

The Wilcox species of Proteaceæ include 6 forms, which are distributed in 4 genera. In addition a probable Banksia fruit is retained in Carpolithus. These genera are Palæodendron, Proteoides, Knightiophyllum, and Banksia. The genus Palæodendron, not heretofore mentioned, was proposed by Saporta for small entire coriaceous leaves from the Sannoisian of southern France and is an entirely extinct type. It is sparsely represented in the Wilcox by a single species. The genus Proteoides was established by Heer for generalized proteaceous types, which are well represented in the Upper Cretaceous floras of the embayment area as well as elsewhere. It is represented in the Wilcox by a single well-marked species that is confined to the Holly Springs sand and Grenada formation. The genus Knightiophyllum is first proposed here for a well-marked long-petioled aquiline-toothed coriaceous form which is common at Puryear, Tenn. It is named from its resemblance to the genus Knightia R. Brown, which contains a few existing species confined to the Australian region, though apparently it was represented in Europe during the Tertiary period, as already indicated.

The genus Banksia includes 3 Wilcox species, 2 of which are particularly well marked and a probable fruit, *Carpolithus proteoides*. It is confined in the existing flora to the Australian region and contains about 50 species. The other genus of the tribe Banksieæ is Dryandra R. Brown, which also includes about 50 existing species confined to the Australian region. It is much like Banksia in its foliar characters. Both genera are abundant in the European Tertiary formations and undoubtedly enjoyed a more or less cosmopolitan range during the early Tertiary period. Their ancestors probably entered the Australian region during the Upper Cretaceous epoch, probably by way of the Antarctic continent, and became adapted to the peculiar soils and climate, but the stock in the Northern Hemisphere appears to have been unable to stand the climatic changes and competition during the Tertiary period, and thus became extinct.

The Aristolochiales is placed by some students among the Gamopetalæ. It includes besides the Aristolochiaceæ the two parasitic families, the Rafflesiaceæ and Hydneraceæ, altogether containing about 235 existing species, of which 205 belong to the Aristolochiaceæ, the only family of this order represented in the Wilcox flora. The genus Aristolochia, to which a typical fruit from the Wilcox is referred, is found in the American Upper Cretaceous and in both Europe and America in the Tertiary. There are about 180 existing species, all perennial herbs or climbing vines and widely distributed in both tropical and temperate regions. About 10 species are found within the United States.

The order Polygonales includes the single family Polygonaceæ with about 800 existing species segregated in about 30 genera and widely distributed. They embrace herbs, shrubs, vines, and trees. The flowers are mostly cyclic, and in their morphologic features show some evidences of transition between the previous choripetalous alliances and the Chenopodiales. Except the widely distributed and much differentiated herbaceous genera, Polygonum and Rumex, the family is essentially American. The geologic history of the family is practically unknown, but a large part of the specific variation, particularly of the temperate herbaceous forms, seems to be relatively modern. The family is represented in the Wilcox by the single genus Coccolobis, which is represented by two species that appear to be the Eocene prototypes of the only two existing arborescent species of Polygonaceæ that reach the United States (the sea grape and the pigeon plum). The genus Coccolobis contains about 120 existing species, all confined to the American Tropics, and it appears to be of American origin. These species, most of which are coastal forms, range from southern Florida to Mexico, Central America, Brazil, and Peru. The two modern species, which are so much like these two ancestral forms in the Wilcox, are strand types, found from the Florida Keys through the West Indies to the northern coasts of South America. The conclusion is almost irresistible that the Wilcox forms had a similar range and an identical habitat.

The genus Ruprechtia C. A. Meyer, of the Polygonaceæ, which include about a score of existing species of shrubs and trees in tropical and subtropical America, includes a species in the Tertiary of Bolivia.

The Chenopodiales (Centrospermæ of Engler) include 10 families which culminate in the Caryophyllaceæ and contain about 3,500 existing species. They appear illy assorted and show a wide range in floral and other morphologic characters. Perhaps a majority are modern types. The single family Nyctaginaceæ represents this order in the Wilcox.

The Nyctaginaceæ, which include about 150 existing species, are predominantly American. They occur within the limits of the southern

United States on the north and Chile and Argentina on the south. The genus Pisonia Plumier, the only genus thus far found in the Wilcox flora, is represented by three well-marked species. It includes about 40 existing species, which live chiefly in the American Tropics, and contains the only arborescent form of the family found within the United States. It has an extended geologic history, well-marked forms being found in the European and American Upper Cretaceous. The Wilcox species were undoubtedly strand types, as are so many of the modern species which inhabit the sea beaches, the shores of salt-water lagoons and marshes, the scrub of beach ridges, and the jungle behind them. In the existing flora Pisonia is associated with Pithecolobium, Reynosia, Metopium, Acacia, Bumelia, Cordia, Coccolobis, Ocotea, Fagara, Mimusops, Conocarpus, Cassia, Eugenia, Anona, Ficus, and the like, exactly as it was during the Wilcox time. Species of Pisonia occur in the Upper Cretaceous of the Atlantic Coastal Plain (Black Creek formation), as well as in the middle (Claiborne) and upper (Jackson) Eocene.

The order Ranales appears to me to be a highly unnatural assemblage, which doubtless explains the prolonged discussion and wide range of opinion regarding its true status. As treated in Engler and Prantl, it includes 16 families and more than 4,000 existing species. Though most of these forms have a distinct calyx and corolla, this feature is combined with such primitive features as apocarpy and hypogyny, by a well-marked tendency to indefinite repetition and spiral arrangement of the floral members. I have removed the Lauraceæ, which contain a fourth of the existing species, to a place in the more evolved order Thymeleales.

The Ranales as a whole show no very close filiation with earlier allied types. They include forms that are more nearly monocotyledons than dicotyledons (Nymphæaceæ), and many botanists (as Wieland, Arber, and Hallier) see in them the zenith of evolution of the Mesozoic Cycadophytes and thus regard them as representing the ancestral stock from which the angiosperms were descended—a most remarkable derivation, apparently, if any except floral features are considered.[1]

[1] For discussion of this theory see recent papers by Wieland, Arber and Parkin, and Hallier.

Since I regard the Ranalian alliance as a plexus containing unrelated elements, any extended consideration of their geologic history would be fruitless. Certain forms are well represented among the oldest known angiosperms in the middle Cretaceous. Only two Ranalian families, the Magnoliaceæ and Anonaceæ, are represented in the Wilcox flora and these two are both natural groups, closely related and typically Ranalian.

The family Magnoliaceæ comprises about 70 existing species segregated into 9 or 10 genera, by far the largest of which is the genus Magnolia, which includes about 21 species of eastern and southern Asia, southern Mexico, and the eastern United States. The family is mainly tropical, and most of the existing forms occur in southeastern Asia, the magnolias of that region being largely found in tropical uplands.

There are many apparent anomalies in the distribution of the recent forms. Thus, none are native in Europe, although Magnolia persisted in that region as late in geologic time as the early Pleistocene. Only one genus, Drimys Förster, occurs in South America or Australasia and a species is recorded by Deane from the Tertiary of New South Wales. This genus extends southward from Mexico along the Andes to Cape Horn and from New Zealand and Australia northward to Borneo, a range which suggests that it will eventually be recorded from the Antarctic Upper Cretaceous or Tertiary deposits. There is a singular pairing of forms of the Magnoliaceæ in southeastern Asia and southeastern North America. For example, Magnolia includes 14 Asiatic species and 7 American; Talauma Jussieu is represented by 3 species in Farther India and 1 in the West Indies; Liriodendron Linné and Schizandra Michaux each contain 1 species in Asia and 1 in North America; and Illicium Linné includes 5 Asiatic species and 2 American. The genera Michelia Linné (13 species) and Kadsura Jussieu (7 species) are confined to southeastern Asia, and Zygogynum Baillon is confined to the island of New Caledonia.

The leaves of all the Magnoliaceæ are entire and are more or less elliptical. They have a coriaceous texture, many of them are evergreen, and they possess a characteristic camptodrome venation. Of the 7 species of Magnolia found within the United States, *Magnolia glauca* Linné ranges northward to Massachusetts and *Magnolia acuminata* Linné to New York and Ontario. About 60 fossil species have been referred to Magnolia. These species are largely based on leaves, although characteristic fruits, and at least two specimens of parts of flowers, have been found at different horizons. Magnolias are very abundant in both individuals and species in the middle Cretaceous (Cenomanian-Turonian), especially in North America, where they are found along the Cretaceous Atlantic coast from Greenland southward to Texas and are equally abundant about the borders of the advancing interior sea represented by the deposits known as the Dakota sandstone. They are much less common in Europe and the genus is either of American or Arctic origin.[1]

The Eocene records include 4 species of Magnolia from the Arctic region and 13 additional forms, most of them American but a few European. The Oligocene series, which in America carries no plant beds, contains in its upper beds in Europe several species of Magnolia. About 8 Miocene species are recorded, the majority of which are American. The Pliocene, also largely unrepresented by plant beds in America, contains 5 or 6 species in Europe and 1 is found in the early Pleistocene of that region. Magnolia seems to have been abundant along the shores of the extended Mediterranean Sea of the Pliocene and to have subsequently been entirely exterminated in that region by the glaciation of the Pleistocene, but it survived in both North America and Asia by reason of the prevalent northward trend of the mountain ranges. Some of the other genera of the Magnoliaceæ are represented by scattered fossil species, but the record is too incomplete to permit generalizations. A survey of all the facts leads me to consider America as probably the original home of Magnolia. Despite the massing of the existing forms in the eastern United States and their extension to the Arctic region in the Eocene, they probably originated in a warm temperate or subtropical latitude, spread northward across the Arctic region to Eurasia, and were cosmopolitan later in the Tertiary. They became restricted to the southeastern parts of Asia and North America by the aridity that accompanied uplift, so well illustrated in the Eocene and later history of the Rocky Mountain and Great Plains provinces, and were finally exterminated in Europe by the Pleistocene glaciation.

Lesquereux referred two forms of the Wilcox of northern Mississippi to Magnolia, but both prove to be species of Terminalia, as Lesquereux had surmised in his preliminary studies. The genus Magnolia is, however, represented in the Wilcox by two large-leafed species, both of which are common to the basal Eocene of the Rocky Mountain province. Neither shows any close affinity with the antecedent Upper Cretaceous forms, which are so common in the embayment area of Alabama and northeastward along the Atlantic Coastal Plain.

The family Anonaceæ contains about 700 existing species, which are distributed among about 48 genera, only two of which live in North America. The family is practically confined to the Tropics, a single Australian species, and the North American genus Asimina, which contains 6 or 7 species, being the only conspicuously extratropical forms. The area of maximum representation is southeastern Asia and the adjoining region of Malaysia, for though only 16 genera are confined to this region they contain more than 350 species, and 6 additional genera (Miliusa, Uvaria, Polyalthia, Oxymitra, Melodorum, and Poporvia), which contain more than 250 species, are represented by most of their species in this area. The family ranks fifth in number of species in the flora of the Malay Peninsula and Borneo. Only a single genus is confined to Australia, and most of the Australian species are regarded as migrants from the Malaysian area. Tropical Africa contains more than 100 species and 6 peculiar genera and America about 200 species and 10 peculiar genera. These forms are all confined to the Tropics, except a species of Anona, which reaches the coast of peninsular Florida, and the genus Asimina, which includes 6 or 7 species of shrubs and small trees of the South Atlantic and Gulf States. One of these, *Asimina triloba* Dunal, is hardy as far north as New York, the farthest distance from the Equator at which any existing member of the family is found. The fossil record of the Anonaceæ is very incomplete. Only the genera

[1] Saporta, G. de, Flore fossile du Portugal, p. 194, pl. 35, fig. 5, 1894. *Magnolia delgadoi* Saporta, recorded from the Albian of Portugal, is almost certainly not a Magnolia.

Anona Linné and Asimina Adanson are known with certainty and both are present in the Wilcox flora. Seeds of Monodorospermum, named from their resemblance to those of the West African genus Monodora, are described by Warburg from the late Tertiary of the Dutch East Indies (Banka). The extinct genus Jongmansia is based on seeds from the Dutch Pliocene.

The genus Anona includes 15 to 20 fossil species, five of which are also represented by seeds. The oldest species comes from the Dakota sandstone. A second species is found in the late Cretaceous or early Eocene of the Rocky Mountain province. The flora of the Wilcox affords a glimpse into the true stage of evolution of Tertiary floras in that expanded belt of the American equatorial region which was the center of radiation of so many recent types. There were 4 exceedingly well-marked species of Anona along the Wilcox coast, and their leaves are very common at some localities, although no seeds have yet been discovered. I assume that these Wilcox forms had habits similar to those of most of the existing species, exemplified by *Anona glabra* Linné, the pond apple of Florida, which frequents shallow fresh-water swamps, low shady hammocks, or stream borders near the coast. Other species occur in the low coppice association or on edges of brackish swamps on the Bahamas. The cultivated species, as the American *Anona reticulata* Linné, which is planted in Guam, often spread naturally along the inner beaches, though attempts to introduce others of the most highly esteemed American species into the Orient have failed. From the prevalent habit among the existing species, the growth in wet shaded soils is evidently an old characteristic, and as the Wilcox anonas are associated with a strand flora, the assumption that they grow on the inner beaches or the shaded and swampy edges of lagoons possesses every degree of probability.

In the pipe clays of Alum Bay, which are contemporaneous with the Wilcox, there are 2 species of Anona, and Engelhardt has described 2 species from the Eocene or Oligocene of Chile. The Oligocene record shows a species in France and another in Saxony. In the Miocene there are 2 species each in England, Styria, and Croatia, and 1 each in Bohemia, Transylvania, and Colorado. There is 1 species in the Pliocene of France and 1 in that of Italy, which shows how modern was their extinction in the south of Europe.

The genus Asimina includes only 4 or 5 recorded fossil species, all American, except a form from the Pliocene of Italy, which has been referred to this genus, although I suspect that it represents an Anona, since Asimina appears to have originated in the Western Hemisphere and been confined there. The oldest known species is based on foliage from the basal Eocene of the Rocky Mountains (Denver formation) and of the embayment (Midway formation). One species is based on a seed from the basal Wilcox and no other records have been found except a form close to the modern from the late Miocene of New Jersey (Bridgeton formation) and the existing *Asimina triloba* Dunal in the interglacial beds of the Don Valley in Ontario.

The order Papaverales (Rhœdales of Engler) includes 6 families—Papaveraceæ, Cruciferæ, Capparidaceæ, Resedaceæ, Tovariaceæ, and Moringaceæ, which together contain about 255 genera and 2,200 species. The Papaveraceæ and Cruciferæ are mostly herbaceous and widely distributed, largely in the North Temperate Zone, and they are of relatively recent evolution. The Resedaceæ is a small family, largely confined to the Mediterranean region. The Capparidaceæ, Tovariaceæ, and Moringaceæ are mainly tropical. The last two families consist, respectively, of a single genus and 2 species of the American Tropics and a single genus and 3 species of the Asiatic Tropics—1 Afric-Arabian and 2 East Indian.

The family Capparidaceæ, which includes about 35 genera and 400 existing species, is the only one of the order represented in the Wilcox flora. Most of the existing species are herbaceous. They are found on all the continents in tropical and subtropical regions. Five subfamilies are recognized. Of these the Cleomoideæ and Capparidoideæ are large and occur on all the continents, including monotypic genera in North America (Isomeris), South America (Stubelia, Atamisquea, Belencita), Africa (Pteropetalum, Cladostemon), and Australia (Roeperia, Apophyllum). The subfamily Dipterygioideæ includes a single genus and only 5 or 6 species in Nubia, Arabia, and the Punjab. The subfamily Roydsioideæ includes about a dozen species, the genera Roydsia and Stixis being confined to India and the genus Forchhammeria to Mexico. The subfamily Emblingioideæ includes only a single genus and species confined to western Australia. No far-reaching conclusions regarding origin or past history can be deduced from the present knowledge of the geographic distribution of the Capparidaceæ, and the fossil record is so imperfect that very little can be said regarding the history.

The only fossil records known to me are the following: F. von Müller has described somewhat uncertainly determined fruits from the Pliocene of Australia as the genera Dieune and Plesiocapparis. Plesiocapparis has 2 species and is considered as probably a member of the section Busbeckia of the genus Capparis. Schenk has described the petrified wood of another form from the Upper Cretaceous or Tertiary of Egypt under the name Capparidoxylon. The genus Capparis is represented by a well-marked Wilcox species very close to the existing Antillean tree *Capparis domingensis* Sprengel. There are about a hundred existing species of Capparis, most of them tropical, and although they are found in the Eastern Hemisphere they chiefly occur in the American Tropics, especially in Central and South America. The oldest known fossil forms are two species described by me as species of Capparites from the Upper Cretaceous of Alabama (Tuscaloosa formation). In addition to the Wilcox species previously mentioned, Engelhardt has described a Tertiary species from Bolivia. Many years ago Unger described a Tertiary species from the middle Miocene of Styria, but Schimper considers it to be a papilionaceous form. Though the fossil record of Capparis is so meager, such facts as are available seem to indicate that it originated in the American Upper Cretaceous. Many of the modern forms are shrubs or small trees of the strand flora, and such is believed to have been the habitat of the Wilcox species.

The order Rosales includes about 18 families and more than 14,000 existing species, the largest families being the Leguminosæ, Rosaceæ, Saxifragaceæ, and Crassulaceæ. The family Platanaceæ, which by the majority of students is referred to the Rosales, I regard as the sole survivor of an independent order, the Platanales, closely related to the Urticales. Some members of the alliance are close to the Ranales in their apocarpy, hypogyny, and the indefinite repetition of certain floral members. The order culminates in the relatively modern Papilionaceæ. Five families of Rosales are present in the Wilcox flora. Of these the three leguminous families are by far the most abundant.

The family Hamamelidaceæ consists of about 19 genera and 50 species. Twelve genera are confined to the Asiatic region, 1 genus is doubtfully confined to Australia, 3 genera are African, and 3 are common to Asia and eastern North America. The family is remarkable for containing no less than 9 monotypic genera. A consideration of the existing distribution is not only of exceeding interest, but also gives conclusive proof of an extended geologic history, which unfortunately has not yet been unraveled. Since the group is scarcely if at all represented in the existing or fossil floras of Australia its present range over Asia would seem to have been accomplished after the land connection with Australia had been interrupted. As the only known Cretaceous fossil forms come from North America, the group may have originated in the North American region. The fossil species are not numerous enough, however, for definite conclusions on this point.

The genus Hamamelis and its generalized fossil type Hamamelites Saporta are represented by 5 species in the Dakota sandstone, one of which occurs in the Upper Cretaceous of the Atlantic coast (Middendorf arkose member of Black Creek formation of South Carolina) and another is doubtfully represented in the supposed Upper Cretaceous of Argentina (Kurtz). There are 2 Paleocene species in France and Belgium, and Conwentz has described characteristic flowers preserved in perfection in the Baltic amber (Sannoisian) as Hamamelidanthium.

The genus Parrotia, which includes a single existing species of northern Persia and the Caucasus, contains 3 species in the Dakota sandstone, 1 species in the Wilcox and Fort Union, 2 in the Oligocene of Europe, and 2 in the Miocene of Spitzbergen, Spain, France, Silesia, Austria, and Hungary. The distribution of Parrotia in the past, so far as it is known, confirms the evidence of a North American origin for the family derived from Hamamelis.

The third genus with a geologic history is Liquidambar, of which more than 20 fossil species have been described. The oldest known forms occur in the Eocene at such widely separated points as Alaska, Oregon, Greenland, and France. There are 2 species in the Oligocene of Asia and Europe. Nine or ten Miocene species are present throughout Europe and North America (New Jersey to Oregon) and in eastern Asia. Three Pliocene species are found in Spain, France, Italy, Germany, Austria, Styria, and Slavonia. Typical fruits preserved in the upper Pliocene of Germany show how late the genus flourished in central and southern Europe. Felix has described the petrified wood from the Tertiary of Hungary as Liquidambaroxylon. The existing *Liquidambar styraciflua* is found in the Pleistocene of West Virginia, North Carolina, and Alabama, and the eastern Asiatic species *L. formosana* occurs in the Pleistocene of Japan. The genus Corylopsis occurs in the post-Miocene deposits of Japan, and its seeds are also found in the Dutch Pliocene. Capsules and seeds of the genus Bucklandia are also present in the Dutch Pliocene.

The family Rosaceæ includes about 90 genera and more than 1,300 existing species, widely distributed, mostly in temperate regions. Some of the genera like Cratægus seem to be undergoing saltation at the present time and hundreds of supposed species have been described in the past few years. The tribe Chrysobalanoideæ is confined to the Tropics, and the Neuradoideæ to the subtropics of Africa and southwestern Asia. All the other tribes of Rosaceæ are widely distributed and their modern and fossil distribution is without especial significance for the present discussion.

The only genera represented in the Wilcox are Chrysobalanus, which includes species that are evidently the prototypes of the still existing forms, shrubs or small trees, but two or three in number, which inhabit the sandy shores in the maritime regions of Florida, tropical America, and western tropical Africa, and the stones of a species of Prunus.

The Leguminosæ, as now segregated into 4 families, constitutes the largest alliance among the Choripetalæ (Archichlamydeæ) and next to the Compositæ is the largest angiospermous group. It contains more than 9,000 existing species segregated among about 450 genera.

There is a well-defined floral progression from the family Mimosaceæ, which has actinomorphic flowers and numerous, mostly free stamens, through the Cæsalpiniaceæ, to the largest group numerically, the Papilionaceæ, which has strongly zygomorphic flowers and coalescent stamens, comparable with the like culmination in floral evolution of the Orchidaceæ among the Monocotyledonæ.

The Mimosaceæ, which includes about 30 genera and 1,400 existing species, is massed in the Tropics of both hemispheres. None of the subfamilies are confined to a single continent, but comparatively few genera occur in more than two continental areas and half the genera are restricted to one continent. Asia and Australia each have 2 peculiar genera, Africa has 4, and America has 7. America also leads in number of species, about half the total number in the family being present in the New World. Australia comes next with more than 300; Africa next, also with more than 300; and Asia last with about 100. In the eastern United States there are only 3 genera and 5 species, none of which are arborescent. In the Gulf States there are 14 genera and 44 species.

The Cæsalpiniaceæ, which includes about 90 genera and 1,000 species, is also mainly tropical and its forms are massed in the American Tropics, where there are more than 600 species and 37 peculiar genera. The tribe Sclerolobieæ is entirely American and contains numerous monotypic genera. Asia and Africa each have about 150 species. There are, however, only 10 Asiatic genera, as compared with 17 African. There are but 3 Australian genera and less than 100 species. In the eastern United States there are 5 genera and 11 species. Three of the genera, Cercis, Gleditsia, and Gymnocladus are arborescent. In the Southern States there are 11 genera and 44 species.

The Papilionaceæ includes about 320 genera and 6,600 species. America leads in the number of peculiar genera, having 82, but Asia leads in the number of species, having about 1,700. Africa contains 47 peculiar genera and about 1,600 species, Australia, 38 peculiar genera and about 1,000 species, and Asia 33 peculiar genera. Europe, which contains 7 peculiar genera and about 700 species, is less rich in both species and genera than any other continent. None of the subfamilies is confined to a single continent but some of the tribes are, the Lipariinæ being South African and the Bossiæinæ Australian. Of the subfamily Podolyrieæ, 20 out of 27 genera and all but 63 out of 436 species are Australian. Two genera in this subfamily are American, 2 African, 1 Asiatic, 1 Mediterranean (Eurasia), and 1 common to North America and Asia.

In the eastern United States there are 46 genera and 194 species of Papilionaceæ. The genera Cladrastis and Robinia are arborescent. In the Southern States there are 55 genera and 318 species. Sargent's "Manual of North American trees," which includes many tropical forms of the Florida Keys, enumerates for the Leguminosæ as a whole only 34 arborescent species for North America in 17 genera.

In Grisebach's "Flora of the British West Indies" the Leguminosæ, with 262 species, outnumber all other families of flowering plants. The same is true of Urban's "Flora of Porto Rico," which includes 136 species.

According to Schomburg the Leguminosæ constitute the largest alliance in British Guiana and include about 475 species. On the Malay Peninsula, in Borneo, and in the Philippines they are exceeded in specific differentiation only by the Orchidaceæ and the Rubiaceæ, and in the Celebes, according to Koorders, the Leguminosæ are the largest alliance. In Central America, according to Hemsley, they rank third in numbers. When Bentham and Hooker published the "Genera plantarum," the Leguminosæ comprised more than 5 per cent of the genera and nearly 7 per cent of the species of all flowering plants. As might be expected the later evolved and more temperate group, the Papilionaceæ, are the most widely dispersed.

The Leguminosæ are but sparsely represented in the New Zealand region. They are also practically unrepresented by endemic species on remote oceanic islands (quite contrary to the prevailing rule among the Compositæ), especially on those unfavorable to colonization by drift seeds. In Hemsley's "Flora of Mexico and Central America" the Leguminosæ include 27 per cent of the genera and 14.5 per cent of the species of Leguminosæ of the whole world, and they constitute 8.1 per cent of the total number of flowering plants in that flora (944 species). At least 12 of the species are common to western Africa.

Of the 50 species in 30 genera of the Leguminosæ that occur in the existing flora of the Fiji Islands, half the species and 20 genera belong to the strand flora. This family comprises about 5 per cent of the total known flora of the islands. It constitutes about 29 per cent of the total Fijian strand flora, and this proportion is equaled or slightly exceeded in the Society, Marquesas, and Paumotus islands. According to Guppy about one-third of the littoral Polynesian plants with buoyant seeds or fruits belong to the Leguminosæ.

The Leguminosæ are represented in the Wilcox deposits by more than 50 species, many of which are individually abundant. They represent the families Mimosaceæ, Cæsalpiniaceæ, and Papilionaceæ. The fourth family of the leguminous alliance, the Krameriaceæ, is a small herbaceous group of the New World, of very late, probably of recent, evolution.

Of these Wilcox species 11 are referred to the Mimosaceæ, 26 to the Cæsalpiniaceæ, and 20 to the Papilionaceæ. Definitely recognized genera are named in the usual way. Forms usually identified as species of Acacia (for example, most of those so named by Heer, Ettingshausen, and Unger), which are referable to the Mimosaceæ but not to the genus Acacia as commonly understood, are referred to the form genus Mimosites. Forms not certainly identified as Cæsalpinia but referable to the Cæsalpiniaceæ are classed under the form genus Cæsalpinites, and a considerable number of Gleditsia-like forms of both leaves and pods are described in the genus Gleditsiophyllum, a form genus first proposed by me for an Upper Cretaceous species from North Carolina. There is a certain unavoidable duplication in the giving of specific names to unattached pods and leaflets, since some of them may belong to the same botanic species, but I have followed this method wherever I was not sure of such a relationship.

The Mimosaceæ of the Wilcox are referred to 4 genera. The genus Acacia, which is represented by a single indisputable species in which the leaves are reduced to phyllodes, is of great interest, since in the existing flora the 450 species are largely confined to the Australian region. The section Phyllodineæ, to which the Wilcox species is referred, contains about 300 existing species, which are confined to Australia and Oceanica, although in Eocene times they were also present in Europe. It is a curious commentary on the modern character of the earlier Tertiary floras that the reduction of foliar organs and the habit of phyllody, often correlated with modern arid conditions, should have really been developed in these early floras.

The genus Inga, represented in the Wilcox by 4 well-marked species, includes more than 150 species in the existing flora, all of which are confined to the American tropical and subtropical regions. Its geologic history is largely unknown, although it appears to be represented in American Upper Cretaceous floras by *Inga cretacea* Lesquereux, which occurs in the Dakota sandstone and in the Tuscaloosa formation of Alabama. Ettingshausen has described a species from the Cenomanian of Saxony (*Inga cottai*); the European Miocene has furnished 2 or 3 species; and Engelhardt has described a Tertiary species from Bolivia.

The genus Pithecolobium, which belongs to the same tribe as Inga (Ingeæ), is represented by 2 Wilcox species. Most of the 100 or more existing species are American, more than a score live in tropical Asia, and a few are found in tropical Australia and Africa. With the exception of a Tertiary species from Bolivia, I do not know of other fossil occurrences.

The genus Mimosites, which includes 4 Wilcox species, represents trees of the Mimosa type that are very abundant in recent species referred to several genera, either American, Asian, Australian, or African, and abundantly represented in European Tertiary floras. Its Cretaceous ancestry is hidden among the species of leaflets referred to the form genus Leguminosites. The genus Mimosa, which is apparently most like the Wilcox Mimosites, includes more than 300 existing species, chiefly confined to the warmer parts of America, although they are represented in Asia, Africa, and Australia.

Except for the family Lauraceæ the Cæsalpiniaceæ, which contains 26 species, is the largest family in the Wilcox flora and it is certainly a fact of considerable interest that the massing of the modern species in the American Tropics should be foreshadowed by their abundance on this Continent as early as the lower Eocene.

The Wilcox genera are 5 in number, of which the largest is Cassia, which includes 12 species. Cassia is the largest Wilcox genus except Ficus, and all of its species find their modern counterparts in existing species of tropical and subtropical America, many of which are mentioned by name in the systematic part of this work. Numerous as are the Wilcox species of Cassia there was apparently greater specific differentiation in contemporaneous European deposits, since Ettingshausen records 15 species in the flora of Alum Bay (Ypresian of Isle of Wight). Cassia has between 300 and 400 existing species, found in the warmer temperate and tropical regions of all the continents and especially abundant in tropical America. Their place of origin is unknown, since they make their appearance in the Upper Cretaceous almost simultaneously in New Zealand, Australia, Bohemia, Saxony, Greenland, the Atlantic Coastal Plain, and the Dakota sandstone of the Rocky Mountain province. More than 100 fossil species are already known. The Eocene distribution sheds no light on the early history of the genus, for species occur in such widely separated regions as North America, Europe, and Australia. There are numerous Oligocene and Miocene species, the Oligocene records being confined to Europe and Africa and the Miocene records being confined to Europe and North America. Cassia was abundant along the shores of the Pliocene Mediterranean of Europe, and 4 species are recorded from South American beds which are thought to be of Pliocene age. Pleistocene species are recorded from Maryland, and also from the East Indies (Java), where they are associated with *Pithecanthropus erectus* Dubois. One fact is certain—the genus has been a part of the American flora since the dawn of the Upper Cretaceous, and several of the Wilcox species are the undoubted prototypes of existing forms of the American Tropics.

The genus Cercis, which includes a single Wilcox species, makes its first recorded appearance in geologic history in the Wilcox species, in the 3 species recorded from the Fort Union formation of the Rocky Mountain province and in a species found in the Ypresian of the Paris Basin, so that its appearance was practically contemporaneous in France and Tennessee. It continues on both continents down to the present, being even represented in the Pleistocene of both regions. The modern species number 5 or 6 and inhabit the warmer temperate regions of America, Europe, and Asia.

There is one species of Cæsalpinia in the Wilcox and it is almost identical in character and habitat with *Cæsalpinia bahamensis* Lamarck of tropical America. The existing species number about two score and are found in the Tropics of both hemispheres. Cæsalpinia is recorded first from the Upper Cretaceous of the Atlantic Coastal Plain, and it seems probable that it originated on this continent and reached Europe during the Eocene by way of the Arctic region, since it is common in the Oligocene, Miocene, and Pliocene of America.

Four Wilcox species are referred to the form genus Cæsalpinites. These species represent true forms of Cæsalpinia or of allied genera in this family. One of them almost certainly belongs in the genus Parkinsonia, a small genus which occurs in the European Oligocene but which in the existing flora is confined to the warmer parts of North America and South Africa. Fossil forms referred to Cæsalpinites include about 20 from the European Oligocene and Miocene.

The genus Gleditsiophyllum makes its appearance in the Upper Cretaceous of the Carolina region. It is represented in the Wilcox deposits by 8 species of leaves, leaflets, and pods, which are abundant in many places. Their relation to modern genera is uncertain, but they were evidently much like Gleditsia.

Two genera of Cæsalpiniaceæ, Hymenæa and Bauhinia, which I confidently expected to find in the Wilcox, must have been present during this time in southeastern North America. Hymenæa is confined to the American Tropics in the existing flora, where it includes about 8 species. It is represented by characteristic forms in the Upper Cretaceous of Alabama. The genus Bauhinia, which contains about 150 existing species of the Tropics of both hemispheres has several especially characteristic forms in the Upper Cretaceous of southeastern North America (New Jersey, Maryland, and Alabama).

The family Papilionaceæ, which comprises more than two-thirds of the existing Leguminosæ, undoubtedly represents the culmination of evolution in the alliance. Most of its species, especially the numerous herbaceous genera, are unquestionably of comparatively recent origin. In spite of this fact, the family is represented by more than 20 species in the Wilcox. These species are distributed among 6 genera, of which Dalbergites, Carpolithus, and Leguminosites are form genera and the other 3 still exist. The largest genus is Sophora, which includes 7 species, one of which, evidently a strand type similar to the cosmopolitan strand plant *Sophora tomentosa* Linné of the existing tropical flora and comparable in its habitat with that species, is very abundant in the Wilcox deposits. There are about 25 existing species of shrubs and small trees referred to this genus, which are scattered over the warmer parts of both hemispheres and are found on all tropical seashores. About a dozen fossil species are known. In addition to North America they are found in both Europe and Asia during the Eocene, a single form from Alum Bay (Ypresian) being contemporaneous with the Wilcox species and the others being later. Though few species have been described, the genus is widely distributed in the European Miocene, where *Sophora europæa* Unger was a common coastal form of the Mediterranean region throughout the Miocene and into the Pliocene epoch.

Four species, three based on leaflets and the fourth on a characteristic pod, represent the genus Dalbergia in the Wilcox flora. Two additional species whose generic relations are not so certain are referred to the genus Dalbergites. The existing species of Dalbergia number about 80 forms found in the Tropics of both hemispheres, and all show a strong generic similarity in their foliar characters. More than two score fossil forms are known. The earliest form occurs in the Atlantic Coastal Plain and western Greenland, so that there is a strong possibility that the genus was of American origin. If this theory was correct they must have undergone a rapid dissemination, for in the Eocene they are not only found in America and the Arctic region, but also in Europe. The Alum Bay beds of the Isle or Wight (Ypresian), which I regard as contemporaneous, in part at least, with the Wilcox, contain, according to Ettingshausen, 6 species of Dalbergia. European deposits furnish about a dozen Oligocene species and a larger number of Miocene species. *Dalbergia primæva* Unger, *D. retusæfolia* Heer, *D. hæringiana* Ettingshausen, and *D. bella* Heer are widespread coastal forms of the European Tertiary. Some of these European species range from the late Oligocene through the Miocene and into the Pliocene.

The genus Canavalia is represented in the Wilcox by a fine species, undoubtedly the ancestor of the existing *Canavalia obtusifolia* (Lamarck) De Candolle, a widely distributed tropical strand plant. A second species is less commonly represented and not as certainly identified. The genus contains about a dozen existing species of the Tropics of both hemispheres, but fossil forms have not heretofore been found.

The Wilcox forms referred to Leguminosites can not be classified satisfactorily, since they represent pods and leaflets of this alliance whose generic relations are uncertain. This form genus was proposed first by Bowerbank for the pyritized remains from the Isle of Sheppey (London clay), and two of his species are tentatively identified in the Wilcox. Subsequently many species have been described. They range in age from the middle Cretaceous to the Pliocene. The oldest form, in the Albian of Portugal, is described by Saporta. They are found in the Cretaceous of Australia, the Cenomanian of Saxony, the Atane and Patoot beds of Greenland, and the Cretaceous formations of the Atlantic Coastal Plain from Marthas Vineyard to Alabama. They are common in the Arctic Eocene and occur also in America, Europe, and Asia. Oligocene records include Europe and the Antarctic Continent; Miocene records are confined to Australia, America, and Europe; and Pliocene records include southern Europe and Japan.

Though the foregoing analysis leaves many problems in the history of the Leguminosæ unsolved, it shows at least that the Wilcox forms would find a congenial habitat in the present-day American Tropics, in the flora of which they are all represented, and that thus early some of the main features of their recent distribution had been determined.

The most similar fossil display of these forms is found in the Ypresian flora of Alum Bay on the Isle of Wight, which unfortunately has never been described or figured, but of which Ettingshausen[1] published an analysis and enumeration in 1880. Another very similar display of forms is that described by Engelhardt from the Tertiary of Cerro de Potosi in Bolivia,[2] whose exact age has never been determined, although its resemblance to this part of the Wilcox flora suggests the possibility that it is Eocene instead of Pliocene, the age which has been assumed. This resemblance may, however, simply be a reflection of the similarity between the Leguminosæ of the embayment area in the lower Eocene and those of subsequent epochs in the American Tropics. The small flora described by Engelhardt from the Tertiary of Ecuador contains 14 species of Leguminosæ.

The order Geraniales includes 21 families and more than 10,000 existing species, of which nearly half belong to the family Euphorbiaceæ. The other large families in the order of their size are the Rutaceæ, Meliaceæ, Malpighiaceæ, and Polygalaceæ, each of which contains more than 500 existing species. The Geraniaceæ, Oxalidaceæ, and Burseraceæ each include more than 300 existing species. The alliance is mainly cyclic in the character of its floral members. The primitive forms are isocarpic and progress is toward reduction of the number of carpels. The phylogenetic importance of the characters by which the Geraniales as an order is separated from the evidently allied Sapindales is not great and in some respects the order is apparently not a natural one. Six families of Geraniales have been recognized in the Wilcox flora. The first of these, the Rutaceæ, consists of about 111 genera and more than 900 existing species, which are widely distributed over the warm temperate and tropical regions. The fruits are capsules, samaras, or drupes, and the leaves, which may be simple or compound, are usually glandular punctate. Though 34 genera and 127 species are confined to America, the family makes its greatest display in the Old World. Africa contains 16 peculiar genera and 196 species and Australia 28 peculiar genera and 185 species. In addition to 6 genera and 7 species which are confined to the Asiatic mainland, 19 genera and 167 species are distributed from southeastern Asia through Malaysia, some of them as far as New Zealand and Polynesia. The only truly cosmopolitan genus is Fagara, which includes more than 150 existing species and is represented in all tropical countries. The tribe Boronieæ, which includes 18 genera and 158 species, is confined to Australia and New Zealand; the Diosineæ, which contains 11 genera and 181 species, is confined to South Africa; and the Cusparieæ, which contains 16 genera

[1] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, pp. 228-236, 1880.

[2] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Sitzungsber. und Abh., 1887, Abh. 5, pp. 36-38, 7 figs.; idem, 1894, Abh. 1, pp. 3-13, pl. 1.

and 83 species, is confined to tropical America. The other rather numerous tribes are all represented in more than one continental region.

The family contains the remarkable number of 42 monotypic genera, and though many of these may be of recent evolution, as a number of those from Australia, the isolated occurrences of many of the others indicate that they are of great age and once occupied intervening areas.

There are only 13 known fossil genera, only about 10 per cent of the existing genera, so that little can be said of the fossil history of the family. The oldest genus is Citrophyllum Berry, which is represented by very characteristic leaves with alate petioles in the Dakota sandstone of the Rocky Mountain province and occurs from New Jersey to Alabama along the Atlantic coast in the Raritan, Magothy, Black Creek (Middendorf arkose member), and Tuscaloosa formations. Another species of Citrophyllum is found in the Wilcox and a third in the overlying Claiborne. These forms are very similar to the leaves of recent members of the Aurantioideæ and undoubtedly represent ancestral forms. The genus Dictamnus Linné, which includes a single existing species widely distributed in Eurasia, is represented by a fossil form in the Pliocene of France and another in the Pleistocene of Japan. Unger in 1850 described petrified wood from the Aquitanian of Greece as *Klippsteinia medullaris*, referring it to the Aurantioideæ.

The genus Amyris (P. Browne) Linné contains about a dozen existing species in the Antilles and Central America, two of which reach the coast of southern Florida. A fossil form is recorded by Unger from the late Miocene (Sarmatian) of Hungary. This determination is not conclusive, however, although Unger had both the leaves and fruit of *Protamyris berenices*. Unger also described the supposed ancestral genus Protamyris, to which he referred 4 species from the Aquitanian of Kumi and the Miocene of Croatia. These determinations are not especially convincing, and both Ettingshausen and Schenk consider *Protamyris radobojana* Unger to represent a species of Cedrela.

The genus Xanthoxylum Linné, which includes 9 or 10 existing species of eastern Asia and North America, has been a favorite receptacle for fossil forms of Rutaceæ. About a score of fossil species have been described. The oldest comes from the basal Eocene of northeastern New Mexico (Raton formation) and a second Eocene species is recorded from the Bartonian of France. Engelhardt has described 2 Eocene or Oligocene species from Chile. There are 4 Oligocene species, 2 in France and 2 in Prussia. There are about 13 Miocene species, widely distributed and represented in California, Colorado, Spain, France, Switzerland, Baden, Bohemia, Croatia, and Hungary. The 2 Pliocene species represent France and Asia Minor, and one of the Recent species is found in the Pleistocene of Japan. It seems probable that Xanthoxylum was derived from Fagara through a loss of the floral calyx and by adaptation to cooler climatic conditions.

The genus Fagara Linné is substituted for Xanthoxylum by many recent systematists, although I prefer to consider it as the ancestral stock and use it in the older sense, as including the 150 cosmopolitan tropical species. To Xanthoxylum I would refer the extratropical forms of Asia and North America. Undoubtedly several if not all of the fossil forms described as species of Xanthoxylum are more properly referred to Fagara, although none have heretofore been described under this name except forms from Florissant, Colo., and from California, which are probably referable to Xanthoxylum. The Tertiary flora of southeastern North America contains several very characteristic forms of Fagara. The oldest forms are three species from the Wilcox group. There is another species in the overlying Claiborne group. The Vicksburg group has furnished a very common form, which has several well-marked varieties in some of the leaves of which the glandular punctate character is beautifully preserved. Still another form is found in the Apalachicola group of Florida.

The genus Ruta Linné, which includes more than 100 existing species, mostly of Eurasia, although found also in Africa and South America, is represented by characteristic capsules in the Aquitanian of Rhenish Prussia, described by Menzel in 1913, and by 2 species in the Pliocene of Limburg described by Reid.

The genus Phellodendron Ruprecht, which includes 2 existing Asiatic species, is represented in the Aquitanian of Rhenish Prussia by fruits (drupe) and 3 well-marked species are present in the Pliocene of Limburg. Engelhardt has described species of Ticorea, Pilocarpus, and Erythrochyton from the early Tertiary of Chile and a species of Condaninea from that of Colombia.

The remaining genus, which is represented by fossil representatives, is Ptelea Linné, which includes 7 or 8 existing species confined to the United States and Mexico. Greene has recently described very many poorly established new species of this genus. The fossil forms are represented by both leaves and characteristic fruits. The oldest comes from the Arctic Eocene. A species is found in the Oligocene of Italy, and 6 Miocene species occur in Colorado, France, Switzerland, Carniola, and Hungary. A Pliocene species is recorded from Italy. Obviously the record will have to be greatly increased before any trustworthy conclusions can be drawn respecting the place of origin and geologic history of the Rutaceæ.

The family Simarubaceæ (often spelled Simaroubaceæ) includes about 28 genera and more than 150 existing species of shrubs or trees that have pinnate leaves and drupaceous fruits. It is confined chiefly to the Tropics and the warmer parts of the Northern Hemisphere. Only 3 existing species reach the coast of southern Florida. The family is represented on all the continents except Europe. Two genera and 4 species are confined to Asia, 3 genera and 4 species are confined to Australia, 4 genera and 6 species are confined to Africa, and 9 genera and 71 species are confined to America. The most widespread species is the monotypic *Suriana maritima* Linné, a cosmopolitan tropical strand plant which occurs on the dunes, keys, and coastal hammocks of southern Florida.

The only genus represented in the Wilcox is Simaruba Aublet, which contains a single species, *Simaruba eocenica* Berry, that closely resembles the existing *Simaruba glauca* De Candolle, found along tropical coasts from southern Florida to Brazil.

The only other existing genus of which fossil forms are known is Ailanthus Desfontaines, which contains 7 existing species in eastern Asia and the East Indies. Ailanthophyllum Dawson, which includes a single species, is described from the Eocene (?) of British Columbia. The fossil species of Ailanthus number about 15. There are 2 species in the Eocene of Wyoming and Oregon; 8 in the Oligocene of France, Alsace, Styria, and Prussia; and 5 in the Miocene of France, Switzerland, Baden, Italy, and Colorado. In the absence of collateral evidence that the Eocene occurrences in North America have any bearing on the origin of the genus, it is merely an interesting speculation that the genus originated in North America and subsequently reached Asia by way of the Eocene land connection across Bering Straits. Certainly the genus lingered on this continent, as is indicated by its presence at Florissant as late as the middle Miocene.

The family Meliaceæ contains about 42 genera and about 680 existing species of shrubs and trees that bear pinnate leaves. Nearly all of these forms range within 30° of the Equator, though they reach 40° north latitude in eastern Asia and 40° south latitude in New Zealand. Moreover, the chinaberry (*Melia azedarach*), which has been cultivated from time immemorial in all Mediterranean countries and throughout the southeastern United States since its settlement and is perfectly hardy, has no temperate outliers. Though the Meliaceæ occupy a greater continuous area in South America, where more than 41 per cent of the existing species occur, the large number of species (about 285) found there represents only 19 per cent of the known genera. There are some remarkable similarities between the species of the American Tropics and those of West Africa. Thus the two small genera Swietenia and Carapa are represented in both areas, and *Carapa procera* is even said to be common to the two. Moreover, the genus Guarea, which includes about 80 species in the American Tropics, is represented by 3 species in West Africa. The larger number of genera are found in the southeastern Asiatic region, and the number of genera and their mutual affinities decrease from Asia toward Africa and also through Polynesia. Several genera (Toona, Xylocarpus, Cipadessa, and Melia) extend from Africa through Asia to Malaysia. Two genera are peculiar to Australia (Synoum and Owenia) and 2 to Polynesia (Vavæa and Meliadelpha). There are 13 monotypic genera, of which 6 are African and 7 Asiatic. From the distribution of the existing species De Candolle [1] infers that southern Asia is the center of radiation of the family. I am

[1] De Candolle, C., On the geographical distribution of the Meliaceæ: Linn. Soc. London Trans., 2d ser., Botany, vol. 1, pp. 233-236, pls. 30, 31, 1880.

inclined to think, however, that he is mistaken, since the oldest known forms, except the entirely doubtful Cedrelospermites of Saporta from the Valanginian of Portugal, are American, and the widespread existing American representatives of the family seem to comprise the specifically multiplied descendants of the original stock already represented in the Wilcox flora.

The Asiatic genera would thus represent immigrants into that area or forms evolved there. The Polynesian and Australian forms are much localized derivatives of the Indian stock, and unless the peculiar species of New Caledonia could not reach that region except by a land connection it may be inferred that this Asiatic radiation was relatively recent.

The fossil species are unfortunately few. So far as I know the only fossil species of Carapa is that found in the Wilcox, where it may have been a mangrove plant, as is the existing *Carapa obovata.* The oriental *Carapa moluccensis* and the occidental *Carapa procera* are also coastal types. The occurrence of Carapa in the early Eocene at least helps to explain its present distribution in both the American and West African Tropics. As *Carapa procera* is common to these two areas, all the African species are perhaps recent immigrants, but it is more probable that there are unrecognized specific differences in this form in the two areas and that the present disconnected distribution is an example of survivors from the early Tertiary radiation. Another genus whose modern distribution is like that of Carapa is Moschoxylon Jussieu (made a section of Trichilia Linné by Harms in Engler and Prantl), which includes about 60 species in tropical America and West Africa. This genus is represented by 2 fossil species described by Engelhardt from the early Tertiary (Eocene or Oligocene) of Chile and by a third species from Colombia. The genus Cedrela, sometimes made the type of an independent family, the Cedrelaceæ, is represented by 4 Wilcox species, Eocene prototypes of existing American species. This genus, which includes 9 or 10 species, is confined to America in the existing flora and is only known outside this area in 2 species from the Miocene of Croatia, which Unger referred to Cedrela, and an undescribed Cedrela recorded by Ettingshausen from the Ypresian of the south of England. Saporta has, however, recorded 6 species of Cedrelospermum from the Sannoisian of southeastern France, and Deane records a Cedrelophyllum from the Tertiary of New South Wales. The fossil record of these three genera, Carapa, Moschoxylon, and Cedrela, brief as it is, shows clearly that the Meliaceæ are not a modern element in the flora of the American Tropics, but were already well differentiated in the early Tertiary.

The remaining fossil references to this family comprise Meliaceæcarpum, based on capsules from the Aquitanian of Prussia, which Menzel, their describer, compares with those of the genera Dysoxylum and Guarea. F. von Müller has described Rhytidotheca and Pleioclinus, 2 supposed meliaceous genera, based on fruits from the Pliocene of Australia.

The small family Humiriaceæ comprises only 3 genera and a score of species of shrubs and small trees, all confined to the American Tropics, except a single species that is found in tropical West Africa (Aubrya), a distribution suggesting a history like that just suggested for Carapa, Moschoxylon, and Cedrela. The only known fossil species is one from the Wilcox that is very close to the existing *Vantanea paniculata* Urban of northern South America.

The family Malpighiaceæ, which is confined to tropical and subtropical countries, contains about 55 genera and 650 existing species, many of which are scandent, including some of the finest lianas of the Tropics, whose stems are as much as 2 decimeters in diameter. Others are shrubs and trees. The leaves are opposite and simple and the fruits drupaceous, capsular, or nutlike, and many of them winged. The only species that reaches the United States is *Byrsonima lucida* (Swartz) De Candolle, a small evergreen tree of the Florida Keys.

The family is predominantly American in its distribution, more than 67 per cent of both genera and species being confined to the Western Hemisphere (37 genera and 440 species). None of the genera occur in more than one continental area. The family is divided into two subfamilies—the Pyramidotoræ and the Planitoræ. The Planitoræ, which includes 2 tribes, the Galphimieæ and the Malpighieæ, is entirely American. Of the 3 tribes into which the Pyramidotoræ is divided the Tricomarieæ is entirely American. The Hiræeæ includes 3 genera and 23 species confined to Asia, 3 genera and 12 species confined to Africa, 1 genus containing 12 species that range from Malaysia to Australia, and 9 genera and 151 species confined to America. The remaining tribe, the Banisterieæ, includes a monotypic genus in Asia, 2 genera and 15 species in Africa, a single genus and 7 species ranging from the East Indies to Australia, and 11 genera and 247 species confined to America.

There are 21 monotypic genera, distributed as follows: Microsteira, confined to Madagascar; Flabellaria, confined to Africa; Caucanthus, confined to Arabia; Brachylophon, confined to Farther India; Mozia, Diplopteris, Lophopteris, Clonodia, Coleostachys, Blepharandra, Lophanthera, Verrucalaria, Pterandra, Acmanthera, Diacidia, and Glandonia, confined to Brazil, Guiana, and Venezuela; Henleophytum, confined to Cuba; Lasiocarpus and Echinopteris, confined to Mexico; and Tricomaria and Mionandra, confined to Argentina.

Monotypic genera in general are susceptible of two interpretations. They represent either the last survivors of a long line, as the Ginkgo and Sassafras, or relatively recent specializations. Of the foregoing monotypic genera it seems probable that most are the result of relatively recent evolution, since there is nothing in their character or distribution to suggest any extended geologic history and none have been found in fossil floras.

The fossil record is most incomplete. No forms are known from the Upper Cretaceous, though Ettingshausen recorded a species of Malpighiastrum and one of Banisteriophyllum from the Upper Cretaceous of Australia. Those identifications, however, are open to the most serious question, and I do not consider them of any weight in the discussion. The family is certainly represented in the lower Eocene by 5 species of Malpighiastrum, Hiræa, and Banisteria in the Ypresian of the south of England and by 5 species of Hiræa and Banisteria in the Wilcox flora, based on both leaves and characteristic fruits. There are also doubtful species of Malpighiastrum and Banisteriophyllum, described from the Tertiary of Australia by Ettingshausen. Thus there is no direct geologic evidence of the place of origin of the family. As the family is so predominantly American at present, and as only 2 genera have reached Australia from the East Indian region, and as 2 of the American genera appear in the northward extension of the early Eocene flora of the American Tropics during the Wilcox epoch, and are as ancient as any certain records of the family anywhere, the conclusion is extremely probable that the family originated in equatorial America. With the exception of the Wilcox records enumerated above nearly all the fossil records relate to Europe and may be briefly enumerated.

The genus Malpighiastrum Unger contains about 30 recorded species, including the doubtful Upper Cretaceous and Tertiary species previously mentioned as recorded by Ettingshausen from eastern Australia; 3 Ypresian species from the south of England; 8 Oligocene species in France, Italy, Dalmatia, Styria, and Transylvania; about 15 Miocene species in Italy, Prussia, Bohemia, Croatia, and Transylvania, and 2 Pliocene species in Italy.

The genus Heteropteris Jussieu, which includes about 90 existing species, ranging from Mexico and the Antilles to Bolivia and Brazil, includes a late Oligocene species in Transylvania and 2 Miocene species in Styria and Croatia.

The genus Hiræa Jacquin, which contains about 25 existing species ranging from Mexico and the Antilles to Peru, is represented by about 10 fossil species, based for the most part on the winged fruits. There is a species in the Ypresian of southern England and a characteristic fruit in the Wilcox; 4 Oligocene species in the Tyrol, Styria, and Transylvania; 3 Miocene species in Baden, Styria, and Transylvania; a Pliocene species in Brazil; and an early Tertiary species in Ecuador.

The genus Tetrapteris Cavanilles, which includes about 60 existing species, ranging from the West Indies and Mexico to southern Brazil and Bolivia, contains a fossil species in the Oligocene of Styria and 3 Miocene species in Bohemia, Styria, and Croatia.

The genus Stigmatophyllon Jussieu, which comprises about 45 existing species in the Bahamas and Antilles and along the east coast of America from Mexico to Uruguay, includes a somewhat doubtful form, identified by Saporta, from the upper Oligocene of France. Similarly the genus Byrsonima L. C. Richard, whose 90 existing species range from the Bahamas and Mexico to southern Brazil and Bolivia, has been recorded by Massalongo from the early Pliocene of Italy, but the identification is extremely doubtful.

The genus Banisteria Linné contains about 70 existing species of climbing or scrambling shrubs, ranging from the West Indies throughout tropical South America and most numerous in Brazil. It is represented by 4 species, based on both leaves and fruits, in the Wilcox, one of them almost identical with the existing *Banisteria laurifolia* Linné, often referred to the genus Heteropterys Kunth, which ranges from southern Mexico through Central America and the West Indies to Colombia. There is an Ypresian species in the south of England; 4 Oligocene species in France, the Tyrol, Alsace, and Styria; 4 Miocene species in France, Switzerland, and Croatia; and an early Tertiary species in Ecuador.

Species of Banisteria, along with climbing Sapindaceæ (Paullinia and Serjania) and bamboos, are common in the great oak forests of upland Mexico, where they are associated with palms of the genus Chamædorea and many arborescent Lauraceæ.

The genus Banisteriophyllum Ettingshausen, which includes a single Upper Cretaceous and a Tertiary species in eastern Australia, I regard as of very doubtful affinities. Schenk also states that wood of a malpighiaceous type occurs among the silicified woods from the Oligocene of the island of Antigua.

The family Euphorbiaceæ is sometimes made the type of a distinct order, the Euphorbiales, although the significance of the characters by which it is segregated from the Geraniales is not obvious. It is an exceedingly large alliance and has about 220 genera and 4,000 existing species (Pax, 1890) of herbs, shrubs, and trees widely distributed throughout the Torrid and Temperate zones. The genus Euphorbia, which comprises more than 700 species, is perhaps the most widely distributed genus in the family. A great many of the recent species, particularly those of xerophytic character so closely simulating the Cactaceæ, are of relatively recent evolution. The Euphorbiaceæ is the fourth largest family in the flora of the Malay Peninsula and the Philippines. According to Beccari it is the third family in the Borneo flora; according to Hemsley it is the sixth family in the flora of Central America; and according to Koorders it is the fourth family in the flora of the Celebes.

In such a multiplicity of existing genera and species any effort to trace the larger features of distribution would occupy more space than it is worth in the present connection. Four arborescent genera and 5 species reach the United States in the Florida region, and several more are naturalized in that area. A considerable but relatively insignificant number are recorded from the Upper Cretaceous and Tertiary. The fossil records will, however, have to be greatly increased before they can be said to shed any definite light on the geologic history of the family. Enough is now known, however, to abrogate the statement made by Schenk [1] and quoted by Pax [2] that there is no certain evidence of the existence of the Euphorbiaceæ during the Tertiary. Fossil representatives of the following genera have been recorded: Euphorbia, a single species based on a fruit described by Heer from the Swiss Miocene; Euphorbioides, based on an inflorescence described by Wessel and Weber from the Aquitanian of Rhenish Prussia; Euphorbiophyllum, several species subsequently noted; Manihotites, a very characteristic species from the Upper Cretaceous of Georgia described by me; Crotonophyllum, several Upper Cretaceous and Eocene species; Cluytia, reported from the Eocene of the Isle of Wight and the Oligocene of Saxony and Rhenish Prussia. A single species of each of the following genera was identified by Ettingshausen from the Miocene of Bohemia—Adenopeltis, Baloghia, Omalanthus, and Phyllanthus. Conwentz has described a euphorbiaceous flower from the Baltic amber (Sannoisian) as *Antidesma maximowiczii*, and Felix has described petrified wood from the Tertiary of Colombia as Euphorbioxylon. Hura-like fruits (Euphorbeocarpum) are also recorded by Knowlton from the lower Eocene (Raton formation) of northeastern New Mexico. Engelhardt has recorded species of Omphalea Linné, Tetraplandra Baillon, and Mallotus Loureiro from the early Tertiary of Chile and seeds of Tithymalus have been recorded by Cockerell from the Wasatch of Wyoming and the "Loup Fork beds" of Kansas.

Though difference of opinion regarding the determination of some of these records is justifiable, I regard Manihotites, Euphorbiophyl-

[1] Schenk, A., Palaeophytologie, pp. 594-597, 1890.

[2] Pax, in Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, 1890.

lum, Crotonophyllum, and Euphorbioxylon as definite evidence of the existence of the Euphorbiaceæ during the Upper Cretaceous and Tertiary.

The 5 Wilcox species are referred to the genera Crotonophyllum, Euphorbiophyllum, and Drypetes. The genus Crotonophyllum was proposed by Velenovsky for a well-marked species from the Cenomanian of Bohemia. I have described a second species from the Upper Cretaceous of South Carolina. Two species are recognized in the Wilcox, and of these *Crotonophyllum eocenicum* Berry may be successfully compared with a number of the 600 existing species of Croton, which is so abundantly represented in tropical America. Comparisons are especially close with *Croton eluteria* (Linné) Bennett, which is found in the low coppice of the beach ridges throughout the Bahama Islands.

The genus Euphorbiophyllum was proposed by Ettingshausen in 1853 for several species from the Sannoisian of the Tyrol. Altogether more than a dozen species have been described by Ettingshausen, Saporta, Heer, and Engelhardt. These species have been compared with the existing, mostly tropical American species of Styloceras, Sapium, Stillingia, Adenopeltis, Excoecaria, Colliguaja, and other genera. The oldest form comes from the Cenomanian of Portugal and another Upper Cretaceous species occurs in the Turonian of southern France. In the Eocene there is a species in western Greenland, a second on the island of Sheppey (Ypresian), and a third in the Paris Basin (Lutetian). Five Oligocene species have been described from the Sannoisian of the Tyrol, and a sixth from the Chattian of northern Bohemia. There are two Miocene species in Switzerland and two in Styria. A Pliocene species is described by Krasser from Brazil. A single small-leafed species of Euphorbiophyllum is of rare occurrence in the Holly Springs sand.

The genus Drypetes Vahl includes about a dozen existing species confined to tropical and subtropical America. Three species extend southward to northern Brazil and 2 range northward to the Florida Keys. There are 2 well-marked species in the Wilcox flora—one an Eocene prototype of the existing *Drypetes keyensis* Urban and the other of the existing *Drypetes lateriflora* (Swartz) Urban, both small trees of the coastal flora of southern peninsular Florida, the Bahamas, West Indies, and Antilles. The genus, which has not previously been recorded in the fossil state, was probably of American origin, and there is no evidence that it ever spread to the Eastern Hemisphere.

The order Sapindales, sometimes called the Celastrales, includes about 20 families and about 3,200 species. The largest families in number of species are the Sapindaceæ, which contain more than twice as many species as any of the others; the Celastraceæ, Anacardiaceæ, Balsaminaceæ, and Ilicaceæ. Like the Geraniales, the Sapindales start with isocarpic forms and pass to those in which the carpels are reduced in number; in the more evolved families the flowers have become zygomorphic. Since there are several distinct lines of development and the separation from the Geraniales is based on characters that seem trivial, it seems probable that the families which comprise these two orders as at present understood represent a plexus of forms whose filiations are not yet understood.

The first family of the Sapindales that is represented in the Wilcox flora is the Anacardiaceæ, an exceedingly natural group. It contains about 58 existing genera and 435 species of shrubs and trees which have round pithy branches, resinous and commonly toxic juice, alternate simple, palmate or pinnate, exstipulate leaves, and drupaceous fruits that carry exalbuminous seeds. The Anacardiaceæ makes its greatest display in the tropics and subtropics of both hemispheres, but in the existing flora is especially characteristic of the Malaysian region. Rhus is by far the largest genus and the only one of the family found in the extratropical regions of both the northern and southern hemispheres. The present geographic distribution shows many anomalies throughout the family. Thus the genus Campnosperma Thwaites includes 8 species in Madagascar, Ceylon, Sumatra, Borneo, and Malakka and a single species in northern Brazil. The genus Sorindeia Thouars of tropical Africa and Madagascar is most closely allied to the genus Mauria Kunth of the Andes of South America. The genus Calesium Adanson includes 13 species in tropical Africa and 1 in the East Indies. The Eurasian genus Pistacia Linné is represented by a single species in Mexico. The genus Thyrsodium Bentham includes 4 species in the Amazon region of South America and 1 in tropical West Africa. The subfamily Mangiferæ, which includes about 80 species, in entirely Malaysian except for a species of Gluta Linné in Madagascar and the genus Anacardium Linné, which is confined to tropical South America, chiefly Brazil. The subfamily Spondieæ is found in the Tropics of both hemispheres. The subfamily Rhoideæ is found on all the continents and shows a pairing of a considerable number of genera in equatorial Africa and America. The two remaining subfamilies, the Semecarpeæ and the Debineeæ, are restricted to the region extending from India to Australia. The family contains 20 monotypic genera, distributed as follows: Asia 5, Australia 3, Africa 6, Madagascar 3, North America 2, and South America 1.

The fossil records of the Anacardiaceæ are very incomplete, although there seems to be no doubt that it was represented in both Europe and North America as far back as the Upper Cretaceous. As in the existing flora, the most abundant genus in the fossil record is Rhus, to which more than 100 species have been referred. Eight of these forms are Upper Cretaceous, the oldest coming from North American strata correlated with the Cenomanian (Raritan and Dakota). The genus appears in Europe in the Turonian of Bohemia. There are more than a dozen Eocene species of Rhus, widely scattered. Thus, there are 3 in the Ypresian of Alum Bay, 4 in western Greenland, and species in the Lance, Kenai, Fort Union, and Green River formations of North America. The genus doubles its known species in the early Oligocene and is especially well represented in southern France but also recorded from the Tyrol, the Baltic amber, Italy, Carniola, and Styria.

In the Miocene Rhus seems to have been as abundant, as well differentiated, and as widely distributed as it is in the existing flora, for more than 60 fossil species have already been described. The records embrace all European countries where Miocene plants have been found, as well as Iceland and the following North American localities: Maryland, Virginia, Colorado, Yellowstone Park, Idaho, Nevada, Oregon, and California. Only a small number of Pliocene species are recorded in Spain, France, Italy, Germany, and Slavonia.

Three Pleistocene species are recorded, 2 from Japan and 1 from China, all closely related to still existing species of that region. Engler[1] some years ago reviewed the geologic records of Rhus and concluded that most of the then known fossil species belonged to the section Trichocarpæ, which in the existing flora contains more than a score of species, mostly confined to North America and eastern Asia, or to the section Gerontogeæ, which includes 75 existing species, principally found in South Africa. A few fossil forms he considered as representing the section Venenatæ, which includes about 14 existing species in North and South America. The other sections into which the genus is subdivided were not recognized among the fossil forms.

The allied genus Cotinus, which contains 2 or 3 existing species in Eurasia and North America, is probably represented by some of the fossil forms referred to Rhus. Saporta considers *Rhus antilopum* Unger from the Aquitanian of Kumi to be a species of Cotinus. This author has also described *Cotinus palæocotinus*, and Cockerell has described *Cotinus fraterna* from the Miocene of Florissant, Colo.

The genus Pistacia, which contains 5 existing Mediterranean species and 1 each in eastern Asia and Mexico, is represented by about 15 known fossil species, the oldest of which, of doubtful value, comes from the Raritan of Staten Island. A second Cretaceous species is found in the Laramie of Colorado. Europe is represented in the record by an Ypresian species from Alum Bay. There are 3 Oligocene species in France and 7 Miocene species in France, Prussia, Bohemia, Styria, Galicia, and Transylvania. There is a Pliocene species in Styria and another in Holland, an extinct Pleistocene species on the island of Madeira, and the existing *Pistacia lentiscus* Linné in the Pleistocene of Santorin.

The genus Anacardites Saporta (Anacardiophyllum) has been used as a form genus for fossil Anacardiaceæ of uncertain generic relationship. As used by Saporta it represented fossil forms that resemble existing species of Mangifera, Anaphrenium, Spondias, Comocladia, Holigarna, and the like, but not determinable with certainty. Heer has described a supposed species of Anacardites from the Atane beds of western Greenland. There are 2 species in the Sparnacian and 1 in the Ypresian of France, and 7 well-marked species in the Wilcox. There

[1] Engler, A., Bot. Jahrb., Bd. 1, pp. 413–419, 1881.

are 2 or 3 Oligocene species in France and Germany, and 2 or 3 Miocene species in France and Styria. Felix has described petrified wood from the Eocene of the Caucasus, which he refers to Anacardioxylon, a type also represented in the Oligocene of Antigua in the American Tropics (species compared with the existing genus Spondias).

The floral genus Heterocalyx Saporta (Trilobium Saporta, Elaphrium Unger, Getonia Unger), which occurs at a number of horizons in the Oligocene of France, Croatia, and Styria, is represented by a species in the Wilcox. Saporta compared it with the South American genus Astronium, but Engler[1] considers it most like the Malayan genus Parishia.

The genus Metopium, not certainly recognized heretofore, contains a well-marked species in the Wilcox. Several Tertiary woods are described by Unger as Rhoidium, and Saporta has described a species of Schinus from the French Oligocene (Gargas), which is wrongly determined according to Schenk.[2]

The genus Spondiæcarpum is represented by a species in the early Eocene of France, a second in the Aquitanian of Rhenish Prussia, and a third in the late Tertiary of the East Indies (Banka). Recently Fritel has described leaves from the Aquitanian of France which he calls Semecarpites and which are very close to the existing Semecarpus, which contains about 40 species that range from India to Australia.

Clement Reid has based an extinct genus, Teschia, on fruits of this family from the Pliocene of Holland.

The family Ilicaceæ (Aquifoliaceæ) is relatively small, comprising only 5 genera and about 180 existing species of shrubs or trees that bear alternate simple, entire or toothed, commonly coriaceous leaves. The flowers are small, diœcious, and hypogynous. The fruit is a drupe, and its thin, fleshy sarcocarp incloses as many crustaceous nutlets as there are carpels. The genus Ilex Linné, to which all but seven of the existing species are referred, is found in all tropical and temperate regions of the world except western North America, Australia, New Zealand, and New Guinea. The remaining genera of the family are Oncotheca Baillon, which includes a single species in New Caledonia; Nemopanthes Rafinesque, which contains a single species in temperate North America; Sphenostemon Baillon, which includes 2 species in New Caledonia; and Byronia Endlicher, which contains 3 species, one in Tahiti, one in the Hawaiian Islands, and one in Australia. This modern distribution is a certain indication that the family has an extended geologic history.

More than a hundred fossil species have been referred to the genus Ilex. At least 13 species are recorded from the Upper Cretaceous. All but one species from the Turonian of Bohemia come from the Western Hemisphere, and include 2 in the Raritan formation, 3 in the Magothy formation, 7 in the Dakota sandstone, 1 in the Atane, and 2 in the Patoot beds of western Greenland.

There are about 14 Eocene species, including 4 in the Wilcox of the southeastern United States, 1 in the Ypresian of England, 1 in the Fort Union, and 4 in the Green River formation of the western United States, 5 in Greenland, and 1 in Alaska. There are more than a score of Oligocene species, including one from Chile, that may even be of Eocene age. The lower Oligocene, or Sannoisian, contains 11 species in France, Tyrol, Saxony, and Prussia, and also includes 3 species of flowers described by Caspary from the Baltic amber. The middle Oligocene, or Tongrian, includes 6 species in France, Italy, Germany, and Styria, and there are 7 species in the upper Oligocene (Chattian) of France, Bohemia, and Greece. More than 50 species have been described from the Miocene of Europe and Asia, and of New Jersey, Colorado, and California in this country. The most prolific Miocene area is that of France. About 10 species are known from the Pliocene of Spain, France, Italy, Prussia, and Asia Minor. One extinct and 4 still-existing species are found in the Pleistocene of Virginia, North Carolina, Alabama, Kentucky, and the island of Madeira. In addition to the fossil forms referred to Ilex, 2 Miocene species from Italy and Styria are referred to the genus Nemopanthes, and 4 forms from the late Oligocene or the Miocene of Prussia, Styria, Croatia, Bohemia, and Greece are referred to the genus Prinos Linné, which is usually considered a section of Ilex. The 4 species from the Wilcox that are referred to Ilex are represented in the

[1] Engler, A., op. cit. [2] Schenk, A., Palaeophytologie, p. 541, 1890.

collections by a small amount of mostly poor material and are without special significance.

The family Celastraceæ includes about 40 genera and more than 400 existing species of trees and shrubs that bear opposite or alternate, simple, persistent or deciduous leaves and capsular or drupaceous fruits. The 3 large genera Euonymus, Celastrus, and Gymnosporia are practically cosmopolitan, and several other genera localized in the modern flora were cosmopolitan in the Tertiary.

The following 12 genera, which include more than 100 species, are confined to America: Fraunhofera, Mortonia, Glossopetalum, Schaefferia, Goupia, Maytenus, Pachystima, Zinowiewia, Plenckia, Wimmeria, Gyminda, Rhacoma. The genera Glyptopetalum and Tripterygium, which include 5 species, are confined to Asia. The genera Hypsophila, Denhamia, and Hedraianthera, which contain 7 species, are confined to Australia. The following 10 genera, which include about 60 species, are confined to Africa or Madagascar: Putterlickia, Catha, Pterocelastrus, Polycardia, Ptelidium, Cassine, Elæodendron, Maurocenia, Schrebera, and Lauridia.

The family is definitely represented in the Cretaceous by at least 5 genera and is an important element in most Tertiary floras. The oldest known genus is the form genus Celastrophyllum, proposed by Göppert. Five well-marked species occur in the Patapsco formation (Albian) of Virginia and Maryland. At the base of the Upper Cretaceous, particularly in North America, a large number of species are found. More than 30 have been described, 2 of which are recorded from New Zealand and 2 from the Cenomanian of Niederschoena, in Saxony. One species is found in the Atane beds of Greenland and 3 are found in the Patoot beds. The remainder occur in the United States, where they are distributed as follows: Ten in the Raritan formation of New Jersey and Maryland, 12 in the Tuscaloosa formation of Alabama, 2 in the Magothy formation of New Jersey and Maryland, 2 in the Black Creek formation (Middendorf arkose member) of South Carolina, 7 in the Dakota sandstone, and 2 in the Black Creek formation of North Carolina. There are 10 Eocene species—7 in the basal Eocene of Belgium, 1 in the Ypresian of England, and 2 in the Claiborne group of the Mississippi embayment. There are 5 Miocene species in Italy, Bohemia, and Styria; a Pliocene species in Italy; and 4 Tertiary species from the island of Java. Another form genus is Celastrinites Saporta, which includes 4 species in the Paleocene of France, 1 in the Denver formation of Colorado, 1 in the Livingston formation of Montana, and 1 in the Miocene of Florissant, Colo.

The genus Celastrus Linné is the largest fossil genus of the family. Though its present center of distribution lies in the uplands of southeastern Asia and the East Indies, its history shows that the ancestral stock was cosmopolitan and very abundant in the Tertiary of America and Europe. It is highly probable that it originated in America at the dawn of the Upper Cretaceous or somewhat earlier. The oldest known species, *Celastrus arctica* Heer, is found in the Raritan and Magothy formations of New Jersey and Maryland and in the Patoot beds of Greenland. No less than 30 species of Celastrus have been described from the Eocene, including 6 Ypresian species from England, 5 species in the Wilcox flora, 1 in the Denver, 10 in the Fort Union, 1 in the Kenai of Alaska, and 3 from Greenland. There are also about 30 Oligocene species, all European, which include remains in the Baltic amber, in France, Switzerland, Germany, Austria-Hungary, and Greece. There are at least a dozen species in the Chattian of Bohemia. More than 50 Miocene species have been described, ranging throughout Europe, in eastern Asia, in Australia, and in Virginia, Colorado, Idaho, and Oregon in this country. About a dozen Pliocene species have been described from Spain, France, Italy, and Sicily.

The genera Cassine Linné and Pterocelastrus Meissner, both now confined to South Africa and Madagascar, each includes a fossil species in the Miocene of Bohemia. The genus Pachystima Rafinesque, which includes 2 existing species in North America, contains an Upper Cretaceous species in North Carolina and a Miocene species in Colorado.

The genus Maytenus Feuillée, which contains about 70 existing species of the Tropics and subtropics of South America, is represented by a well-marked species in the Wilcox flora. There are 2 species in the early Tertiary of Chile, 1 in the late Oligocene and 3 in the Miocene of southeastern Europe.

The monotypic genus Gyminda Sargent, which is confined to Florida and the West Indies in the existing flora, contains a doubtfully determined fossil species in the Magothy formation of the Atlantic Coastal Plain. The genus Microtropis Wallich, which includes 9 or 10 existing species of the mountains of southeastern Asia from India to China and Japan, is represented by a doubtfully determined form in the early Pliocene of Italy.

A well-preserved flower in the Baltic amber is described by Conwentz as *Celastrinanthium hauchecornei*.

The genus Elæodendron Jacquin, which includes about 25 existing species that are confined to South Africa, has a rich geologic history. Four Upper Cretaceous species have been described—1 from Australia, 1 from the Dakota sandstone, and 2 from the Magothy formation of the Atlantic coast. There are 4 Eocene species, which show that the genus was represented in Alaska, the Ypresian of England, and the Fort Union of the Rocky Mountain region. There are 5 Oligocene species in the Tyrol, Bohemia, and Transylvania; 10 Miocene species in France, Switzerland, Italy, Prussia, Bohemia, Styria, Australia, and New Zealand; and 4 Pliocene species in Italy.

The remaining genus known in the fossil state, Euonymus Linné, contains about 60 existing species, which are widely distributed throughout the northern hemisphere, but are most numerous in the Asiatic Tropics and in China and Japan. More than 30 fossil species are known, based on both fruits and leaves. There are 4 well-marked Eocene species, all of which are confined to North America, where they are represented in west Greenland, in the Fort Union and Green River formations of the Rocky Mountain region, and in the Wilcox of the Mississippi embayment. The species of the Mississippi embayment is a very abundant and characteristic form. Four or five Oligocene species of Euonymus are recorded from Bavaria, the Tyrol, and Bohemia. The 12 Miocene species occur in France, Prussia, Bohemia, Styria, Croatia, and Hungary. There are 4 Pliocene species in Germany, Italy, and Slavonia, and 2 still-existing species occur in the Pleistocene of France.

This very brief survey of the fossil history of the Celastraceæ shows the probability, similar to that exhibited by so many other families of Dicotyledonæ, that the ancestral stock originated in the Western Hemisphere.

The family Sapindaceæ consists of about 118 genera and more than 1,000 existing species of trees or shrubs that bear alternate pinnate exstipulate, persistent or deciduous leaves and drupaceous or capsular fruits whose seeds are crustaceous and mostly solitary. About one-third of the genera are lianas. The family is chiefly confined to tropical and subtropical regions, and about 23 per cent of the genera (27) and 34 per cent of the species (345) are confined to America. There are more genera (30) confined to the African region, but only about one-fifth as many species (75).

The genera Cardiospermum, Schmidelia (Allophylus), and Sapindus are found in all tropical countries. The genus Paullinia, which contains more than 120 existing species, though mostly American, is represented in Africa and Madagascar. The genus Dodonæa, which contains more than 40 species in Australia, is represented by one or two forms which are found in all tropical countries, and a single species lives in the Hawaiian Islands and Madagascar. Harpullia is common to Asia, Africa, and Australia. Two genera and about 15 species are confined to Australia, 4 genera and 66 species range from Asia to Australia, 10 genera and 22 species are confined to the East Indies, 2 genera and 20 species are confined to Polynesia, and 6 genera and 35 species range from Malaysia or the East Indies to Australia. These few facts regarding the existing distribution make it obvious that the family is ancient and that there has been an extensive evolution of both generic and specific types in relatively modern times in the American Tropics on the one hand and in the Malaysian region on the other.

The fossil record, though much less complete than might be wished, includes at least 13 genera, of which 6 are extinct, and about 160 species, by far the largest number of which are referred to the still existing genus Sapindus, which appears to have been well differentiated and widely distributed at the dawn of the Upper Cretaceous. There are about 10 Upper Cretaceous species, of which all but 4 occur in pre-Senonian strata. Thus there are 2 species in the Perucer beds of Moravia and Bohemia and 1 at Niederschoena, in Saxony, all Cenomanian. Two species are found in the Atane and 1 in the Patoot beds of western Greenland.

Two species come from the Dakota sandstone, 2 from the Tuscaloosa formation of Alabama, 1 from the Black Creek formation (Middendorf arkose member) of South Carolina, 1 from the Woodbine sand of Texas, 2 each from the Raritan and Magothy formations of the Middle Atlantic States, 1 from the Montana group, and 2 from the Laramie. I have given this Upper Cretaceous distribution in some detail because of the special interest attached to the deployment of the Upper Cretaceous Dicotyledonæ. It should be noted that seven of these Upper Cretaceous forms are North American. There are more than 30 Eocene species of Sapindus, of which two-thirds are North American. The genus is very abundantly represented in both individuals and species in the coastal floras of the Wilcox group, from which I have described no less than 9 species. The overlying Claiborne group contains 4 species. Species of Sapindus are equally common in the Rocky Mountain province in the Denver, Fort Union, and Green River formations. An Eocene species comes from Greenland, 4 undescribed species are found in the Ypresian of England, and a fifth is contained in beds of the same age in Hungary. There is an upper Eocene species from France and a second from Oregon.

Six or more Oligocene species are well distributed in Europe, and species which occur in Chile, New Zealand, Australia, and Tasmania may be of Oligocene age. More than 30 Miocene species are found throughout southern Europe, in eastern Asia, and in North America (Colorado, Oregon, and Yellowstone Park). The 8 or 10 Pliocene species are confined to southern Europe.

Several form genera have been derived from the same root as the genus Sapindus. Thus, Sapindophyllum has been applied to 2 species from the Albian of Portugal (?). To this genus are also referred a Cenomanian and a Chattian species from Bohemia and a Tertiary species from Japan. The term Sapindoides has been used by Perkins for Sapindus-like fruits preserved in the early Tertiary lignites of Brandon, Vt., from which 8 species have been described. In some respects the most interesting genus is Sapindopsis Fontaine, which is represented by 3 abundant and well-preserved species in the Patapsco formation (Albian) of Maryland and Virginia, one of which is also present in the Fuson formation of the Black Hills, and which I have shown [1] to be very probably ancestral forms of the genus Matayba Aublet (Cupanieæ) which contains more than two score existing species in the tropical and subtropical regions of America. This well-marked type suggests the interesting question, How early in the Mezosoic were the ancestors of many modern genera present in equatorial America?

The genus Paullinia Linné, which contains about 122 existing species, mostly confined to the American Tropics but sparingly represented in Africa and Madagascar, is represented by an Oligocene species in Prussia and 2 early Miocene species in southeastern France and Bohemia.

The genus Thouinia Poit, which in the modern flora has about 15 species confined to the West Indies and Mexico, is represented by an early Tertiary, probably Eocene species in Chile. The genus Nephelium Linné, which contains more than a score of existing species in southeastern Asia, is recorded by Unger from the Aquitanian of Greece and by Geyler from the Tertiary of Borneo.

The genus Koelreuteria Laxmann is represented by 2 Chinese species in the existing flora. In the fossil state it is recorded from the Tertiary of the island of Sakhalin, from Spitzbergen, and from Switzerland and Baden. Felix has described a genus, Schmideliopsis, based on fossil wood from the Oligocene of the island of Antigua, very close to the existing genus Schmidelia Linné, which contains more than a hundred existing species in all tropical countries.

Deane records 3 species of Nephelites from the Tertiary of New South Wales.

The modern Cupanieæ are represented in paleobotanic literature not only by Cupania, but by species of Cupanites and Cupanoides. The term Cupanoides was proposed by Bowerbank for cupaniaceous fruits and seeds, of which he described several characteristic species from the Ypresian of the Isle of Sheppey. Similar forms have also been recognized in the Miocene of Carniola and in the Pliocene of Italy. The genus Cupania Linné contains about 35 existing species, which are confined to the American Tropics. Several Ypresian

[1] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, pp. 467-474, pls. 83-88, 1911.

species from the south of England have been referred to it by Ettingshausen, and it has also been recorded from the Miocene of the island of Sakhalin. The greater number of Cupania-like forms have, however, been referred to the genus Cupanites Schimper, of which 9 or 10 species have been described, and with the exception of extremely doubtful forms from the Upper Cretaceous of New Zealand and the Tertiary of Australia, the oldest authentic occurrences are the two species of the Wilcox flora. There is a third species in the overlying Claiborne group of the Mississippi embayment. The oldest European form comes from the late Oligocene of Styria. Miocene species are recorded from Germany, Bohemia, Austria, Croatia, and Hungary.

The genus Dodonæa Linné, often made the type of a distinct family, the Dodonæaceæ, includes about 50 existing species four-fifths of which are Australian. *Dodonæa viscosa* Linné is cosmopolitan in the Tropics and there are one or two additional species in the American Tropics, as well as one in the Hawaiian Islands and another in Madagascar. The genus (including Dodonæites) was evidently widespread in former times and more than a score of fossil species, based on both leaves and fruits, have been described. The oldest known forms are two species in the Ypresian of the south of England and the two contemporaneous species in the Wilcox, which are represented by both leaves and characteristic fruits. There are 5 Oligocene species in France, Tyrol, Bohemia, and Styria, and 10 Miocene species in Prussia, Baden, Switzerland, Bohemia, and Croatia. A well-marked species occurs in the Claiborne (Lutetian), ranging along the Claiborne coast from northeastern Georgia to central Louisiana.

It is impossible from the known facts to determine the place of origin of the family, but certain genera were obviously evolved toward the close of the Lower Cretaceous in equatorial America and have lived there or in adjacent areas throughout the long stretch of time until the present.

The order Rhamnales includes about 1,000 existing species of shrubs, trees, and vines, about equally divided between the families Rhamnaceæ and Vitaceæ. It closely parallels the Sapindales in its floral development, but is distinguished by its mostly tetracylic flowers with opposite stamens, many of them lacking a corolla. The leaves are simple and typically alternate. Of the two families only the Rhamnaceæ is represented in the Wilcox flora.

The family Rhamnaceæ (Frangulaceæ) includes 47 genera and about 500 species of shrubs and trees, mostly of the Tropics, though several genera extend for considerable distances into the Temperate Zone, the genus Rhamnus in particular being mostly extratropical in the Northern Hemisphere. The genera Zizyphus, Adelia, and Gouania are found in all tropical countries. Almost half the genera are common to more than one continental area. America has the greatest number of peculiar genera (15) with about 85 species. Two monotypic genera are confined to Asia, 5 genera, including the large genus Phylica Linné, which together include about 70 species, are confined to Africa, and 5 genera, including the two large genera Spyridium Fenzl and Cryptandra Smith, in all about 70 species, are confined to Australia.

Ten or 11 genera, of which 5 are represented in the Wilcox flora, are found fossil, the three largest being Rhamnus, Paliurus, and Zizyphus. The genus Rhamnus Linné, which is cosmopolitan in the northern warm temperate and subtropical zones, includes about 70 existing species. There are considerably more than 100 fossil species, mostly well characterized, the leaves of which are simple, commonly entire, and have ascending secondaries and closely spaced fine percurrent nervilles. A dozen or more species have been described from the Upper Cretaceous, the genus appearing in the Cenomanian in both Europe (Niederschoena, Saxony) and America (Raritan formation). There are 6 species in the Dakota sandstone, 2 in the Magothy formation, 1 in the Atane, and 2 in the Patoot beds of Greenland. The genus is represented in the Montana group and the Laramie formation of the western interior region and in the Senonian of Westphalia. There are about 30 Eocene species, most of them North American. Species of Rhamnus are very common in the Raton and Denver formations along the Front Range of the Rocky Mountains and from the base to the top of the Wilcox. There are 4 species in the Raton, 8 in the Denver, and 6 in the Wilcox. The genus is also well represented in the later Eocene along the Pacific coast and in western

Greenland. In Europe only a single species is recorded from the Paleocene. The Ypresian, which is synchronous with the Wilcox, contains 3 species in the south of England.

There are 11 or 12 Oligocene species in France, Prussia, Tyrol, Italy, Dalmatia, Styria, and Greece and a single undescribed species in the Apalachicola group of Florida. There are more than two score species in the Miocene of Switzerland, Italy, Bohemia, Prussia, and Styria, Rhamnus being especially abundant. It is also found in the Miocene of Iceland, Spitzbergen, Manchuria, and the island of Sakhalin. In this continent there are species in British Columbia and in Colorado.

There are about 13 Pliocene species, of which no less than 9 are recorded from Italy and 1 from the island of Java. There is an extinct species in the Pleistocene of Hungary and a still-existing species in the Pleistocene of the island of Madeira. In addition to the species referred to Rhamnus the form genus Rhamnites Forbes, founded on 3 species from the Eocene of the Isle of Mull, contains 2 American Upper Cretaceous species found in the Raritan, Tuscaloosa, Magothy, and Dakota formations. A species occurs in the Fort Union and another in the Wilcox. The genus Rhamnacinium of Felix is based on petrified wood. It contains 5 or 6 species found in the Eocene of the Caucasus, Texas, and Saskatchewan, and in the Miocene of Yellowstone Park.

The genus Paliurus Jussieu, which includes only 2 existing species, ranging from southern Europe through southern Asia to China and Japan, was cosmopolitan in former times. More than 40 fossil species have been described. At least 12 are known from the Upper Cretaceous, all confined to North America. There are 2 species each in the Raritan, Magothy, and Laramie; 5 in the Dakota; and 1 each in the Eutaw formation of Georgia, in western Greenland, and Vancouver Island. There are 10 Eocene species, also confined to North America, 2 of them found in the Fort Union and 3 each in the Denver, in western Greenland, and in the Wilcox. The leaves are rare in the Wilcox, but the characteristic peltate fruits are not uncommon. The oldest European forms are 2 species in the Oligocene of France, and a well-marked species is contained in the Oligocene (Vicksburg group) of Louisiana. The 13 Miocene species are found in Asia (Siberia and Sakhalin), Europe (Switzerland, Baden, Germany, Bohemia, Italy, Styria, and France), and North America (Colorado and Oregon). The presence of numerous species of Paliurus in the Upper Cretaceous and Eocene of North America and their absence on other continents before the Oligocene renders it very probable that the genus originated in the Western Hemisphere.

The genus Zizyphus Jussieu, which contains about 40 existing species, largely shrubs, many of them prostrate or scrambling, and a few small trees, is mostly Indo-Malayan in its distribution but is represented by a few species in the tropics of Eastern Asia, America, Africa, and Australia. The naturalized *Zizyphus vulgaris* forms extensive thickets in some localities in southeastern Louisiana. There are more than 50 known fossil species, and the 10 Upper Cretaceous species, like those of the genus Paliurus, are confined to North America. They are found in the Raritan and Magothy formations of New Jersey and Maryland, the Eutaw formation of Georgia, the Tuscaloosa formation of Alabama, the Woodbine sand of Texas, the Dakota sandstone of the West, the Patoot beds of Greenland, and the Upper Cretaceous of Alaska. There are about 20 Eocene species, including the two common and characteristic species of the Wilcox and 1 in the overlying Claiborne of the embayment region, 5 in the Denver, 3 in the Fort Union, 2 in the Green River, 1 in Alaska, and 1 in west Greenland. There are 2 Paleocene species in France and Belgium, 4 Ypresian species in the south of England, and a Lutetian species in France. Eight Oligocene species are very common in deposits of this age throughout Europe. More than 20 species have been recorded from the Miocene of Colorado and California in this country, of France, Switzerland, Germany, Italy, Austria-Hungary, and Russia in Europe, and of Japan and Java in Asia. There are 3 or 4 Pliocene species in Europe. Though the evidence is not so clear as for Paliurus, there is a possibility that Zizyphus too is of occidental origin.

The genus Reynosia Grisebach, which contains only 2 existing coastal species, ranging from the Florida Keys through the West Indies, includes 2 characteristic species based on leaves in the Wilcox flora and a third species based on the petrified wood in the overlying Claiborne of Texas.

The genus Berchemia Necker contains about a dozen existing species, 10 of which are confined to eastern and southeastern Asia, 1 lives in eastern extratropical North America, and 1 in eastern Africa. This distribution could not have been brought about except by the agency of a cosmopolitan Tertiary range. Though the specific differentiation of Berchemia is limited to 5 or 6 fossil forms, these are very common and have a wide range. The earliest occurrences are in North America and include the Raton, Denver, and Fort Union formations of the Rocky Mountain province. The genus makes its appearance in Europe during the Oligocene and is common throughout that region in the Miocene, becoming restricted to southern Europe (France, Italy, Sicily, and Slavonia) during the Pliocene, except for a form recorded by Reid from Limburg.

A species of Hoveniphyllum, supposed to represent the existing genus Hovenia Thunberg, which includes a single existing species in southeastern Asia, is found in the Plio-Pleistocene of Japan. The genus Colubrina Brongniart, which contains 15 existing species in tropical America and 1 in southeastern Asia, is recorded from the Miocene of Bohemia.

The genus Pomaderris Labill, which contains about 24 existing species confined to Australia and New Zealand, is represented by 2 species in the Tertiary of Australia and 3 species (Pomaderrites Ettingshausen) in the Miocene of Prussia, Bohemia, and Styria.

The genus Gouiana has 2 species in the Tertiary of Colombia, according to Engelhardt.

The genus Ceanothus Linné, which comprises about 40 existing species that are confined to North America, has been made to include numerous fossil species subsequently referred to Paliurus or Zizyphus. There are 4 species recorded from the Upper Cretaceous of Greenland, New Jersey, Vancouver Island, and Westphalia; 2 Eocene species from Greenland and British Columbia; a Miocene species from Prussia, Switzerland, and Italy; and a Pleistocene species in Kentucky.

The next order, the Malvales, includes 9 families and about 1,800 existing species. The Tiliaceæ, Sterculiaceæ, and Bombacaceæ are the only families represented in the Wilcox flora. The largest modern family, the Malvaceæ, which contains more than 800 species, many of which are herbaceous and range from 65° north latitude in Russia to 45° south latitude in New Zealand, is not represented in the Wilcox. The order displays somewhat uneven or but little understood phylogenetic characters, but is evidently allied to the succeeding order, the Parietales, through the family Elæocarpaceæ. These inequalities of evolution are shown, among other ways, by the complete syncarpy in the Tiliaceæ, associated with an indefinite number of stamens and by the complex arrangement of the stamens in the Sterculiaceæ, associated with more or less incomplete union of the carpels. Both the leaves, flowers, and fruits exhibit a wide range of variations throughout the order.

The family Tiliaceæ, represented in the Wilcox flora by a single, not very common form of Grewiopsis, includes about 35 genera and 370 existing species, mostly of tropical lands, and shows two centers of differentiation and distribution—one the area surrounding the Indian Ocean and the other in northern South America. The geologic history is chiefly confined to the four genera Tilia (or Tiliæphyllum), Grewia, Grewiopsis, and Apeibopsis. The genus Luhea has been described from the Eocene of Sézanne (Langeron) and from the Oligocene of Menat (Laurent), both French localities, and also from the Tertiary of Ecuador. The genus Tilia Linné, which includes 18 or 20 widely distributed existing species in the North Temperate Zone, exclusive of western North America and central Asia, has furnished about 25 fossil species based on both leaves and fruits. The oldest known species comes from the North American Eocene. There are no conclusive Oligocene records except two French species, but about 15 Miocene species are found in North America, Europe, Asia, and the Arctic regions. There are 5 Pliocene species recorded from Europe and Japan and 6 Pleistocene species from Ontario, New Jersey, France, Germany, Holland, and Denmark. The existing range of the genus apparently dates from Miocene time.

The genus Grewia Linné includes about 90 existing species that range from Arabia to China and Japan and through Malaysia to Australia, and from Abyssinia to South Africa, as shown roughly on the accompanying sketch map (fig. 7). About 15 fossil forms have been described. The oldest known, 5 Eocene species, come from western North America. There are 2 Oligocene species in Europe and about 6 Miocene species in Oregon, Spitzbergen, and throughout Europe. The larger number of Grewia-like fossil forms are, however, referred to the genus Grewiopsis of Saporta. Six of these forms come from the Upper Cretaceous and all are confined to North America, a very significant fact, since several of them are especially well marked. They are found in the Magothy formation of the east coast, the Tuscaloosa formation of the south coast, and the Dakota, Montana, and Laramie formations of the western interior region. There are about 6 Eocene species in the Denver, Lance, and Fort Union, 1 in the Wilcox and 1 in the Claiborne of the Mississippi embayment region, 6 in the Paleocene of France, and 1 in the Ypresian of England. A Miocene (?) species is recorded from Yellowstone Park. This geologic distribution is plotted on the accompanying sketch map for comparison with the existing range of Grewia, and, though some of the fossil records ascribed to the genus Populus are possibly those of Grewia or its ancestral stock, it seems clear that the Grewia or its immediate ancestors were common in the Upper Cretaceous and Eocene of North America.

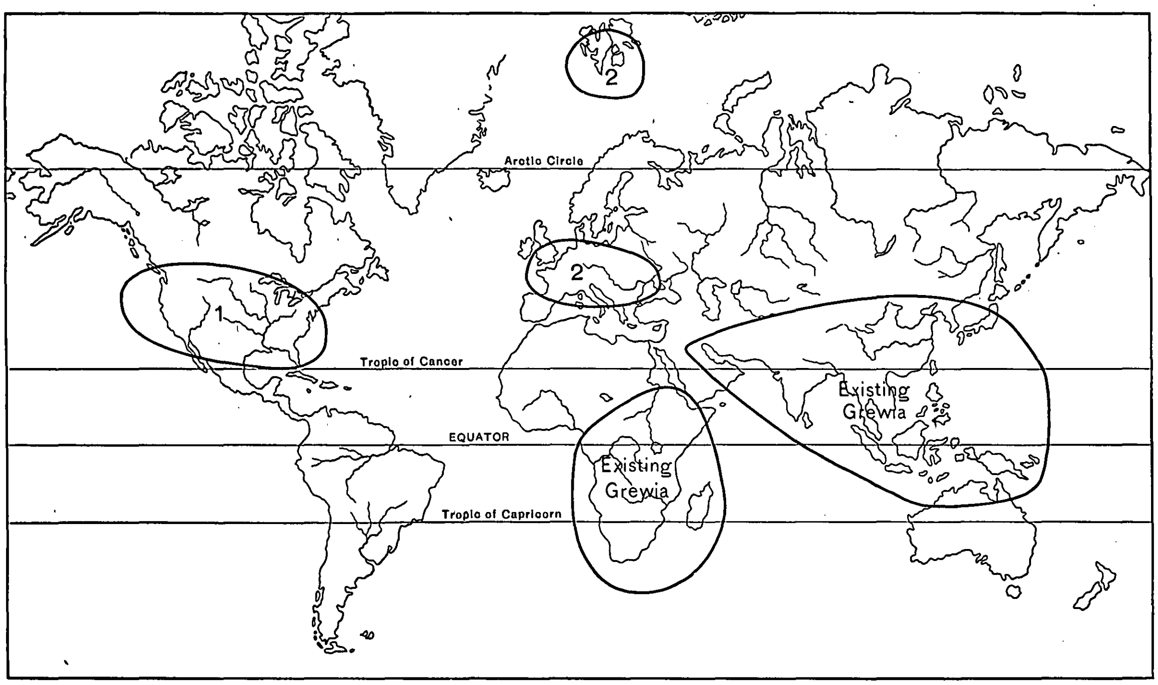

FIGURE 7.—Sketch map showing areas of distribution of recent and fossil species of Grewia and Grewiopsis. 1, Cretaceous and Tertiary species of Grewia and Grewiopsis; 2, Tertiary species of Grewia.

The fourth fossil genus of Tiliaceæ is Apeibopsis Heer, named from its affinity with the existing genus Apeiba Aublet, which contains 5 or 6 species that are confined to tropical South America. To this genus should probably be referred the Arctic forms described by Heer as Nordenskioldia. Apeibopsis includes not only leaves but very characteristic fruits. To it are referred somewhat doubtfully determined leaves from the Upper Cretaceous Dakota sandstone and Atane beds. There are about 14 Tertiary species, including a basal Eocene form from Wyoming, 2 Ypresian forms from England, a species from west Greenland, 3 species in the lignites of Brandon, Vt., 2 Oligocene species from Italy, and 5 Miocene species from France, Switzerland, and Bohemia.

The family Bombacaceæ,[1] which includes 20 genera and about 120 existing species, is confined to the Tropics, and principally to the American Tropics. The only known fossil forms are those of the genus Bombax or the allied Bombaciphyllum and Bombacites. Bombax Linné includes about 50 existing species, all large tropical trees and almost confined to

[1] Ettingshausen, C. von, Ueber die nervation der Bombaceen: K. Akad. Wiss. Wien, Math.-nat. Cl., Denkschr., Bd. 14, pp. 49-62, pls. 1-11, 1858.

America. There is a single species in Africa, about 6 in southern Asia, and 1 in Australia. The fossil species number more than 20, the oldest known being a common form in the Perucer beds (Cenomanian) of Bohemia and Moravia. An Albian species of Bombax described by Fontaine is entirely valueless. There are 3 species in the Ypresian of southern England and 2 well-marked forms in the Wilcox flora. There are 3 additional Eocene forms from Chile. There are 5 or 6 Oligocene species recorded from South America, France, Saxony, Bohemia, and Carniola. The genus is represented in the early Oligocene (Sannoisian) of southeastern France not only by the foliage but by beautifully preserved flowers, so that there is little ground for questioning the correctness of the identifications. There are 7 Miocene species in Bohemia, Croatia, Styria, and Australia.

The family Sterculiaceæ includes about 5 genera and 800 existing species of mostly tropical shrubs and trees which bear prevailingly large, simple, or digitately lobed or divided leaves. Some of the flowers are apetalous and differ from those of the Malvaceæ in their 2-celled extrorse anthers. Syncarpy is more or less complete.

The Sterculiaceæ of the existing flora are found on all the continents except Europe. The genera Sterculia, Helicteres, Melochia, Buettneria, and Hermannia are represented by species in both the Eastern and Western hemispheres. The geologic history of the family extends back to the base of the Upper Cretaceous but is confined to a relatively few genera. The most abundant of these genera is Sterculia Linné, which in the existing flora comprises about 100 species of large-leafed trees. These species are grouped into three tribes named from the habit of the leaves the Digitatæ, Lobatæ, and Integrifoliæ. The first of these tribes ranges from Farther India to Australia and includes only one or two American species. The second is most abundant in the American Tropics but is also found in Asia and Africa and shows many parallelisms between the American and Asiatic forms. It is most abundantly represented in the past history of the genus. The third and largest modern tribe, the Integrifoliæ, contains 5 or 6 American species, and the remainder are found in Asia and Africa.

The fossil forms (sometimes referred to Sterculiphyllum) comprise more than 50 species. More than a score are known from the Upper Cretaceous. They are mostly American and are referable to the tribe Lobatæ, which may well have originated in the Western Hemisphere. The Credneria sandstone of Saxony and the Perucer beds of Bohemia (both Cenomanian) each contain a species, and a third occurs in the Turonian of Bohemia. The other forms are North American and include species in the Raritan formation, the Cheyenne sandstone of southern Kansas, and in British Columbia, a species in the Patoot beds of western Greenland, 6 species in the Magothy formation of the Atlantic Coastal Plain, and 8 species in the Dakota sandstone of the western interior region. There are less than a dozen Eocene species, most of them confined to the lower Eocene. Thus there are 3 species in the Paleocene of France and another in the Ypresian of England, as well as 1 or 2 in the Denver and Raton formations of the Rocky Mountain Front Range. The single large Wilcox species is entirely typical and shows the usual variability in lobation and size. It appears to be filiated with *Sterculia snowii* Lesquereux from the American Upper Cretaceous and exactly matches several existing species. There is a small-leafed species in the middle Eocene (Claiborne group) of the embayment, which exactly matches the typical *Sterculia labrusca* Unger from the European Tertiary and the existing *Sterculia diversifolia* Don. It is closely paralleled by 2 American Upper Cretaceous species—*S. minima* Berry and *S. mucronata* Lesquereux. There are more than 10 Oligocene species widely scattered over Europe and about 15 Miocene species, mostly European, but including a single species on the east coast of Asia (Sakhalin) and 2 species in Colorado, one of them especially well marked. There are several Pliocene species in southern Europe.

Two somewhat different species of sterculiaceous capsular fruits from the Wilcox are referred to a new genus, Sterculiocarpus. The larger of these forms, *S. eocenicus*, seems referable to the subfamily Buettnerieæ, and the smaller, *S. sezannelloides*, is referable to the Lasiopetaleæ or Helictereæ. Both are very similar to the fruits from the Paleocene of Sézanne referred to the genus Sezannella, which contains 2 species described by Viguier from casts of wonderfully preserved flowers as well as fruits from the celebrated travertines of Sézanne, and referred with great certainty to the Lasiopetaleæ.

The tribe Dombeyeæ, which includes 7 genera and about 75 existing species, is almost entirely confined to Africa and the adjacent islands, only 5 or 6 species of the genus Melhania Förskal ranging from Arabia to Farther India. This tribe is represented in fossil floras by the genus Dombeyopsis Unger, named from its supposed affinity with the modern genus Dombeya Cavanilles, which embraces 40 African species, mostly from Madagascar. About 30 species have been referred to Dombeyopsis. They are liable to be confused with Luhea, Grewia, and other forms of the allied family Tiliaceæ. There are 3 species in the Laramie Cretaceous, 2 in the Denver formation, 12 (according to Massalongo) in the upper Eocene of Monte Bolca in Italy, 5 in the European Oligocene, and 6 in the Miocene of Iceland, France, Switzerland, Prussia, Silesia, and Styria. A Pliocene species is recorded from central France. Fossil wood described as Dombeyoxylon is recorded by Schenk from the late Tertiary near Cairo, Egypt.

The Buettnerieæ are represented by a doubtful species described from the Miocene of Colorado and probably by some of the fossil forms referred to other genera, for instance some of the palmately veined Ficus-like forms, such as *Ficus occidentalis* and *Ficus schimperi*, both of which are present in the Wilcox flora. Flowers of Buettneria were reported from Sézanne by Solms-Laubach, but should probably be referred to the subsequently described genus Sezannella, previously mentioned.

The Helictereæ are represented by a doubtful species of Helicteres Linné described from the Pliocene of Italy and by forms referred to the existing genus Pterospermum Schreber or to the extinct genus Pterospermites Heer. More than 30 species have been described. There are 9 or 10 in the Upper Cretaceous, all of which are North American, and their combined range extends from New York to western Alabama, throughout the Rocky Mountain and Great Plains province and in the Atane beds of Greenland. There are about a dozen Eocene species, all North American, except a single species in the Paleocene of France. The American forms extend northward to west Greenland and Alaska. There are 2 or 3 species in the European Oligocene and 10 Miocene species throughout Europe and in western North America (Yellowstone Park, California, and the mouth of Mackenzie River). A single Pliocene species is recorded from France. This type probably originated in the Western Hemisphere, since it is so abundantly represented in that region during the Upper Cretaceous and Eocene. The modern species of Pterospermum are, however, confined to eastern tropical Asia.

The order Parietales includes 30 families and more than 4,000 existing species. The largest families are the Guttiferæ (775 species), Flacourtiaceæ (530 species), Begoniaceæ (425 species), Violaceæ (400 species), and Dipterocarpaceæ (330 species). None of these families are found in the Wilcox flora, where the order is represented by the 2 families Dilleniaceæ and Ternstrœmaceæ. The Parietales are prevailingly syncarpous and show affinities with the Ranalian plexus through the Dilleniaceæ, which were formerly referred to that order. The alliance as a whole is complex and includes several divergent lines of development with a gradual increase on the whole in floral complexity.

The family Dilleniaceæ contains 14 genera and about 275 existing species found on all the continents, the genus Tetracera being cosmopolitan in the Tropics. The genera Empedoclea, Curatella, Doliocarpus, and Davilla, which include 50 species, are confined to the American Tropics; Hibertia and Pachynema, which include 75 species, are Australian; 5 genera and 25 species are confined to the Asiatic Tropics; the genus Saurauia (or Saurauja), which comprises about 60 species, is common to Asia and South America; and the genus Dillenia, which contains about 25 species, ranges from Asia to Australia; so that on the whole the family is prevailingly oriental in the existing flora.

The fossil record is unfortunately most incomplete, though it illustrates the wider range of the genera in response to milder climatic conditions in both the North Temperate and South Temperate zones during the Tertiary, and also the fact that several of the modern American genera have been American through their known geologic history. Thus Empedoclea, which includes 2 existing South American species, sometimes made a subgenus of Tetracera, has a fossil form in the early Tertiary of Chile. The genus Doliocarpus, which comprises about 20 recent species, also in the South American Tropics, has 2 fossil forms in the early Tertiary of Chile. The genus Davilla, which embraces 25 modern species in tropical America, is doubtfully represented in the Wilcox flora by *Calycites davillaformis* Berry.

The genus Saurauja, which includes 60 modern species in South America and Asia, is represented by a species in the Paleocene of France, another in the Ypresian of the south of England, and a third in the Miocene of Croatia.

The genus Actinidia, comprising oriental shrubs, is represented by characteristic seeds in the Pliocene of the Holland-Prussian border.

The genus Dillenia, which comprises 25 existing species that are confined to Asia and Australia, is represented by a form in the Paleocene of Belgium and by some of the Wilcox species referred to the form genus Dillenites. The genus Tetracera, which includes 40 recent species found in all tropical lands, is represented by 2 fossil species in the early Tertiary of Chile, another in the Pliocene of Java, and by some of the species of Dillenites in the Wilcox flora. I have recognized 5 well-marked species of Dillenites in the Wilcox, which appear to represent modern forms of both Dillenia and Tetracera.

Conwentz described 3 species of Hibbertia, a large Australian genus, in the Baltic amber (Sannoisian), but Schenk considered that they did not belong to this genus or even to the family.

The family Ternstrœmiaceæ (Theaceæ) contains about 16 genera and 175 existing species, mostly tropical, though they extend into the North Temperate Zone in North America and eastern Asia (Thea, Gordonia, and Stewartia). The following 7 out of the 16 genera are confined to a single area: Bennetia Martius, which includes 5 species, inhabits the South American strand; Asteropeia Thouars is confined to Madagascar; Thea Linné, which includes 16 species, is confined to southern and eastern Asia; Mountnorrisia Szyszlowicz, which includes 2 species, is a native of the East Indies; the 3 monotypic genera Visnea Linné, Tremanthera Müller, and Pelliciera Triana and Planchon are confined respectively to the Canary Islands, New Guinea, and Central America. The remaining 9 genera, all relatively small, are all found in more than one region. Thus Archytæa Martius includes 2 species in northern South America and a third in the East Indies; Gordonia Elliott includes 2 North American species and 14 scattered from India to Malaysia; Hæmocharis Salisbury includes 9 American and 5 Asiatic species; Stewartia Linné, which includes 5 species, is found in North America and Japan; Taonabo Aublet has 20 species in South America and 8 in Asia; Adinandra Jack has 19 African species and 1 Asiatic; Eurya Thunberg, which comprises 36 species and many varieties, is confined to tropical America and the East Indies.

This remarkable existing distribution and the pairing of America and Asia, as well as the fact that 5 subfamilies are required for only 16 genera, are sure indications that the family has an extended geologic history and that many of the genera were once cosmopolitan. Unfortunately most of this history is unknown.

The genus Stewartia is represented in the Baltic amber by a fine flower (*Stewartia kowalowskii* Caspary), by fruits in the Pliocene of Limburg, and by leaf remains from the Plio-Pleistocene of Japan (Mogi). Gordonia has a species in the Pleistocene of Java. The genus Eurya Thunberg, now American and East Indian, is represented by a species in the Oligocene of France (Freziera Swartz). Fossil wood described by Felix and named Ternstrœmiacinium occurs in the Eocene of the Caucasus. Visnea Linné, now confined to the Canaries, includes a typical fruit in the Aquitanian of Rhenish Prussia. The genus Ternstrœmia Nuttall (antedated by Taonabo Aublet) includes several fossil species, the oldest of which (Ternstrœmiphyllum) comes from the Perucer beds (Cenomanian) of Bohemia. It is represented by 2 species in the Ypresian of the Isle of Wight, one in the Miocene of Bohemia, and another in the Miocene of Croatia. I have described 4 well-marked species of Ternstrœmites from the Wilcox group and similar forms are found in the overlying Claiborne group (Lutetian). Finally the very abundant species in the North American Cretaceous described as Celastrophyllum, already mentioned in the discussion of the Celastraceæ, are very probably, in part at least, referable to this family, so that enough is known of the geologic history of the group to confirm at least the statement previously made that it must have had a long and complex history.

The family Lauraceæ, which includes about 1,000 existing species distributed among 40 to 50 genera, is often placed next to the family Anonaceæ among the Ranales.[1] It may be noted, however, that the spiral arrangement of floral organs characteristic of the order Ranales is replaced by a cyclic arrangement, and hypogyny is also replaced by epigyny, so that I follow various students in referring the Lauraceæ to the order Thymeleales, the other large family of which, the Thymelæaceæ (not known in Wilcox flora), contains about 400 existing species, chiefly of temperate Australia and the Cape region of Africa.

The geographic distribution of the Lauraceæ can not be set forth as briefly as the classification, since there are not only many anomalies in the distribution of the existing species, but so much of the geologic history is known that the difficulties seem increased thereby rather than diminished. Thus the existing species of the family are divided into 8 tribes, no one of which, except the monotypic Eusideroxyleæ of Borneo, is restricted to a single continental region.

The largest of these tribes, the Cinnamomeæ, includes more than 500 species endemic on all the continents but Europe, though chiefly Asiatic and American. The 4 genera Persea, Phœbe, Notaphœbe, and Mespilodaphne are found in both hemispheres; Cinnamomum and Machilus are oriental; and Oreodaphne, Strychnodaphne, Nectandra, Pleurothyrium, Umbellularia, Dicypellium, and Synandrodaphne are occidental. The first three of these genera are large, and the last four are monotypic.

The tribe Litseeæ, which includes 6 genera and about 200 species, is represented on all the continents except Europe and Africa. Only 9 of these 200 species are found in the Occident, yet among these is the monotypic North American genus Sassafras, and the genus Sassafridium which is confined to the American Tropics. All the other genera are found on more than one continent.

The tribes Apollonieæ, Cryptocaryeæ, and Cassytheæ are found on all the continents but Europe. The Laureæ are Eurasiatic and the Acrodiclidieæ are confined to Central and South America, except the genus Endiandra, which comprises 10 species in the East Indies and Australia.

The problem of correctly identifying leaves of the genera of this family is beset with almost insurmountable difficulties, not the least of which are the wide differences in usage among students of the recent forms, where the whole plant is available for study. Long-continued paleobotanic practice has been to refer most fossil leaves that lacked the more apparent characters of Cinnamomum or Sassafras, Persea or Malapœnna, and the like, to the comprehensive genus Laurus, a practice adopted at a time when Laurus was used in a comprehensive sense. Some paleobotanists generalized still further, as by using Laurophyllum for lauraceous leaves of uncertain generic affinity and not necessarily close to the existing species of Laurus. In fact the species of Laurophyllum are in general not true species of Laurus. I have departed from this practice of describing new species of Laurus for many reasons, foremost among which is the very great affinity between the Wilcox flora and the existing flora of the American Tropics, so that the evidence from the foliage of a large number of genera is corroborated by fruits or seeds or wood anatomy. I have used this similarity with a great deal of confidence, perhaps with too much, and the result has been that the following stand out as the more important lauraceous types in the Wilcox flora. Nearly all these forms are seemingly members of the subfamily Persoideæ of the tribe Cinnamomeæ, as segregated in Engler and Prantl's "Natürlichen Pflanzenfamilien."

First, the genus Cinnamomum, usually readily recognized and certainly represented in our Eocene floras.

Second, the genus Persea, represented by the larger and wider forms with the typical venation of this genus.

Third, the genus Nectandra, so abundant and characteristic of the existing flora of tropical and subtropical America, represented by several species very close to modern forms.

I have failed to follow the latest usage, which recognizes the genus Ocotea as such, since for obvious reasons it seems wise to recognize the genera Mespilodaphne and Oreodaphne of Nees rather than to regard them as subgenera of

[1] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, 1887-1901.

Ocotea. The third subgenus of Ocotea, Strychnodaphne, I have failed to recognize in the Eocene flora of this area.

The only apparent oddity in distribution shown by the Wilcox Lauraceæ in comparison with recent floras of tropical America is the abundance of Cinnamomum, and this simply confirms the well-known cosmopolitanism of this genus in the early Tertiary. Grisebach records only 28 species of Lauraceæ in his flora of the British West Indies, most of which are not coastal forms, although many have a wide range from lowlands to mountains. Hemsley records only 36 species of Lauraceæ in his flora of Mexico and Central America, though Brazil on the other hand has furnished more than 350 species. As regards the Lauraceæ, those of the Wilcox, which number 30 different forms, are more closely comparable with the more abundant modern representation of this family in northern South America. This receives more or less confirmation from a study of the remainder of the Wilcox flora. All the facts seem to show that the early Eocene floras of the Mississippi embayment are much more like those existing at the present time along the Caribbean Sea in Central America and northern South America than they are like those of the West Indies. I do not mean that the Wilcox flora has not many points of resemblance to the lowland flora of the West Indies and that of the Florida Keys. They contain very many common types but with this difference. The Mississippi embayment Eocene floras represent a maximum northward extension of a flora like that which now inhabits northern South America. At the end of the Oligocene, along with the southward migration of the temperate Miocene fauna as far as Florida, this flora retired to the South American mainland, and the present floras of the West Indies, Florida Keys, Bahamas, and Bermuda represent a later northward migration from that area, a migration in which some of the Wilcox types were left behind.

The existing species of Cinnamomum [1] number about 50. They are confined to the oriental Tropics except for their extension into the warmer, more humid part of the Temperate Zone in Japan, and they have their chief center of differentiation in the elevated region of Burma, Siam, Cochin-China, and Malaysia, although they are cultivated in all tropical countries and outside the Tropics in Europe, Africa, and North America. Their fruits are eaten by birds, which seed them freely so that they commonly escape from cultivation. Thus *Cinnamomum camphora* (Linné) Nees and Ebermaier is naturalized throughout peninsular Florida and the commercial *Cinnamomum zeylanicum* Breyn is readily naturalized in the same manner from the oriental camphor plantations.

Though the records for constructing the geologic history of Cinnamomum are far from complete the known fossil species are more numerous than the recent species, and, as is the case with so many plant groups, the extension of range during the Upper Cretaceous and Tertiary is surprising. The original home of the genus is unknown, for it appears in the early part of the Upper Cretaceous at about the same time in New Zealand, Australia, central Europe, Greenland, and North and South America. The European and North American records appear to be slightly older than the others and would indicate that the Asiatic region may have been the original home of the genus, which spread northeastward across the Bering region to America and northwestward into the European region, which was largely an archipelago at that time.

The Eocene records include all the continents except the Antarctic Continent and South America. The Oligocene records are chiefly European and African, although the genus is still represented in the Alum Bluff formation of Florida. During the Miocene Cinnamomum was abundant in Europe and also occurred in Asia but appears to have become extinct in North America—at least there are no conclusive North American records. Some fruits from the lignites of Brandon, Vt., have been referred to Cinnamomum, but these lignites are in my opinion pre-Miocene in age. The Pliocene records are entirely European and East Indian. The genus appears to have lingered as a common type in Mediterranean Europe until the changing climates that ushered in the Pleistocene glaciation caused its extinction. Any connected distribution with its present oriental home across southwestern Asia had already been interrupted by the orogenic movements and the development of arid conditions in southwestern Asia.

[1] Staub, M., Die Geschichte des genus Cinnamomum, Budapest, 1905.

Six well-marked types of Cinnamomum leaves are described from the Wilcox group, some of them abundant and generally distributed, and all but two appear to be new to science. In addition buds and flowers that suggest this genus are described under the form genus Laurophyllum.

There are 2 species of Persea in the Wilcox flora. Besides the fossil forms referred to Laurus in a comprehensive sense there are about 50 known fossil species of Persea, which is about the number of the existing species. All six of the Upper Cretaceous forms are widely distributed in America. By Eocene times they had reached Europe and South America and they are cosmopolitan in the Northern Hemisphere throughout the Tertiary, being especially abundant in the Pliocene of the Mediterranean region. It would seem as if their Cretaceous origin was occidental, that they spread over the Northern Hemisphere during the Tertiary and became restricted to southeastern Asia, the Canary Islands, and America during the Pleistocene.

The genus Ocotea Aublet, which includes more than 200 existing species, is, it seems to me, composite, and I regard the 3 genera Mespilodaphne, Oreodaphne, and Strychnodaphne of Nees as distinct. The modern species of Mespilodaphne are confined to South Africa and tropical America. The fossil record is almost entirely merged in the forms referred to Laurus. I have recognized 4 well-marked species in the Wilcox flora, which are abundant types. Some of them range from the base to the top of the deposits and along the Wilcox coast from Mississippi around the head of the embayment and westward to Texas.

The genus Oreodaphne has been recognized in the American Upper Cretaceous and throughout the European Tertiary. At present its numerous species are confined to the American Tropics. In the Wilcox it is represented by 7 well-marked species, which are abundant individually, some of which range from Mississippi to Texas and from the base to the top of the Wilcox. The genus is probably of American origin and it has been a member of the flora of the American Tropics from the Upper Cretaceous to the present.

The geologic history of the genus Nectandra, which includes 70 existing species that are confined to tropical and subtropical America, is probably entangled with the fossil forms referred to Laurus. It occurs in the American Upper Cretaceous and the European and South American Tertiary. There are at least 5 characteristic Wilcox species, some of which were abundant along the Wilcox coasts, and some range from the base to the top of the deposits. Like Oreodaphne, this genus appears to have been of American origin, becoming cosmopolitan in the Tertiary and restricted to its original home during the Pleistocene, where it is still a vigorous and much differentiated type.

The tribes Eusideroxyleæ, Litseeæ, Apollonieæ, Acrodiclidieæ, Laureæ, and Cassytheæ do not appear to be represented in the Wilcox flora, although the Litseeæ are represented in the Upper Cretaceous of the Mississippi embayment area and the Laureæ are common in the American Upper Cretaceous. The tribe Cryptocaryeæ, now largely American, is represented in the Wilcox by a single well-marked species of Cryptocarya. The existing species of Cryptocarya number about 40, one-fourth of which are South American and the rest Oriental. Only 2 or 3 fossil species are known. They come from the Tertiary of Australia and South America and the Pleistocene of Java.

The form genus Laurus, which serves to render insecure the discussion of the geologic history of the preceding genera, includes a very large number of fossil forms, of which no less than 25 are Cretaceous, the oldest of which come from the Albian of France and Portugal. Species of Laurus are abundant throughout North America in the Cenomanian, ranging northward to Greenland, and they also occur in Europe and Australia. There are more than a score of species in the Eocene and these have a similar wide range. The 30 or more Oligocene species are confined to Europe. More than 30 Miocene species are confined to Europe and America, and the score of Pliocene species are Mediterranean and largely Italian.

I will mention only one other genus, since it definitely shows a past history that is probably typical of a large number of genera of Lauraceæ. The genus Sassafras,[1] which is monotypic and confined to North America in the existing flora,[2] belongs to a large tribe—the Litseeæ, which to-day is chiefly oriental, ranging from Asia

[1] Berry, E. W., Bot. Gazette, vol. 34, pp. 426–450, figs. 1–4, pl. 18, 1902.

[2] A second existing species has recently been discovered in southwestern China.

through Malaysia to Australia. Sassafras has well-marked foliar characters of both form and venation that render it readily recognizable in the fossil state. More than two score fossil forms have been described, the oldest of which are 3 well-marked species in the Patapsco formation (Albian) of the middle Atlantic slope in Maryland and Virginia. A species is recorded from this horizon in Portugal, but the identification is very doubtful, as is also that of a Cenomanian species described from Bohemia, which latter probably represents the genus Sterculia. In America, on the other hand, the genus is widespread and well differentiated at the base of the Upper Cretaceous, ranging from Greenland along the coast and in the interior to South America. It comprises about a dozen known species. By Eocene time Sassafras had reached Europe, where it has been found throughout the Oligocene and Miocene, probably by way of the Arctic regions. A very doubtful form is recorded from the later Tertiary of Australia. In the Pliocene the European forms had retreated southward but remained common in Italy, France, and Spain. The glaciation of the Pleistocene caused their extinction on that continent, the single existing species surviving to-day in the original home of the genus.

The order Myrtales, as developed in the Wilcox flora, contains 11 species of Myrtaceæ, 9 species of Combretaceæ, 1 species of Trapaceæ, and 1 species of Melastomataceæ, as against 7,000 species in the existing flora.

The family Myrtaceæ includes over 3,100 existing species, which are separated by taxonomists into 2 subfamilies. The first of these, the Myrtoideæ, comprise 32 genera and about 2,400 species, mostly tropical forms, more than 75 per cent of which are confined to the Western Hemisphere. There are over 200 species in Asia, one of which extends into southern Europe, about 75 in Africa, about 200 in Australia, and about 60 in Oceanica. Nineteen genera are confined to America, including the only 3 monotypic genera in the subfamily, as well as large and greatly differentiated genera like Myrcia, with upward of 450 species. The two other large genera, Myrtus, which includes 178 species, and Eugenia, which includes about 1,300 species, are the only two genera found on all the continents. America contains 135 species of Myrtus and 850 species of Eugenia, or more than 75 per cent in the genus Myrtus and more than 65 per cent in the genus Eugenia. The second subfamily, the Leptospermoideæ, comprises the Leptospermæ, which contain 28 genera and about 700 species, and the Chamælaucieæ, which contain 12 genera and about 165 species. Both these tribes are even more strikingly Australian than the Myrtoideæ are American. The Chamælaucieæ are entirely Australian and mainly confined to western Australia. The Leptospermæ include a single monotypic genus in Chile, and the distribution of the other members of this tribe suggest that it should be placed in some other alliance, since with the exception of Metrosideros, which is represented in Africa, and the genus Bæckea, which reaches the Asiatic mainland, all the genera are confined to Australia or the surrounding islands southeast of Asia.

In a recent paper Andrews [1] has presented some interesting statistics of distribution and an ingenious theory of the history of the family. He considers that the original stock was arborescent or shrubby and bore entire, simple, opposite, penni-veined leaves, with dots and intramarginal acrodrome veins; the calyx lobes and petals were imbricate, probably in fives; flowers regular, solitary or in cymes; stamens indefinite, numerous, free, with versatile, 2-celled anthers; ovary inferior and contained two or more cells; style simple; fruit inferior, crowned with persistent limb of calyx, indehiscent, succulent, or fleshy (rarely dry); no albumen; cotyledons thick and fleshy with a short radicle.

From the character of Cretaceous climates this or some other theoretic prototype flourished in a mesophytic environment. Among modern groups the nearest approach to this theoretical stock is furnished by the Myrtoideæ, which are fleshy fruited, most numerous in species, and widely spread in the equatorial regions, over 75 per cent of them, however, being confined to America. The existing Myrtaceæ, whose capsular fruits represent the extreme of specialization in the family, are Australian, and the Chamælaucieæ, which stand in an intermediate position between the two preceding groups, are almost wholly confined to western Australia.

[1] Andrews, E. C., The development of the natural order Myrtaceæ: Linn. Soc. New South Wales Proc., vol. 38, pt. 3, pp. 529-568, 1913.

These are the facts of modern distribution. Their interpretation may vary. Andrews,[1] from a study of the present distribution, geologic climates, and the geologic history of the Australian region, concludes that the Leptospermoideæ originated from the Myrteæ, and that the Cretaceous forms were widespread, as they undoubtedly were. Before the separation of Australia from the Asiatic mainland he believes that the fleshy fruited forms found themselves in a region of warm, moist climate, but relatively poor soil, and that this edaphic factor was the principal stimulus to the differentiation of the Leptospermoideæ, which, with the exception of the genus Metrosideros, show adaptations to poor soil and temperate or dry climates, and this exception explains the relatively wide distribution of Metrosideros from Asia to the Fiji Islands. The Eucalyptus forms, according to the view of this student, were derived from Metrosideros after the separation of New Caledonia from Australia and the separation of that continent from Asia. To support this last point, Andrews is obliged to consider all the Cretaceous identifications of Eucalyptus and all the Tertiary identifications outside of Australia as equally misleading. With regard to the presence of Eucalyptus in North America, I think this contention to be not unlikely, for, although in accordance with paleobotanic usage, I have identified numerous forms of Eucalyptus in the North American Upper Cretaceous, I have long thought that these leaves represented ancestral forms of Eugenia or Myrcia, but have hesitated suggesting any change in nomenclature from the havoc it would play with stratigraphic paleobotany.

The supposed American Cretaceous fruits of Eucalyptus have long since been shown to be referable to Dammara-like forms, and in my studies of the Tertiary flora I have scrupulously refrained from referring any of the numerous myrtaceous leaves to the genus Eucalyptus. Regarding the possible occurrence of Eucalyptus in Europe, I am not so sure that the identifications of Heer, Unger, and Ettingshausen are erroneous. Certain remains considered Eucalyptus fruits seem very convincing from the published figures, and there is not the slightest doubt that the other great modern Australian alliance—the Proteaceæ—was represented in both Europe and America during the Cretaceous and Tertiary. There is one additional argument against the Cretaceous radiation and the paleobotanic determination of Eucalyptus and that is the great persistence of the peculiar juvenile opposite, cordate, sessile, and horizontal leaves, which must represent an ancestral character of long standing before the evolution of the falcate leaves of the genus with twisted leaf stalks and other xerophytic features.[2]

I have dwelt at some length on this question because of its phylogenetic importance and the possible bearing of the Wilcox flora on this point. In considering the morphology of the existing species, Eugenia has many claims to be considered the most primitive, although Myrcia is almost equally old and is certainly closely related to Eugenia. Among the numerous Cretaceous plant fossils from North America now referred to Eucalyptus, all without an exception, exhibit characteristic features of Eugenia or Myrcia, especially Myrcia, a fact greatly impressed on me in handling a large amount of recent material during my study of the Wilcox forms.

In the Wilcox flora there are 6 well-marked species of Myrcia and 4 nearly equally well marked species of Eugenia, as well as a single species of Calyptranthes, which appears also to be represented in recent collections from the Oligocene of the Isthmus of Panama. The presence in the Wilcox flora of numerous Combretaceæ and a representative of the great tropical family Melastomataceæ, largely American in the existing flora, both of which are families closely related morphologically to the Myrtaceæ, together with other known facts, though confessedly these are meager, as well as the law of probabilities, suggests America as the original home of the family and that it reached Europe either by way of Asia or the North Atlantic plateau early in the Upper Cretaceous and became cosmopolitan before the close of the Cretaceous. During the late Tertiary this ancestral stock, which largely coincided with the existing subfamily Myrtoideæ, was forced to withdraw from temperate North America to the American Tropics, where it had originated

[1] Andrews, E. C., op. cit.

[2] Deane, H., Observations on the Tertiary flora of Australia: Linn. Soc. New South Wales Proc., vol. 15, pp. 463–475, 1900. Cambage, R. H., Development and distribution of the genus Eucalyptus: Presidential address: Roy. Soc. New South Wales Jour. Proc., 1913.

and to which it has since been so largely confined. The types peculiar to the Australian region represent the relics of the Cretaceous radiation and include numerous new types evolved on that continent, as Andrews has suggested. This is exactly the reverse of the hypothesis proposed by Deane,[1] but one that accords far better with the facts not only of geologic history but with those of existing distribution.

As is pointed out in the systematic part of this work all the Wilcox forms are coastal types closely related to existing American species of similar habitat.

About 150 fossil forms have been referred to the Myrtaceæ, one-third at least having been described as species of Eucalyptus. At least half of these forms occur in the Cretaceous of all parts of the world but particularly throughout the Northern Hemisphere. They are especially well represented in North America, and the possibility that they are ancestral forms of Myrcia or Eugenia has already been pointed out. A similar widespread distribution but less specific variation characterizes the Eocene forms that have been referred to Eucalyptus. The Oligocene records are all European and the Miocene records include both Europe and Asia.

The genus Myrtus is represented by about 24 fossil species, all European, most of them almost equally divided between the Oligocene and the Miocene. The oldest forms are early Eocene, but the form genus Myrtophyllum Heer includes several Upper Cretaceous species in Europe, America, and Australia, as well as Tertiary species in Europe, Asia, and South America.

The genus Myrcia De Candolle, so well represented in the Wilcox flora, contains species in the European Oligocene, 4 species in the early Tertiary of Chile, 1 in the Tertiary of Ecuador, and 1 in the Pliocene of Brazil.

The oldest known species of Eugenia, a genus also prominent in the Wilcox flora, occurs in the Dakota sandstone. The genus is represented in Europe throughout the Tertiary from the lower Eocene to the Pliocene and is recorded from the Tertiary of Ecuador.

The genus Callistemon R. Brown has been identified in both the Upper Cretaceous and Tertiary of Europe, and no less than 25 species have been referred to the genus Callistemophyllum Ettingshausen. These species include Upper Cretaceous forms in America and Europe, Eocene forms in Greenland, Oligocene forms in Australia, and numerous Oligocene and Miocene species in Europe.

The genus Myrciaria Berg, often included in Eugenia, contains about 60 existing species ranging from the West Indies to Brazil and Peru. It is recorded by Engelhardt from the Tertiary of Ecuador.

Leptospermum, Leptospermites, and Leptospermocarpum have been identified from the Upper Cretaceous and Tertiary of Europe; Tristania-like fruits have been described as Tristanites by Saporta from the lower Miocene of France, and by Kitson from the Miocene of Australia; the genus Psidium Linné, which includes about 100 modern species in the West Indies and Mexico, is represented in Chile by an early Tertiary species; and finally the genus Metrosideros has been identified in the Atane beds of Greenland and in both the Oligocene and Miocene of Europe.

The family Combretaceæ (Terminaliaceæ) embraces about 16 genera and 285 existing species of shrubs or trees and tropical vines that bear simple, entire, coriaceous, persistent, exstipulate, alternate or opposite leaves. The inflorescence is racemose or capitate, and the flowers are regular, perfect or polygamous, many of them apetalous. The stamens are two or three times as numerous as the petals and the one-celled ovary develops into a drupaceous or berry-like indehiscent fruit, in many species crowned with the accrescent calyx, and containing a solitary seed without endosperm.

The existing species are all tropical or subtropical, ranging from 34° north latitude to 35° south latitude, and a relatively large number are littoral or strand types. The continental areas contain the following numbers of peculiar species: America 75, Africa 85, Madagascar 36, Asia 57, Australia 23. About ten or a dozen species are found in more than one area. There is a remarkable identity between the American tropics and those of West Africa, the genera Cacoucia, Conocarpus, and Laguncularia having identical species in both regions.

The geologic history of the family is most incomplete, but it is exceedingly prominent in the Wilcox flora, where it is represented not

[1] Deane, H., op. cit.

only by characteristic leaves but by flowers and fruits. No species are certainly known from horizons as old as the Upper Cretaceous, although a species of Terminaliphyllum has been described from the Perucer beds (Cenomanian) of Bohemia, a species of Combretiphyllum from the Upper Cretaceous of the Kamerun (West Africa), and a species of Conocarpites from the Tuscaloosa formation of Alabama. So far as I know there are no authentic occurrences as old as those of the Wilcox. In this flora there are 3 well-marked species of Combretum, a genus that contains about 130 existing species found in all tropics except Australia and Polynesia. More than 30 of these species are endemic in South America, and their abundance in the Wilcox, as well as the occurrence of a species in the early Tertiary of Chile, strongly suggests that the genus is of American origin. This statement, as well as the determination of the Wilcox species of leaves, receives confirmation in the remarkably preserved flower from these beds described as Combretanthites. Combretum has been recorded from the Miocene of Switzerland and Germany and from the Pliocene of Italy. It occurs in the Claiborne group of the Mississippi embayment, and Felix has described petrified wood from the supposed Eocene of the Caucasus which he calls Combretacinium.

The genus Conocarpus Gärtner, a member of the tropical mangrove association, is represented by a well-marked species in the Wilcox flora that is supposed to be descended from the Conocarpites described from the Tuscaloosa formation in this same general region. Another species very close to the modern form of the American Tropics occurs in the Claiborne group. Fruits of Conocarpus have also been described recently from the Aquitanian of Rhenish Prussia.

The genus Laguncularia Gärtner, monotypic in the mangrove association of America and the west coast of tropical Africa, is represented by both leaves and fruits in the Wilcox flora. The only other genus of Combretaceæ that has known fossil representatives is Terminalia Linné. It is a large genus in the existing flora and contains more than 100 species almost equally divided between America, Asia, Africa, and Australia; several of the species are very wide-ranging littoral types. There are 3 Wilcox species, based on both leaves and fruit. One of the species makes its appearance in the underlying Midway (?) formation of the western Gulf region and possibly represents the beginning of its extension northward along the coast in the embayment region from tropical America. It continues in this region as late as the upper Eocene after nearly the entire Wilcox flora had been replaced by different forms.

Five Oligocene species of Terminalia have been described from Europe, the determinations resting on both leaves and fruits. The occurrences range from the Sannoisian to the Chattian and geographically from southeastern France to Greece. There are 7 well-distributed Miocene species in Europe, as well as Pliocene species in both Spain and Italy along the shores of the Pliocene Mediterranean Sea. A supposed Pliocene species is also recorded from Bolivia.

Though future discoveries must greatly amplify the fossil record before the history of the family in past times can be traced with any degree of surety, the remarkable display of those forms in the Mississippi embayment region, evidently derived from the American Tropics, gives much probability to the theory that the family originated in the American Tropics during the Upper Cretaceous.

The genus Trapa Linné formerly included in the family Onograceæ, is now made the type and only genus of the family Hydrocaryaceæ (Trapaceæ Dumortier, 1827). There are 3 existing species, all aquatics and all confined to the Old World except for the naturalization of *Trapa natans* Linné in New England and New York. This species is irregularly scattered throughout central and southern Europe, though its area of distribution is contracting, as is shown by its occurrence in postglacial deposits at many localities beyond its present range in Russia, Finland, Sweden, and Denmark. The two other existing species are *Trapa bicornis* Linné of China and *Trapa bispinosa* Roxburg of southeastern and southern Asia, which is said also to occur in Africa.

The genus has an extended geologic history. Rosettes supposed to represent the floating leaves (*Trapa? microphylla* Lesquereux and *Trapa? cuneata* Knowlton) are widespread in the Rocky Mountain province in beds of late Cretaceous and early Tertiary age. The oldest recognizable fruits are a large bicornute form from the Eocene of Canada and Alaska and *Trapa wilcoxensis* of the Wilcox flora. Two supposed upper Eocene species occur in the Payette formation of Idaho. An Oligocene species (*Trapa credneri* Schenk) has been described from Saxony, and no less than 5 species have been described from the Miocene, 1 occurring in Japan and the rest in Europe, where 2 species continue into the Pliocene. A species from the late Pliocene of America is found in southern Alabama. The existing *Trapa natans* has been recorded from the preglacial beds of England and Saxony and from very many interglacial and postglacial deposits in Portugal, Italy, Netherlands, Germany, Sweden, Russia, and Denmark. Gunnar Andersson in a paper published in 1910 mentions 18 localities in west Prussia, 6 in Denmark, 17 in Sweden, and 29 in Finland.

The family Melastomataceæ is relatively large, prevailingly shrubby rather than arborescent, and includes about 150 genera and more than 3,000 existing species. It comprises distinctly humid types and is almost strictly tropical, although some members range southward to 40° south latitude. Although it abounds in Malaysia, it is a typically American family, 7 of the 15 tribes into which the family is divided being confined to tropical America, and about 2,500 of the existing species being also endemic in this region. It ranks ninth in Hemsley's flora of Central America and abounds in the West Indies and especially in Brazil. Though the geologic history of this vast assemblage of forms is practically unknown, there is no evidence to disprove the theory that, like the allied families Combretaceæ and Myrtaceæ, the Melastomataceæ had its origin in that most prolific region—the American Tropics.

The few fossil forms that have been found, including leaves, flowers, and calices, have been referred to the form genus Melastomites, first proposed by Unger. A doubtfully determined species, which probably belongs to the Lauraceæ, has been recorded from the Upper Cretaceous of Westphalia. The only known Eocene species is the well-marked form present in the Wilcox flora. Four Oligocene species have been described from Bohemia, Styria, and Egypt; 4 Miocene species from Switzerland, Prussia, and Croatia; and a Pliocene species from Italy.

The order Umbellales (Umbellifloræ of Engler) includes only three families, the Araliaceæ, Umbelliferæ, and Cornaceæ, but more than 3,000 existing species, of which more than two-thirds belong to the Umbelliferæ. The three families are closely related and stand somewhat apart from the rest of the choripetalous orders. Though undoubtedly there has been great specific variation in modern times, especially among the herbaceous forms of Umbelliferæ, some members of the alliance go back as far as undoubted dicotyledons have been found, and this fact is one of the strongest arguments for considering its relationships to the Gamopetalæ to be less close than some botanists have suggested, a suggestion based primarily on a consideration of the floral structures apart from the morphologic features of the whole plants. As regards floral evolution the Umbellales clearly mark the highest expression among the Choripetalæ and parallel the Gamopetalæ. The flowers are epigynous, the stamens cyclic, the carpels reduced, and the sepals commonly reduced. The Araliaceæ and Cornaceæ are both represented in the Wilcox flora and the Umbelliferæ doubtfully so.

The family Araliaceæ contains about 52 genera and 500 existing species, chiefly inhabitants of the Tropics, though notable exceptions are found in North America and eastern Asia. The modern center of development is in Asia and Australia, no less than 33 genera being confined to Asia, Malaysia, Australia, or Polynesia. Africa contains 3 peculiar genera and about 30 species and America 5 peculiar genera and about 100 species. The genus Schefflera is cosmopolitan. Hedera and Polycias occur in Eurasia and Africa. Two genera are common to Asia and America, and a third (Aralia) is found not only in these continents but in Australia. Pseudotenax which contains about 6 species is peculiar to western South America and New Zealand.

The fossil record is not nearly complete enough to afford a secure basis for generalizations. Several genera are found, however, in the oldest deposits in which undoubted dicotyledons are known. The largest genus is Aralia, which is commonly used by paleobotanists as a form genus for generically unidentified species of Araliaceæ, rather than for forms falling within a strict modern definition of Aralia. No less than 50 species of Aralia have been described from the Cretaceous, 2 of which come from horizons as old as the Albian of

Portugal. In beds of similar age in eastern America (Maryland and Virginia) there are 2 well-marked species, which are referred to Araliæphyllum and are clearly the ancestors of the numerous species of Aralia so common in the Upper Cretaceous of that region. Very similar forms, some of them identical, are found in the Cretaceous on both sides of the Atlantic. There are 15 species in the Perucer beds (Cenomanian) of Bohemia and Moravia and about the same number in the Dakota sandstone of the western United States. Along the east coast of the United States there are 9 species in the Raritan formation, 8 in the Magothy formation, and 1 each in the Black Creek formation of North Carolina, the Eutaw formation of Georgia, the Tuscaloosa formation of Alabama, and the Woodbine sand of Texas. In Greenland there are 2 species in the Atane beds and a third in the Patoot beds. In the Upper Cretaceous there are 2 species in Bohemia, 2 in Westphalia, and 1 in Colorado. Australia contains a species and 10 supposed varieties of Aralia in the Upper Cretaceous beds. In addition to the foregoing display of Aralia, a number of well-marked species of the allied genus Araliopsoides (Berry, 1911) have been found in the Raritan, Magothy, and Dakota formations, so that the araliaceous stock was evidently well differentiated and cosmopolitan before the close of the Cretaceous period.[1]

There are more than a score of Eocene species of Aralia which are especially common in the Fort Union of the western United States and the Paleocene of Belgium. The 3 Wilcox species are not common in the Wilcox, though 2 of them are common Fort Union species, and the third was described originally from western Greenland. In addition there are species in the Denver formation, the Green River formation, and in Oregon, New Zealand, Italy, and the south of England.

There are more than 20 Oligocene species, especially in the Sannoisian of southeastern France, from which 14 species have been described. All the other Oligocene records are also European.

There are also about 25 Miocene species distributed over North America, Europe, Australia, and Asia. Some of the California species, such as *Aralia whitneyi*, are clearly the ancestors of existing forms from the east coast of Asia. A fruit (Araliæcarpum) is described from the Miocene of Prussia. There are in addition between 15 and 20 fossil species of Aralia more or less doubtfully connected with other genera of the family. These forms include a species of Arthrophyllum, doubtfully identified from the upper Oligocene of France; a species of Cephalopanax (?) from the lower Miocene of France; several forms of Sciadophyllum (?) from Greenland, Bohemia, and France; and species of Paratropia (?) from the Paleocene, Oligocene, and Miocene of France and the Miocene of Bohemia.

There are 2 species of Oreopanax in the Wilcox flora, one of them exceedingly well marked and clearly referable to the section Digitatæ of Oreopanax. This genus contains about 80 existing species divided into simple, lobate, and digitate leafed sections, confined to tropical America, though its fossil forms occur in the Paleocene, Tongrian, and Aquitanian of France. The modern Asiatic genus Acanthopanax Decaisne and Planchon is represented by Oligocene species in France and Germany and by a Miocene species in Japan.

The genus Panax Linné, which contains about 6 existing species in Asia and North America, is represented by several fossil forms, based on numerous characteristic fruits as well as leaves. It occurs from Greenland to Alabama along the west coast of the Atlantic and in the Perucer beds of Bohemia (Araliphyllum). It includes 5 Oligocene species in Europe and 6 Miocene species in Europe and Colorado. The genus Cussonia Thunberg, which contains about 25 African species in the existing flora, is doubtfully recorded from the Albian of Portugal. It is present in the Perucer beds of Bohemia (Cussoniphyllum) and in the Oligocene of France and Greece.

The genus Hedera Linné, which includes only 3 existing species of Europe, Asia, and Africa, is represented by numerous and well-defined fossil forms. The forms from the Potomac group of Maryland and Virginia described by Fontaine as species of Hederæphyllum are entirely worthless. No less than 15 species of Hedera have been described from the Upper Cretaceous of both America and Europe. There are about 7 Eocene species in Greenland, Alaska, the Fort Union of the western United States, and the Paleocene of Belgium and France. The

[1] Berry, E. W., Aralia in American paleobotany: Bot. Gazette, vol. 36, pp. 421-428, 1903.

genus remains common during the Tertiary in Europe and is found in America as late as the upper Miocene lake of Florissant, Colo. The ancestor of the existing *Hedera helix* Linné occurs in the Pliocene of central France, and the modern form itself is found in the Pleistocene of England, France, and Italy. A species of Polyscias occurs in the Pleistocene of Java associated with *Pithecanthropus erectus*.

The family Umbelliferæ, which includes 170 genera and more than 2,000 existing species, is distinctly an extratropical family with numerous boreal forms, chiefly herbaceous and of relatively modern origin. It is very sparingly and doubtfully represented in the fossil state. The only Wilcox form that suggests such an affinity is the fruit described as *Carpolithus prangosoides*, which greatly resembles the existing genus Prangos Lindley.

The third family of the Umbellales, the Cornaceæ, is relatively small. It comprises only 16 genera and about 100 existing species, mostly of the Temperate Zone. The majority of the fossil forms are confined to the two genera Cornus and Nyssa, although the oriental genus Camptotheca is represented by fruits in the Dutch Pliocene. Cornus includes about 40 existing species of herbs and small trees, mostly confined to the North Temperate Zone in Eurasia and North America but represented in Mexico and also by a single species in Peru. More than 50 fossil species have been described. There are at least 12 forms in the Upper Cretaceous, all confined to North America, ranging from Greenland to Alabama. There are about a dozen Eocene species in America, Europe, and the Arctic region, one of which is sparingly represented in the Wilcox flora. Oligocene records are few, but more than 25 Miocene species have been described. The genus was particularly abundant at this time throughout central Europe and was also represented in both North America and Asia. About 5 Pliocene species are recorded from Spain, France, Italy, and Japan, and the genus has afforded Pleistocene material in New Jersey, Holland, England, and other countries.

The genus Nyssa Linné (including also Nyssidium Heer and Nyssites Geyler and Kinkelin) comprises about 7 existing species that range from shrubs to large trees and are natives of southeastern North America and eastern and central Asia. It is represented by more than 50 fossil forms, most of them based on the characteristic costate stones. The oldest known forms come from beds near the base of the Upper Cretaceous (Dakota and Tuscaloosa) of North America. By Eocene time Nyssa had reached Alaska, Greenland, and Europe. There are 2 characteristic species in the Wilcox, both based on stones, and a third occurs in the overlying deposits of the Claiborne group. In the lignite deposit of Brandon, Vt., which is of uncertain but probably early Tertiary age, no less than 18 so-called species of stones have been described. Though doubtless the specific differentiation is overrefined, the abundance of Nyssa in New England at that time is indicated. Nyssa is abundant in the European Oligocene, and survives on that continent in the Pliocene. There are Miocene species in New Jersey, Virginia, Europe, and Asia. A Pliocene species occurs in Alabama. Some of the modern species are common in the Pleistocene of this country from New Jersey southward.

Though much remains to be learned regarding the history of the Cornaceæ, it seems clear that the two genera, Cornus and Nyssa, that have yielded fossil forms are types that originated in North America during the Cretaceous.

No family of the Choripetalæ has succeeded in maintaining a world-wide distribution, as have several families of Monocotyledonæ and Gamopetalæ. No distinctly boreal group has been developed, as among the Gamopetalæ (Ericales). Certain great families characterize the North Temperate region, and these are all herbaceous forms, believed to be of relatively recent origin, such as Polygonaceæ, Caryophyllaceæ, Cruciferæ, Saxifragaceæ, Onagraceæ, and Umbelliferæ. Though aquatic forms are common, this habit does not characterize whole families, as among the Monocotyledonæ. The Choripetalæ predominate in the American Tropics, and many of the families in the Wilcox flora probably originated in that region.

The second grand division of the Dicotyledonæ, the Gamopetalæ (Sympetalæ), constitutes a rather well defined group, presumably derived from the Choripetalæ, which is characterized by a complete cyclic arrangement of the floral parts, a corolla that is generally gamopetalous, and ovules that have a small nucellus and as a rule a single integument. The Gamopetalæ contain nine or ten orders and more than 50,000 existing species. Most of the orders appear to be more compact and natural groups than the corresponding alliances among the Choripetalæ. The Ericales, Primulales, and Ebenales are pentacyclic and isocarpous, but the Gentianales, Polemoniales, Personales, Plantaginales, Rubiales, Valerianales, and Campanulales are tetracyclic and anisocarpic, the last three orders being epigynous.

The herbaceous forms of the alliance predominate and several of the families are distinctly boreal. Though the Compositæ, Labiatæ, and Plantaginaceæ are of world-wide distribution, there are no notable continental pairings, such as usually accompany an extended geologic history. These and many other facts suggest that the Gamopetalæ as a whole, especially the more evolved, herbaceous, extratropical families, are of relatively modern origin and that their major specific differentiation was concomitant with their occupation of the Temperate zones after the retreat of the Pleistocene ice sheets.

The so-called Compositæ are, from the viewpoint of floral structures, clearly the culmination of the evolution of floral structures, as is shown not only by their gamopetaly, epigyny, connivent anthers, and the formation of seedlike fruits with a pappus but by the complex flowerhead, the prevalence of diclinism, the dimorphism of the corollas, and other special features. This evidence is corroborated by the general modernness of the alliance.

Six gamopetalous orders are represented in the Wilcox flora. The first of these, the Primulales, in its fullest development in existing floras includes the three families Myrsinaceæ, Primulaceæ, and Plumbaginaceæ. They are structurally much alike and have a single cycle of stamens opposite the petals and a unilocular ovary with a free central placenta. This community of floral organization can only be attributed to convergence and not to filiation, since the Myrsinaceæ are old forms which in modern floras are predominantly tropical and American, whereas the Primulaceæ are chiefly North Temperate and boreal herbs of relatively recent evolution, and the Plumbaginaceæ are very modern halophytic herbs and undershrubs of salt beaches and steppes, mostly of the Mediterranean and Caspian regions.

The Myrsinaceæ, the only family represented in the Wilcox flora, is characterized by alternate, simple, coriaceous, punctate, exstipulate leaves; perfect, regular flowers; and single-seeded drupaceous fruits.

The family contains about 30 genera and 530 existing species of shrubs or trees, largely tropical and predominantly American. Thus, 11 genera and more than 200 species are peculiar to America, only 4 genera and less than a dozen species are peculiar to Asia, and 3 genera and about 100 species are peculiar to Africa.

The genus Myrsine Linné is found in all the continents except Europe and in Polynesia. Its distribution is extratropical in the African region. Euardisia Pax is found in all the Tropics. Maesa Förskal lives in all oriental tropical countries as does also the monotypic genus Ægiceras Gärtner, a member of the coastal mangrove association. The genus Cybianthus Martius, largely South American, is represented by species in the Philippines and in New Grenada. There is little that is significant in the recent distribution of the family, and the fossil record is very incomplete.

More than 75 fossil forms have been referred to Myrsine, the oldest of which are the 7 or 8 forms recorded from the Upper Cretaceous. All the older of these forms (Cenomanian) come from North America, and only one, from the Turonian of Bohemia, occurs in the European Upper Cretaceous. The American forms are not varied specifically, but have a wide range and are common, extending from the Atane beds of Greenland along the Atlantic coast to the Tuscaloosa formation of western Alabama. They are also found in the Dakota sandstone of the western interior region.

The Eocene records of Myrsine number 7 or 8 species and include an early Eocene form of Alum Bay, 3 in the upper Eocene of France, and 2 in western Alaska. Myrsine is exceedingly varied and abundant during the Oligocene throughout southern Europe, more than 30 species having been described, of which 11 occur in the basal Oligocene of southeastern France (Sannoisian). There are more than 30 Miocene species throughout Europe, one from Colorado being the only known American occurrence. One species is also recorded from Australia. Several species linger in the Pliocene of southern Europe in France and Italy, and one species is found in the Pliocene of Brazil. In addition to the forms referred to Myrsine several forms from the European Tertiary have been referred to the form genus

Myrsinites. Ettingshausen recorded a species of Pleiomerites from the Miocene of Bohemia, and the genus Maesa Förskal, which contains about 40 modern species in Asia, Africa, Australia, and Polynesia, is represented in the Oligocene of Transylvania and Egypt, in the Miocene of Styria, and in the Pliocene of Limburg.

The genus Ardisia Swartz (including Ardisiophyllum Geyler) includes about a dozen fossil species, the oldest of which, a very doubtfully determined form, comes from the Turonian of Bohemia. There is an Eocene or Oligocene species in Chile. Three Oligocene species are found in Bohemia and one occurs in Transylvania. There are 4 Miocene species in France, Bohemia, and Styria, and Pliocene species in Holland, Italy, and Borneo.

The genus Icacorea Aublet is the only member of the Myrsinaceæ found in the Wilcox flora. The genus contains numerous existing species confined to South America. The fossil record is meager but includes 2 or 3 species of the European Oligocene. The Wilcox species is thus considerably older than any European occurrence. It represents a form which is very close to the modern *Icacorea paniculata* Sudworth, a shrub or slender tree of the Florida Keys, the Bahamas, Cuba, and the east coast of southern Mexico. In addition to the foregoing records at least 4 kinds of flowers have been described from the Baltic amber (Sannoisian). These are Berendtia Göppert (2 species), Myrsinopsis Conwentz, and Sendelia Göppert.

Though the geologic history of the family is so incomplete it is not without significance that, like so many families previously discussed, the oldest fossil representatives of this predominantly American family in the existing flora occur in the basal Upper Cretaceous of North America.

The order Ebenales includes the families Sapotaceæ, Ebenaceæ, Styracaceæ, and Symplocaceæ, which contain more than 1,000 existing species. The larger families are the Sapotaceæ and Ebenaceæ, both of which are represented in the Wilcox flora; the other two families are sparingly represented in the European Tertiary. The considerable range in floral structures, from indefiniteness in the number of stamens and carpels and polypetaly to a 4 to 8 cyclic arrangement, leads floral morphologists to consider the order as among the most primitive of the Gamopetalæ.

The family Sapotaceæ comprises trees or shrubs that have a milky juice and that bear alternate, simple, entire, mostly coriaceous, petiolate, exstipulate leaves. It contains about 32 genera and nearly 400 existing species in all tropical countries. About half of the existing species are American. Eleven genera are confined to America, 7 to Africa, 3 to Australia, 2 to New Caledonia, 2 to Asia and Malaysia, 2 to Malaysia, and 1 to Asia. The three large genera Sideroxylon, Chrysophyllum, and Mimusops are represented in all tropical countries. Four genera and 12 species are represented in the Wilcox flora. The largest of these genera is Bumelia Swartz, which includes 6 well-marked Wilcox species. Bumelia, which contains about a score of species, is confined to America in the existing flora, ranging from the southern United States through the West Indies and Central America to Brazil. It includes numerous fossil species, the oldest of which comes from the Upper Cretaceous (Dakota sandstone) of the western interior region. In addition to the 6 Wilcox species, which are prototypes of still existing forms, there are 2 Eocene species (Ypresian) in southern England. There are about a dozen Oligocene species, 10 of which are widespread in Europe, 1 is found in the Apalachicola group of western Florida, and two forms, representing both leaves and fruit, are found in the Vicksburg group of Louisiana and Texas. Seven or eight Miocene species are widespread in Europe, and one is recorded from the late Miocene of Colorado.

The genus Chrysophyllum Linné, which includes about 60 existing species, found in all tropical countries but chiefly American, contains a supposed species in the Upper Cretaceous of Saxony (Niederschoena), a well-marked species in the Wilcox, 3 Oligocene and 6 Miocene species in Europe, and 1 in Colombia.

The genus Mimusops Linné, which contains about 40 existing species in the Tropics, includes 3 well-marked Wilcox species and a fourth in the overlying Claiborne deposits. To it has been referred a species from the Upper Cretaceous of Saxony (Niederschoena), and it is undoubtedly represented in the Upper Cretaceous of the embayment region as well as elsewhere by the leaves that have been referred to the form genus Sapotacites. Reid refers a seed from the Pliocene of Limburg to this genus.

The genus Sideroxylon Linné, which includes about 80 existing species in the oriental Tropics and about 15 in the American Tropics, is represented by 2 species in the Wilcox flora, which are the oldest thus far discovered. To this genus have been referred 4 Oligocene and 1 or 2 Miocene species from Europe.

Isonandra Wright, a small modern genus of the Malayan region, is represented in the Tertiary of Borneo by Isonandrophyllum Geyler. The genus Achras Linné (Sapota Plumier), now monotypic in tropical America, contains 3 species in the European Miocene. Labatia Swartz, which includes 6 existing species in the American Tropics, has been doubtfully determined in the Miocene of Prussia and Italy. Felix has described two forms of petrified wood, which he refers to this family under the name Sapotoxylon, one species from Germany and the other from an unknown locality and horizon. The genus Calophyllum Pierre is represented by handsome leaves, as yet undescribed, in the upper Eocene (Jackson formation) of Texas; and a very characteristic seed has recently been described[1] from the middle Eocene (Claiborne group) of Mississippi as the type of a new genus, Eoachras.

A large number of fossil forms of Sapotaceæ have been referred to the form genus Sapotacites proposed by Ettingshausen (also Sapotophyllum). At least 10 Upper Cretaceous forms are widespread in North America and are represented in Europe in the Perucer beds of Bohemia and the Credneria stage of southern Saxony (Cenomanian). Three of these Upper Cretaceous forms from the Tuscaloosa formation of Alabama undoubtedly represent the ancestors of some of the Wilcox forms. There are about 10 recorded species of Sapotacites in the Eocene of France and southern England. There are about a score of species in both the Oligocene and Miocene, most of which are European, though there is an undescribed species in the Apalachicola group of western Florida. In the Pliocene there are species in southern Europe and on the island of Java.

Notwithstanding the incompleteness of the record, the family obviously became well differentiated during the Upper Cretaceous, and though it would not be safe to assign its place of origin to the American region, it is probable that at least several of the genera, such as Bumelia, originated in this region.

The family Ebenaceæ includes about 8 genera and more than 300 existing shrubs and trees, of which over half are referred to the genus Diospyros Linné. The family is mainly tropical, as are most of the species of Diospyros, though that genus is represented in the North Temperate Zone in eastern North America, eastern Asia, and the Mediterranean region. The 3 modern monotypic genera, Tetraclis, Brachynema, and Rhapidanthe, are confined, respectively, to Madagascar, Brazil, and West Africa, and none have been found fossil. The genus Royena is mostly South African; Euclea is entirely confined to Africa; Maba, a large genus, ranges from Africa eastward to Polynesia; and Macreightia is common to tropical Africa and America.

Diospyros, which includes about 180 existing species, is cosmopolitan. Between 90 and 100 fossil forms have been described. In that grand display of dicotyledonous genera which during the middle-Cretaceous replaced the old Mesozoic flora of ferns, cycads, and conifers, and which appeared with such apparent suddenness in many localities in the Northern Hemisphere, we find unmistakable evidence of the abundance and wide distribution of species of Diospyros. No less than 17 different forms have been described from the rocks of this age, and the localities are scattered from Australia to Bohemia, Greenland, and Vancouver Island. Nearly all these species are American, and they seem to have been especially at home along the Cretaceous coast of the Atlantic and along the border of the Mediterranean Sea which extended northwestward from the Gulf of Mexico over much of our present Great Plains area. One of these species, well named *Diospyros primæva* by Heer in 1866, is especially widespread and abundant. It occurs not only in Iowa, Kansas, and Nebraska in the West, but also from Texas eastward through Alabama and northward in South Carolina, North Carolina, Maryland, New Jersey, Long Island, and Greenland, or from latitude 33° to latitude 71° north. That these early persimmons were not very different from those of to-day is shown by their similar foliage. This resemblance is also shown by the fossilized

[1] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 39, pp. 208-213, pl. 1, 1915.

remains of the calices of various species. One of these calices from another early Cretaceous species, recently described by the writer as *Diospyros vera*, is found in what is known in the Potomac River valley as the Raritan formation. Apparently the habit of accrescence had not been fully formed, but the calyx was persistent then as now and entirely like a modern calyx in appearance. It was four-parted, as is the rule in existing persimmons, but other fossil forms had a five-parted calyx, like many present-day tropical species.

In the Eocene epoch, which succeeded the Cretaceous, the records of the fossil occurrences of Diospyros show that it was truly cosmopolitan. These records include about 20 species in Siberia, Alaska, and Greenland on the north and in Canada and various localities in Europe, as well as Colorado, Montana, Wyoming, Nevada, Oregon, Washington, and other Western States. Unfortunately we have no Eocene or later Tertiary records along the Atlantic coast of North America outside the embayment region, since the preserved deposits are all of marine origin and contain no fossil plants. There is little doubt, however, that Diospyros continued to be an abundant element in the arborescent flora of this area.

There are 2 well-marked species of Diospyros in the Wilcox flora, one of which continues in this region through the Claiborne. A large calyx is found in deposits of Jackson age in southwestern Texas.

There are about 24 Oligocene species, most of them especially common throughout southern Europe. There is an American species of this age in the Apalachicola group of western Florida and abundant petrified fruits in the Oligocene of the Isthmus of Panama. The luxuriant forests of the Miocene have furnished about 20 species of Diospyros. The known distribution at this time includes European localities from Spain to Hungary and American records in Oregon, California, Yellowstone Park, and Colorado. There are 7 Pliocene species in southern Europe and in Java, and the genus is still represented in Holland.

The allied genus Royena Linné is represented by splendidly preserved fruits from the oasis of Chargeh in Egypt (Upper Cretaceous) as well as by 4 Oligocene and 2 Miocene species in Europe. It seems never to have been cosmopolitan like Diospyros, since it has never been recognized in the Western Hemisphere. The fossil history of the genus Euclea Linné was evidently similar to that of Royena. It makes its appearance in the basal Oligocene of Europe, where it is represented throughout the Oligocene and Miocene epochs and becomes confined to Africa in Pliocene and Pleistocene times.

The genus Macreightia De Candolle includes 9 or 10 existing species, one occurring in tropical Africa and the remainder in America. Macreightia is represented by both leaves and flowers in fossil floras and it has been a favorite receptacle for tripartite calices, not all of them of assured botanic identity. The oldest form comes from the German Oligocene, and there are 5 or 6 species in the European Miocene. It has not been definitely recognized in North America, although some of the Wilcox material is not unlike some European material referred to Macreightia.

Felix has recognized wood of this family (Ebenoxylon) in the Oligocene of Antigua.

The order Gentianales (Contortæ of Engler) includes 6 families and between 4,000 and 5,000 existing species. The largest family is the Asclepiadaceæ, which contains more than 2,000 species. The families are complexly related among themselves and with the next two orders, almost the only constant characters being the opposite leaves and the generally twisted corolla in æstivation. The Asclepiadaceæ, not found in the Wilcox, shares with the Apocynaceæ in the development of a latex system and in other specializations, and the elaborate contrivances for entomophily in the Asclepiadaceæ reach a degree of complexity almost comparable with that of the Orchidaceæ. The Loganiaceæ, also not represented in the Wilcox flora, are lianas characteristic of South America and Asia, which are regarded by Engler as relatively primitive and possibly the ancestral stock of the Gentianales and Rubiales. The order as a whole is numerically massed in the Tropics by reason of the many tropical genera of the two largest families, the Asclepiadaceæ and Apocynaceæ, which together contain three-fourths of the existing species of the order.

The family Oleaceæ, sometimes considered as an order, the Oleales, contains 21 genera and about 400 existing species. Three small genera are peculiar to Asia and 4 are peculiar to

America; the remaining 14 genera are found in more than one continental area. The 3 largest genera, Fraxinus (40 species), Mayepea (50 species), and Jasminum (160 species), are all cosmopolitan. Eight of the 21 genera have been found fossil, and the family evidently has an extended history, although there are no known Cretaceous records worthy of credence. Nor is the record well enough known to warrant generalizations. It is obvious from the early Eocene occurrence of leaves of Fraxinus associated with characteristic fruits that the family must have been evolved before the close of the Upper Cretaceous, but none of the genera have any well-marked or abundant known representation until Tertiary times.

The genus Fraxinus Linné is represented by 2 species in the Wilcox flora—a characteristic samara and foliage identical with that described by Heer from western Greenland as *Fraxinus johnstrupi*. Heer's species furnishes an interesting example of the extended distribution of members of the Eocene flora, at the same time illustrating the northward radiation of floras during the Eocene. More than 10 additional Eocene species are known, all of which are American, ranging from Tennessee to Alaska and Greenland. The Oligocene marks the appearance of the genus in Europe, from which time to the present the genus has been represented throughout the warmer parts of the North Temperate Zone, at least 4 of the existing species making their appearance in the Pleistocene.

The second genus represented in the Wilcox flora is Osmanthus Loureiro. It includes about 10 existing species of eastern North America, eastern Asia, and Polynesia. The Wilcox species is exceedingly close to *Osmanthus americanus* Bentham and Hooker, of the Atlantic and Gulf coasts from North Carolina southward. A second fossil species is found in the Miocene of Florissant, Colo.

The Old World genus Phillyrea Linné is found fossil in Europe. The genus Notelæa Ventenat, which contains 6 existing Australian species and an isolated remnant of its former distribution in Madeira and the Canary Islands, is represented in the Eocene, Oligocene, and Miocene of Europe. The genus Olea Linné, which includes more than 30 existing species, about equally divided between Africa, Asia, and Australia and Polynesia, is represented by about 20 fossil forms (including Oleophyllum Conwentz and Oleæcarpum Menzel) in Europe, where they range in age from the basal Eocene through the Oligocene, Miocene, and Pliocene to the Pleistocene. The genus is not known in American fossil floras, but there is a supposed species in the early Tertiary of Australia.

The genus Ligustrum Linné, which contains about 35 existing species in southeastern Asia and the East Indies, is represented by 3 species in the Oligocene and Miocene of Europe. A species of Ligustrum recorded by Hollick from the Upper Cretaceous of Long Island is probably a Pisonia. Saporta has described representatives of the genera Syringa Linné, based on floral remains from the Sannoisian of southeastern France.

The family Apocynaceæ comprises 133 genera and between 1,000 and 1,100 existing species of perennial herbs, vines, shrubs, and trees, most of which have a milky acrid juice and simple exstipulate leaves. The fruit as a rule consists of a pair of follicles or drupes and the seeds of many forms are comatose. The family is almost equally divided into 2 subfamilies, the Plumeroideæ, which contains 68 genera and about 550 species, and the Echitoideæ, which includes 65 genera and about 500 species. The genera Plumeria Linné, which comprises about 40 species, and Rauwolfia Linné, which comprises about 45 species, are cosmopolitan, mostly tropical. Twenty-four genera and about 300 species occur in more than one continental area. America heads the list, with 36 peculiar genera and about 325 species, followed by Africa, with 28 peculiar genera and about 130 species, and Asia, with 20 peculiar genera and about 75 species. Australia has few endemic genera or species, but numerous genera range from Asia or Africa to the Australian region, and several genera are peculiar to Malaysia and to Polynesia. In the present state of our knowledge the distribution does not furnish material for generalization.

The fossil record, although it includes representatives of at least a dozen genera, is too incomplete to shed much light on the history of the family or its existing distribution. The largest fossil genus is the form genus Apocynophyllum, proposed by Heer, which embraces fossil forms that resemble Thevetia, Cerbera, Apocynum, and other existing genera of the family. Five species which are recorded from the Upper Cretaceous come from the Dakota sandstone of the western interior States and from Australia, Westphalia, and Saxony. More than a score of Eocene species are widely distributed. Of 5 species in the Wilcox flora several are exceedingly well marked and common. There are also 5 species in the Ypresian of southern England. Other Eocene records include Greenland, New Zealand, and Chile. The score or more of known Oligocene species are confined to European localities. The Miocene species number about 25, mostly confined to Europe, but recorded also from Australia.

Fossil forms have been sparingly referred to the following genera: Allamanda, Hæmadictyon, and Thevetia have been recognized by Engelhardt in the early Tertiary of Chile. Alyxia, Alstonia, Cerbera, and Tabernæmontana have been recognized in the European Tertiary by different students. The genus Neritinium Unger includes 4 or 5 species in the European Miocene. The genus Plumeria contains 4 Miocene species in Europe and a Pliocene species in Brazil. The genus Echitonium Unger includes more than a dozen fossil species. There are 5 species in the Eocene, including a well-marked form in the Wilcox flora; 2 in the Oligocene and 5 in the Miocene of Europe.

The genus Nerium Linné contains only 3 or 4 existing species of shrubs or trees in the warmer parts of Eurasia. However, the commonly cultivated *Nerium oleander* Linné of the Levant grows to a relatively large size and is extensively naturalized in Florida, Bermuda, and the West Indies. Saporta recorded an Upper Cretaceous species, *Nerium rohlii*, from the Campanian of Westphalia, but it is almost certainly a member of the Myrtaceæ and not a Nerium. Undoubted species do occur in the Eocene of Europe, including the remains of a characteristic flower from the Paris Basin. There are several Oligocene and Miocene species in Europe, and the existing *Nerium oleander* or its immediate ancestor occurs in the Pliocene of southern Europe in France and Spain. The Wilcox species *Apocynophyllum tabellarum* is very suggestive of Nerium, but the genus is not certainly known in the Western Hemisphere.

It may be noted that with the exception of species of Apocynophyllum, which are not certainly identified, the family is not represented in the abundant known Upper Cretaceous floras of the world, which might indicate that it originated in the Southern Hemisphere.

The order Polemoniales or Tubifloræ (not the Tubifloræ of Engler, which includes the orders Polemoniales and Personales, here regarded as distinct) contains the four families Convolvulaceæ, Polemoniaceæ, Hydrophyllaceæ, and Boraginaceæ. The first three are characteristically American. The Convolvulaceæ are chiefly tropical, and the largest family, the Boraginaceæ, is typically developed in the North Temperate Zone.

The family Boraginaceæ, the only one of the order known in the Wilcox flora, contains about 85 genera and 1,600 existing species, chiefly of widely distributed North Temperate herbs and shrubs, or of trees in tropical countries, characterized by alternate, exstipulate, mostly entire leaves. The known fossil forms are few and of slight significance. They comprise for the most part Tertiary remains described as species of Boraginites and Heliotropites. The family is represented in the Wilcox by two species of Cordia, a genus that contains about 230 existing species of shrubs and trees of the warmer regions of both hemispheres, especially the western. There is a species in the Upper Cretaceous of the Mississippi embayment area (Tuscaloosa formation) and a Miocene species in Europe. Early Tertiary forms are recorded from Chile by Engelhardt and from Tasmania by Ettingshausen. The slight evidence available indicates that the genus originated in the American Tropics and that the bulk of the family is of late Tertiary origin.

The order Personales or Labiatifloræ includes 16 families distinguished from the Polemoniales by the zygomorphism of the flowers. The specific differentiation is great and the lines of descent are confusing. The largest families are the Labiatæ, which contains more than 3,000 existing species; the Scrophulariaceæ, which contains about 2,500 species; the Acanthaceæ, which comprises about 2,000 species; and the Solanaceæ, which comprises about 1,800 species. Two of the 16 families, the Verbenaceæ and Solanaceæ, are represented in the Wilcox flora.

The family Verbenaceæ includes about 73 genera and 1,300 existing species of widely distributed herbs, shrubs, or, in tropical countries, trees. The family is largely tropical or subtropical and is notably represented in the South American region. The fossil record is most incomplete. The largely Old World genus Clerodendron Linné is unmistakably present in both Eocene and Oligocene of Europe, and Ettingshausen has referred somewhat doubtfully determined forms from the European Oligocene to the American genus Petræ Linné and to the cosmopolitan genus Vitex Linné. The genus Citharexylon Linné contains about 20 existing species, which range from the Florida Keys and Lower California through the American Tropics to Bolivia and Brazil. A single species found in the Holly Springs sand and Grenada formation is extremely close to the existing *Citharexylon villosum* Jacquin, a small coastal tree of the Florida Keys, the Bahamas, and the Antilles. With the exception of one or two doubtfully determined forms in the Miocene of southeastern Europe and a form described by Engelhardt from the Tertiary of Colombia it is the only known fossil form.

The genus Avicennia Linné, sometimes made the type of a distinct family, the Avicenniaceæ or black mangrove family, includes from 3 to 30 existing species, according to the interpretation of different students. These plants are found on all tropical tidal shores. Two species have been recognized in the Wilcox flora, one based on leaves and the second on a not conclusively identified capsule.

The family Solanaceæ includes about 70 genera and about 1,600 existing species, widely distributed and largely tropical but extending into the Temperate Zone, notably in the Western Hemisphere. It comprises herbs, shrubs, vines, or, in tropical countries, trees, which bear opposite, stipulate, toothed, lobed, or dissected leaves. Their fossil history is almost entirely unknown. The single Wilcox representative of the family is a flower described as Solanites, a genus founded on the somewhat younger remains of a similar flower found in the Sannoisian of France and comparable with the existing South American genus Saracha Ruiz and Pavon, as well as with Witheringia, Solanum, and similar forms.

The last order of Gamopetalæ positively recognized in the Wilcox flora is the Rubiales, which includes more than 5,000 existing species, segregated into 5 families. More than four-fifths of the species are referred to the family Rubiaceæ, the only one represented in the Wilcox.

The Rubiaceæ includes about 355 genera and more than 4,500 existing species of herbs, shrubs, and trees that bear simple, opposite or verticillate, mostly stipulate leaves. They are widely distributed and largely tropical. According to Beccari the Rubiaceæ is the largest family in the flora of Borneo. It ranks second in the flora of the Malay Peninsula and in that of the Philippines, fourth in the flora of Central America (Hemsley), and third in that of the Celebes (Koorders). Though the Wilcox representation is confined to a single species each of Exostema, Psychotria, and Guettarda, great interest must attach to the fossil record of so highly organized a family, which is my justification for introducing the following brief sketch of our knowledge of it.

No less than 27 genera have been recognized in the fossil state. With the exception of the very doubtful determination of a species referred to, Rubiæphyllum from the Turonian of Bohemia, which doubtless is a species of Ericaceæ, the family is unknown in the Upper Cretaceous. It is, however, represented in the early Eocene, both in America and Europe. The Wilcox forms represent a species of Exostema Richard, close to the existing *Exostema caribæum* Roemer and Schultes, which ranges from the Florida Keys to Central America. The genus comprises about 20 existing species of shrubs and small trees, which are confined to the Tropics and subtropics of America. The second Wilcox species is referred to Guettarda Endlicher, a genus that comprises about 50 species, most of which are confined to the American Tropics, though one or two cosmopolitan tropical maritime species are included. The Wilcox form is very close to the existing *Guettarda elliptica* Swartz, a small tree of the Florida Keys, the Bahamas, and the West Indies. The third Wilcox species is *Psychotria grandifolia*, described originally by Engelhardt from the early Tertiary of Chile. The genus Psychotria Linné comprises about 350 (the "Index Kewensis" lists between 600 and 700) existing species of shrubs and small trees in tropical America, Africa, Asia, and the East Indies. Two-thirds of its species are American. The fossil form is compared with *Psychotria grandis* Swartz of the American Tropics.

The genus Coussarea Aublet, which includes about 40 existing species in the Brazilian region, has been identified by Engelhardt from the early Tertiary of Chile. The genus Hoffmannia Swartz, which includes about a score of existing American herbs or shrubs, mostly confined to Central America, is represented by a fossil species in the early Tertiary of Chile. Likewise the genera Sabicea Aublet and Gouatteria Martius each have a single species in the Tertiary of Chile, and Sabicea has also been recorded from the Tertiary of Colombia.

The Baltic amber (Sannoisian) has yielded a flower referred to Sendelia and a leafy twig referred to Enantioblastos. The genus Galium, which comprises more than 250 widely distributed existing herbaceous forms, has been doubtfully identified from the Eocene of Greenland. Its fruits are also not uncommon in Pleistocene deposits. The genus Randia Houston, which embraces about 100 existing species of shrubs or trees in the Tropics, is identified by a fruit in the Aquitanian of Rhenish Prussia.

The genus Rubiacites, so named by Webber from its resemblance to the existing forms of Rubia Linné, contains 3 species of leaves and flowers in the Aquitanian of Prussia and Switzerland. The genus Gardenia Ellis, which contains about 60 species, chiefly shrubs, but also a few trees, of the Eastern Hemisphere, is represented by characteristic fruits in the Sparnacian of France, the Aquitanian of Germany and England, the Miocene of Baden and Italy, and the Pliocene of Italy. The genus Posoqueria Aublet, which includes 5 or 6 existing South American shrubs or trees, is represented according to Unger by both leaves and fruits in the Miocene of Croatia and Engelhardt has described a species from the Tertiary of Colombia. The genus Ixora Linné, which comprises 100 existing species of shrubs and small trees in the Tropics, is likewise recorded from the Miocene of Croatia, as is also Pavetta Linné, a genus which includes about 70 existing species of shrubs or small trees of the oriental Tropics and which has furnished leaves, flowers, and fruits from the celebrated plant and insect beds of Radoboj, in Croatia.

The genus Coprosoma Förster, which includes 40 existing species in Australia, New Zealand, and Oceanica, was recorded by Ettingshausen from the Tertiary of Tasmania. The genus Nauclea Linné, which includes 30 existing species of shrubs and trees in tropical Asia and Oceanica, was identified by Unger in the European Miocene, and petrified wood of this type (Naucleoxylon) was described by Crié from the Pliocene of Java.

Deane has recorded a species of Psychotriphyllum from the Tertiary of New South Wales.

The genus Morinda Linné includes about 40 existing species in the Tropics, especially in the Orient and the islands of the Pacific. A fossil species has been recorded from the Oligocene of Italy, and 5 additional species, based on leaves, have been described from the Miocene of Croatia.

The genus Bothriospora Hooker fils, which includes a single existing species in Guiana, occurs in the Tertiary of Colombia according to Engelhardt. The genus Endlichera Presl (Emmeorrhiza Pohl), which includes a single existing species that ranges from Colombia to Sao Paulo, Brazil, has been identified by Engelhardt from the Tertiary of Ecuador.

A fruit from the Tertiary lignites of Brandon, Vt., has been described by Perkins as Rubioides and another from the Aquitanian of Rhenish Prussia by Menzel under the name Rubiaceæcarpum. Geyler has identified the Old World genus Grumilea Gärtner in the Tertiary of Borneo. Finally the genus Cinchonidium, proposed by Unger for fossil fruits and leaves which were very similar to those of the existing South American genus Cinchona Linné, is represented by a number of species; 4 or 5 of them in the Eocene, including the Fort Union of the western United States and the Ypresian of England; 5 in the late Oligocene of southeastern Europe; and about 8 species in the Miocene, 1 from the Esmeralda formation of Nevada and the others European.

The family is thus well represented in fossil floras throughout the Tertiary, but the small proportion of existing genera which have fossil representatives and the incompleteness of their record render untrustworthy any generalizations that might be made.

Under "Incertæ sedis" (pp. 350–353) are grouped 14 species of the Wilcox flora, including 2 forms referred to Calycites, 2 to Antholithus, and 10 to Carpolithus. It would be quite useless to attempt any botanic discussion or comparison of these uncertain forms, such remarks as they suggest being more suitably confined to the discussion of the individual species.

PHYSICAL CONDITIONS.

No part of North America is so favorably situated for the study of the floras which preceded the present, extending back to the first recorded appearance of angiosperms, as the South Atlantic and Gulf States. No single part of North America contains so continuous a series of Tertiary deposits that carry fossil plants. In this area are found abundant floras in the lower and middle parts of the Eocene, a small flora in the upper Eocene, large floras in the Oligocene, some material in the later Miocene, and rather abundant fossil plants in the Pliocene, as well as in many Pleistocene deposits. The Rocky Mountain region is rich in Eocene fossil plants and contains some Miocene floras, but practically no Oligocene or Pliocene floras. The Pacific coast region likewise furnishes Eocene and Miocene fossil plants but none of Oligocene age.

The fossil floras of the Coastal Plain occur in an area in which some measure of accuracy can be attained in predicating the general character and course of ocean currents and winds and other physical features of the environment. On the other hand, the western floras just mentioned grew in areas where at times the effects of volcanism were great; in areas where orogenic movements were active and where numerous changes in topography that involved elevations of several thousands of feet are recorded; areas in which climatic conditions not only differed from place to place but passed through a large cycle of secular changes. All these factors greatly complicate the floral history.

The floras of the southern Coastal Plain are, moreover, checked for the most part by very abundant marine faunas that are contained in intercalated beds, or else the plant-bearing beds, which represent the coastal swamps and the shallow-water deposition of the old embayment, merge laterally into the contemporaneous limestones or marls which were forming in more open waters along the coasts to the south, so that evidence regarding land temperatures, derived from the flora, can be compared with evidence regarding depth, character of the bottom, and marine temperatures derived from the sedimentary rocks and their faunas. These criteria have been admirably worked out for the Florida area by Dall and Vaughan for the post-Eocene, and their results furnish a reliable basis for deductions from the study of fossil floras of that age.

With the exception of fragments of the petrified stems of conifers, palms, and dicotyledons the plant remains occur in the form of impressions, mostly of foliage, though there is a goodly representation of fruits and seeds, and even a few flowers have been preserved.

Though the oscillations of the embayment area have been numerous, their amount, as I have just mentioned, has been inconsiderable, only a few hundred feet at most, and the coastal region has uniformly been one of slight relief. The floras show an almost complete absence of upland types, which is in striking contrast to the European older Tertiary floras. Europe, the only large area of the globe which has been thoroughly studied, was far less stable than this region in Tertiary times, and as it lay much farther toward the pole it was subsequently subjected to the rigors of Pleistocene conditions, whose influence never reached our Southern States.

The paleobotanic record of the Atlantic and Gulf Coastal Plain furnishes a history which extends back beyond the oldest known angiosperms to a time (Lower Cretaceous) when the flora was made up almost entirely of tree ferns, conifers, and those interesting cycadophytes (Cycadeoidea) whose trunks are in places preserved with such marvelous perfection that the outlines of the embryos in the ovules can commonly be made out in detail. To come a step nearer my present theme, a step of some millions of years, from the Lower into the Upper Cretaceous, we find the first great modernization of the floras of the world, which was due to the seemingly sudden evolution of the main types of angiosperms. These Upper Cretaceous floras are well represented in the Coastal Plain from Marthas Vineyard to Texas. They extend northward to Greenland and southward to Argentina in South America and indicate very different physical conditions from those which prevail at the present time. I do not intend, however, to dwell on the Upper Cretaceous floras in this connection, but pass to a consideration of the succeeding Eocene epoch of plant evolution.

The Eocene, as defined by Lyell, was marked by the dawn of the recent species of marine Mollusca. It is equally well marked by the sudden expansion and evolution of modern types of plants after a long antecedent Cretaceous development. The floras become thoroughly modernized as compared with those which preceded them, although they are still very different in their general facies and distribution from those of the present.

In the earliest epoch of the Eocene, known as the Midway, the relations of sea and land in the Gulf area differed in only minor particulars from those in the late Cretaceous. The waters of the Mississippi Gulf, however, were deeper. This factor, combined with a much smaller influx of fresh water from the tributary streams, owing in some measure to the low relief of the land, enabled marine faunas to reach well toward the head of the Gulf. These faunas indicate subtropical bottom temperatures northward as far as Paducah, Ky. The known floras are very scanty and unsatisfactory and in the present state of our knowledge do not merit an extended discussion. The maximum transgression of the sea during the Midway epoch is shown on the accompanying sketch map (fig. 8).

The Midway Eocene was succeeded by a long interval during which the sea is believed to have withdrawn southward at least as far as the position indicated on the accompanying sketch map (fig. 9), since terrestrial conditions are shown at the extreme base of the Wilcox in the most southerly areas of its outcrop. This interval of emergence of the embayment area was followed by an equally long interval during which was laid down a great thickness of deposits that are collectively known as the Wilcox group. The character of these sediments and their faunas show that the Mississippi Gulf was somewhat smaller in area and much shallower than in the preceding epoch and that true marine conditions prevailed only when a part of the Wilcox group was being laid down. The shores were low and relatively flat. They were flanked by current or wave built bars and separated from the mainland by shallow inlets or lagoons. The lower courses of the streams were transformed into shallow estuaries or broad swamps through which the smaller streams meandered.

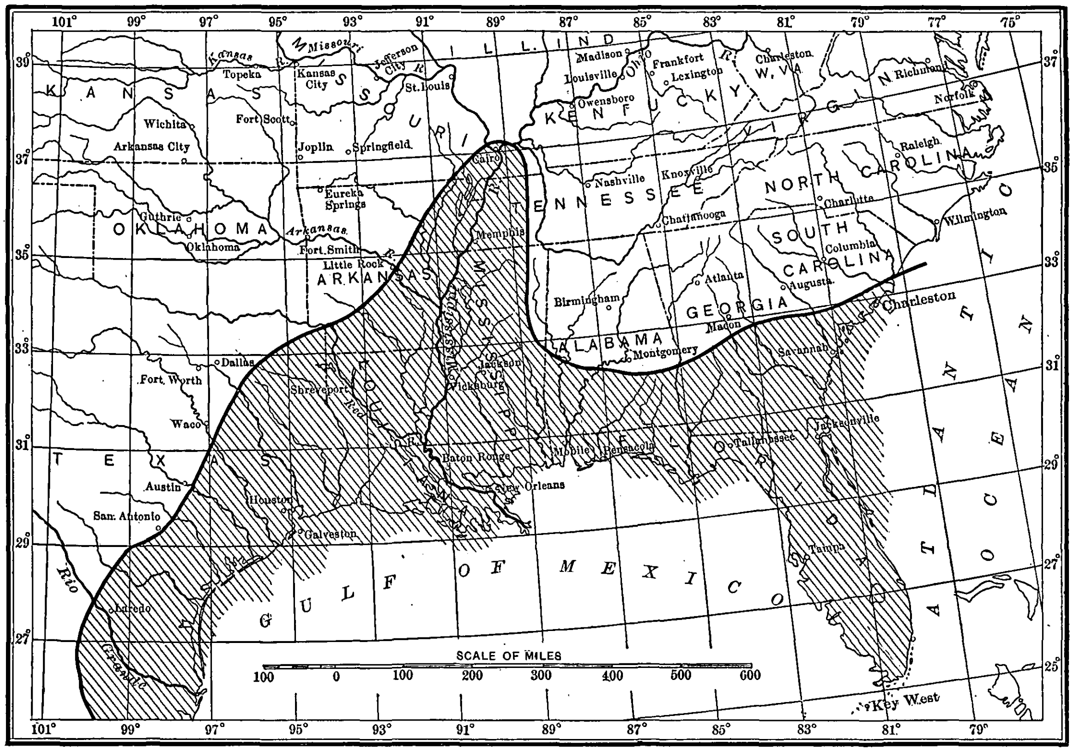

Figure 8.—Map showing the maximum extent of the Midway transgression.

The maximum area of the Wilcox deposits is also indicated on the accompanying sketch map (fig. 9), which shows approximately the shore line along which the vegetation migrated. The Wilcox deposits have yielded one of the most extensive of known fossil floras, an assemblage of extinct species which sheds considerable light on the physical conditions of the marginal lands of Wilcox time.

Before taking up in detail the evidence of the flora I wish to point out certain general climatic conditions in the Wilcox area based on cosmic causes and deduced from studies of recent climates.

As the factors governing atmospheric circulation are general and not local, the relatively slight changes in the relation of land to sea in Wilcox time as compared with the present are low, more or less landlocked water would have a very appreciable effect in raising total temperatures and in preventing widely separated extremes. At the same time it would increase the rainfall and increase the width of the marginal lands over which this augmented rainfall would be effective. Whether this would be sufficient to furnish the subtropical conditions that the flora seems to indicate is doubtful.

Speculation regarding the Eocene climate of the world as a whole is perhaps out of place, but it may be said that the sum total of

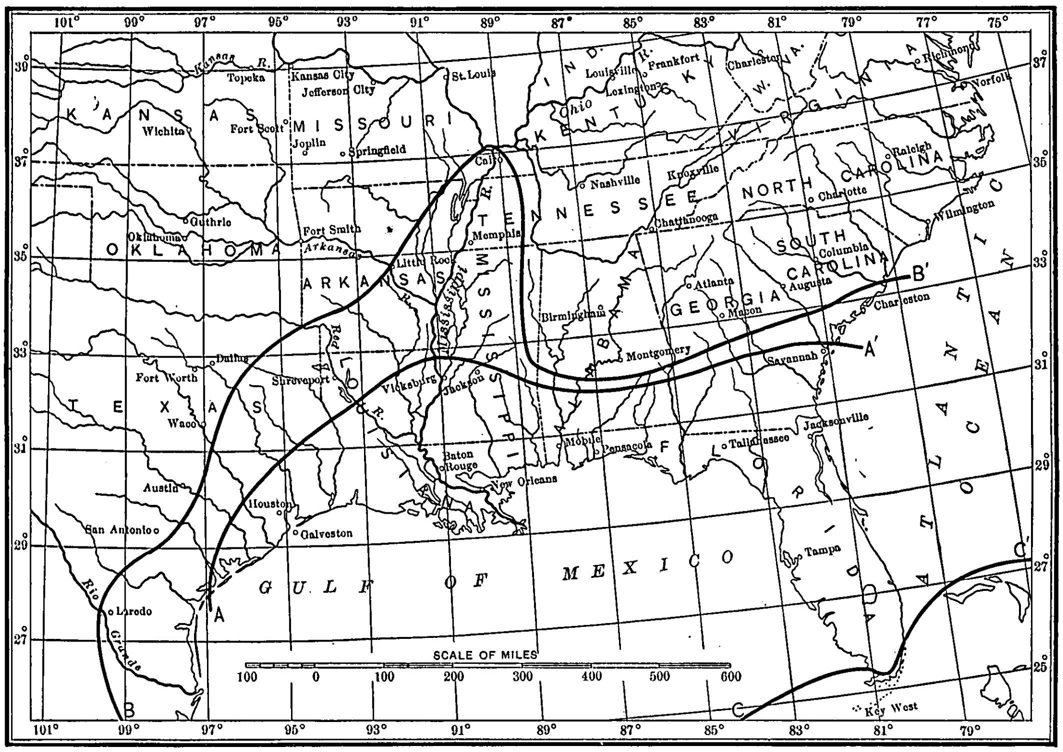

FIGURE 9.—Map showing (A–A′) the strand line at the beginning of Wilcox deposition, (B–B′) the maximum extent of the Wilcox transgression, and (C–C′) the northern limit of the Wilcox flora under existing climatic conditions.

entirely too small to have caused much modification of the then existing conditions. Then as now there was a persistent area of high pressure over the North Atlantic and an equally persistent area of low pressure over the continent. Consequently the prevailing winds were from the east. Cyclonic disturbances, like those which originate to-day in the Gulf of Mexico or those more violent and widespread storms of the West Indian hurricane type which to-day originate in the Caribbean Sea, would traverse at least a part of the Mississippi embayment. So large an area of shal-

paleontologic evidence indicates that the familiar succession of seasons or of types of vegetation in passing from the luxuriant Tropics to the ice-capped poles did not hold in Eocene time. Paleobotanists have long maintained that the climate of the present is essentially a Pleistocene climate of an interglacial character and that for the great bulk of geologic time uniformity and not differentiation has been the rule rather than the exception. Though the older paleobotanists were inclined to overestimate the conditions of torridity, it remains true that from the Lower Cretaceous until toward the close of the Oligocene, not to mention the evidence derived from still older floras of more remote botanic affinities, wherever fossil floras are found, from the Equator to the region within the Arctic Circle, they show a degree of uniformity which proves that former climates were secularly unlike those of to-day, and it is obvious that this floral evidence would be equally convincing if all the vast number of fossil plants were simply called Phyllites as in Schlotheim's day and no attempts were made to determine their botanic affinity.

The student of fossil floras is naturally more sanguine and enthusiastic in predicting former physical conditions than perhaps is warranted by the facts. When, however, a common Upper Cretaceous flora can be traced from Texas to Greenland or when we find in the Eocene such unmistakable forms as leaves of Artocarpus, fruits of Engelhardtia, and nuts of the nipa palm associated with forms as characteristic as ferns of the genus Acrostichum, all extending almost across the Temperate Zone in both the Eastern and Western hemispheres, it would seem that the burden of proof that climates were not very different from those of to-day rests with the physicist and not with the paleobotanist.

In a short paper[1] read before the American Philosophical Society in 1911 a few of the features of the Wilcox environment were pointed out and in the present discussion of the botanic character as well as in the systematic description of the Wilcox flora it has been inexpedient to refrain from mentioning certain ecologic features in the discussion of the elements of the flora. The table of general distribution at the end of the discussion of correlation indicates in a general way the most similar living species with their habitats, and the systematic descriptions abound in comparisons with recent forms, so that it is inadvisable to give detailed lists here. It may be noted that the Wilcox plants, almost without exception, are plants whose modern representatives inhabit the warmer parts of the earth. There is not a single strictly temperate type in the whole assemblage, the nearest approach to such types being the genera Juglans, Myrica, Magnolia, Cercis, Ilex, Nyssa, and Fraxinus, and in all these or in closely related genera there are existing tropical forms. None of them extend beyond the warmer parts of the Temperate Zone and some, as Juglans and Fraxinus, indicate in their compound leaves their tropical ancestry, as was first pointed out by Grisebach. The ferns are all tropical types, and their relative unimportance in the Wilcox flora furthermore indicates that the major part of this flora is a strand flora. This character is shown more especially by forms like the nipa palm, which never grows outside of tidal marshes, and by Conocarpus, Laguncularia, and Avicennia, which inhabit like regions. Coastal marsh or lagoon plants like Canna, Trapa, and Sabalites, and the large number of strand types that inhabit beaches or the jungle behind the beach ridges or dunes add to this evidence. The more striking of these genera are Myrica, Artocarpus, Ficus, Coccolobis, Pisonia, Anona, Capparis, Chrysobalanus; several genera of Lauraceæ, Apocynaceæ, Sapotaceæ, and Leguminosæ; Fagara, Cedrela, Drypetes, Metopium, Ilex, Celastrus, Sapindus, Dodonæa, Reynosia, Rhamnus, Myrcia, Eugenia, Laguncularia, Combretum, Terminalia, Cordia, Citharexylon, Exostema, and Guettarda.

It needs but a slight acquaintance with the existing Antillean flora or that of the Florida Keys, or in lieu of actual acquaintance a perusal of the few ecologic discussions of the flora of the American Tropics or even of Schimper's classic Indo-Malayan strand flora, to see at once that the general facies of the Wilcox flora is overwhelmingly that of a strand flora, some of the elements of which indicate that they grew on the sandy beaches, others in muddy tidal flats, others between or behind dunes or beach ridges, and others in estuary bayous or marshes. Such a Wilcox bayou, subsequently converted into a small coal basin, is that at Hoyt Station, Wood County, Tex., which winds across the strike of the Wilcox beds and has a diameter of half to three-quarters of a mile and an exposed length of 3 miles.[2] None of the forms can certainly be considered inland or upland types. Even genera like Banksia, which is not usually considered a coastal type, furnishes in the existing flora *Banksia marginata* Cavanilles to the coastal sand dunes of South Australia

[1] Berry, E. W., A study of the Tertiary floras of the Atlantic and Gulf Coastal Plain: Am. Philos. Soc. Proc., vol. 50, No. 199, 1911.

[2] White, David, Bur. Mines Bull. 38, p. 12, 1913.

(Tepper) and several other species of the genus grow on the dunes of Queensland, Victoria, and western Australia.

Little has been written of the plant associations of the American Tropics, and collector's notes almost always fail to describe habitats adequately. Though the marginal Wilcox lands were low, there was such a large continental area to the north from which to draw, and the long coast furnished such varied edaphic conditions, that the flora was far richer than floras of small insular areas of the American Tropics of the present, as, for example, that of the Bahamas, which are relatively close to the mainland and where, in addition to the difficulties of introduction, there is relatively great uniformity of edaphic factors and directly adverse factors exist, such as winds, which limit the floral display.

Without pursuing the subject in greater detail it may be assumed to be proved that the Wilcox flora is a typical coastal flora. When it is compared with recent coastal floras it is at once apparent that its affinities are entirely with those of tropical and subtropical America. It has much in common with the Bahaman flora and that of the Florida Keys but is far richer in arborescent forms. Comparisons with the larger islands of the West Indies show more elements in common, and the differences which are apparent are due to the prevalence of porous coral rock along these recent shores, whereas the Wilcox shores were of a different character. The Wilcox flora agrees most completely with the floras along the Caribbean coast from Central America to northern Brazil. Many genera of the Wilcox flora do not now range through the West Indies, and the explanation seems to be that the Wilcox flora more closely resembles the original flora of the whole American equatorial region, which became restricted during the epeirogenetic and climatic changes of the Miocene or Pleistocene, and the elements now lacking in the West Indies never regained all the area of distribution which they lost at that time. In a measure confirmatory of this statement it may be mentioned that Hemsley, in his elaborate discussion of the flora of Mexico and Central America, lists 698 South American species of flowering plants in those floras which in 1888 were unknown in the West Indies. These included 1 gymnosperm (Podocarpus), 183 monocotyledons, and 514 dicotyledons.

The following comments on the existing flora of northern South America are not out of place in this connection. Undoubtedly the richest botanic province on the globe is the tropical rain forest of South America. In the monumental "Flora Brasiliensis" Martius has described 22,800 species of plants, and this number probably represents not more than half of the total botanic wealth of this trackless wilderness. Wallace in 1911 estimated that there were about 80,000 species of flowering plants in tropical South America; in other words, a number about equal to that of all the other tropical floras of the world combined. This region is also notable in that it comprises the largest equatorial forest of the world. The Amazon plain alone is approximately 2,000,000 square miles in area, and it is covered by an almost continuous forest, which extends southward along the valleys into central Brazil and along the Atlantic coast to latitude 30° south. It extends westward to the eastern slopes of the Andes and thence southward into the Temperate Zone. It extends northward over the Guianas and through Venezuela to Trinidad, and thence along the coast to Central America and the lowlands along the Atlantic and Pacific coasts of southern Mexico. This wonderful region may be regarded as a vast preserve in which the living representatives of so many elements of our southern Tertiary floras have not only avoided extinction but become greatly differentiated and multiplied. I have mentioned the possibility of finding Engelhardtia in the western part of this relatively unexplored region, and it may contain many other genera which were American in past epochs.

Seemann[1] has graphically described the flora of the Isthmus of Panama, and his description affords an interesting comparison with that of the Wilcox, although it is undoubtedly more tropical and would probably be more closely comparable with the flora of the lower Oligocene of our Gulf States, if that flora was as well known as the Wilcox flora. He says that the dunes abound in Leguminosæ, Euphorbiaceæ, coconut palms, and Hippomane scrub. Crescentia and Paritium form thickets. A wet

[1] Seemann, Berthold, Flora Panamensis, Botany of the voyage of H. M. S. *Herald*, pp. 57-346, 1852-1857.

strip about 2 miles in width is covered with mangroves, chiefly Rhizophora and Avicennia, interspersed in the somewhat drier areas with extensive tracts of Acrostichum, some of the fronds of which are 10 feet tall. Bowers of wild figs, fragrant evergreen pithecolobiums, bamboos, and ivory palms are also found near the coast. The evergreen forest zone consists chiefly of Sterculiaceæ, Tiliaceæ, Mimosaceæ, Papilionaceæ, Euphorbiaceæ, Anacardiaceæ, Melastomaceæ, and Rubiaceæ, with small palms (Chamædorea, Trithrinax, and Bactris).

It may seem improper to say that a flora which contains abundant forms of Artocarpus, Nipa, Cinnamomum, Banksia, and the like is entirely American in character, but from the brief sketches in the botanic discussion it is obvious that these genera, though oriental in the existing flora, were cosmopolitan in the early Tertiary, so that it is misleading to draw conclusions from existing distribution alone.

The Wilcox waters of the upper embayment were always shallow. There were fringing bars and lagoons as well as deltas, estuaries, and swampy bayous. Most of the Wilcox lignites were probably formed in these coastal swamps, and the immediately underlying clays or clayey sands usually show evidence of roots in place, some of them of large size. The sand films in the lignites indicate flood periods of rivers. The deposits in places show the action of the rivers and the shifting of streams over sand flats. Regarding actual temperatures so little is known of the relations of modern plants to their climatic environment that general estimates only can be given.

It is obvious that the flora could not have existed if the region had been ever visited by frost, and temperatures appear to have been like those to-day on the Florida Keys. Aside from the meteorologic evidence that there was a wide coastal belt of abundant precipitation, confirmation is furnished by the flora itself. It would seem to me proper to compare the Wilcox flora with those of the regions to which the somewhat loosely used term subtropical rain forest is applied by plant geographers. Too little is known of the Midway (?) flora for accurate comparisons. If compared with the Upper Cretaceous flora of the embayment area, in which, however, 40 per cent of the genera are extinct, the Wilcox would seem to have become more tropical, a progression from what might be termed a warm temperate to a subtropical rain forest. On the other hand, the floras as well as the faunas show a gradual increase of tropical conditions in the later Eocene, culminating in the Oligocene, the flora of which in southeastern North America is strictly tropical.

Bailey and Sinnott have formulated[1] a method of approximating climatic factors by a study of the percentage of dicotyledonous leaves with entire and toothed margins. Although subject to a variety of modifying factors and as yet practically untested, the method at least offers an additional means of checking results obtained by other methods. The Wilcox flora represented by leaves and leaflets comprises 264 species with entire margins and 46 species with toothed margins, or 0.826 per cent of the first and 0.174 per cent of the second. This percentage of entire margined forms is much greater than Bailey and Sinnott find in any existing warm-temperate floras for which they have compiled statistics. It is comparable with the percentage of entire leafed forms in the floras of Ceylon (80 per cent), Manila (81 per cent), West Central Africa (81 per cent), Queensland (82 per cent), New South Wales (82 per cent), Florida (83 per cent). In view of the more complete data obtainable for recent floras and the uncertainty regarding the unknown part of the Wilcox flora positive results are not to be expected. The percentage of entire leaves in the existing floras of moist lowland tropical regions is stated to be 88 per cent. As the Wilcox flora is known to have been one of moist lowlands, it could not on this basis be tropical, which conclusion is in accord with those derived from other considerations, and I am disposed to consider the close agreement in the percentage of entire-leafed forms between the flora of the Wilcox and that of the existing flora of Florida as being of considerable significance.

Lianas were apparently not as common in the Wilcox as they are in the existing floras with which it has been compared. No traces of the Bignoniaceæ, so common in the American Tropics, have been detected, the scandent

[1] Bailey, I. W., and Sinnott, E. W., A botanical index of Cretaceous and Tertiary climates Science, new ser., vol. 41, pp. 832-833, 1915.

types being represented by Lygodium, Aristolochia, Malpighiaceæ, Canavalia, Pisonia (?), and Zizyphus. I am inclined to think that the great uniformity of climatic conditions, together with the abundant rainfall, have combined to make the Wilcox flora seem more tropical in character than was actually the case. That reef corals are not found in the Wilcox is I believe entirely due to physical conditions other than those of temperature, as, according to Vaughan,[1] is so often strikingly shown in Recent seas.

I have indicated on the sketch map (fig. 9, C–C′, p. 135) what I conceive would be the northern limit of range of the Wilcox flora under existing climatic conditions in southeastern North America.

Most of the generic types of the Wilcox were probably differentiated by the close of the Cretaceous period. If, as I believe, the equatorial region of America was the place of origin of a majority of those types which have not as yet been recorded from the Cretaceous, they must have spread northward along the Mississippi Gulf either during the Cretaceous-Eocene interval, during the Midway, or during the Midway-Wilcox interval. Though the time available for this northward dispersal was thus sufficiently long to account for the migration of even the most slowly spreading forms, a short statement on the adaptations and agencies of this dispersal is not without interest.

The Wilcox plants which bear winged fruits or seeds are Engelhardtia, Paraengelhardtia, Dodonæa, Paliurus, Fraxinus, and the Proteaceæ and Malpighiaceæ. None of these plants are capable of long flights except those of the last two families, which during high winds might readily be carried for miles along coasts, although it is doubtful if they could have crossed great stretches of open water, even through the agency of a West Indian hurricane. The heavier winged fruits, such as those of Engelhardtia, Paraengelhardtia, Paliurus, Dodonæa, and Fraxinus, float readily, but I do not know of any experimental data to show how long they can float in oceanic waters without losing their vitality. Certainly Dodonæa has reached the Bermudas in recent times through the agency of the Gulf Stream, and Guppy states that the fruits of *Dodonæa viscosa* float for months in sea water without injury. Among the Wilcox forms more or less adapted for floating, the following genera may be enumerated: Nipadites, Canna, Taxodium, Carapa, Dalbergia, Canavalia, Anona, Cæsalpinia, Sophora, Cordia, Sapindus, Sterculiocarpus, Trapa, Avicennia, Solanites, Exostema, and the Combretaceæ. Among these forms Canna, Taxodium, Trapa, and Exostema are scarcely adapted for sea voyages, but, on the other hand, Nipadites, Sapindus, Sterculiocarpus, Avicennia, Carapa, and the Combretaceæ are singularly adapted for dispersal by ocean currents and would be in the van of forms colonizing the shores of the transgressing Wilcox sea.

Many of the Wilcox genera had fleshy or drupaceous fruits, which form the food of mammals and also especially of frugivorous birds. Among these forms the following may be mentioned: Myrica, Ficus, Coccolobis, Magnolia, Pisonia, Asimina, Chrysobalanus, Simaruba, all the Lauraceæ, Ilicaceæ, Celastraceæ, Myrtaceæ, Ebenaceæ, Sapotaceæ, Meliaceæ, Euphorbiaceæ, Anacardiaceæ, Zizyphus, Guettarda, Citharexylon, Cordia, Osmanthus, Icacorea, Rhamnus, and Reynosia. Many of these plants bear crustaceous stones that pass uninjured through birds or are disgorged with their vitality unimpaired (avivectent), and these stones could undoubtedly be carried long distances over seas. Even soft seeds, like those of many of the Leguminosæ, are often ejected uninjured by birds that have eaten them greedily. Birds also may be killed while carrying undigested seeds. These are by no means unimportant factors in distribution. Clement Reid, in his discussion of the origin of the British flora, mentions a dead wood pigeon from whose crop beans were sprouting, and when it is remembered what a great number of birds meet an untimely end it is conceivable that a single hurricane might readily be the means of introducing new forms from the Antilles on the Wilcox coast. Other Leguminosæ, although more rarely, are dispersed by ocean currents, for example the modern Entada or snuffbox seabean. *Canavalia obtusifolia* has buoyant pods and seeds, which retain their vitality after prolonged immersion in sea water, and this may well have been true of the Wilcox species of Canavalia that so closely resemble this modern form.

[1] Carnegie Inst. Washington Pub. 182, 1914; Washington Acad. Sci. Jour., vol. 4, no. 2, 1914.

All the storms moved from the Equator northward, the main ocean currents had the same general direction, and the prevailing winds were easterly, so that all these important factors combined to cause a relatively rapid introduction and spreading of forms along the Wilcox coasts. Given favorable climatic conditions many of the forms need not have taken the time to spread from Central or South America along continuous coasts.

Many examples of the means of dispersal of the modern relatives of the Wilcox species are given in the systematic part of this paper.

CORRELATION.

NOMENCLATURE.

In the consideration of the correlations indicated by the Wilcox flora it is desirable that the successive stages of the Franco-Belgian basin should be adopted as the time scale. These stages should be universally adopted for Tertiary discussions not only because of the desirability of writing in terms of general understanding but because of the early description of the Tertiary stages in France and, furthermore, because of the remarkable alternation of fossiliferous fluviatile, lacustrine, terrestrial, and marine deposition in that country.

Western North America affords an almost complete succession of continental deposits from the Cretaceous to the top of the Oligocene, and the Mississippi embayment affords an almost unparalleled succession of marine and estuary deposits from the Cretaceous well into the Oligocene. In the western interior section, however, practically all the described fossil plants are from the lower (Fort Union) and the middle (Green River) Eocene, but in the embayment area there are considerable floras at numerous other Tertiary horizons.

As the French nomenclature is used in the comparative discussions throughout the present work, it is desirable to indicate at this point the sense in which its units are employed. The stages employed for the basal and lower Eocene are the following:

Lower Eocene	Ypresian (Dumont, 1849)	Marine facies=Cuisian. Lagoon facies=Laonnian.
	Sparnacian (Dollfus, 1880)=Upper Landenian (Mayer Eymar, 1857).	
Basal Eocene	Thanetian (Renevier, 1873)=Heersian (Dumont, 1849), Lower Landenian (Mayer Eymar, 1857).	
	Montian (Dewalque, 1869)=Paleocene of Von Koenen and others (not of Schimper, 1874).	

Together these stages correspond to the Eonummulitic of Haug (1911), to the Suessonian of D'Orbigny, and to the Paleocene of Schimper (1874), but not to the Paleocene of Von Koenen, Dollo, and others, which is limited to the Montian stage.

CORRELATION OF LOCAL SECTIONS WITHIN THE WILCOX GROUP.

Before taking up the question of the relative age of the Wilcox as compared with the early Eocene of other areas, it is desirable to indicate the relation of the different fossiliferous Wilcox sections to each other. This has been done to a certain extent in the discussion of local sections on pages 38–60, so that a summary in this place will suffice. The fossil plants are much more valuable for precise correlations than the invertebrate faunas not only because they are so much more abundant over so large a portion of the Wilcox outcrop but also because the life periods of the plants appear to have been shorter and therefore can be applied to more minute stratigraphic differentiation than the faunas.

The Wilcox flora, from the intrinsic evidence which it furnishes, as well as from the evidence of stratigraphy in the eastern Gulf area, where a nearly complete section is available for study, may be divided into a lower, middle, and upper Wilcox, corresponding with the lithologic divisions proposed by Lowe for Mississippi, namely, the Ackerman formation (lower Wilcox), the Holly Springs sand (middle Wilcox), and the Grenada formation (upper Wilcox).

The flora of the Ackerman formation is the most incomplete because of its discovery at fewer outcrops. It includes these forms:

Lygodium binervatum.
Asplenium eolignitica.
Asplenium hurleyensis.
Chamædorea danai.
Myrica elæanoides.
Dryophyllum moorii.
Ficus puryearensis.
Ficus schimperi.
Ficus monodon.
Ficus occidentalis.
Pisonia chlorophylloides.
Magnolia leei.
Asimina leiocarpa.
Cinnamomum mississippiensis.

Oreodaphne mississippiensis.
Oreodaphne puryearensis.
Oreodaphne obtusifolia.
Mespilodaphne eolignitica.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Gleditsiophyllum hilgardianum.
Fagara hurleyensis.
Zizyphus meigsii.
Rhamnus marginatus.
Rhamnus marginatus apiculatus.
Dillenites ovatus.
Myrcia bentonensis.
Eugenia hilgardiana.
Combretum ovalis.
Terminalia lesleyana.
Terminalia hilgardiana.
Bumelia hurleyensis.
Bumelia pseudotenax.
Mimusops eolignitica.
Osmanthus pedatus.
Cordia (?) lowii.

There are thus 36 species in the Ackerman formation as against 257 in the Holly Springs sand and 111 in the Grenada formation. Of these 36 species 13 do not occur in the rest of the section and are thus peculiar to the Ackerman formation in this area; 16 range upward through the Holly Springs sand and 7 extend to the top of the Grenada formation. The Ackerman flora shows no botanic characters of collective interest apart from the remainder of the flora, nor does it show any evidence that physical conditions differed materially from what they were in later Wilcox time. The fossiliferous localities are few and the only important one, that at Hurleys, Miss., was well up toward the head of the early Wilcox embayment and removed from the littoral conditions of sedimentation, as is shown by the extensive development of siderite. The other localities referred to this epoch of the Wilcox are Raglands Branch, Lafayette County; Lockhart, Lauderdale County; Colemans Mill, Choctaw County; DeKalb-Herbert road, Kemper County; all in northeastern Mississippi.

The flora of the Holly Springs sand includes the following forms:

Cœnomyces annulata.
Cœnomyces cassiæ.
Cœnomyces laurinea.
Cœnomyces myrtæ.
Cœnomyces pestalozzites.
Cœnomyces sapotæ.
Lycopodites (?) eoligniticus.
Aneimia eocenica.
Asplenium eolignitica.
Glyptostrobus europæus.
Taxodium dubium.
Taxodium sp.
Arthrotaxis (?) eolignitica.
Sabalites grayanus.
Canna eocenica.
Juglans berryi.
Juglans schimperi.
Juglans saffordiana.
Engelhardtia ettingshauseni.
Engelhardtia mississippiensis.
Engelhardtia puryearensis.
Paraengelhardtia eocenica.
Myrica elæanoides.
Dryophyllum anomalum.
Dryophyllum moorii.
Dryophyllum tennesseensis.
Dryophyllum puryearensis.
Artocarpoides wilcoxensis.
Pseudolmedia eocenica.
Ficus pseudolmediafolia.
Ficus puryearensis.
Ficus puryearensis elongata.
Ficus wilcoxensis.
Ficus myrtifolius.
Ficus schimperi.
Ficus vaughani.
Ficus pseudocuspidata.
Ficus monodon.
Ficus cinnamomoides.
Ficus denveriana.
Ficus pseudopopulus.
Ficus planicostata maxima.
Ficus sp.
Knightiophyllum wilcoxianum.
Palæodendron americanum.
Proteoides wilcoxensis.
Banksia saffordi.
Banksia puryearensis.
Banksia tenuifolia.
Aristolochia wilcoxiana.
Coccolobis eolignitica.
Coccolobis uviferafolia.
Pisonia eolignitica.
Pisonia puryearensis.
Magnolia angustifolia.
Magnolia leei.
Anona wilcoxiana.
Anona ampla.
Anona eolignitica.
Laurophyllum juvenalis.
Laurophyllum florum.
Laurophyllum preflorum.
Cinnamomum obovatus.
Cinnamomum mississippiensis.
Cinnamomum oblongatum.
Cinnamomum vera.
Persea longipetiolatum.
Oreodaphne mississippiensis.
Oreodaphne wilcoxensis.
Oreodaphne pseudoguianensis.
Oreodaphne puryearensis.
Oreodaphne obtusifolia.
Mespilodaphne pseudoglauca.
Mespilodaphne eolignitica.

Mespilodaphne coushatta.
Mespilodaphne puryearensis.
Nectandra glenni.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Nectandra lowii.
Nectandra puryearensis.
Nectandra sp.
Capparis eocenica.
Parrotia cuneata.
Chrysobalanus eocenica.
Chrysobalanus inæqualis.
Acacia wilcoxensis.
Inga mississippiensis.
Inga puryearensis.
Pithecolobium eocenicum.
Pithecolobium oxfordensis.
Mimosites inæquilateralis.
Mimosites lanceolatus.
Mimosites acaciafolius.
Mimosites variabilis.
Cercis wilcoxiana.
Cassia eolignitica.
Cassia glenni.
Cassia glenni major.
Cassia tennesseensis.
Cassia fayettensis.
Cassia puryearensis.
Cassia mississippiensis.
Cassia wilcoxiana.
Cassia marshallensis.
Cassia emarginata.
Cæsalpinia wilcoxiana.
Cæsalpinites mississippiensis.
Cæsalpinites aculeatafolia.
Cæsalpinites pinsonensis.
Gleditsiophyllum ovatum.
Gleditsiophyllum eocenicum.
Gleditsiophyllum constrictum.
Gleditsiophyllum fructuosum.
Gleditsiophyllum ellipticum.
Gleditsiophyllum entadaformis.
Gleditsiophyllum minor.
Sophora henryensis.
Sophora wilcoxiana.
Sophora palæolobifolia.
Sophora mucronata.
Sophora repandifolia.
Sophora puryearensis.
Dalbergia eocenica.
Dalbergia tennesseensis.
Dalbergia wilcoxiana.
Dalbergia monospermoides.
Canavalia eocenica.
Canavalia acuminata.
Leguminosites prefoliatus.
Leguminosites subovatus (?).
Leguminosites reniformis (?).
Fagara eocenica.
Fagara puryearensis.
Citrophyllum wilcoxianum.
Simaruba eocenica.
Cedrela puryearensis.
Cedrela odoratifolia.
Cedrela mississippiensis.
Cedrela wilcoxiana.
Carapa eolignitica.
Vantanea wilcoxiana.
Banisteria repandifolia.
Banisteria pseudolaurifolia.
Banisteria fructiosa.
Banisteria wilcoxiana.
Hiræa wilcoxiana.
Crotonophyllum eocenicum.
Crotonophyllum appendiculatum.
Euphorbiophyllum fayettensis.
Drypetes prekeyensis.
Drypetes prelateriflora.
Anacardites metopifolia.
Anacardites falcatus.
Anacardites puryearensis.
Anacardites serratus.
Anacardites minor.
Anacardites marshallensis.
Anacardites grevilleafolia.
Metopium wilcoxianum.
Heterocalyx saportana.
Ilex eolignitica.
Ilex vomitoriafolia.
Maytenus puryearensis.
Celastrus eolignitica.
Celastrus minor.
Celastrus bruckmannifolia.
Celastrus veatchi.
Euonymus splendens.
Cupanites eoligniticus.
Sapindus pseudaffinis.
Sapindus oxfordensis.
Sapindus mississippiensis.
Sapindus linearifolius.
Sapindus formosus.
Sapindus eoligniticus.
Sapindus knowltoni.
Dodonæa knowltoni.
Dodonæa wilcoxiana.
Reynosia prænuntia.
Reynosia wilcoxiana.
Zizyphus falcatus.
Zizyphus meigsii.
Paliurus mississippiensis.
Paliurus pinsonensis.
Paliurus angustus.
Rhamnus marginatus.
Rhamnus eoligniticus.
Rhamnus puryearensis.
Grewiopsis tennesseensis.
Sterculia puryearensis.
Sterculiocarpus sezannelloides.
Bombacites formosus.
Bombacites wilcoxianus.
Dillenites serratus.
Dillenites tetracerafolia.
Calycites davillaformis.
Ternstrœmites ovatus.
Ternstrœmites lanceolatus.
Ternstrœmites eoligniticus.

Ternstrœmites preclaibornensis.
Myrcia vera.
Myrcia wortheni.
Myrcia puryearensis.
Myrcia parvifolia.
Myrcia bentonensis.
Calyptranthes eocenica.
Eugenia puryearensis.
Laguncularia preracemcsa.
Combretum ovalis.
Combretum obovalis.
Combretum wilcoxensis.
Terminalia lesleyana.
Terminalia hilgardiana.
Conocarpus eoligniticus.
Combretanthites eocenica.
Trapa wilcoxensis.
Melastomites americanus.
Oreopanax minor.
Oreopanax oxfordensis.
Nyssa wilcoxiana.
Nyssa eolignitica.
Sideroxylon ellipticus.
Sideroxylon prematichodendron.
Bumelia pseudohorrida.
Bumelia pseudotenax.
Bumelia lanuginosafolia.
Bumelia wilcoxiana.
Mimusops sieberifolia.
Mimusops eolignitica.
Diospyros wilcoxiana.
Diospyros brachysepala.
Icacorea prepaniculata.
Fraxinus johnstrupi (?).
Fraxinus wilcoxiana.
Osmanthus pedatus.
Echitonium lanceolatum.
Apocynophyllum tabellarum.
Apocynophyllum wilcoxense.
Cordia eocenica.
Citharexylon eoligniticum.
Avicennia eocenica.
Avicennia nitidaformis.
Solanites saportana.
Exostema pseudocaribæum.
Guettarda ellipticifolia.
Psychotria grandifolia.
Carpolithus puryearensis.
Carpolithus prangosoides.
Carpolithus henryensis.
Carpolithus tennesseensis.
Carpolithus dictyolomoides.
Carpolithus hyoseritiformis.
Carpolithus proteoides.
Antholithus arundites.
Antholithus marshallensis.

Of these 257 species, 193 are peculiar to the Holly Springs sand, 23 range upward from the Ackerman formation, and 47 continue to the top of the Grenada formation. The largeness of the number of species that range to the top of the Grenada formation is explained by the more extensive Holly Springs and Grenada floras, and also by the fact that the exceedingly rich flora at Puryear, Tenn., is near the top of the beds of Holly Springs age. The plant localities which fall in the Holly Springs epoch as here delimited are, in Mississippi, those around Oxford in Lafayette County, near Lamar in Benton County, and Holly Springs and Early Grove in Marshall County; in Tennessee, at Puryear and Henry in Henry County, Pinson in Madison County, Shandy, around Grand Junction, Baughs Bridge, and Lagrange in Hardeman and Fayette counties; in Arkansas, at Boydsville in Clay County, Bolivar Creek in Poinsett County, near Gainesville and Hardys Mill in Greene County; in Louisiana, the localities around Shreveport in Caddo Parish; and in Texas, at Old Port Caddo Landing in Harrison County which belongs at the top of the Holly Springs horizon or more probably in the horizon of the Grenada formation.

These beds are not all of exactly the same age, but some of them, for example, the beds in the very rich locality at Puryear, are much younger than the bulk of the Holly Springs. A detailed argument for these correlations is believed to be unnecessary. The exact correlation is shown in the accompanying columnar sections (fig. 10) and is based on the facts presented by the local distribution of the flora as given in the chapter devoted to that subject as well as in the table of distribution.

The Grenada flora includes these species:

Cænomyces pestalozzites.
Meniphylloides ettingshauseni.
Pteris pseudopinnæformis.
Cupressinoxylon calli.
Poacites sp.
Cyperites sp.
Nipadites burtini umbonatus.
Sabalites grayanus.
Canna eocenica.
Phyllites wilcoxensis.
Hicoria antiquorum.
Juglans schimperi.
Engelhardtia ettingshauseni.
Myrica wilcoxensis.
Dryophyllum tennesseensis.
Dryophyllum puryearensis.
Planera crenata (?).
Artocarpus lessigiana.
Artocarpus pungens.
Artocarpus dubia.
Ficus puryearensis.
Ficus eolignitica.
Ficus monodon.

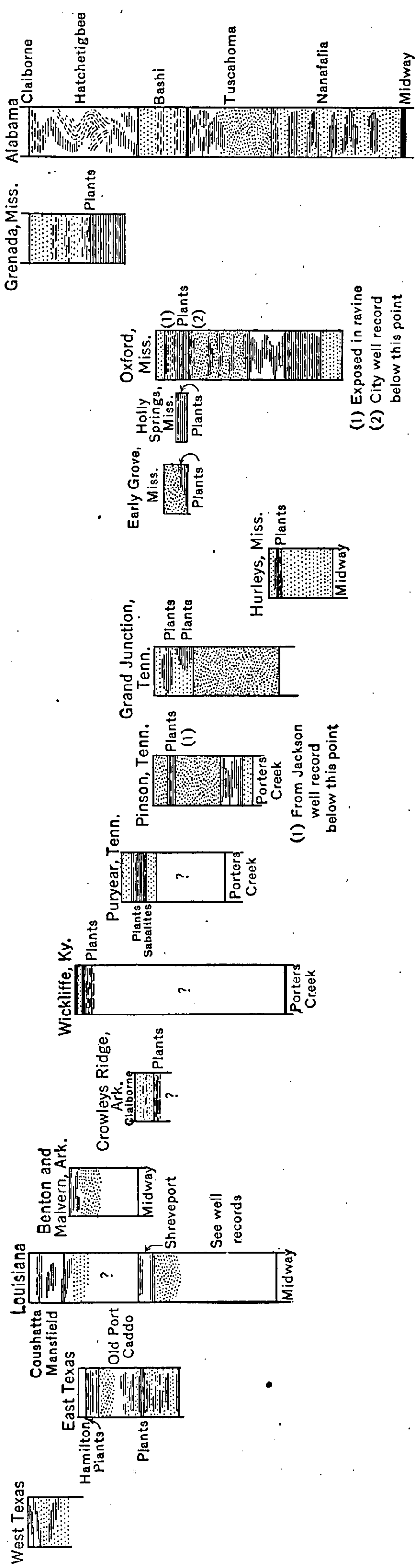

FIGURE 10.—Columnar sections showing approximately the stratigraphic relations of the more important plant-bearing outcrops of the Wilcox formation.

Ficus harrisiana.
Ficus artocarpoides.
Proteoides wilcoxensis.
Banksia saffordi.
Banksia tenuifolia.
Cinnamomum postnewberryi.
Cinnamomum buchii.
Persea longipetiolatum.
Persea wilcoxiana.
Oreodaphne salinensis.
Oreodaphne coushatta.
Oreodaphne obtusifolia.
Mespilodaphne eolignitica.
Mespilodaphne coushatta.
Nectandra lancifolia.
Nectandra pseudocoriacea.
Cryptocarya eolignitica.
Laurinoxylon branneri.
Capparis eocenica.
Chrysobalanus inæqualis.
Chrysobalanus eocenica.
Inga mississippiensis.
Inga laurinafolia.
Inga wickliffensis.
Mimosites variabilis.
Cassia glenni.
Cassia lowii.
Cassia bentonensis.
Cassia mississippiensis.
Cæsalpinites bentonensis.
Gleditsiophyllum eocenicum.
Sophora wilcoxiana.
Sophora lesquereuxi.
Dalbergites ovatus.
Dalbergites ellipticifolius.
Leguminosites wickliffensis.
Leguminosites arachioides.
Carapa eolignitica.
Anacardites grevilleafolia.
Anacardites metopifolia.
Metopium wilcoxianum.
Ilex (?) affinis.
Ilex sp.
Celastrus taurinensis.
Celastrus veatchi.
Cupanites eolignitícus.
Cupanites loughridgii.
Sapindus oxfordensis.
Sapindus bentonensis.
Sapindus mississippiensis.
Sapindus formosus.
Sapindus eolignitícus.
Sapindus coushatta.
Rhamnites berchemiaformis.
Rhamnus coushatta.
Rhamnus cleburni.
Grewiopsis tennesseensis.
Sterculia puryearensis.
Sterculiocarpus eocenicus.
Dillenites texensis.
Dillenites tetracerafolia.
Dillenites microdentatus.
Ternstrœmites ovatus.

Ternstrœmites lanceolatus.
Myrcia bentonensis.
Myrcia grenadensis.
Eugenia densinervia.
Eugenia grenadensis.
Terminalia wilcoxiana.
Melastomites americanus.
Aralia acerifolia.
Aralia notata.
Aralia jorgenseni (?).
Cornus studeri.
Chrysophyllum ficifolia.
Bumelia grenadensis.
Bumelia americana.
Mimusops mississippiensis.
Diospyros brachysepala.
Fraxinus johnstrupi (?).
Apocynophyllum sapindifolium.
Apocynophyllum mississippiensis.
Apocynophyllum constrictum.
Citharexylon eoligniticum.
Exostema pseudocaribæum.
Calycites ostryaformis.
Carpolithus grenadensis.
Carpolithus sophorites.
Carpolithus pilocarpoides.

Of these 112 species, 56, or exactly half, are peculiar to the Grenada formation; the other half range upward from the older Holly Springs and Ackerman formations. The localities of Grenada age include none from Mississippi, except Grenada in Grenada County. In Tennessee the deposits at Somerville in Fayette County and near Trenton in Gibson County are of this age. In Kentucky the deposits at Boaz in Graves County and at Wickliffe in Ballard County are of Grenada age. In Arkansas the deposits at Benton and vicinity in Saline County and at Malvern in Hot Springs County are believed to be of Grenada age. In Louisiana the beds at Coushatta in Red River Parish, which contain a large flora, and at Mansfield and around Naborton in De Soto Parish are of this age. In Texas the beds at Old Port Caddo Landing in Harrison County belong here or at the top of the Holly Springs horizon; the beds exposed in the bluff on Sabine River, near Hamilton in Sabine County, the beds on Colorado River in Bastrop County, and on Calaveras Creek in Wilson County, are believed to be of this age. Figure 10 shows the approximate stratigraphic relations of these outcrops.

RELATION TO CRETACEOUS FLORAS.

The relation of the Midway and Wilcox floras to those of the Lower Cretaceous of Texas or of the Potomac group of the Middle Atlantic slope is so remote that direct comparisons are impossible. The Lower Cretaceous flora became practically extinct before the close of the Upper Cretaceous, and the abundant ferns, cycadophytes, and to a less extent the conifers were replaced by the prenuntial representatives of the now dominant race of plants, the Dicotyledonæ. At the close of the Upper Cretaceous or the dawn of the Eocene a second modernization of the floras of the world practically wiped out all the older types.

Very extensive Upper Cretaceous floras are now known from both North America and Europe, as well as from the Arctic regions. North America is especially rich in Upper Cretaceous plants, several hundred species having been described from the Dakota sandstone and from later Cretaceous deposits of the interior region. The Coastal Plain from New York to Texas is rich in Upper Cretaceous plants, and a large flora has been described by me from beds of this age in the embayment area in Alabama, Mississippi, Tennessee, and Texas. This Upper Cretaceous embayment flora includes about 150 species, most of which come from the Tuscaloosa formation of western Alabama.

More than 40 per cent of the genera are not represented in the existing flora. The most abundant orders are the Ranales, Coniferales, and Urticales. The largest genus is Celastrophyllum. Of the 123 species of Dicotyledonæ 87 per cent are Choripetalæ and only 13 per cent Gamopetalæ. The flora as a whole indicates less tropical conditions than the early Eocene floras of the embayment area.

Not one of these Upper Cretaceous species passes over into the Eocene; in fact, none of the Wilcox species occur in the Cretaceous of this or any other known area.[1] The following genera recorded in the Upper Cretaceous of the embayment area are not found in the Midway (?) or Wilcox:

Abietites.	Cissites.
Acerates.	Cladophlebis.
Andromeda.	Cocculus.
Androvettia.	Colutea.
Araucaria.	Cornophyllum.
Bauhinia.	Cunninghamites.
Brachyphyllum.	Cycadinocarpus.
Celastrophyllum.	Dammara.
Cephalotaxospermum.	Dermatophyllites.

[1] A possible exception to this statement is *Artocarpus lessigiana*, which has been recorded from the Laramie, but which I am not sure came from that horizon.

Dewalquea.
Dicksonia.
Doryanthites.
Dryopterites.
Eorhamnidium.
Equisetum.
Geinitzia.
Gleichenia.
Hymenæa.
Jungermannites.
Kalmia.
Liriodendron.
Liriodendropsis.
Malapœnna.
Manihotites.
Marattia.
Menispermites.
Myrsine.
Palæocassia.
Panax.
Persoonia.
Pinus.
Piperites.
Platanus.
Podozamites.
Populus.
Protodammara.
Protophyllocladus.
Pterospermites.
Salix.
Sapotacites.
Sassafras.
Sequoia.
Tricalycites.
Tumion.
Widdringtonites.

The most prominent of these forms with regard to plant evolution are the gymnospermous genera Abietites, Androvettia, Araucaria, Brachyphyllum, Cephalotaxospermum, Cunninghamites, Cycadinocarpus, Dammara, Geinitzia, Pinus, Podozamites, Protodammara, Protophyllocladus, Sequoia, Tumion, and Widdringtonites. Upper Cretaceous genera which were expected in the Wilcox but which have not been discovered are Bauhinia, Cocculus, Gleichenia, Hymenæa, Liriodendropsis, Marattia, Myrsine, Pterospermites, and Sassafras.

The following 24 genera recorded from the Upper Cretaceous of the embayment are also found in the Wilcox: Cassia, Cinnamomum, Citrophyllum, Cordia, Crotonophyllum, Diospyros, Eugenia, Ficus, Grewiopsis, Ilex, Inga, Juglans, Leguminosites, Magnolia, Myrica, Nyssa, Oreodaphne, Paliurus, Persea, Proteoides, Rhamnus, Sabalites, Sapindus, and Zizyphus. It is thus evident that one of the striking features of difference between the two floras is the elimination of the Mesozoic coniferous types like Androvettia, Brachyphyllum, Cycadinocarpus, Dammara, Geinitzia, Podozamites, Protodammara, Protophyllocladus, and Widdringtonites, and the withdrawal from this region, more or less in response to climatic conditions, of Araucaria, Pinus, Andromeda, Liriodendron, Malapœnna, Menispermites, Persoonia, Platanus, Salix, and the like.

There is, however, a well-defined basis for the statement that the Eocene floras were modernized, which is furnished by the following 62 Wilcox genera, all but 6 of which are dicotyledonous and of modern aspect, that have not been found in the Upper Cretaceous:

Cænomyces.
Meniphylloides.
Glyptostrobus.
Taxodium.
Chamædorea.
Canna.
Hicoria.
Paraengelhardtia.
Engelhardtia.
Pseudolmedia.
Palæodendron.
Knightiophyllum.
Aristolochia.
Coccolobis.
Anona.
Asimina.
Mespilodaphne.
Cryptocarya.
Capparis.
Chrysobalanus.
Pithecolobium.
Cercis.
Cæsalpinia.
Gleditsiophyllum.
Sophora.
Canavalia.
Fagara.
Simaruba.
Carapa.
Cedrela.
Vantanea.
Hiræa.
Banisteria.
Drypetes.
Metopium.
Anacardites.
Heterocalyx.
Maytenus.
Cupanites.
Dodonæa.
Reynosia.
Sterculiocarpus.
Bombacites.
Dillenites.
Ternstrœmites.
Myrcia.
Calyptranthes.
Laguncularia.
Combretum.
Terminalia.
Conocarpus.
Melastomites.
Icacorea.
Sideroxylon.
Chrysophyllum.
Mimusops.
Osmanthus.
Citharexylon.
Avicennia.
Solanites.
Exostema.
Guettarda.

Some of these have Cretaceous relatives. For example, Capparis is represented by the Tuscaloosa species of Capparites, Conocarpus is represented in the Tuscaloosa by Conocarpites, Sapotacites represents Upper Cretaceous Sapotaceæ, and some of the numerous Upper Cretaceous species of Celastrophyllum may represent the Wilcox genus Ternstrœmites.

It is obvious without further discussion that the Wilcox flora is decidedly more modern than not only the Upper Cretaceous floras of the embayment area but even the youngest known Upper Cretaceous floras represented by the Laramie flora of North America and the Maestrichtian flora of Europe and is almost wholly unlike those floras. The flora of the Wilcox is, then, in complete accord with the stratigraphy and paleozoology in indicating that it is decidedly post-Mesozoic and much younger than any known Upper Cretaceous floras.

RELATION TO THE MIDWAY (?) FLORA.

The Midway (?) flora is so small that it affords little basis for comparison. However, none of its types are Cretaceous and 30 per cent of its small number of species are common to the Wilcox; in addition, 80 per cent of its species are found in the floras of the Raton and Denver formations of the Rocky Mountain province. It may therefore be considered to be essentially the same type of flora as that of the Wilcox, one which, if it could be known in its entirety, would be found to contain a number of identical species and others ancestral to those of the Wilcox.

RELATION TO THE CLAIBORNE FLORA.

A large flora from different horizons in the Claiborne group has been more or less fully described in manuscript, but the only published account is that of the small upper Claiborne flora from Georgia described by me in 1914 in Professional Paper 84 of the United States Geological Survey. Plants of lower Claiborne age have been collected by me in Arkansas, and upper Claiborne plants are now represented in the collections from Georgia, Alabama, Mississippi, Arkansas, and Texas.

The following Wilcox species have already been recognized in the Claiborne: *Aneimia eocenica, Taxodium dubium, Oreodaphne obtusifolia, Sapindus mississippiensis, Sapindus formosus, Myrcia bentonensis,* and *Diospyros brachysepala.* Moreover there are Claiborne species which are affiliated with Wilcox species in the genera Ficus, Coccolobis, Pisonia, Engelhardtia, Cinnamomum, Persea, Nectandra, Inga, Cæsalpinites, Sophora, Celastrus, Zizyphus, Ternstrœmites, Laguncularia, Combretum, Terminalia, Conocarpus, and Mimusops. Though only 2 per cent of the Wilcox species have been recognized in the Claiborne, this figure may be slightly increased when the Claiborne floras are finally published. The community of genera show that the Claiborne flora is similar in its general facies to that of the Wilcox, and the very marked differences are in the main differences in specific and not in generic types.

COMPARISON OF WILCOX FLORA WITH OTHER AMERICAN EOCENE FLORAS.

PURPOSE OF THE COMPARISON.

A comparison of the Wilcox flora with other American Eocene floras adds but little to our knowledge of the Wilcox. At the same time it will shed some light on the age of some of these floras, as the Wilcox is very definitely fixed stratigraphically and paleozoologically and since, as I will show subsequently, it can be very definitely correlated with the European section. In my table of distribution and in this discussion I have ignored the Lance formation of the Rocky Mountain and Great Plains province, as the flora of that formation has never been fully described, though it is represented in the literature by lists of species that indicate a flora much less extensive but essentially Fort Union in its facies. Those who wish to make comparisons with the flora of the Lance are referred to the publications of F. H. Knowlton on this subject.

FLORA OF THE RATON FORMATION.

Willis T. Lee has proposed the name Raton formation for a series of coal-bearing sandstones in the Raton Mesa country of northeastern New Mexico and southeastern Colorado (the Raton and Trinidad coal fields), which carry an abundant flora, recently described in an unpublished paper by F. H. Knowlton. The first plants from the Raton formation to be studied were collected by Le Conte in 1867 and submitted to Lesquereux, who referred them to the Eocene. Hayden visited the region in 1869, and his collections were likewise studied by Lesquereux, who pointed out their affinity with the "Eolignitic" [Wilcox] of Mississippi, as it was known to him.[1] According to Knowlton,[2] the Raton flora comprises 148 species, of which 5 occur in the Laramie and about 40 in the Denver formation. From the floral relations, as well as the stratigraphic and structural relations, Knowlton and Lee conclude that the Raton formation represents the southward continuation of the Denver along the Rocky Mountain front. The relation to the Wilcox, first recognized by Lesquereux, is confirmed in the recent studies, although the size and coastal character of the Wilcox flora render the affinity less prominent than it was when comparatively few species were known in each area.

The following Wilcox species are represented in the Raton flora: *Sabalites grayanus, Juglans berryi, Juglans schimperi, Engelhardtia ettingshauseni, Dryophyllum moorii, Dryophyllum tennesseensis, Ficus schimperi, Ficus monodon, Ficus harrisiana, Ficus denveriana, Ficus pseudopopulus, Ficus pseudolmediafolia, Ficus*

[1] U. S. Geol. and Geog. Survey Terr. Fifth Ann. Rept., Suppl., p. 19, 1872.

[2] Knowlton, F. H., Am. Jour. Sci., 4th ser., vol. 35, pp. 526–530, 1913.

neoplanicostata, *Ficus occidentalis*, *Ficus artocarpoides*, *Osmanthus pedatus*, *Euonymus splendens*, *Leguminosites arachioides*, *Combretum ovalis*, *Magnolia angustifolia*, *Magnolia leei*, *Cinnamomum mississippiensis*, *Nectandra lancifolia*, *Zizyphus meigsii*, *Apocynophyllum wilcoxensis*, *Terminalia lesleyana*, and *Terminalia hilgardiana*. Sixteen of these species are peculiar to the two formations.

In addition to the species common to both formations a number of closely related forms are found in each formation, the distinctness of some of them being a matter of personal opinion. The following Wilcox species are represented by closely allied forms in the Raton formation: *Aneimia eocenica*, *Asplenium hurleyensis*, *Pteris pseudopinnæformis*, *Chamædorea danai*, *Canna eocenica*, *Dryophyllum puryearensis*, *Artocarpus wilcoxiana*, *Cinnamomum oblongatum*, *Cassia glenni*, *Sophora henryensis*, and *Sapindus eolignitícus*.

This is an imposing array of identical or closely related forms and indicates that the two floras can not differ very materially in age; that is, that one can not be Eocene and the other Cretaceous. The Wilcox differs from the Raton flora in the large number of Leguminosæ and Lauraceæ, and in the presence of many genera whose representatives still live in the tropical and subtropical regions of America. The presence of 2 Laramie species in the Raton and the fact that the commonest and not the most significant forms usually occur in remote areas, leads me to the conclusion that the Wilcox flora is somewhat younger than the Raton flora to which it bears the same relation that it does to the Midway (?) flora. This conclusion is also influenced by the stratigraphic relations in the embayment area and the result is that I consider the Midway as in whole or in part synchronous with the Raton. I have seen a large amount of the Raton material in connection with my Wilcox studies and have also visited the area and feel entirely justified in the conclusion that it is of Eocene age and slightly older than the Wilcox.

FLORA OF THE DENVER FORMATION.

Although fossil plants were discovered in the Denver Basin by Le Conte in 1867, it was not until 1896 that the Arapahoe and Denver formations were shown to be so strikingly distinct from the Laramie in structural relations, stratigraphy, and fossil content.[1] Although the flora of the Denver formation is large, it has never been adequately described, and the difficulty of disentangling the early records is so great that no list has ever been published. The published Denver species number 98, according to Knowlton.[2] Large collections have been made, and the real Denver flora is undoubtedly much more extensive, for many new species are discovered when a flora receives monographic study.

The following Wilcox species are recorded from the Denver: *Asplenium eolignitica*, *Pteris pseudopennæformis*, *Taxodium dubium*, *Sabalites grayanus*, *Juglans schimperi*, *Artocarpus lessigiana*, *Artocarpus pungens*, *Ficus occidentalis*, *Ficus denveriana*, *Ficus pseudopopulus*, *Ficus planicostata latifolia*, *Leguminosites arachioides*, *Rhamnus cleburni*, *Aralia notata*, *Cinnamomum affine*, and *Cornus studeri*. Eight of these species have not been found in the Raton formation.

The following Wilcox species are represented by closely allied forms in the Denver flora: *Ficus monodon*, *Ficus harrisiana*, *Ficus planicostata maxima*, *Cinnamomum mississippiensis*, *Persea longipetiolatum*, and *Rhamnus coushatta*.

According to Knowlton, nearly half the described Denver species occur in the Raton flora, and he is emphatically of the opinion that the two floras are nearly if not exactly synchronous. The Denver flora differs from that of the Wilcox in the individual abundance and specific differentiation of Quercus, Platanus, and Populus, in the large number of ferns, and in the presence of a Ginkgo. The families Aceraceæ, Caprifoliaceæ, and Vitaceæ, which are present in the Denver, are unknown in the Wilcox.

What was said regarding the Raton flora is equally true of the Denver flora, that though it is somewhat older than the Wilcox flora its similarities to that flora, as well as its facies as a whole, are sufficient to indicate its Eocene age.

THE FORT UNION FLORA.

The Fort Union formation has furnished a very extensive flora, and although it was long confused with the Laramie both paleontologists and geologists are now agreed that it is of Eocene age.

[1] Emmons, S. F., Cross, Whitman, and Eldridge, G. H., Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27, 1896.
[2] Am. Jour. Sci., 4th ser., vol. 35, p. 528, 1913.

The following Wilcox species are found in the Fort Union: *Glyptostrobus europæus*, *Taxodium dubium*, *Hicoria antiquorum*, *Juglans schimperi*, *Ficus artocarpoides*, *Parrotia cuneata*, *Leguminosites arachioides*, *Celastrus taurinensis*, *Terminalia hilgardiana*, *Aralia acerifolia*, *Aralia notata*, and *Diospyros brachysepala*. Seven of these species are not found in the Raton or Denver formations, so that there are altogether 41 Wilcox species, or more than 10 per cent of the flora and about half of the Wilcox species that have an outside distribution, which occur in the Raton, Denver, or Fort Union formations of the western interior region. Wilcox species which have closely related forms in the Fort Union are *Ficus monodon*, *Ficus pseudopopulus*, *Cinnamomum mississippiensis*, *Cinnamomum buchii*, *Oreodaphne coushatta*, *Celastrus veatchi*, *Euonymus splendens*, *Sapindus pseudaffinis*, *Sapindus oxfordensis*, *Sapindus formosus*, *Sapindus eolignitieus*, *Rhamnus eolignitieus*, *Grewiopsis tennesseensis*, and *Apocynophyllum sapindifolium*.

After eliminating duplications there are in addition 21 Wilcox species which have closely related forms in the Raton, Denver, or Fort Union formations. The Fort Union embraces a great thickness of continental deposits which extend from the top of the Lance formation upward to the base of the Wasatch, so that it obviously extends from a horizon near the base of the Eocene to the Wasatch, which is correlated by Osborn [1] with the Ypresian of France. It therefore follows that the Wilcox is in part the equivalent of the Fort Union and the Wasatch. It might have been expected that there would be much more community of facies between two such extensive floras of so similar age, but this is not the case. The Fort Union flora abounds in hardwood trees of upland type and temperate affinities. It grew in a topographically varied region of wide extent and great inequalities of climate, especially of rainfall, remote from the sea, and it appears to represent, in part at least, a southward spreading of more northern forms.

FLORA OF THE GREENLAND TERTIARY.

More than 200 species of Tertiary plants were recorded by Heer from western Greenland. This very remarkable flora was described from material more fragmentary than Heer's figures would lead one to suspect. Heer's preparation for this great work was his long-continued studies of the Swiss Miocene (Aquitanian to Tortonian), so that many of the Greenland fragments naturally received names of the European Miocene forms most familiar to their describer. Many of these determinations of Arctic plants are erroneous, and until the subject is reworked with the original material at hand attempted correlations are fruitless. Heer called the Greenland flora Miocene. Saporta, and following him Starkie Gardner, pointed out its earlier age. It is referred to the Eocene in the last edition of De Lapparent, and Menzel recently advances the view that it is in part Eocene and in part Aquitanian. Students in general have come to assume that it was Eocene or Oligocene, the preponderance of opinion perhaps favoring its Eocene age.

The following 5 Wilcox species occur in the Greenland Tertiary: *Glyptostrobus europæus*, *Taxodium dubium*, *Aralia jorgenseni*, *Fraxinus johnstrupi*, and *Echitonium lanceolatum*. Two or three additional Wilcox species are represented in Greenland by closely allied forms. I consider the Wilcox as older than the Greenland Tertiary, the interval being perhaps measurable by the time it took these forms to reach Greenland from the embayment region. In the embayment region the succeeding Claiborne floras are more tropical than the Wilcox and those of the Vicksburg group (lower Oligocene) mark the maximum of the northward trend of equatorial conditions. The Greenland Tertiary flora was possibly contemporaneous with these southern floras, from the Claiborne to the Vicksburg, which show the most tropical conditions. It would not be worth while to dwell on this point were it not that in the Upper Cretaceous the floras of the embayment can be traced without any striking change from Texas and Alabama northward in the interior and along the Atlantic coast to the same localities in western Greenland. The difference in this respect between the Upper Cretaceous and Tertiary is still unexplainable.

RELATION TO EUROPEAN EOCENE FLORAS.

Though it is not yet possible to make exact correlations of minor horizons on the two sides of the Atlantic the increasingly apparent synchroneity of the more important diastrophic events lends support to the theory that these events are due to general and not local factors.

[1] Osborn, H. F., U. S. Geol. Survey Bull. 361, 1909.

It is not now and perhaps never will be advisable to part with the terminology and consequent perspective which has orginated in the historical development of the Cenozoic geology of southeastern North America. At the same time the standard chronologic units should be international and not provincial. In order, therefore, to state the results of my study of the American Tertiary floras in terms of general understanding, I have attempted correlations with standard European sections, and as the Eocene and Oligocene terranes of the Paris Basin were not only the first to be elucidated but also because the nomenclature used is highly philosophic and has already come to be widely accepted as the standard, I have endeavored to make close comparisons with the French étages.

Most floral studies are provincial at first and many are never further developed. However, a great variety of important and interesting questions regarding the origin, evolution, migration, and extinction of the plant types of the Tertiary, which are in reality the most important questions that a study of Tertiary floras can solve, can only be attacked by very exact comparisons between the floras of the different continents and by more exact correlation between these remote regions. It is obviously impossible to determine in which areas certain types make their first or last appearance if our chronology is inexact. This is my main reason for attempting precise correlation with European plant-bearing horizons.

The composition, habitat, and environment of the Tertiary floras of southeastern North America can be worked out by a careful study of the preserved flora, but this is after all only provincial. Which are the endemic and which the exotic types, whence they came and whither they went, when they originated and when they became extinct—such questions can only be answered by the broader study which includes the known Tertiary floras of the whole world.

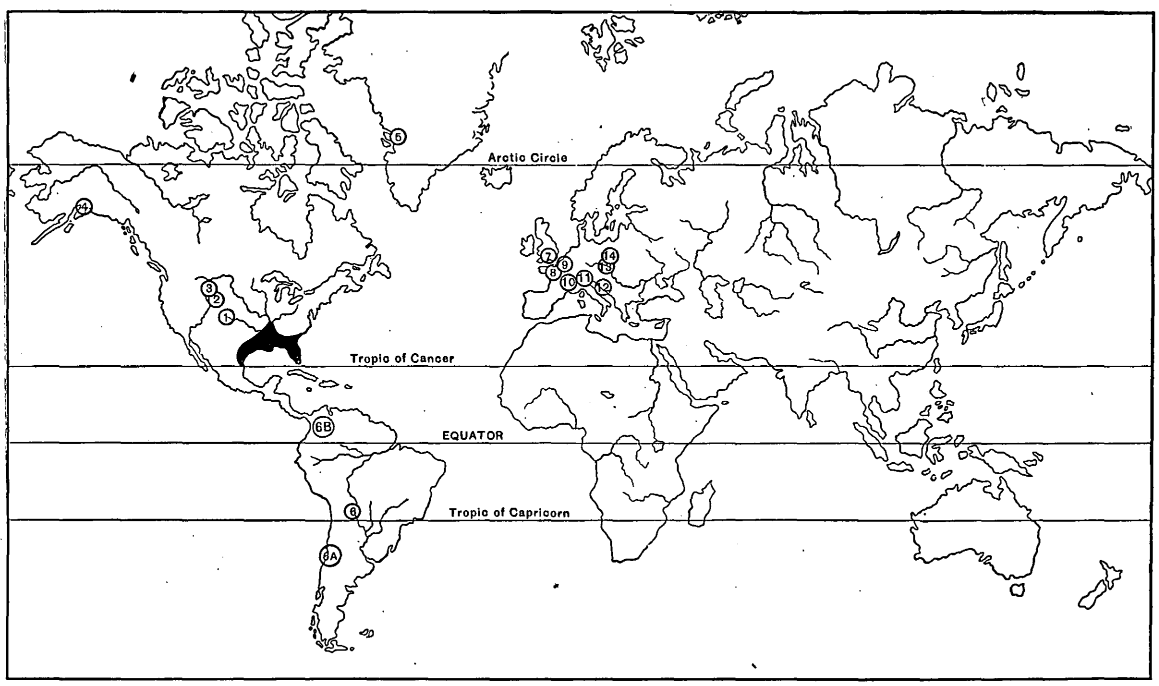

FIGURE 11.—Sketch map showing the area of Wilcox sedimentation (solid black) and the location of fossil floras with which that of the Wilcox has been compared. 1, Raton formation (Knowlton); 2, Denver formation (Knowlton); 3, Fort Union formation (Knowlton); 4, Kenai formation (Hollick); 5, West Greenland (Heer); 6, Bolivia (Engelhardt); 6A, Chile (Engelhardt); 6B, Colombia and Ecuador (Engelhardt); 7, Southern England (Ettingshausen, Starkie Gardner); 8, Paris Basin (Watelet, Fritel); 9, Gelinden (Saporta and Marion) Trieu de Leval (Marty); 10, Provence (Saporta); 11, Haering (Ettingshausen); 12, Dalmatia (Ettingshausen); 13, Austria (Ettingshausen); 14, Bohemia (Ettingshausen).

In Professional Paper 84 I gave a brief account of the more important Eocene floras of Europe and enumerated the recorded species. The present work is so lengthy that it is not worth while to repeat these enumerations. The areas where Tertiary floras have been found with which the Wilcox can be compared most profitably are shown on the accompanying sketch map of the world (fig. 11). The whole of the Eastern Hemisphere except Europe has not yet furnished any comparative fossil material, so that at least three-fourths of the present land surface of the earth must yield its fossil plant material before questions of origin and migration can be discussed with any approach to finality. There are some known Eocene floras in European Russia, and the Tertiary floras of Manchuria, Sakhalin, and elsewhere in eastern Asia offer points of comparison with the Fort Union flora of the interior region of the United States and the Kenai flora of Alaska. Engelhardt has also made known some most interesting Tertiary floras from South America. A discussion of North American Eocene floras needs a more complete knowledge of the Eocene paleobotany of Asia and South America.

No richly fossiliferous European plant horizons exactly equivalent to the Wilcox have as yet received monographic study. The Eocene of the south of England is rich in fossil plants at horizons that I consider equivalent to the Wilcox, but comparisons are unfortunately limited to the long lists of nomina nuda published by Ettingshausen, to which I will have occasion to refer in detail. It thus happens that the exhaustively studied Sannoisian floras of Provence and the Tyrol, so effectively monographed by Saporta and Ettingshausen respectively, although considerably younger, have afforded many more elements for comparison with the Wilcox than the Eocene flora of England.

The early Eocene of Europe (Montian and Thanetian stages) includes small floras in England, Belgium, and France, the most extensive being the flora of the marnes heersiennes in Belgian Limburg, southeast of St. Trond, on the road to Liege, so elaborately described by Saporta and Marion; that of the travertines of Sézanne on the shore of the old lake of Rilly east of Paris, monographed by Saporta; that of the Trieu de Leval in Belgium (Hainaut), monographed by Marty; and the small scattered floras in the Thanet sands (grès de Vervins, etc.) studied by Watelet and recently revised by Fritel of the Paris Museum. None of these floras are extensive enough for detailed comparisons with the Wilcox. Such comparisons as are possible show that the Wilcox is younger than the Montian or the Thanetian, whose floras are more similar to those of the early Eocene of the western interior region of the United States and are at least partly represented in the embayment area by the deposits of the Midway formation. The one feature of noticeable parallelism between these early Eocene floras of Europe and that of the Wilcox is the abundant and strikingly similar species of Dryophyllum in each.

The next succeeding stage of the European section is the Sparnacian, which contains fossil plants in the "argile plastique" and the "lignites du Soissonnais" of the Paris Basin. The old work of Watelet has recently been revised by Fritel, and though the flora is still relatively small (less than 150 species) it shows resemblance to the Wilcox in species of Asplenium, Taxodium (identical), Sabalites, Ficus, Laurus, Cinnamomum, Aralia, and Sapotacites. The Woolwich and Reading beds of West Kent, Surrey, and Sussex, in England, of this age, contain a mostly undescribed flora of somewhat more temperate facies than that of the Wilcox, though it affords comparable forms in the genera Lygodium, Asplenium, Ficus, Laurus, Aralia, and Sabalites. I regard the Wilcox as partly the equivalent of the Sparnacian, although the evidence for this correlation can not be considered conclusive. The succeeding stage of the European section, the Ypresian, yields an extensive flora. Though this flora is not very rich in the grès de Belleu of the Paris Basin (150 species), it is very representative in the pyritized seeds and fruits of the London clay on the Isle of Sheppey and in the pipe clay of Alum Bay on the Isle of Wight.

The flora of the grès de Belleu has comparable species of Lygodium, Sabalites, Cannophyllites, Juglans, Myrica, Artocarpidium, Ficus, Anona, Persea, Laurus, Dryophyllum, Cercis, Banisteria, Cinnamomum, Sterculia, Acacia, Sapotacites, Banksia, Anacardites, Apocynophyllum, Chrysophyllum, Diospyros, Magnolia, Grewia, Terminalia, Eugenia, Gleditsia, Cæsalpinia, Entada, and Leguminosites.

Ficus schimperi is much like *Ficus cuspidata* Watelet, *Oreodaphne mississippiensis* is represented by *Laurus attenuata* Watelet, *Mespilodaphne coushatta* by *Persea regularis* Watelet, *Cercis wilcoxiana* by *Cercis deperdita* Watelet, *Gleditsiophyllum fructuosum* by *Acacia brongniarti* Watelet, *Gleditsiophyllum entadaformis* by *Entada dubia* Watelet, *Banisteria pseudolauri-*

folia by *Banisteria juglandoides* Watelet, and *Bumelia americana* by *Piscidia protogea* Watelet.

The European flora most similar to that of the Wilcox appears to be that of Alum Bay and the Isle of Sheppey, although this comparison rests on the long list of names (nearly all nomina nuda) representing Ettingshausen's preliminary studies of these floras which were never brought to completion. These lists were republished by me in Professional Paper 84.

The Alum Bay flora includes about 275 species in 116 genera and 63 families and comprises 3 thallophytes, 2 ferns, 5 gymnosperms, 6 monocotyledons, and 97 dicotyledons. It is thus less extensive than the Wilcox. Nevertheless the Wilcox flora contains the following 39 genera in common with that of Alum Bay (Isle of Wight):

Anemia.	Bombacites.
Glyptostrobus.	Ternstrœmites.
Cyperites.	Grewiopsis.
Sabalites.	Sapindus.
Myrica.	Cupanites.
Ficus.	Dodonæa.
Juglans.	Cedrela.
Banksia.	Celastrus.
Cinnamomum.	Ilex.
Laurus.	Zizyphus.
Pisonia.	Rhamnus.
Aristolochia.	Eugenia.
Fraxinus.	Dalbergia.
Sapotacites.	Leguminosites.
Bumelia.	Sophora.
Diospyros.	Cæsalpinia.
Aralia.	Cassia.
Cornus.	Acacia.
Magnolia.	Mimosites.
Anona.	

The following 36 Wilcox families are represented at Alum Bay:

Pinaceæ.	Lauraceæ.	Rhamnaceæ.	Araliaceæ.
Palmæ.	Mimosaceæ.	Filiaceæ.	Cornaceæ.
Juglandaceæ.	Cæsalpiniaceæ.	Sterculiaceæ.	Sapotaceæ.
Myricacæ.	Papilionaceæ.	Bombacaceæ.	Ebenaceæ.
Fagaceæ.	Meliaceæ.	Ternstrœmiaceæ.	Oleaceæ.
Moraceæ.	Malpighiaceæ.	Myrtaceæ.	Apocynaceæ.
Proteaceæ.	Euphorbiaceæ.	Melastomataceæ.	Verbenaceæ.
Aristolochiaceæ.	Anacardiaceæ.		
Nyctaginaceæ.	Ilicaceæ.		
Magnoliaceæ.	Celastraceæ.		
Anonaceæ.	Sapindaceæ.		

Not only are these families represented in both floras, but the general facies and that of each family are much the same. Thus there are 42 species of Leguminosæ at Alum Bay, and the next most abundant families are the Moraceæ, Lauraceæ, Sapindaceæ, Myrtaceæ, and Celastraceæ, just as in the Wilcox area. Furthermore, on both sides of the Atlantic these floras show identical climatic conditions and both include a large number of genera and families that contain allied species which appear for the first time. Many of these forms are indicated in the table of distribution, and throughout the systematic description comparisons are constantly made with Ypresian species.

Comparisons are not as easily made with the Sheppey flora, since it consists entirely of fruits and seeds. Notwithstanding these difficulties it may be noted that 3 Wilcox species, the most positively identified as well as the most significant of which is *Nipadites burtini umbonatus*, are identical with Sheppey forms and still others are closely allied to Sheppey forms. In addition the following 21 Wilcox genera are represented in the Sheppey flora: Cyperites, Canna, Sabalites, Dryophyllum, Juglans, Euphorbiophyllum, Proteoides, Laurus, Nyssa, Apocynophyllum, Solanites, Sapotacites, Diospyros, Magnolia, Sapindus, Cupanites, Eugenia, Myrcia, Leguminosites, Mimosites, and Carpolithus.

Thus between the Wilcox flora and the combined flora of Sheppey and Alum Bay the closest sort of a parallel exists.

In view of the foregoing discussion I have no hesitation in making the most positive statement that the Wilcox flora is largely of Ypresian age. This is rendered conclusive by the exact agreement between the flora of the overlying Claiborne group and that of the Lutetian of Europe as brought out in my unpublished studies of the Claiborne flora.

DISTRIBUTION OF WILCOX PLANTS IN OTHER FORMATIONS.

The details of distribution of the Wilcox flora in other formations are shown in the appended table.

Distribution of Wilcox plants in other formations.

	Midway (?) formation.	Claiborne group.	Vicksburg group.	Apalachicola group.	Raton formation.	Denver formation.	Fort Union formation.	Eocene of Europe.	Most closely allied fossil species.	Horizon.	Most similar living species.	Habitat.
Cænomyces laurinea									Depazea andromedæ Saporta.	Sannoisian		
Cænomyces pestalozzites									Graphiolites sabaleos Fritel.	Sparnacian	Pestalozzia spp	Palmæ.
Aneimia eocenica		×			(a)				Aneimia subcretacea (Saporta).	Lower and middle Eocene.	Aneimia cicutaria, A. cuneata, and A. adiantifolia.	American Tropics.
Lygodium binervatum											Section Palmata Prantl of Lygodium.	Climbing, mostly tropical.
Meniphylloides ettingshauseni									Meniphyllum elegans Ettingshausen and Gardner.	Lutetian	Meniscium	American Tropics.
Asplenium hurleyensis					(a)							
Asplenium eolignitica						×			Asplenium issyacense Fritel.	Sparnacian	Asplenium serra Longsdorf and Fischer.	American and African Tropics.
Pteris pseudopinnæformis					(a)	×						
Glyptostrobus europæus							×	×		Arctic Eocene; Kenai of Alaska.	Glyptostrobus pendulus and G. heterophyllus Endlicher.	River bottoms of southeastern Asia.
Taxodium dubium		×			×	×	×	×		do	Taxodium distichum	Southeastern North America, swamps of.
Arthrotaxis (?) eolignitica									Arthrotaxis subulata Gardner.	Ypresian	Arthrotaxis spp	Coastal swamps of Tasmania.
Zamia (?) wilcoxensis									Zamia tertiaria Engelhardt.	Eocene of Chile	Zamia pumila Linné	East coast of Florida.
Pistia wilcoxensis											Pistia stratiotes Linné	Tropical estuaries.
Araceæites friteli									Araceæites Fritel	Sparnacian	Spathiphyllum and Monstera.	Northern South America.
Chamædorea danai					(a)						Chamædorea spp	Central America.
Nipadites burtini umbonatus								×	Nipadites umbonatus Bowerbank.	Ypresian of England.	Nipa fructicans Thunberg.	Tidal waters of tropical Indian Ocean.
Sabalites grayanus					×	×			Sabal major Heer	Eocene to Miocene	Sabal palmetto	Southeastern North America, coastal region of.
Canna eocenica					(a)						Canna flaccida Roscoe	South Carolina to West Indies.
Hicoria antiquorum							×					
Juglans schimperi					×	×	×					

a Closely related species.

Distribution of Wilcox plants in other formations—Continued.

	Midway (?) formation.	Claiborne group.	Vicksburg group.	Apalachicola group.	Raton formation.	Denver formation.	Fort Union formation.	Eocene of Europe.	Most closely allied fossil species.	Horizon.	Most similar living species.	Habitat.
Juglans berryi					×							
Engelhardtia mississippiensis		(a)							Engelhardtia brongniarti Saporta.	Oligocene	Oreomunnea sp	Central America.
Engelhardtia ettingshauseni					×						Engelhardtia chrysolepis Hance.	Southeastern Asia.
Engelhardtia puryearensis											Engelhardtia spicata Blume.	Do.
Myrica wilcoxensis									Myrica spp	American and European Tertiary.	Myrica cerifera Linné	Dunes and sandy coastal swamps of southeastern North America.
Dryophyllum moorii					×				Dryophyllum levalense Marty.	Thanetian		
Dryophyllum tennesseensis					×				Dryophyllum palæocastanea and D. curticellense.	Thanetian and Ypresian.		
Dryophyllum puryearensis					(a)							
Artocarpus lessigiana					(a)	×					Artocarpus incisa Förster.	Southeastern Asia.
Artocarpus pungens				(a)		×					Artocarpus spp	Do.
Artocarpus dubia											do.	Do.
Artocarpoides wilcoxensis									Artocarpoides spp	Thanetian of France.		
Pseudolmedia eocenica											Pseudolmedia spuria Grisebach.	West Indies.
Ficus pseudolmediafolia					×							
Ficus puryearensis		(a)									Ficus ferruginea and F. angustifolia.	
Ficus neoplanicostata					×							
Ficus puryearensis elongata } Ficus wilcoxensis }									Ficus jynx Unger	Tongrian	Ficus americana Aublet.	Tropical America.
Ficus pseudocuspidata											Ficus cuspidata Blume	Oriental Tropics.
Ficus schimperi					×				Ficus cuspidata Watelet	Ypresian		
Ficus eolignitica											Ficus elastica, etc	Do.
Ficus monodon					×	(a)	(a)					
Ficus occidentalis					×	×						
Ficus harrisiana					×	(a)						
Ficus denveriana	×				×	×						
Ficus pseudopopulus					×	×	(a)		Ficus micheloti Watelet	Thanetian		
Ficus artocarpoides?					×		×					
Ficus planicostata maxima						(a)		?		Ypresian		
Ficus planicostata latifolia						×						
Ficus sp									Cecropia heerii Ettingshausen.	Aquitanian	Cecropia spp. and Ficus spp.	Cosmopolitan in the Tropics.

Knightiophyllum wilcoxianum											Knightia excelsa R. Brown.	Australia.
Palæodendron americanum									Palæodendron gypsophileum Saporta.	Sannoisian		
Proteoides wilcoxensis									Proteoides crassipes Ettingshausen.	Ypresian		
Banksia saffordi									Banksia hæringiana Ettingshausen.	Sannoisian	Banksia spp	Do.
Banksia tenuifolia									Banksia longifolia Ettingshausen.	Bartonian	do	Do.
Aristolochia wilcoxiana					(a)						Aristolochia spp	Tropical America.
Coccolobis eolignitica											Coccolobis laurifolia Jacquin.	Beaches of tropical America.
Coccolobis uviferafolia		(a)									Coccolobis uvifera Jacquin.	Do.
Pisonia eolignitica		(a)									Pisonia longifolia Sargent.	Florida Keys to Brazil.
Pisonia chlorophylloides									Pisonia eocenica Ettingshausen.	Sannoisian	Pisonia aculeata Linné	West Indian strand.
Magnolia angustifolia					×							
Magnolia leei					×							
Anona wilcoxiana											Anona glabra Linné	Florida Keys and throughout West Indies.
Anona ampla											Anona spp	Tropical America.
Anona eolignitica											do	Do.
Asimina leiocarpa											do	Do.
Capparis eocenica											Capparis domingensis Sprengel.	Antilles.
Parrotia cuneata							×				Parrotia spp	Southwestern Asia.
Chrysobalanus inæqualis											Chrysobalanus icaco Linné and C. oblongifolius Michaux.	Subtropical and tropical America.
Chrysobalanus eocenica											do	Do.
Acacia wilcoxensis									Acacia dianæ Ettingshausen.	Sannoisian	Acacia oblunata Cavanilles and A. pycnantha Bentham.	Australian Tropics.
Inga mississippiensis		(a)									Inga spp	Tropical America.
Inga puryearensis											do	Do.
Inga laurinafolia											Inga laurina Willdenow.	West Indies.
Inga wickliffensis											do	Do.
Pithecolobium eocenicum											Pithecolobium saman	Nicaragua to Brazil.
Pithecolobium oxfordensis			(a)						Palæolobium hæringianum Unger.	Sannoisian		
Cercis wilcoxiana									Cercis deperdita Watelet	Ypresian		
Cassia glenni					(a)				Cassia berenices Unger	Oligocene		
Cassia fayettensis									Cassia feroniæ Ettingshausen.	Sannoisian	Cassia stipulacea Aiton	Tropical South America.
Cassia bentonensis									Cassia berenices Unger	Oligocene	Cassia apouconita Aublet.	Do.
Cæsalpinia wilcoxiana									Cæsalpinites colligendus Saporta.	Sannoisian	Cæsalpinia bahamensis Lamarck.	West Indies.

a Closely related species.

Distribution of Wilcox plants in other formations—Continued.

	Midway (?) formation.	Claiborne group.	Vicksburg group.	Apalachicola group.	Raton formation.	Denver formation.	Fort Union formation.	Eocene of Europe.	Most closely allied fossil species.	Horizon.	Most similar living species.	Habitat.
Cæsalpinites aculeatafolia		(a)							Parkinsonia recta Laurent.	Tongrian	Parkinsonia aculeata Linné.	Southern California to the Rio Grande.
Cæsalpinites pinsonensis				(a)					Cæsalpinia townshendi Heer.	Stampian		
Gleditsiophyllum ovatum Gleditsiophyllum eocenicum									Cassia zephyri Ettingshausen and C. pseudoglandulosa Ettingshausen.	Sannoisian		
Gleditsiophyllum constrictum Gleditsiophyllum fructuosum									Acacia brongniarti Watelet.	Ypresian		
Gleditsiophyllum ellipticum Gleditsiophyllum entadaformis Gleditsiophyllum minor									Entada dubia Watelet	do.	Entada spp.	Tropical America and Asia.
Gleditsiophyllum hilgardianum												
Sophora henryensis					(a)				Sophora europæa Unger	Sannoisian	Sophora tomentosa Linné	Tropical strand.
Sophora wilcoxiana		(a)										
Sophora palæolobifolia									Palæolobium spp.	Sannoisian		
Dalbergia tennesseensis Dalbergia eocenica [b] Dalbergia wilcoxiana									Dalbergia sp.	Eocene to Pliocene.	Dalbergia spp.	Tropical America.
Canavalia eocenica											Canavalia obtusifolia (Lamarck) De Candolle.	West Indian strand.
Leguminosites arachioides					×	×	×					
Fagara hurleyensis Fagara eocenica Fagara puryearensis											Fagara spp.	Cosmopolitan tropical forms.
Simaruba eocenica											Simaruba glauca De Candolle.	West Indies to Brazil.
Cedrela mississippiensis											Cedrela fissilis Velloso	Northern South America.
Carapa eolignitica											Carapa guianensis Aublet.	West Indies and northern South America.
Vantanea wilcoxiana											Vantanea paniculata Urban.	Northern South America.
Banisteria repandifolia											Banisteria laurifolia Linné.	Central America.
Banisteria pseudolaurifolia									Banisteria juglandoides Watelet.	Ypresian	do.	Do.
Banisteria fructuosa Banisteria wilcoxiana									Banisteria sotzkiana Ettingshausen.	Tongrian	do.	Do.
Hiræa wilcoxiana									Hiræa intermedia Ettingshausen.	Ypresian		

Crotonophyllum eocenicum											Croton eluteria (Linné) Bennett.	Bahamas.
Euphorbiophyllum fayettensis									Euphorbiophyllum eocenicum Ettingshausen.	Ypresian		
Drypetes prekeyensis											Drypetes keyensis Urban.	Florida Keys and West Indies.
Drypetes prelateriflora											Drypetes lateriflora Urban.	Do.
Anacardites metopifolia											Metopium metopium Small.	Do.
Anacardites falcatus					×							
Anacardites puryearensis											Anacardium spp	Tropical America.
Anacardites serratus												
Heterocalyx saportana									Heterocalyx ungeri Saporta.	Sannoisian	Astronium and Loxostylis.	Brazil.
Ilex vomitoriafolia											Ilex vomitoria Aiton	Virginia to Florida Keys.
Maytenus puryearensis									Maytenus europæa Ettingshausen.	Bohemian Tertiary	Maytenus boaria, M. chilensis, and M. verticillatus.	Tropical and subtropical South America.
Celastrus eolignitica									Celastrus noaticus Unger and C. splendidus Saporta.	Oligocene		
Celastrus taurinensis							×					
Celastrus bruckmannifolia		(a)							Celastrus bruckmanni Alexander Braun.	Wide range in Tertiary.		
Celastrus veatchi							(a)		Celastrus persei and C. andromedæ Unger.	Aquitanian		
Euonymus splendens					×		(a)		Euonymus proserpinæ Ettingshausen.	do	Euonymus spp	Southeastern Asia and North America.
Cupanites eolignitícus									Cupania spp	Ypresian	Cupania spp	Tropical America.
Cupanites loughridgii											do	Do.
Sapindus pseudaffinis							(a)		Sapindus affinis Newberry and S. grandifoliolus Ward.		Sapindus inæqualis De Candolle.	Do.
Sapindus oxfordensis							(a)				Sapindus saponaria Linné	Do.
Sapindus mississippiensis		×										
Sapindus formosus		×					(a)					
Sapindus eolignitícus					(a)		(a)					
Sapindus knowltoni											Sapindus marginatus Willdenow.	Peninsular Florida.
Dodonæa knowltoni											Dodonæa viscosa Linné	West Indian strand.
Dodonæa wilcoxiana											Dodonæa angustifolia Swartz.	West Indies.
Reynosia prænuntia											Reynosia septentrionalis Urban.	Florida Keys and Bahamas.
Reynosia wilcoxiana											do	Do.
Zizyphus falcatus		(a)							Zizyphus ungeri Heer	Oligocene	Zizyphus spp	Tropical America.
Zizyphus meigsii					×						Zizyphus napica	Java.
Paliurus mississippiensis									Paliurus tenuifolius Heer.	Tertiary	Paliurus aculeatus Lamarck and P. ramossimus Poiret.	Asia.

[a] Closely related species.

[b] Closely related species in the Eocene of Greenland.

Distribution of Wilcox plants in other formations—Continued.

	Midway (?) formation.	Claiborne group.	Vicksburg group.	Apalachicola group.	Raton formation.	Denver formation.	Fort Union formation.	Eocene of Europe.	Most closely allied fossil species.	Horizon.	Most similar living species.	Habitat.
Paliurus pinsonensis									Paliurus colombi Heer	Arctic Eocene	Paliurus aculeatus Lamarck and P. ramosissimus Poiret.	Asia.
Rhamnus eoligniticus							(a)		Cornus rhamnifolia O. Weber.	Point of Rocks, Wyo.		
Rhamnus coushatta						(a)						
Rhamnus cleburni						×						
Grewiopsis tennesseensis							(a)		Populus sp	Fort Union and Arctic Eocene.	Grewia spp	Do.
Sterculia puryearensis									Platanus sirii Unger	Styrian Oligocene		
Sterculiocarpus eocenicus									Sezanella major Viguier.	Thanetian		
Sterculiocarpus sezannelloides									do	do		
Bombacites formosus									Bombax neptuni Ettingshausen.	Sannoisian	Bombax spp	Tropical America.
Dillenites tetracerafolia											Tetracera spp	Cosmopolitan in the Tropics.
Dillenites microdentatus									Castanea sezannensis Watelet.	Thanetian	Dillenia spp. and Tetraceras spp.	
Calycites davillaformis											Davilla spp	Tropical America.
Ternstrœmites eoligniticus									Ardisia myricoides Ettingshausen.	Aquitanian	Freziera spp	Do.
Ternstrœmites preclaibornensis		(a)										
Cinnamomum affine						×						
Cinnamomum postnewberryi								(a)				
Cinnamomum mississippiensis	(a)				×	(a)	(a)	(a)				
Cinnamomum oblongatum		(a)			(a)							
Cinnamomum vera									Cinnamomum rossmässleri Heer.		Cinnamomum spp	Asia.
Cinnamomum buchii							(a)	×		Eocene to Miocene	do	Do.
Persea longipetiolatum						(a)					Persea spp	Tropical America.
Persea wilcoxiana		(a)									do	Do.
Oreodaphne mississippiensis									Litsæa expansa Saporta and Marion. Laurus attenuata Watelet.	Thanetian Ypresian	Oreodaphne spp	Do.
Oreodaphne coushatta							(a)					
Oreodaphne pseudoguianensis											Oreodaphne guianensis Aublet.	Northern South America.
Oreodaphne puryearensis											Oreodaphne fœteus Nees	Do.
Oreodaphne obtusifolia		×							Cinnamomum sezannense Saporta.	Thanetian		
Mespilodaphne pseudoglauca											Mespilodaphne glauca	Brazilian Tropics.

Mespilodaphne eolignitica											Mespilodaphne sassafras Meissner.	Do.
Mespilodaphne coushatta									Persea regularis Watelet.	Ypresian		
Mespilodaphne puryearensis									Persea palæomorpha Saporta and Marion.	Thanetian		
Nectandra glenni											Nectandra patens Grisebach and N. krugii Mez.	West Indies.
Nectandra lancifolia		(a)			×						Nectandra antillana Meissner.	Do.
Nectandra pseudocoriacea									Laurus primigenia Unger.	Eocene to Miocene	Nectandra coriacea Grisebach.	Florida Keys and West Indies.
Cryptocarya eolignitica											Cryptocarya spp	South America.
Laurinoxylon branneri									Laurus biseriata Castary.	Tertiary of Russia		
Myrcia vera									Myrcia lancifolia Friedrich.	Oligocene	Myrcia rostrata De Candolle and M. acutata Berg.	Tropical Brazil.
Myrcia wortheni											Myrcia spp	Tropical America.
Myrcia puryearensis											Myrcia terebinthacea Pöpp.	Do.
Myrcia parvifolia											Myrcia spp	Do.
Myrcia bentonensis		×									do	Do.
Myrcia grenadensis											do	Do.
Calyptranthes eocenica									Myrtus rectinervis Saporta.	Tongrian	Calyptranthes syzygium (Linné) Swartz.	West Indies.
Eugenia densinervia											Eugenia spp	Tropical America.
Eugenia grenadensis											do	Do.
Eugenia hilgardiana											Eugenia axillaris, E. rhombea, and E. confusa.	Florida Keys and West Indies.
Eugenia puryearensis											Eugenia spp	Tropical America.
Laguncularia preracemosa		(a)									Laguncularia racemosa Gärtner.	Tidal flats of American and West African Tropics.
Combretum ovalis		(a)			×						Combretum spp	Tropical America.
Combretum obovalis											do	Do.
Combretum wilcoxensis											do	Do.
Terminalia lesleyana					×			(b)	Terminalia radobojensis Unger.	Tongrian	Terminalia hylobates or T. phæocarpa Eichler.	Tropical South America.
Terminalia hilgardiana	×	(a)		(a)	×		×				Terminalia spp	Tropical America.
Terminalia wilcoxiana											do	Do.
Conocarpus eolignitieus		(a)									Conocarpus erectus Linné.	Tidal flats of American and West African Tropics.
Combretanthites eocenica											Combretum guianaense Rusby.	Bolivia.
Melastomites americanus											Melastomataceæ	Tropical America.
Aralia acerifolia							×					
Aralia notata						×	×					
Aralia jorgenseni?									Occurs in Arctic Eocene.			

a Closely related species.

b Similar form in Sparnacian and Ypresian of Paris Basin.

Distribution of Wilcox plants in other formations—Continued.

	Midway (?) formation.	Claiborne group.	Vicksburg group.	Apalachicola group.	Raton formation.	Denver formation.	Fort Union formation.	Eocene of Europe.	Most closely allied fossil species.	Horizon.	Most similar living species.	Habitat.
Oreopanax minor											Oreopanax xalapensis (Humboldt, Bonpland, and Kunth) De Candolle.	Central America.
Oreopanax oxfordensis												
Cornus studeri						×			Artocarpoides conocephaloides Saporta.	Thanetian	O. taubertianus Donnell Smith.	
Nyssa wilcoxiana											Nyssa spp	Southeastern North America.
Nyssa eolignitica												
Sideroxylon ellipticus									Sideroxylon putterliki Unger.	Aquitanian	Sideroxylon surinamense Miki.	Northern South America.
Sideroxylon premastichodendron											S. mastichodendron Jacquin.	Florida Keys and West Indies.
Chrysophyllum ficifolia											Chrysophyllum oliviforme Lamarck.	Bahamas and Antilles.
Bumelia pseudohorrida											Bumelia horrida Grisebach.	West Indies.
Bumelia hurleyensis											B. cuneata Swartz	Do.
Bumelia pseudotenax												
Bumelia lanuginosafolia											B. lanuginosa Persoon	Southern States.
Bumelia wilcoxiana									Bumelia oreadum Unger.	Sannoisian	B. retusa Swartz	West Indies.
Bumelia grenadensis									do.	do.		
Bumelia americana									Piscidia protogea Watelet.	Ypresian		
Mimusops sieberifolia											M. sieberi A. De Candolle.	Florida Keys and Bahamas.
Mimusops eolignitica		(a)									Mimusops spp	Tropical America.
Mimusops mississippiensis											do.	Do.
Diospyros wilcoxiana											Diospyros virginiana Linné.	Southeastern North America.
Diospyros brachysepala		×					×	×		A widespread Tertiary species.	Diospyros spp	Cosmopolitan in the Tropics.
Icacorea prepaniculata											Icacorea paniculata Sudworth.	Florida Keys and West Indies.
Fraxinus johnstrupi?									Occurs in Arctic Eocene.			
Osmanthus pedatus					×						Osmanthus americanus Bentham and Hooker.	Carolinas to Louisiana.
Echitonium lanceolatum									Occurs in Arctic Eocene.		Echites spp	Tropical America.
Apocynophyllum sapindifolium							(a)					
Apocynophyllum wilcoxense					×				Nerium sarthacense Saporta.	Lutetian		

Cordia eocenica											Cordia spp	Do.
Cordia? lowii											Citharexylon villosum Jacquin.	Florida Keys and West Indies.
Citharexylon eolignitlcum												
Avicennia nitidaformis											Avicennia nitida Jacquin.	Tidal flats of tropical America.
Avicennia eocenica											do.	Do.
Solanites saportana									Solanites brongniarti Saporta.	Sannoisian	Saracha spp	Central America.
Exostema pseudocaribæum											Exostema caribæum Roemer and Schultes.	Florida Keys to Central America.
Guettarda ellipticifolia											Guettarda elliptica Swartz.	Florida Keys and West Indies.
Carpolithus prangosoides											Prangos spp	Orient.
Carpolithus henryensis									Aristolochites sp	Brandon lignites		
Carpolithus sophorites											Sophora spp	Tropical America.
Carpolithus pilocarpoides											Pilocarpus sp. of Rubiaceæ.	
Carpolithus proteoides											Proteaceæ	
Carpolithus hyoseritiformis											Compositæ	
Carpolithus dictyolomoides											Malpighiaceæ	
Carpolithus ostryaformis									Ostrya walkeri	Greenland Eocene	Ostrya spp	Warm Temperate Zone.

[a] Closely related species.

50243°—16——11

SYSTEMATIC DESCRIPTIONS.

Phylum THALLOPHYTA.

Class FUNGI.

Order PYRENOMYCETES (?).

Genus CÆNOMYCES Berry, n. gen.[1]

The presence of spots of different shapes on the leaves of fossil plants is exceedingly common, and a very large number of so-called species of fossil leaf-spot fungi have been described by Ettingshausen, Heer, Saporta, and others. These species are referred for the most part to the genera Sphæria, Phacidium, Dothidia, Depazea, Sclerotia, Hysteria, Rhytisma, Xylomites, and the like. A large list of such forms was published by Meschinelli in 1892.[2] All these determinations are based entirely on superficial similarities between the fossil and some modern leaf-spot fungus, of which there are thousands of species, most of them distinguishable only by their methods of reproduction or the morphology of their reproductive parts.

The identification of these fossil forms obviously rests on a very insecure foundation, especially when it is recalled that scale insects and a great variety of insect galls would resemble epiphyllous fungi when preserved on impressions of fossil leaves. Nevertheless large numbers of undoubted fungi are preserved in this manner and it is the legitimate duty of the paleobotanist to describe and illustrate them. In order to accomplish this work without unwarranted definiteness in generic classification, I propose the term Cænomyces as a form genus for leaf-spot fungi of Cenozoic age whose precise botanic affinities can not be determined. I do not propose to burden the literature with any large number of new forms nor to make any new combinations by referring species which other authors have described as Sphæria and the like to this genus, but I shall use the term in my own studies of Tertiary floras where well-marked remains of this sort require commemoration either because of especial geologic or biologic interest. Most such forms probably represent the Ascomycetes. (See Pl. CXI, fig. 6.)

[1] From καινός, recent, and μύκης, a fungus.

[2] Meschinelli, A., Fungi fossilis, in Saccardo's Sylloge fungorum, vol. 10, 1892.

CÆNOMYCES LAURINEA Berry, n. sp.

Plate LXXXVIII, figure 4.

Description.—Usually situated or most extensively developed on or near the vascular framework of the leaf and comparable with modern forms that cause leaf blight by their interference with the circulation in the leaf. This form is abundant on the leaves of *Nectandra lowii* Berry, particularly along the midrib, where perithecia are represented by elliptical, more or less confluent masses of discoloration about 3 millimeters in length and 1.5 millimeters in width, evidently starting as small circular spots which become elongated and run together, since they are isolated in the upper part of the leaf but form a common mass toward the base of the midrib. This species resembles *Depazea andromedæ* described by Saporta [3] on a species of Andromeda from the Ligurian (Sannoisian) of Aix in southeastern France.

Occurrence.—Holly Springs sand, Oxford Gully, Lafayette County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CÆNOMYCES SAPOTÆ Berry, n. sp.

Plate XCIX, figure 4.

Description.—The leaves of *Sideroxylon premastichodendron* Berry from Oxford are badly infested with a leaf blight, which causes the formation of irregularly oval spots that range in size from 1 millimeter to 5 millimeters in diameter. Margins irregular and commonly confluent. Perithecial masses thick, aggregated in the basal half of the leaf, especially along the midrib.

Occurrence.—Holly Springs sand, Oxford Gully, Lafayette County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CÆNOMYCES PESTALOZZITES Berry, n. sp.

Plate IX, figures 2 and 3.

Description.—Leaf spots circular or elliptical in outline, margins generally well marked, that range in size from 0.25 millimeter to 6 millimeters, somewhat thickened and showing con-

[3] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 1, p. 7, pl. 9, fig. 12, 1889.

centric surface markings. Common on both the leaf stalks and rays of *Sabalites grayanus* Lesquereux and named from its resemblance to those species of the existing genus Pestalozzia De Not which make their home on the foliage of members of the palm family.

Though extended comparisons with previously described fossil forms which appear similar is without much value, attention may be called to the resemblance of the present form to *Graphiolites sabaleos* which infests *Sabalites suessionensis* from the Sparnacian of the Paris Basin. Fritel,[1] its describer, compares it with species of the existing genus Graphiola (Basidiomycetes).

Occurrence.—Holly Springs sand, Oxford Gully, Lafayette County; Grenada formation, Grenada, Grenada County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CÆNOMYCES ANNULATA Berry, n. sp.

Plate XLV, figure 17b.

Description.—Perithecia circular in outline, 1 millimeter to 5 millimeters in diameter, that show a central, somewhat papillose portion surrounded by a double well-defined regular margin, on a leaf of *Cassia emarginata* Berry, shown in Plate XLV, figure 17b. This form is strikingly different in appearance from the other forms referred to Cænomyces. Its regular circular form and annulate margin serves to distinguish it from *Cænomyces cassiæ* Berry, which has been found infesting this same species of Cassia.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CÆNOMYCES CASSIÆ Berry, n. sp.

Plate IX, figure 1.

Description.—Perithecia aggregated, circular in outline, more or less stellate, thick, averaging 1.75 millimeters in diameter. This form is found in abundance on the leaves of *Cassia emarginata* Berry. It has a characteristic appearance decidedly different from that of *Cænomyces annulata* Berry, which infests this same species of Cassia.

[1] Fritel, P. H., Soc. géol. France Mém. 40, p. 12, pl. 1, fig. 12, 1910.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn).

Collection.—U. S. National Museum.

CÆNOMYCES MYRTÆ Berry, n. sp.

Plate XC, figure 7.

Description.—Perithecial masses which form irregularly oval spots that have a depressed, somewhat granulose central area and a narrow raised margin. Variable in outline and 1 millimeter to 2 millimeters in diameter. Situated on the leaves of *Myrcia bentonensis* Berry, as a rule away from the midrib or larger veins.

Occurrence.—Holly Springs sand, Oxford Gully, Lafayette County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Phylum PTERIDOPHYTA.

Class LEPIDOPHYTA.

Order LYCOPODIALES.

Family LYCOPODIACEÆ.

Genus LYCOPODITES Brongniart.

LYCOPODITES? EOLIGNITICUS Berry, n. sp.

Plate IX, figures 4 and 5.

Description.—Plants slender and elongated, probably pendulous, dichotomously branched, stems covered with tiny appressed pointed leaves. Stems not more than 0.17 millimeter in diameter, and leaves not over 0.33 millimeter in length.

I was at first disposed to refer this unique specimen to the form genus Muscites, but the elongated dichotomous stem, combined with appearances suggestive of vascular plants, led me to refer it to the form genus Lycopodites. This conclusion was strengthened by the association of the specimen with a fruiting specimen which appears to belong to the same plant. This at first also suggests a moss, but the strobilar part shows small triangular markings suggesting scales. The fruiting specimen is about 6 millimeters in length, and the feature which I interpret as the strobilus is about 1.75 millimeters in length and is borne on a naked peduncle about 2.5 millimeters in length, thus much less elongated than most Lycopodiales. The specimens are preserved as impressions in clay and fail to show essential features, which is unfortunate, since nothing like them has been described in the fossil state and I know of no existing species that resembles them very closely.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Class FILICES.

Order FILICALES.

Family SCHIZÆACEÆ.

Genus ANEIMIA Swartz.

ANEIMIA EOCENICA Berry, n. sp.

Plates IX, figure 7; X, figure 2; and XI, figures 1 and 2.

Description.—Frond character unknown, stipate, dichotomous and bipinnate or tripinnate in the closely allied species *Aneimia subcretacea* (Saporta) Gardner and Ettingshausen,[1] which is a widely distributed and well-known species that ranges from the base of the Eocene as high as the Lutetian and is more abundant in the later than in the earlier horizons. Pinnæ ovate-lanceolate, pinnately divided almost to the rachis into lanceolate lobes. Lobes attached very obliquely by their entire base (possibly those lower down on the frond may have had a narrowed base and been free pinnules) and more or less confluent, becoming more and more confluent distad. Angle of divergence about 20° or less, becoming more acute distad. Lobes linear-lanceolate, sharply pointed, with distant serrate teeth, commonly in pairs; decurrent, separated by narrow acute sinuses. Texture coriaceous. Stipe stout, prominently winged. Rachis slender, flexuous, prominent on the lower surface of the pinnæ. Midrib of the lobes (pinnules) diverges from the rachis at a very acute angle (between 5° and 10°) and near the lower decurrent margin curves outward, retaining its identity nearly to the tip of the lobe, although becoming reduced by repeated branching. Commencing at the base on the outer side alternate branches are given off on each side of the midrib at a narrow angle, and these are almost straight and all branch dichotomously. The distal branch usually forks before reaching the margin, but the proximal one generally remains simple. There are five or six of these branches on each side in lobes the size of those figured. The veins are thin but distinct and all terminate in the margin, one entering each marginal tooth. Marginal teeth 6 or 8 in number on each margin, commonly in pairs as shown in the figure of the enlarged lobe, somewhat irregularly spaced, in general becoming closer distad. These teeth are distinctly serrate, with the points produced and directed upward, and the apex of the lobe is gradually narrowed and acuminate.

This species is closely allied to the previously mentioned *Aneimia subcretacea*, which was described originally from the Paleocene of France by Saporta[2] as *Asplenium subcretaceum.* Shortly afterward Lesquereux described what subsequently was correlated with this same species as *Gymnogramma haydeni.*[3] This species came from the divide between Snake River and Yellowstone Lake. The locality, which has never been rediscovered, has commonly been assumed to be Laramie, although it may be basal Eocene. In 1880 Gardner and Ettingshausen,[4] by means of abundant remains from the Middle Bagshot beds (Lutetian) of the south of England, were able to associate these occurrences and to prepare a full account of the species. The species under discussion, though close to this widespread lower and middle Eocene form, differs in sufficiently important particulars to warrant its description as a closely allied but distinct form The lobes in *Aneimia eocenica* are narrower, more ascending and acuminate, and not abruptly and more or less obtusely pointed as in Lesquereux's material, and the venation is much more open than in his forms. Though some of the English material has as slender lobes, all the foreign material as well as the western material has crenate or dentate teeth passing gradually into rounded distal lobes. In *Aneimia eocenica*, on the other hand, the lobes preserve their character distad and all have distinctly serrate teeth, more or less produced upward and usually double.

Gardner, in the course of his work on the English material, submitted either specimens

[1] Gardner, J. S., and Ettingshausen, C. von, British Eocene flora, vol. 1, pt. 2, p. 45, pls. 8 and 9, 1880.

[2] Saporta, G. de, Prodrome d'une flore fossile des travertins anciens de Sézanne: Soc. géol. France Mém., 2d ser., vol. 8, p. 315, pl. 23, fig. 4, 1868.

[3] Lesquereux, Leo, U. S. Geol. and Geog. Survey Ann. Rept., 1871, p. 295, 1872; The Tertiary flora, p. 59, pl. 5, figs. 1-3, 1878 (not The Cretaceous and Tertiary floras, p. 122, pl. 19, fig. 2, 1883, which is a Pteris).

[4] Op. cit., p. 45.

or plates to Saporta, Heer, Stur, and Lesquereux, and the first and last authors both agreed that their material from France and America, respectively, was identical with the English material. These students did not agree, however, on Gardner's reference to Aneimia, Saporta inclining toward a new genus allied to Todea and Stur suggesting Osmunda. Heer also opposed Aneimia, and Lesquereux thought that his material was more closely allied to *Gymnogramma tartarea* Desvaux of tropical America.

Aneimia eocenica, though distinct, is very similar to a new species of Aneimia described by Knowlton (unpublished) from the Raton formation of the southern Rocky Mountain province. Knowlton's species, which comes from a horizon slightly older than the Wilcox, has relatively narrower and greatly elongated lobes with prominent pointed teeth, which do not occur in pairs.

Among antecedent forms from the Upper Cretaceous that may be compared with the present species are *Asplenium dicksonianum* Heer [1] and *Dicksonia grœnlandica* Heer [2] both of which are present in the Tuscaloosa formation of Alabama and are more or less common in the Coastal Plain, ranging northward to western Greenland. Their reference to Asplenium and Dicksonia is not at all justified by the evidence.

Though most of the existing species of Aneimia are rather different in appearance, the subgenus Aneimiorrhiza J. Smith, especially the exclusively American section Cuneatæ Prantl, including *Aneimia cicutaria* Kuntze, *Aneimia cuneata* Kuntze, and *Aneimia adiantifolia* Swartz of the American Tropics, is very much like these two fossil species, Gardner having first pointed out the resemblance between *A. subcretacea* and *A. adiantifolia*, which is found as far northward as southern peninsular Florida and is referred by Underwood to the genus Ornithopteria Bernhardi. *Aneimia eocenica* is present in the upper Claiborne deposits of the Texas coastal plain.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry): Wilcox group, 4 miles southwest of Boydsville, Clay County, Ark. (collected by E. W. Berry). One and one-half miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Genus LYGODIUM Swartz.

LYGODIUM BINERVATUM (Lesquereux) Berry.

Plate X, figures 3–8.

Salisburia binervata. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 412, pl. 15, figs. 3–6, 1869.

Ginkgo binervata. Knowlton, U. S. Geol. Survey Bull. 152, p. 110, 1898.

Description.—This species was described by Lesquereux on the basis of fragmentary specimens that were collected by Hilgard from the red shales of Benton County, Miss., which at that time was included in the western part of Tippah County. The type specimens in the Hilgard collection do not conform to Lesquereux's figures, which either must be very inaccurate or else are based on still other fragmentary specimens of this species which have since been lost.

Lesquereux's description, which he wrote with the idea that he was dealing with the foliage of a gymnosperm allied to the existing Ginkgo, is very misleading, and the species may be recharacterized in the following terms: Pinnules large and stout, equilateral and usually bilobate; some individuals may have had a subsidiary and relatively small basal lateral lobe on each side. Lobes elliptical in outline, their margins undulate or indented by shallow broad crenations. The lobes are broadly rounded at the apex and diverge at angles of about 90°. The base is not preserved, but from the venation in this region it must have been truncately rounded or more or less cordate. The texture was somewhat coriaceous. Venation characteristic of Lygodium. Two primaries diverge at the base of the pinnule at an angle of about 35°; they are stout and curve outward, become much thinner distad, and are eventually lost by repeated branching. The branches diverge at acute angles and are much curved outward, forking dichotomously several times and terminating at the margins. The lobes are broad, 1.5 to 3 centimeters in width, generally nearer the larger dimension. They are relatively short, the free limb being

[1] Heer, Oswald, Flora fossilis arctica, vol. 3, pt. 2, p. 31, pl. 1, figs. 1–5, 1874.

[2] See under *Aneimia stricta* in Newberry, J. S., U. S. Geol. Survey Mon. 26, p. 38, pl. 3, figs. 1, 2, 1896.

only 4 to 5 centimeters in length. The central sinus which separates the two principal lobes is angular or rounded. It is relatively shallow and is 3 to 4.5 centimeters distant from the base of the pinnule.

This robust form is clearly referable to Lygodium, and it is as clearly distinguished from known forms by the large, broad, bluntly rounded, and not elongated lobes, as a rule but two in number. Incomplete material, which appears to be assignable to this species but which can not be identified with certainty, is associated with an upper Wilcox flora in western Louisiana.

The present species may be distinguished from *Lygodium kaulfusii* Heer, which occurs in the upper Claiborne, by its more robust form, stouter, somewhat more open and less numerously forked veins, and by its two short and wide lobes.

A visit to Hilgard's classic locality resulted in the collection of abundant fruiting material of this species, thus confirming the transfer of the foliage from Ginkgo to Lygodium. The fertile pinnæ are of the palmatum type and form a terminal panicle, but the lamina is much more reduced. Each group of sporangia is pedunculate and is elongated and narrowly lanceolate in outline. The sporangia are solitary and sessile and are borne on alternate veins that branch from the flexuous midrib. There are 30 to 35 sporangia in each spike. Two of the most complete panicles are figured. The spikes are well preserved, and the fossilization is by ferruginous replacement. Some specimens show the single ovate sporangium beneath the scalelike indusium.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard, E. N. Lowe, and E. W. Berry). Deposits of Wilcox age, secs. 22 and 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by E. G. Woodruff and G. C. Matson).

Collections.—U. S. National Museum; State University, Oxford, Miss.

Family POLYPODIACEÆ.

Genus MENIPHYLLOIDES Berry, n. gen.

Ferns with simple pinnate fronds, the fronds or pinnæ ligulate, entire. The venation is of the *Drynaria composita* type, but differs from previously known fossil or recent genera of this type in lacking free venules. The general characters of the genus are those of the type and only known species.

MENIPHYLLOIDES ETTINGSHAUSENI Berry, n. sp.

Plate XI, figures 4–7.

Description.—Fronds, or pinnæ of a pinnate frond, simple, entire; lanceolate in general outline; about 15 to 20 centimeters in length and 2 to 3 centimeters in maximum width, which is midway between the apex and the base. From the region of greatest width the lamina narrows about equally distad and proximad to the extended acuminate tip and the narrowly decurrent base. Texture subcoriaceous. Margins entire for a short distance proximad, above this point beset with somewhat irregularly spaced, generally close, fine, upwardly directed, serrate teeth. Midrib fibrous, very broad and rather flat, generally curved, becoming attenuated distad. Laterals thin, closely spaced and parallel, about 0.67 millimeter apart; they diverge from the midrib at angles of about 60°, become somewhat more ascending in both apex and base, and run in a slightly flexuous but generally straight course to the margins, where their ends are joined by a well-marked marginal vein. The venules diverge from both sides of the laterals at acute angles and anastomose in a somewhat irregular manner to form obliquely elongated areolæ. No free veinlets occur within the meshes.

The venation of this species differs from that of any fossil or recent forms known to the writer. It is closest to the form from the English Eocene (Middle Bagshot = Lutetian) described by Ettingshausen and Gardner as *Meniphyllum elegans*,[1] but differs in its serrated margin and in lacking free veinlets within the meshes. It is not unlike a number of existing netted-veined Polypodiaceæ, but differs in the irregular character of the areolation and the absence of free endings, thus combining venation characters of recent species of Acrostichum and Meniscium. It is represented by considerable more or less broken material and is named in honor of the late Baron Ettingshausen, who did so much in the elucidation and methods of study of Tertiary floras.

[1] Gardner, J. S., and Ettingshausen, C. von, British Eocene flora, vol. 1, p. 36, pl. 3, figs. 10–14, 1879.

This species seems clearly to be dryopteroid, and among the more than 1,000 existing species referred to the genus Dryopteris in Christensen's recent monographic work[1] it suggests the subgenera (often and probably more properly considered as genera) Lastrea Bory, Goniopteris Presl, and Meniscium Schreber, which together include more than 300 of existing and variable species. The venation of several of these modern forms is exceedingly variable, as may be seen by examining the recent species of Goniopteris and Meniscium. In my manuscript of the flora of the Claiborne group I have described a splendidly preserved new species of Goniopteris, which I regard as undoubtedly of generic rank, and this species well illustrates the great variation in the venation of these members of the tribe Dryopterideæ (Aspideæ). The genus Meniscium is confined to the American Tropics, and some of its forms (*Meniscium reticulatum* Swartz, for example), have pinnæ like the fossil. Though the venation in Meniscium is commonly variable, the tertiaries diverge from the secondaries, which are more widely spaced, at more regular intervals, and the ultimate venules, which result regularly from the junction of two tertiaries midway in their course, end free. The secondaries are closer, there is a marginal vein, and no free venules have been observed in the fossil. The figures of Meniphyllum given by Gardner[2] and Ettingshausen should be consulted for critical comparison with Meniphylloides, and what these authors say about Meniphyllum may be amended to include Meniphylloides, namely, that in the combination of a marginal and netted venation these genera present a special type of venation which has never been observed in recent forms. Dr. W. R. Maxon, who has seen drawings of the Meniphylloides, confirms this statement. He has suggested that the peculiar intramarginal veinlet may be an impression resulting from a revolute callous margin, and this possibility should not be lost sight of, although the considerable amount of material, which is preserved in very fine clay, does not confirm this suggestion, and it is also rendered improbable by the well-preserved toothed margin.

[1] Christensen, C., On a natural classification of the species of Dryopteris: Saertryk af Biologiske Arbeijdner Tilegnede Eug. Warming, pp. 73–85, 1911.

[2] Op. cit., pl. 3, figs. 10–14.

A species of Meniscium has been described by Engelhardt[3] from the Tertiary of Colombia.

Occurrence.—Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan); 4½ and 5 miles southeast of Naborton, De Soto Parish, La. (collected by O. B. Hopkins). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collections.—U. S. National Museum.

Genus ASPLENIUM Linné.

ASPLENIUM EOLIGNITICA Berry, n. sp.

Plate XI, figure 3.

Gymnogramma haydenii. Lesquereux, The Cretaceous and Tertiary floras, p. 122, pl. 19, fig. 2, 1883. (Not the same as the type of *Gymnogramma haydenii* Lesquereux, The Tertiary flora, p. 59, pl. 6, figs. 1–3, 1878, which was subsequently referred to the genus Aneimia.)

Description.—Pinnæ very large, linear-lanceolate in outline. Margins strongly serrate-toothed, the teeth irregular in size and spacing but very different from the shallow dentate teeth of *Pteris pseudopinnæformis.* Texture coriaceous. Midrib stout. Laterals diverge from the midrib at acute angles of about 40° and are thin, subparallel, and rather more curved and more closely spaced than in the associated *Pteris pseudopinnæformis* Lesquereux. They are immersed in the thick leaf substance, are rarely simple, fork (many of them several times), and terminate in the margins. Length of pinnæ about 20 centimeters. Maximum width, in middle part, 3.5 centimeters.

This species may be identical with *Pteris pseudopinnæformis*, although it appears distinct. It is larger and more coriaceous, the laterals are closer and more commonly forked, with different and much more prominent teeth. The form figured in 1883 by Lesquereux from Golden, Colo., as *Gymnogramma haydenii* appears to me to be quite distinct from the earlier material Lesquereux described under that name, and to be identical with this species. This adds another element common to the early Eocene of the Gulf and Rocky Mountain areas.

[3] Engelhardt, H., Senckenbergische naturf. Gesell. Abh., vol. 19, p. 38, pl. 3, figs. 12–17, 1895.

A foreign form from the Sparnacian of the Paris Basin and scarcely if at all distinguishable from *Asplenium eolignitica* is described in a recent work by Fritel[1] as *Asplenium issyacense.* He compares it with the existing *Asplenium serra* Langsdorf and Fischer, *Asplenium nitens* Swartz, and *Asplenium macrophyllum.* The first is a form common to the Tropics of America and Africa. The second is from the Mascarenes, and the third has a wide range from Ceylon through Malaysia and Polynesia. The genus Asplenium, as conceived in current systematic works devoted to the Filicales, is of very wide geographic distribution, and contains between 300 and 400 existing species, some of which, in addition to those mentioned above, are very close to this fossil form in appearance.

Occurrence.—Ackerman formation, hill along the DeKalb-Herbert road, Kemper County, Miss. (collected by E. W. Hilgard); Wilcox group, Hardys Mill near Gainesville, Greene County, Ark. (collected by J. C. Branner); and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan).

Collections.—U. S. National Museum.

Asplenium hurleyensis Berry, n. sp.

Plate X, figure 1.

Description.—Fronds pinnate. Pinnæ elongate-falcate-lanceolate, gradually tapering to acuminate tips. Base obscure. Length of pinnæ about 7 centimeters. Maximum width about 1 centimeter. Margins finely serrate. Midrib stout, curved. Laterals thin and diverge from the midrib at acute angles, curving almost immediately outward, so that their general course is straight at angles of about 60° with the midrib. The laterals fork once at an acute angle and run directly to the margins. Texture seems to have been coriaceous.

This fine species is unfortunately represented by the single incomplete specimen figured, which is hardly sufficient for a complete description. It is, however, clearly unlike previously described fossil forms, although it shows more or less resemblance to several fossils commonly referred to the genus Pteris. Although not conclusively shown, it seems probable that it represents a species of Asplenium. It is very close to an undescribed form from the Raton coal field in New Mexico, if not identical with it.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe).

Collection.—U. S. National Museum.

Genus PTERIS Linné.

Pteris pseudopinnæformis Lesquereux.

Plate IX, figure 6.

Pteris pinnæformis. Lesquereux (not Heer), U. S. Geol. and Geog. Survey Terr. Ann. Rept for 1870, p. 384, 1871; idem for 1871, p. 283, 1872.

Newberry (not Heer), U. S. Geol. Survey Mon. 35, p. 7, pl. 48, fig. 5, 1898.

Pteris pseudopinnæformis. Lesquereux, The Tertiary flora, p. 52, pl. 4, figs. 3, 4, 1878.

Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 279, pl. 32, fig. 1, 1899.

Knowlton, U. S. Geol. Survey Bull. 204, p. 22, 1902.

Description.—Pinnæ large, linear-lanceolate in outline, gradually narrowed both proximad and distad. Margins entire below, usually to or above the middle; above with obtusely dentate teeth. Texture subcoriaceous. Midrib stout, more or less flexuous, grooved. Laterals diverge from the midrib at acute angles between 35° and 40°. They are thin, subparallel, straight, closely and regularly spaced, and simple or once-forked dichotomously. Rachis stout, alate.

This species, originally referred by both Lesquereux and Newberry to Heer's European Miocene species *Pteris pinnæformis*, is similar to that form in a general way but is entirely distinct. It is generally represented by fragments of pinnæ, the most complete specimen being the one figured by Hollick from Louisiana and refigured in this paper. This specimen is somewhat larger than the western material, the largest pinna being about 20 centimeters in length and nearly 3 centimeters in maximum width in the middle part.

The species has a wide range, having been recorded from the Denver formation at Golden, Colo., and the upper Eocene of Currant Creek, Oreg. (lower part of Clarno formation). It resembles somewhat *Asplenium eolignitica* Berry of the Wilcox flora, which is larger, more coriaceous, and has closer, more numerously forked laterals and prominent serrate marginal teeth. It is represented by a related form in the flora of the Raton formation of the southern

[1] Fritel, P. H., Soc. géol. France Mém. 40, p. 16, pl. 1, figs. 1–4, 1910.

Rocky Mountain province. Its reference to the genus Pteris is entirely problematic and in the present work is made entirely in conformity with previous usage and not based on personal conviction. Its resemblance to the associated species *Asplenium eolignitica* and to certain modern tropical aspleniums leads me to think it may really be referable to Asplenium.

It appears to have an uncommon element in the Wilcox flora.

Occurrence.—Wilcox group, Vineyard Bluff, Cross Bayou, Caddo Parish, La. (collected by A. C. Veatch); 2¾ miles southeast of Naborton, 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins); Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMÆ.

Order CYCADALES.

Family CYCADACEÆ.

Genus ZAMIA Linné.

ZAMIA (?) WILCOXENSIS Berry, n. sp.

Plate CXIV, figure 2.

Description.—Pinnule of medium size, lanceolate in general outline, abruptly narrowed proximad to a constricted base, which is about 5 millimeters in width. The distal half of the pinnule is missing. Estimated length about 7 or 8 centimeters. Maximum width, in the middle part of the length, about 1.4 centimeters. Margins entire, slightly revolute. Texture coriaceous. Venation consists of about twenty longitudinal, subparallel, thin but well-marked veins, slightly reduced in number proximad, where some join their fellows in dichotomous forks.

The material is most unsatisfactory for the characterization of a new form, but though it can not be given a proper diagnosis, it is most clearly new to science and unlike anything heretofore known in the Wilcox flora, so that I prefer to give it a name and trust to the future to furnish more complete material. When compared with the foliage of the two existing species of Zamia found in the Florida region, the fossil agrees very closely with *Zamia pumila* Linné of the east coast hammocks. Detailed comparisons with this or the other existing species of Zamia are obviously without much value in the absence of complete material.

Since Zamia-like foliage is so common and widespread in the Mesozoic and more than 30 species still exist in tropical and subtropical America, two of which are common along the east coast of the Florida Peninsula, it was expected that this or some allied genus of cycads would be found at some point along the Tertiary Gulf coast of southeastern North America. Notwithstanding the probability of their occurrence, they are thus far represented by the single imperfect specimen described and its counterpart.

The rarity of Tertiary species of cycads is responsible for the unusual interest excited by their occurrence. Their cosmopolitanism in the Mesozoic seems to have ended almost abruptly. France, Switzerland, and Greece have furnished Tertiary species, and Engelhardt[1] has described a Zamia from the early Tertiary of South America which is much like this fragment of a Wilcox species.

Occurrence.—Wilcox group, 4½ miles southeast of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

Order CONIFERALES.

Family PINACEÆ.

Genus GLYPTOSTROBUS Endlicher.

GLYPTOSTROBUS EUROPÆUS (Brongniart) Heer.

Plate XV, figure 3.

Taxodium europæum. Brongniart, Annales sci. nat., vol. 30, p. 168, 1833.

Taxodites europæus. Endlicher, Synopsis coniferarum, p. 278, 1847.

Unger, Genera et species plantarum fossilium, p. 350, 1850.

Cupresites racemosus. Göppert, Monographie der fossilen Coniferen, p. 184, 1850.

Glyptostrobus œningensis. Alexander Braun in Stizenberger's Uebersicht der Versteinerungen des Grossherzogthums Baden, p. 73, 1851.

Heer, in Regel's Garten Flora, pl. 65, figs. 1, 2.

Unger, Iconographia plantarum fossilium, p. 21; pl. 11, figs. 1–3, 1852.

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 16, pt. 4, p. 646, pl. 2, fig. 16, 1891.

Glyptostrobus europæus. Heer, Flora tertiaria Helvetiæ, vol. 1, p. 51, pls. 19, 20, 1855.
Ettingshausen, Die fossile Flora von Köflach, p. 10, pl. 1, fig. 2, 1857.
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Zwanziger, Beiträge zur Miocänflora von Liescha, p. 18, pl. 2, figs. 6, 7, 1878.
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Dawson, Roy. Soc. Canada Trans., vol. 8, pt. 4, pp. 34, 791, 1882.
Velenovsky, Die Flora aus den ausgebrannten tertiären Letten von Vřsovic, p. 15, pl. 1, figs. 21–26, 1882.
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Lesquereux, The Cretaceous and Tertiary floras, p. 22?, pl. 46, fig. 1, 1883.
Ettingshausen, Die fossile Flora von Schönegg bei Wies in Steiermark, pt. 1, p. 10, pl. 1, figs. 23–67, 1890.
Boulay, Flore pliocène des environs de Théziers, p. 25, pl. 2, fig. 5, 1890; Flore pliocène du Mont-Dore, p. 101, 1892.
Ettingshausen, Ueber neue Pflanzenfossilien aus den Tertiärschichten Steiermarks, p. 2, 1893.
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Knowlton, Washington Acad. Sci. Proc., vol. 11, pp. 188, 189, 197, 198, 211, 214, 1909.

Glyptostrobus Ungeri. Heer, Flora tertiaria Helvetiæ, vol. 1, p. 52, pl. 18; pl. 21, fig. 1, 1855.
Lesquereux, The Cretaceous and Tertiary floras, p. 139, pl. 22, figs. 1–6a, 1883.
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Glyptostrobus europæus Ungeri. Herr, Flora tertiaria Helvetiæ, vol. 3, p. 159, 1859.
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Heer, idem, vol. 4, p. 58, pl. 11, fig. 28; pl. 12, fig. 1; pl. 31, fig. 6b, 1877.
Heer, idem, vol. 5, pt. 2, pl. 9, figs. 9a, 10–13; pl. 13, figs. 2b, 3, 4b, c, 1878.
Heer, idem, vol. 7, p. 61, pl. 70, figs. 9, 10; pl. 66, figs. 5c, 9; pl. 85, figs. 6–8, 1883.
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Knowlton, Torrey Bot. Club Bull., vol. 29, p. 705, 1902.
Palabin, Russ. k. mineral. Gesell. Verh., 2d ser., vol. 42, p. 58, 1905.

Glyptostrobus bilinicus. Ettingshausen, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 1, p. 39, pl. 11, figs. 1, 2, 10, 1866.

Sequoia Nordenskioldi. Lesquereux (not Heer), U. S. Nat. Mus. Proc., vol. 11, p. 19, 1888.

Description.—Twigs slender, bearing dimorphic foliage. One form carries short thick appressed leaves, the other acute spreading slender leaves. Male catkins ovate, single, sessile on lateral shoots; scales few. Cones ovate, relatively large; scales narrow, imbricated, cuneate at the base, summits expanded, semicircular, with obtusely dentate margins, the dorsum more or less longitudinally costate; seeds inequilateral, winged.

Glyptostrobus europæus is one of the most interesting Tertiary plants. It was discovered nearly a century ago by Brongniart and has been identified from many horizons in Europe, Asia, and America. That it was a cosmopolitan type can not be doubted, for the present distribution of the Taxodieæ is in itself a sufficient indication of this. I have given above a partial synonymy, which must be used with caution, since it is very probable that several closely related species are inextricably tangled in it, but the problem can not be satisfactorily settled without actual specimens from a very large number of localities.

In North America this species is recorded from the basal Eocene to the Pliocene and from the present recorded occurrence in Mississippi northwestward through the Rocky Mountain region, on the Pacific coast, and along the shore of the Arctic, at the mouth of Mackenzie River, and also in Greenland. It is certainly not abundant in the Wilcox and is very sparsely represented by the typical terete twigs with appressed leaves and by seeds. No cones have been found in association with it in the Wilcox and it is possible that this occurrence may represent the twigs of the same small tree represented by cone scales in Tennessee that I have referred to Arthrotaxis, which has foliage that is very similar to that of Glyptostrobus. Since, however, the foliage can not be differentiated from the abundant remains of Glyptostrobus found elsewhere in America and Europe, where the fruiting characters are known, I have identified it as Glyptostrobus. Glyptostrobus contains only two existing species, *G. pendulus* Endlicher and *G. heterophyllus* Endlicher, which are small trees known as water pines, inhabitants of the low river bottoms of certain parts of China.

A multitude of small, irregularly fusiform, inequilateral winged seeds are distributed through the clays at Early Grove, Miss. They are about 5 millimeters long and 1.5 millimeters in maximum width and have a curved oblique nucleus near the broad end. They are not especially well preserved, being ferruginous replacements, but they are clearly of organic origin and except for their slightly smaller size are in exact agreement with the seeds from the Oligocene of Schönegg in Styria referred by Ettingshausen[1] to this species. Similar but still larger remains occur in the Swiss Tertiary, which Heer[2] describes as seeds of Pterospermites but which Ettingshausen is confident are also seeds of Glyptostrobus.

Occurrence.—Holly Springs sand; twigs from ravine at Oxford, Lafayette County, Miss.; and seeds from Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Ettingshausen, C. von, Die fossile flora von Schönegg bei Wies in Steiermark, pt. 1, p. 10, pl. 1, figs. 23-67, 1890.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, pp. 36, 37, pl. 109, figs. 1-6, 1859.

Genus TAXODIUM L. C. Richard.

TAXODIUM DUBIUM (Sternberg) Heer.

Plate XV, figures 4-6.

Phyllites dubius. Sternberg, Flora der Vorwelt, vol. 1, p. 37, pl. 24, fig. 2; pl. 36, figs. 3, 4, or 34, 1824.

Taxodites dubius. Presl in Sternberg's Flora der Vorwelt, vol. 2, p. 204, 1838.

Unger, Genera et species plantarum fossilium, p. 351, 1850: Iconographia plantarum fossilium, p. 20, pl. 10, figs. 1-7.

Göppert, Die tertiäre Flora von Schossnitz, p. 6, pl. 2, figs. 4-16, 1855.

Taxodium distichum fossile. Alexander Braun in Leonhard's Jahrb., 1845.

Pax, Engler's Bot. Jahrb., vol. 40, pp. 53, 66, 72, 1908.

Taxodium Rosthorni. Alexander Braun in Stizenberger's Uebersicht der Versteinerungen des Grossherzogthums Baden, p. 73, 1851.

Taxites affinis. Göppert, Die im Bernstein befindlichen organischen Reste der Vorwelt, p. 104, pl. 3, fig. 30, 1845.

Taxodium dubium (Sternberg). Heer, Flora tertiaria Helvetiæ, vol. 1, p. 49, pl. 17, figs. 3, 15, 1855.

Abich, Acad. Sci. St. Pétersbourg Mém., 6th ser., vol. 7, p. 570, pl. 7, fig. 2, 1858.

Massalongo, Studii sulla flora fossile e geologia stratigrafica del Senigalliese, p. 149, pl. 5, fig. 11; pl. 6, figs. 1, 5, 7, 10; pl. 40, figs. 3, 4, 1859.

Ettingshausen, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 1, p. 34, pl. 10, figs. 13, 20-22; pl. 12, figs. 1-16, 1866.

Saporta, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 191, 1866; idem, vol. 3, p. 150, 1867.

Heer, Flora fossilis arctica, vol. 1, pp. 89, 156, pl. 2, figs. 24-27; pl. 12, fig. 1c, pl. 30, figs. 3, 4; pl. 45, figs. 11a-d, 12, 1868.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 409, 1874.

Zwanziger, Beiträge zur Miocänflora von Liescha, p. 16, pl. 2, fig. 1, 1878.

Sieber, Zur Kenntniss der nordböhmischen Braunkohlenflora, p. 93, 1880.

Velenovsky, Die Flora aus den ausgebrannten tertiären Letten von Vřsovic, p. 14, pl. 1, fig. 27, 1882.

Gaudin, Contributions à la flore fossile italienne, pt. 2, p. 35, pl. 2, figs. 1, 5, 10-13; pl. 10, fig. 4, 1889.

Engelhardt, Flora aus den unteren Paludinenschichten des Caplagrabens, p. 173, pl. 1, figs. 5-11, 19, 20, 1894.

Prindle, U. S. Geol. Survey Bull. 375, p. 26, 1909.

Engel, Geognostischer Wegweiser durch Württemberg, p. 550, 1908 (1909).

Taxodium distichum miocenum. Heer, Miocene baltische Flora, p. 18, pl. 2; pl. 3, figs. 6, 7, 1869.

Schimper, Paléontologie végétale, vol. 2, p. 323, 1870.

Heer, Flora fossilis arctica, vol. 2, pp. 32, 463, pl. 3; pl. 4, figs. 13b, 27b, 27c; pl. 11, fig. 7c; pl. 16, figs. 8b, 8c, 38d; pl. 43, figs. 4, 5, 1871.

Taxodium distichum miocenum. Heer, idem, vol. 3, pt. 2, pp. 9, 13, 16, 19, pl. 1, figs. 13d, 15b, 4b; pl. 2, figs. 20d, 21; pl. 4, fig. 5, 1874.
Heer, idem, vol. 4, p. 57, pl. 13, figs. 12, 13; pl. 25, figs. 9, 13, 1877.
Heer, idem, vol. 5, pt. 1, p. 23, pl. 2; pt. 4, p. 33, pl. 8, fig. 25b; pl. 9, fig. 1; pt. 6, pp. 49, 52, pl. 15, figs. 1, 2, 10–12; pt. 7, pp. 22, 60, pl. 1, fig. 9; pl. 70, fig. 11; pl. 87, fig. 7; pl. 88, fig. 2b; pl. 96, figs. 8, 9, 1878.
Dawson, Roy. Soc. Canada Trans., vol. 8, sec. 4, p. 79, 1882.
Nathorst, Pal. Abh. Dames und Keyser, vol. 4, Heft 3, p. 7, pl. 1, fig. 4, 1888.
Ettingshausen, Die fossile Flora von Schönegg bei Wies in Steiermark, pt. 1, p. 10, 1890.
Peola, Le conifere terziarie del Piemonte, p. 53, 1893: Riv. ital. paleont., vol. 5, p. 96, 1899: Soc. geol. ital. Boll., vol. 18, pp. 45, 228, 1899.
Newberry, U. S. Geol. Survey Mon. 35, p. 22, 1898.
Paolucci, Nuovi materiali e ricerche critiche sulle piante fossili terziarie dei gessi di Ancona, p. 12, pl. 2, figs. 12–14, 1896.
Knowlton, U. S. Geol. Survey Bull. 204, p. 27, 1902.
Knowlton, Alaska, vol. 4, p. 152, Harriman Alaska Expedition, 1904.
Penhallow, Roy. Soc. Canada Trans., 2d ser., vol. 8, sec. 4, pp. 51, 68, 1902.
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Penhallow, Canada Geol. Survey Summary for 1904, pp. 7, 8.
Menzel, K. preuss. geol. Landesanstalt Abh., Neue Folge, Heft 46, p. 6, 1906.
Knowlton, Washington Acad. Sci. Proc., vol. 11, pp. 204, 207, 215, 1909.
Berry, Jour. Geology, vol. 17, p. 22, pl. 1, 1909.
Schullerus, Siebenbürgischer Verein Naturw. Hermannstadt Verh. u. Mitt., vol. 59, p. 147, fig. 43, 1909.
Reininger, K.-k. geol. Reichsanstalt Jahrb., vol. 58, p. 510, 1909.
Engel, Geognostischer Wegweiser durch Württemberg, p. 561, 1908 (1909).
Gothan, Die Natur, vol. 6, pp. 101, 102, fig. 57b, 1909.
Fritel, Soc. géol. France Mém. 40, p. 24, 1910.

Abies nevadensis. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 372, 1874.

Taxodium distichum. Von Gellhorn, K. preuss. geol. Landesanstalt Jahrb. für 1893 Abh., p. 3, pl. 1, fig. 1.
Rein, Naturh. Verein preuss. Rheinlande und Westfalens Sitzungsber. 1907, pp. 37, 38, 1908.
Fliegel, Blatt Frechen, Gradabt. 66, No. 3, p. 17, 1909.
Keilhack and Schmierer, Blatt Senftenberg, Gradabt. 59, No. 29, p. 13, 1909.
Fritel, Cong. Soc. sav. Compt. rend., 1908, p. 316, 1909.

Description.—Heer's description in 1855 is as follows:

T. ramis perennibus foliis squamæformibus tectis, ramulis caducis filiformibus, foliis approximatis distantibus, alternis, distichis, breviter petiolatis, lineari-lanceolatis, planis, uninerviis.

Remains of foliage, cone scales, seeds, staminate catkins and wood, which have been referred to this species, characterize the Tertiary of Eurasia and North America. The records embrace innumerable localities and horizons, from the island of Sakhalin westward to France and Spitzbergen; from Grinnell Land, Alaska, and Greenland southward to Wyoming and Virginia. The European records extend from the Sparnacian to the close of the Pliocene and the American records from the Lance formation (Eocene?) to the Calvert formation of the Chesapeake Miocene.

It is quite possible that more than one botanic species is represented by this host of records, and the impracticability of separating some of them from the existing bald cypress, *Taxodium distichum* Richard, as well as a considerable range of variation, lends weight to this conclusion. However, no satisfactory constant characters for a segregation are observable, and the conclusion is inevitable that a single or closely related series of forms, very much like the modern bald cypress in characters and habit, extended widely over the northern hemisphere during the Tertiary period.

In general the deciduous twigs are larger than in *Taxodium distichum*, and the leaves are longer, broader, and more lanceolate. There is, however, considerable variation even on a single twig. Thus, the larger specimen figured from Pinson shows some elliptical leaves like those of *Taxodium occidentale* Newberry.[1] They may be distinguished from the contemporaneous *Sequoia langsdorfii* (Brongniart) Heer,[2] an equally widespread form with which they are liable to be confused, owing to the fact that their leaves are narrowed to a petiole at the base and are not decurrent.

The abundant preservation of the twigs strongly reminds the collector of the occurrence of the twigs of the modern species in the Pleistocene deposits of our Southern States or the appearance of the estuaries and bayous after a windstorm, when the surface of the water is thickly strewn with the floating twigs and in

[1] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 23, pl. 26, figs. 1–2, 1898.
[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 1, p. 54, pl. 20, fig. 2; pl. 21, fig. 4, 1855.

places the estuary shores are strewn with windrows chiefly of the detached leaves. These deciduous twigs are also a considerable element in the formation of peat in the South Atlantic and Gulf States. Every consideration of distribution and character indicates that *Taxodium dubium* was much like *Taxodium distichum* in appearance, structure, and habit. The similar deciduous foliage, fructification characters, and wood anatomy show that it required much the same environment as its closely related descendant. The species found with it and the lack of terrigenous materials in the sediments where it is commonest, as in the diatomaceous beds of our east coast Miocene, indicate that it dwelt in swamps and was preeminently a coastal species.

It has been found only at the one locality in the Wilcox and it is not especially common. It is also much macerated, which indicates probably a riverside swamp habitat, somewhat removed from the coastal zone. The absence of the cypress at the numerous other Wilcox localities is positive proof that the species was not abundant in the embayment area during the Eocene. Conditions of topography, rainfall, and humidity were especially favorable for its extensive development at this time, and the question arises, Why was it largely absent? It is believed that the only answer to this question is that the temperature was too high for its optimum conditions of existence. It was likewise absent during the more torrid periods of the Eocene in Europe, as for example the Lutetian of the Paris Basin and the south of England, and at about this time it was common in far northern areas—Alaska, Grinnell Land, Greenland, and Spitzbergen. This is in conformity with all the paleobotanic and paleozoologic facts derived from a study of our southern earlier Tertiary, which indicate an advance of tropical climate northward over many degrees of latitude, pushing warm temperate conditions northward well beyond the Arctic Circle.

A single doubtful fragment of what appears to be a twig of this species has been found in the lower part of the Claiborne group (St. Maurice formation) of Arkansas. From the Sparnacian of the Paris Basin Fritel[1] has figured specimens of the dimorphic *Sequoia tournali* (Brongniart) Saporta, which in their general aspect and variation of the broad-leafed forms, strongly suggest *Taxodium dubium*. It may be significant that the reduced foliage associated with the cones is more Sequoia-like than the broad-leafed twigs.

Occurrence.—Lagrange formation (in beds of Wilcox age), Pinson, Madison County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Taxodium sp.

Plate XV, figure 9.

Description.—An unmistakable seed of a species of Taxodium occurs in the plastic clays of Wilcox age west of Grand Junction. It is rather larger than the average seed of the existing *Taxodium distichum*, measuring 1.25 centimeters in length by 9.5 millimeters in maximum width. In its irregular form it is not distinguishable from recent seeds of members of this genus and it is probably a seed of the same species that is represented by foliage in the deposits near Pinson.

Occurrence.—Lagrange formation (in beds of Wilcox age), $1\frac{1}{2}$ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Subfamily TAXODIEÆ.

Genus ARTHROTAXIS Don.

Arthrotaxis (?) eolignitica Berry, n. sp.

Plate XV, figures 1 and 2.

Description.—Cone scale small, rhomboidal in cross section, ligneous, with a rounded keel or lower (morphologically dorsal) angle, and a thick base, expanding regularly outward to the enlarged truncate tip. Lateral outlines straight. Costate; ribs well shown in the figured specimens. Length about 1 centimeter or slightly less. Diameter at the base about 2 millimeters, across the expanded apex about 6 millimeters; wider than high and flattened on upper (ventral) side, indicating that the scales were ascending and slightly imbricated.

These well-marked cone scales are not uncommon in the clays at Puryear, Tenn. They do not suggest any of the modern conifers that bear deciduous scales, but on the other hand they strongly suggest certain Cretaceous conifers such as Geinitzia, Sphenolepis, and Arthrotaxopsis, all of which I have recently handled

[1] Fritel, P. H., Soc. géol. France Mém. 40, pl. 2, figs. 2-12, 1910.

in large numbers. They may be compared with the cone scales of the existing genus Arthrotaxis more satisfactorily than with any other conifers. They do not on the other hand offer any satisfactory points of contact with the genera Glyptostrobus or Taxodium, which are represented by foliage in the Wilcox flora. In fact these cone scales, in the absence of fruits of the foregoing genera, suggest that possibly the foliage identified as Glyptostrobus may be that of Arthrotaxis.

The modern species of Arthrotaxis are relatively small trees of mesophytic habitat, allied to Sequoia, but confined entirely to Tasmania.

But few fossil species have been recognized. Gardner[1] describes foliage and cones from the Ypresian of the Isle of Sheppey as *Arthrotaxis subulata*. The cones are slightly smaller but comparable with the present species. The same author furnished good evidence[2] for considering certain remains from the Bartonian and Ligurian of southern England which were formerly referred to *Sequoia couttsiæ* Heer to be more closely related to Arthrotaxis. These specimens also are similar to the Wilcox form.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CUPRESSINOXYLON Göppert.

CUPRESSINOXYLON CALLI Knowlton.

Plate XVI, figures 1–5.

Cupressinoxylon Calli. Knowlton, Geol. Survey Ann. Rept. Arkansas for 1889, vol. 2, p. 254, pl. 9, figs. 3–7, 1891.

Description.—This species was based on collections from a silicified stem standing erect in place in a bluish clay. The species shows a distinct seasonal ring, 1 millimeter to 3.5 millimeters broad, marked by a series of reduced, very much thickened tracheids, 6 to 15 or more in number. The tracheids show two or three close rows of bordered pits on their radial walls, 0.012 millimeter in diameter. Medullary rays numerous, separated by two to four rows of tracheids, thin walled, uniseriate, and from 2 to 25 (average, 6 to 15) cells high. Some of the tracheids show pits on their lateral walls, of which there are usually 3 in the thickness of each tracheid. Resin tubes consist of a chain of short rectangular cells.[3]

This species is unquestionably from deposits now referred to the Wilcox and is unique in having been found erect at its place of growth.

Occurrence.—Wilcox group, 5½ miles northwest of Gainesville, Greene County, Ark. (collected by R. E. Call).

Collection.—U. S. National Museum.

Class ANGIOSPERMÆ.

Subclass MONOCOTYLEDONÆ.

Order GRAMINALES.

Family POACEÆ.

Genus POACITES Brongniart.

POACITES sp. Hollick.

Poacites sp. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 279, pl. 32, fig. 2, 1899.

Description. — Indefinite fragmentary remains of the foliage of some monocotyledon, thought to be a grass by Hollick and described as Poacites sp. He compared it with the European Tertiary species *Poacites lævis* Alexander Braun and *Poacites firmus* Heer.

I have collected numerous similar fragmentary specimens of foliage of grasses or sedges, but none more complete than Hollick's material. I have decided that they are too indefinite for specific description, and thus are of no stratigraphic value. I have therefore ignored them entirely, except this and the following so-called species, which are in the literature.

Occurrence.—Wilcox group, Slaughter Pen Bluff on Cross Bayou, Caddo Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

Family CYPERACEÆ.

Genus CYPERITES Heer.

CYPERITES sp. Hollick.

Cyperites sp. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 279, pl. 32, figs. 3, 4, 1899.

Description.—Like the preceding species this is based on fragments of monocotyledonous foliage which are considered by Hollick to be

[1] Gardner, J. S., British Eocene flora, vol. 2, p. 43, 1883; pl. 11, figs. 2–14, 1884.

[2] Idem, p. 90, pl. 6, figs. 1–9; pl. 10, figs. 6–9; pl. 22, fig. 10; pl. 27, figs. 4, 4a, 1884.

[3] Description based on Knowlton's work. The specimens of wood collected during my study of the Wilcox were not sectioned in time for the results to be included in this volume. They will form the basis for a subsequent special contribution.

referable to the genus Cyperites, although he remarks that they might equally well be considered as fragments of palm rays.

I have found similar specimens at different localities, but they are so incomplete that they have neither biologic nor geologic value. Any unprofitable discussion of them is therefore omitted.

Occurrence.—Wilcox group, Slaughter Pen Bluff on Cross Bayou, Caddo Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

Order ARALES.

Family ARACEÆ.

Genus PISTIA Linné.

PISTIA WILCOXENSIS Berry, n. sp.

Plate CXIII, figure 4.

Description.—Leaves elliptical in outline, with a broadly rounded or slightly truncated apex and a broadly rounded base. Petiole missing. Length about 4.25 cubic centimeters. Maximum width, in the median region, about 3.6 cubic centimeters. Margins entire. Texture of considerable consistency. Venation entirely of a single caliber, fasciculate-flabellate, forming by repeated and somewhat irregular cross branches an open polygonal mesh.

This species is based on the single specimen figured and its counterpart. It is unquestionably referable to Pistia and is strictly comparable with the still existing forms of that genus. It is clearly distinct from previously described fossil forms of Pistia, although in size and venation it is much like *Pistia corrugata* described by Lesquereux from the Upper Cretaceous of the western interior region.

In size, outline, and venation this Wilcox species is not very different from the modern *Pistia stratiotes* Linné, which occurs in the coastal regions of our Gulf States and is common in tropical estuaries like that of the Guayaquil of Ecuador. Engler[1] has united in this single species all the living representatives of the genus. The result of Engler's classification makes this a somewhat variable and widely distributed species, in general confined to the tropical and subtropical regions. In this country it is found from Florida to Texas. It occurs in the West Indies and southward through Mexico and Central America to Paraguay and northern Argentina. In Africa it occurs from Natal to Senegambia and Nubia, and also in Madagascar and the Mascarene Islands. In Asia it appears throughout the East Indies and northward to the Philippines.

Few fossil forms have been referred to this genus. Hosius and Von der Marck[2] described in 1880 a form which they called *Pistites loriformis* from the Emscherian of Westphalia, but this is probably cycadean in nature, as Schimper suggested.[3] Lesquereux[4] in 1876 named a remarkably well preserved form from Wyoming *Pistia corrugata*, and later fully described and illustrated it,[5] his specimens including leaves of different sizes and rootlets. These specimens came from the Montana group, which is of about the same age as the French beds from which Saporta and Marion[6] described *Pistia mazelii*. I have recently shown[7] that Heer's *Chondrophyllum nordenskioldi*, described from the Atane beds of Greenland, is a true Pistia and is exceedingly abundant in the Black Creek formation (Upper Cretaceous) of North Carolina. The only Tertiary species previously known is *Pistia claibornensis* Berry, described recently[8] from the upper Claiborne of Georgia. This species is markedly different from the Wilcox species, being broad and retuse, approaching in these features some of the older leaves of the existing American form.

Occurrence.—Wilcox group, 4½ miles southeast of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

Genus ARACEÆITES Fritel.[9]

ARACEÆITES FRITELI Berry, n. sp.

Plate CXIV, figures 3 and 4.

Description.—Flattened remains, seemingly of a large, many-fruited spadix, which may be incompletely characterized as follows: Spadix large elongate-cylindrical; the incomplete specimen has a length of 6.5 centimeters and a max-

[1] Die natürlichen Pflanzenfamilien.

[2] Palæontographica, vol. 26, p. 182, pl. 38, figs. 151-152, 1880.

[3] In Zittel's Handbuch, p. 378, 1890.

[4] U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 299, 1876.

[5] Lesquereux, Leo, The Tertiary flora, p. 103, pl. 61, figs. 1, 3-7, 9-11, 1883.

[6] Saporta, G. de, and Marion, A. F., L'évolution du règne végétale, Phanérogames, vol. 2, p. 37, figs. 114c, 114d, 1885.

[7] Berry, E. W., Torrey Bot. Club Bull., vol. 37, p. 189, pl. 21, figs. 1-15, 1910.

[8] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 137, pl. 26, figs. 1, 2, 1914.

[9] Fritel, P. H., Soc. géol. France Mém., vol. 16, no. 4, p. 28, 1910.

imum width of 2.5 centimeters. Fruits single seeded, numerous, oblate-spheroidal in shape, circular in transverse section, about 2.25 millimeters in diameter, and about 4 or 5 millimeters in length, united and nearly immersed in a compact spadix. Outline of the coalesced perianth (if present) deformed by pressure, seen to be angular in some parts of the specimen and apparently hexagonal.

The remains on which this species is founded are unfortunately scanty and imperfectly preserved in clay ironstone, so that the interpretation must be accepted with due reserve. Comparisons have been made with a variety of botanic material. The first fragments were thought to represent a small crushed compound fruit comparable with Nelumbo, and comparisons were also made with the cicatrices of the rhizomes of certain Nymphæaceæ. When the larger figured specimen was worked out of the matrix it at once suggested a spadix of some aroid. The only other alternative that seemed worthy of consideration was that the fossil might represent a small-fruited Artocarpus, the leaves of that genus being common in these beds. The apparent remains of Artocarpus fruits have been described by Heer[1] from the Tertiary of Switzerland, by Nathorst[2] from the Cretaceous of Greenland, and by Marty[3] from the Miocene of France. The Wilcox remains, however, do not compare favorably with these fossils nor with the living material of Artocarpus.

The genus Araceæites Fritel, to which the present fossils are referred, was described in 1910 from material of Sparnacian age (the same age as a part of the Wilcox group) from the Paris Basin. It was proposed for araceous remains of this sort of not determinable generic affinity and was based on a single form, smaller and better preserved than that from the Wilcox, compared by its describer with the existing *Spathiphyllum floribundum* Engler and *S. lanceolatum* Kotz, both of northern South America. The genus Spathiphyllum Schott comprises about a score of existing species, all but one of which, an East Indian form, are confined to tropical America. Another genus with which the fossil may be compared is Monstera Adanson, which is represented by about 15 species in tropical America. The individual fruits of the fossil are very similar in appearance to those of *Monstera deliciosa* Liebman, with which it has been compared, and probably to those of other species of Monstera, of which material was not readily available for comparison.

The species under discussion is named in recognition of the fine work of P. H. Fritel, of the Paris Museum, in his revision of the Tertiary floras of the Paris Basin.

Occurrence.—Wilcox group, 4½ miles southwest of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

Order ARECALES.

Family ARECACEÆ.

Genus NIPADITES Bowerbank.

NIPADITES BURTINI Brongniart var. UMBONATUS Bowerbank.

Plate CXII, figures 13 and 14.

Nipadites umbonatus. Bowerbank, A history of the fossil fruits and seeds of the London clay, p. 9, pl. 1, 1840.[4]

Description.—Drupelike fruits of different sizes, ranging from 5 to 8 centimeters in length and from 3 to 5 centimeters in diameter, obovate in outline with a narrowed truncated base and a broadly rounded, umbilicate apex. Surface fibrous and obscurely angled.

This material consists of compressed, rather illy preserved but perfectly characteristic fruits of a nipa-like palm found in the hard clay of Grenada. Similar remains were noted from the English Eocene by Parsons as early as 1757 and from the Belgian Eocene by Burtin in 1784. In 1840 Bowerbank recognized their true affinity and proposed the name Nipadites, describing 13 species from the London clay of the Isle of Sheppey (Ypresian). Later authors have greatly reduced the number of species, recognizing that the variations were due in a large measure to the position of the fruits in the head and their condition of preservation. It is quite possible to match these Eocene fruits from Mississippi with one or more of Bowerbank's types, but in the main they are most closely allied to his species *umbonatus*, which Ettingshausen[5] in 1879 referred to *Nipadites*

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 69, pl. 84, fig. 7, 1856.

[2] Nathorst, A. G., Kgl. Svenska Vetens.-Akad. Handl., vol. 24, pp. 1-10, pl. 1, 1890.

[3] Marty, P., Flore miocène de Joursac, p. 50, pl. 9, figs. 11, 12, 1903.

[4] Those interested will find the detailed synonymy of *Nipadites burtini* in the paper by A. C. Seward and E. A. N. Arber (Mus. roy. hist. nat. Belgique Mém., vol. 2, 1903).

[5] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 29, p. 393, 1879.

A. HABITAT OF THE NIPA PALM, NIPA FRUCTICANS, LUZON, PHILIPPINE ISLANDS.
Photo by Philippine Bureau of Science.

B. HABITAT OF THE BLACK MANGROVE, AVICENNIA NITIDA, PONCE, PORTO RICO.
Photo by Marshall A. Howe.

burtini Brongniart, the species to which Seward and Arber refer all the nipa fruits from the lower, middle, and upper Eocene of Belgium. Though it is improbable that a single species ranges throughout the Eocene, and though I also regard it as improbable that the American and European forms are specifically identical, in spite of their contemporaneity and their distribution by ocean currents, no reliable characters separate the American from the European form.

The occurrence of Nipadites in the early Eocene of the Mississippi embayment is of the greatest interest, as it throws so much light on the contemporaneous physical conditions. In the existing flora the genus Nipa is monotypic and stands in an isolated position among the palms, formerly being placed with the family Pandanaceæ. The existing nipa palm is a stemless form, some of whose large pinnate leaves attain 25 feet in length. It inhabits the tidal waters of the Indian Ocean, ranging from India through the Malay Archipelago to the Philippines and vying with the mangroves for possession of the tidal flats. It produces clusters of large fruits which are distributed by ocean currents. During the Eocene the closely allied if not identical genus Nipadites is represented by the characteristic fruits in southern England, Belgium, France, northern Italy, southern Russia, and northern Egypt. Until the present discovery in Mississippi neither Nipa or Nipadites had been found in the living or fossil floras of the Western Hemisphere.

A characteristic view of the habit and the habitat of the modern Nipa is shown on Plate VII, *A*.

The path of migration by which these palms were introduced into the Eocene Gulf of Mexico is worth considering. Since their remains are so widespread and common in the early Tertiary deposits of the Mediterranean region, and since they occur there earlier than in America, it seems probable that they represent an introduced element in the Wilcox flora. Their fruits may have reached this hemisphere by floating across the Atlantic, which would not be possible if the Atlantic Ocean currents of the Eocene were at all similar to those of the present time. On the other hand, the more probable hypothesis is that their range may have covered Oceanica during the late Cretaceous and early Eocene, and they may have been carried by ocean currents across the submerged lands of Central America and into the Mississippi Gulf.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by Lowe and Berry).

Collection.—U. S. National Museum.

Genus SABALITES Saporta.

SABALITES GRAYANUS Lesquereux.

Plates XII, figures 1–3, and XIV, figure 1.

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.)

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

Description.—Lesquereux's description, published in 1869, is as follows:

S. fronde petiolate, rachide in plano posteriore subplana, e basi dilatata ovata, lineari cuspidata 6–8 policari; foliis flabelliformibus, radiis numerosis, elongatis, sensim dilatatis, nervulis distantibus, gracilimis.

This somewhat protean species was described by Lesquereux from the soft white ("Eolignitic") clay of Lafayette County, Miss. None of Lesquereux's specimens of it can at present be found in the Hilgard collection, but it seems very probable that the type came from the railroad cut just north of Oxford. Not only is this the sole locality in the county known to the writer where these white clays are fossiliferous but there are several specimens of this species from this locality in the collections of the University of Mississippi, which have been collected at different times by different individuals, and some of these fragments may possibly represent Lesquereux's type material. There is also a specimen from this outcrop in the collections of the United States National Museum, collected some 15 or 20 years ago by Mr. T. O. Mabry.

Within the next 10 years after his original characterization of this species Lesquereux identified it from a large number of western localities in Colorado, Wyoming, and on Vancouver Island. Nearly all this material is now in the National Museum. In my judgment all these determinations are open to very grave doubt, not only on account of the inadequacy of the material but also because of the a priori improbability of a single species ranging from the Cretaceous Montana group to a horizon well above the base of the Eocene at such widely removed localities, in the one area associated with a subtropical coastal flora, which suggests the existing flora of the West Indies and northern South America and which advanced northward in the Mississippi embayment region, and in the western area associated with a very different type of flora.

It is quite true that the determination of the foliage of fossil palms is often beset with unusual if not insuperable difficulties, as witness the parallel range both geographic and geologic, that is accorded to *Sabal major* Heer by European students, a range extending from England, France, and Italy to India and from the Eocene through the Oligocene and Miocene to the Pontian stage.

Since the original description of *Sabalites grayanus* is more or less incomplete and all subsequent descriptions have been either composite or else based on material which I would exclude from this species, it becomes important to give as complete a description of this palm, based on the present material from the type locality and adjacent localities of the same age, as is possible from the nature of the remains.

Leaves of large size but mostly fragmentary. Estimated diameter in some of the larger specimens, where nearly half the leaf is preserved, as great as 1.3 meters. Most of the leaves are somewhat smaller than this, no doubt because the larger the leaves the more fragmentary they would be likely to become before fossilization. Petiole long and stout, unarmed, enlarged at the base of the leaf, and tapering into an extended and gradually narrowed acumen, which is not visible on the upper surface of the leaf, where the petiole is broadly rounded and a short and inconspicuous ligule is developed. From the manner of preservation and attitude of the rays on some of the specimens it is inferred that the acumen was recurved as it is in the existing *Sabal palmetto* (Walter) Roemer and Schultes. Rays very numerous, about 100 in number, a few reduced basal ones on each side free, the remainder united for a variable distance above the base. Their dimensions and the relative thickness of the venation are variable features dependent on the size of the leaves. The largest specimens seen have thick carinate stout-veined rays, 5 centimeters in maximum width. They increase in size from the base of the leaf upward and individually they are narrow at their point of attachment, widening medially and becoming gradually narrowed into long acuminate tips. Venation characters variable, largely dependent on the size of the leaves and the condition of preservation of the epidermis in the fossil specimens. In well-preserved material there are four or five relatively thin intermediate veins. Between each pair of veins there are six to eight fine veinlets, which are not visible except in well-preserved specimens. The species seems to be infested by at least two species of leaf-spot fungi.

This species appears to have been a common form during Wilcox time. It is more like the modern *Sabal palmetto* than any other existing species, and, like it, was probably a form that did not extend inland any great distance. It appears to have been an arborescent form and less gregarious than, for example, our other existing species of Sabal and Serenoa. It is very common in the deposits near Oxford, and perfect leaves are not uncommon, but it is impossible to get out good specimens from the massive and more or less jointed clays. A single fragment of a ray from Wilson County, Tex., is doubtfully referred to this species.

It is a striking illustration of the wealth of plant material entombed in the clays of the embayment area, as well as of the inadequacy of arguments based on the absence of certain genera in the collection, that very extensive collections from Puryear should have furnished only two or three fragments of single rays of this species, and yet a single specimen of clay from this locality, exhibited at the Louisiana Purchase Exposition (St. Louis) by a clay-mining company, should show a fine specimen of the central part of a leaf, with the acumen preserved. I am indebted to Prof. L. C. Glenn, of Vanderbilt University, for the loan of this specimen. The western form, from Black Buttes, Wyo., described originally by Lesquereux as *Flabellaria eocenica* and later found to be common in the Raton and Denver formations, undoubtedly represents *Sabalites grayanus*.

Occurrence.—Holly Springs sand, Oxford, Lafayette County, Miss. (collected by E. W. Hilgard, T. O. Mabry, and E. W. Berry), and Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. W. Berry). Wilcox group: Benton, Saline County, Ark. (collected by E. W. Berry); and near

Boydsville, Clay County, Ark. (collected by E. W. Berry); sec. 12, T. 17 N., R. 15 W., near Shreveport, Caddo Parish, and 5 miles southeast of Naborton, De Soto Parish, La. (collected by O.B. Hopkins); Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age): Breedlove Pit, near Henry, Henry County, Tenn. (collected by E. W. Berry); Pinson, Madison County, Tenn. (collected by E. W. Berry); and Baughs Bridge, Wolf River, near La Grange, Fayette County, Tenn. (collected by L. C. Johnson). Beds of Wilcox age: Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum; University of Mississippi.

Genus CHAMÆDOREA Willdenow.

CHAMÆDOREA DANAI (Lesquereux).

Plates XII, figure 4, and XIII, figures 1-3.

Cycas. Hilgard, Report on the geology and agriculture of Mississippi, pp. 108, 117, 1860.
Calamopsis Danai. Lesquereux in Dana, Manual of geology, 1st ed., p. 513, fig. 795, 1866.
Calamopsis Danai. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 411, pl. 14, figs. 1-3, 1869.

Description.—Lesquereux's description, published in 1869, is as follows:

C. foliis magnis, frondosis, pinnatis; pinnis gramineis, planis, oppositis, æquidistantibus, basi subattenuatis; nervis primariis 3-5 æqualibus, secondariis unicis, gracilioribus, lineales areas dividentibus, nervulis minimis, parallelibus, approximatis, notatas.

This handsome feather palm is represented by rather scanty material, that collected by Hilgard more than 50 years ago being by far the best that has come to light. Lesquereux's figured specimens are still preserved in the Hilgard collection, and with this and some additional material for study the writer is unable to verify Lesquereux's diagnosis in several rather important particulars. In the first place, the leaflets or rays are not opposite; they are markedly decurrent, and a fairly prominent midrib is found in all the material. The species may be recharacterized as follows: Rachis long and slender, bearing numerous alternate leaflets, at least more than a dozen pairs. These leaflets are linear-lanceolate in outline, the tips are extended and gradually narrowed, and the bases are more abruptly narrowed. They form an angle of about 40° with the rachis, but this angle may have been wider toward the base, as all the preserved specimens are from the distal half of the leaf. These lateral rays or leaflets (pinnæ) differ considerably in size, the maximum dimensions being 30 centimeters in estimated length and 2.5 centimeters in width in the basal half of the leaflet. The average dimensions appear to be about 25 centimeters in length by 1.5 centimeters in maximum width. The venation consists of a markedly decurrent midrib of about twice the caliber of the secondaries. Secondaries, one or two on each side parallel with the midrib. Halfway between the adjoining pairs of secondaries, or between the secondaries and the midrib, are fine tertiaries, the outside one on each side running rather close to the margin at a distance from the outside secondary that amounts to half the space between that secondary and the one next to it. In each of the areas between a secondary and a tertiary there are from three to five very fine, equally spaced, parallel veinlets, and there are one or two of these veinlets between the outside tertiary and the margin. No transverse nervilles are visible with magnification. This characteristic venation is illustrated in Plate XIII, figure 3, which shows the appearance and relative dimensions when enlarged four times of a ray with a single secondary on each side. In texture the leaflets seem to be thin, but of a firm consistency. Figure 12 (p. 180) shows a much reduced restoration of a complete leaf.

The genus Calamopsis, to which Lesquereux referred this species, was described by Heer[1] in 1859 with *Calamopsis bredana* from the Tortonian of Baden as the type and only species. Its distinguishing character was the absence of a midrib. This suggested to Prof. Heer a comparison with the numerous oriental species of the Recent genera Calamus, Plectocomia, and Zalacca. Schenk[2] in his discussion of Heer's species considers it to be referable to the subfamily Phœniceæ and that it is allied with those species usually referred to Brongniart's genus *Phœnicites.*

Schenk appears not to have been familiar with Lesquereux's species, although that species was published nearly a score of years before. I am unable to judge from Heer's figures whether the basis for Schenk's suggestion is

[1] Herr, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 169, pl. 149, 1859.
[2] Schenk, A., in Zittel's Handbuch der Palaeontologie, Abth. 2, Lief 4, p. 373, 1885.

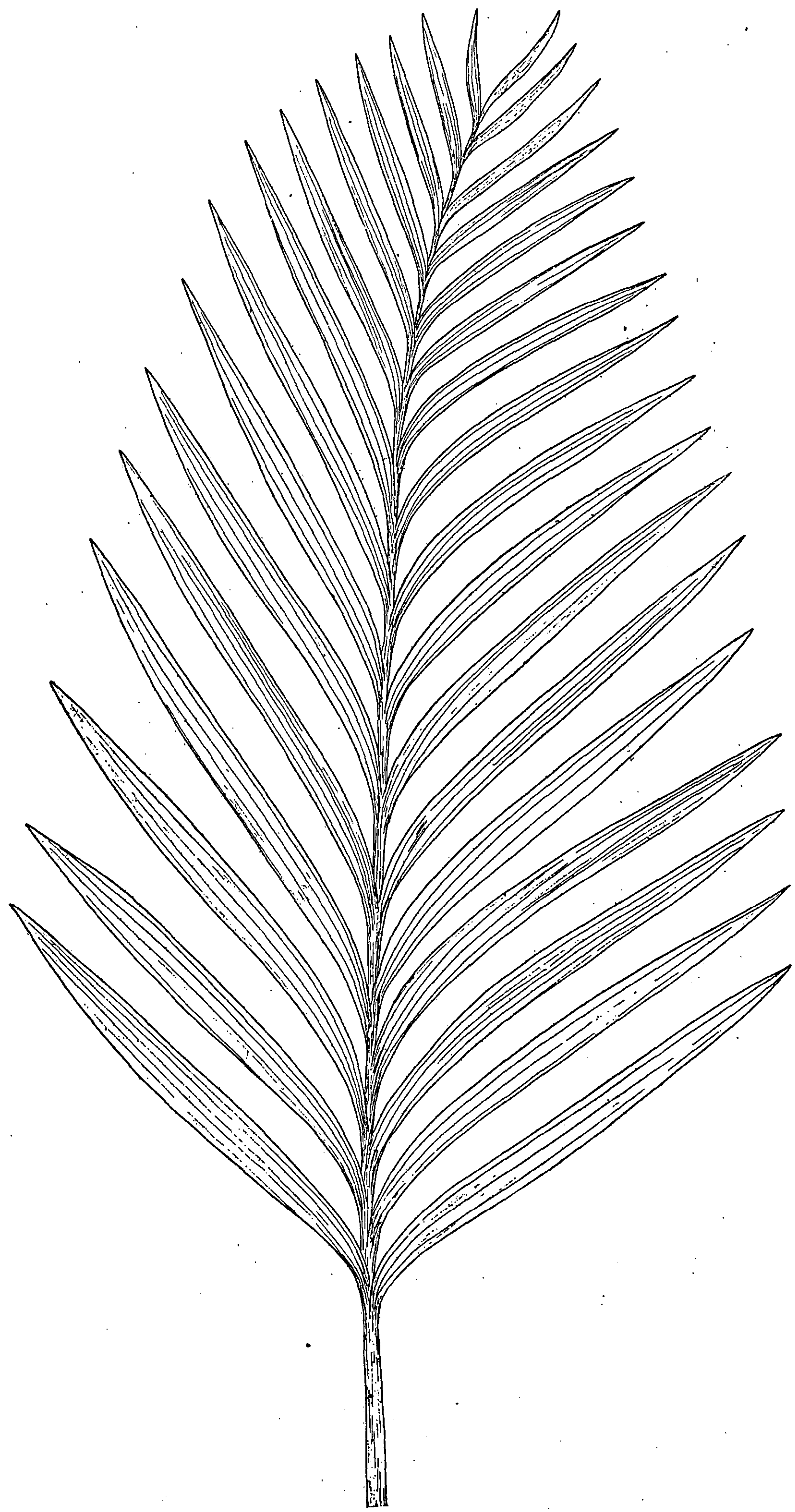

FIGURE 12.—Restoration of a leaf of *Chamædorea danai* (Lesquereux) Berry. (About one-third natural size.)

sound, but the present species from Mississippi can not be retained in the genus Calamopsis, even if that is a valid genus.

The present species appears to be closely related to the existing genus Chamædorea of Willdenow, a genus of small palms with reedlike stems, which commonly spreads by runners. It has, in the existing flora, about 60 species, ranging from central Mexico to Bolivia and Peru in the Andes and in western Brazil. It is richest in species in the humid mountainous region of Central America, and several of these Central American forms are practically indistinguishable from this Wilcox species.

Occurrence.—Ackerman formation, Colemans Mill, Choctaw County, Miss. (collected by E. W. Hilgard). Wilcox group, Benton (?), Saline County, Ark. (collected by R. E. Call).

Collections.—U. S. National Museum.

Order SCITAMINALES.

Family CANNACEÆ.

Genus CANNA Linné.

CANNA EOCENICA Berry, n. sp.

Plate XV, figures 7 and 8.

Description.—Leaves elongate-lanceolate, at least 25 or 30 centimeters in length and probably longer. Maximum width not preserved. Fragments show a width of 6 centimeters on one side of the midrib without reaching the margin. Margins entire, gradually narrowing distad. Midrib stout below, at least 1 centimeter in width, becoming obsolete in the tip. Secondaries thin, equally spaced, subparallel, and numerous, diverging from the midrib at acute angles, 60° in large, presumably proximal fragments, at intervals of about 2 millimeters, becoming increasingly more ascending distad until in the upper part of the leaf they are approximately parallel with each other and with the long axis of the leaf. Tertiaries numerous, thin, several between the secondaries, with which they are parallel. A specimen from Old Port Caddo Landing measures 9 by 26 centimeters and indicates a leaf 12 by 56 centimeters.

This species is not especially well preserved, although it is represented by numerous fragments in the clays of the Holly Springs sand at Oxford, Miss. Larger fragments from the Grenada formation at Grenada, Miss., are better preserved than the specimens figured. It may be compared with numerous existing species of Cannaceæ and Marantaceæ and is referred to Canna because it shows no generic differences and also because more complete forms from the Claiborne group, described in manuscript, are clearly referable to Canna.

The genus Canna is exclusively American and contains from 25 to 50 species, mostly hygrophilous in habit and confined to the Tropics and subtropics. One species, *Canna flaccida* Roscoe, penetrates northward as far as South Carolina in the swamps that skirt the coast. Among fossil forms that are referred to the Scitaminales is the genus Scitaminophyton described by Massalongo from the Italian Tertiary and the genus Cannophyllites of Brongniart, with several species ranging from the Upper Cretaceous to the Pliocene in the European area. Fritel has recently shown that the French Ypresian species of the Paris Basin described originally by Watelet as *Cannophyllites ungeri* is in reality based on fragments of an undeterminable palm.[1] Allied forms supposed to represent the family Zingiberaceæ have been referred to the form genus Zingiberites Heer, which comprises several species, one Upper Cretaceous and the others early Tertiary. One of these species, *Zingiberites dubius* Lesquereux,[2] is based on very fragmentary material from the Denver formation of Colorado not identical with the present species. The Zingiberaceæ is a large family and is confined almost exclusively to the Eastern Hemisphere. Though no competent student would dispute its possible occurrence in the American Tertiary, the evidence should be more complete than that furnished by Lesquereux to be at all convincing.

Another form genus for fossil leaves much like the one under consideration is *Musophyllum*, first described by Göppert for an undoubted Tertiary species of Musaceæ from the island of Java. Ten or a dozen species have since been described from the Tertiary of Europe and one, *Musophyllum complicatum* Lesquereux, from the early Eocene of the Rocky Mountain region. Though it is beyond the province of the present work to discuss at any length the botanic affinities of these species of Musophyllum, I would at least point out that

[1] Jour. botanique, vol. 22, pp. 110, 111, fig. 4, 1909.
[2] Lesquereux, Leo, The Tertiary flora, p. 95, pl. 16, fig. 1, 1878.

in my judgment several species are referable to the Cannaceæ and not to the Musaceæ, as, for example, *Musa bilinica* Ettingshausen, *Musa speciosa* Saporta, and some at least of the forms referred to *Musophyllum complicatum* Lesquereux. Another form which probably represents a species of Canna is *Convallaria latifolia* described by Ludwig[1] from the Aquitanian of Münzenberg, Hesse. Tuzson[2] has also recently described a comparable form from the upper Oligocene of the Zsil Valley in Transylvania as *Schafarzikia oligocænica* gen. et sp. nov.

Occurrence.—Holly Springs sand, Oxford, Lafayette County, Miss., and Grenada formation, Grenada, Grenada County, Miss. (collected by E. W. Berry). Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan).

Collection.—U. S. National Museum.

MONOCOTYLEDONÆ INCERTÆ SEDIS

PHYLLITES WILCOXENSIS Berry, n. sp.

Plate CXII, figure 12.

Description.—Leaves of relatively large size, broadly lanceolate in general outline, apex bluntly pointed and base narrowly cuneate, extended, sheathing. Length about 20 to 25 centimeters. Maximum width, in the middle part of the leaf, about 4 to 5 centimeters. Margins entire. Texture thin, somewhat flabellate. Midrib stout, broad, and flat. Secondaries thin, diverging from the midrib at acute angles and pursuing a flexuously curved course toward the margins, with which they eventually become subparallel until they are lost in the tertiary areolation (dictyodrome). Tertiaries irregularly flabellate, forming laterally elongated, narrow, acutely pointed meshes.

This species is unfortunately based on but two specimens which hardly admit of adequate characterization or identification. It is obviously a netted-veined monocotyledon, and among the netted-veined families it is probably referable to the Araceæ.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

[1] Ludwig, R., Palæontographica, vol. 8, p. 87, pl. 19, fig. 6, 1859.

[2] Tuzson, J., K. ungarischen geol. Anstalt, Mitt. Jahrb., Bd. 21, Heft 8, p. 251, pl. 19, fig. 1, 1914.

Subclass DICOTYLEDONÆ.

Superorder CHORIPETALÆ.

Order JUGLANDALES.

Family JUGLANDACEÆ.

Genus JUGLANS Linné.

(?) JUGLANS SAFFORDIANA Lesquereux.

Juglans Saffordiana. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 20, fig. 7, 1869.

Description.—The description given by Lesquereux in 1869 is as follows:

J. foliis ovate lanceolatis, acutis, basi inæqualiter cordatis, remote obtuse serratis, nervis secundariis angulo suberecto egredientibus, arcuatis.

This species was founded on a single specimen, figured by Lesquereux, which has subsequently disappeared. Lesquereux is positive that the base was cordate, but it appears to me to represent, as far as one may judge from the figure, a specimen of some species of Dryophyllum broken symmetrically across near the middle. There is no plausible reason for regarding it as representing a Juglans, but as I have been unable to correlate it with any other form in the vast amount of Wilcox materials that have passed through my hands, I have left it as above, since it is scarcely worth while to endeavor to discover the botanic affinity of such poor material.

Occurrence.—Lagrange formation (in beds of Wilcox age), La Grange, Fayette County, Tenn. (collected by J. M. Safford).

Collection.—Type lost.

JUGLANS SCHIMPERI Lesquereux.

Plates XVIII, figures 3–5, and XIX, figure 4.

Juglans Schimperi. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. 1871, Suppl., p. 8, 1872; The Tertiary flora, p. 287, pl. 56, figs. 5–10, 1878. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 32, fig. 5; pl. 33, figs. 1, 2; pl. 35, fig. 3, 1899.

Juglans rugosa. Lesquereux (not Lesquereux, 1878), U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888.

Description.—Leaves ovate-lanceolate and somewhat inequilateral in outline. Apex gradually acuminate. Base broadly cuneate or rounded, inequilateral. Size variable; length ranges from 10 to 18 centimeters; maximum width, in middle or lower half of the leaf, from 2 to 4.8 centimeters. Margins entire, slightly undulate. Petiolule generally not preserved; in some of the specimens from Wyoming it ranges from 3 to 7 millimeters in length. Midrib stout, usually curved. Secondaries thin, numerous, rather evenly spaced, subparallel, about 14 to 15 subopposite to alternate pairs; they branch from the midrib at wide angles and curve upward close to the margins in a camptodrome manner. Tertiaries mostly percurrent and distinct. Areolation subquadrate.

This species was described by Lesquereux from the Green River Eocene, where it is very abundant. It has also been recorded from the Denver formation at Golden, Colo., and from the Raton and Fort Union formations. It was recorded by Hollick in considerable abundance from the Wilcox of Louisiana. Whatever may be thought of the probability of a single species extending from the base of the Eocene to the Green River, the forms from the Wilcox are not distinguishable from those of the Green River, as may be readily observed by a comparison of the figures of specimens from both horizons. Their reference to the genus Juglans is not above question, although no better disposition of them has suggested itself. No extensive new material has been collected and Hollick's more complete figures have been reproduced in the present work.

Occurrence.—Wilcox group, a quarter of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); 2 miles south of Naborton and sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Bolivar Creek, 3½ miles north of Harrisburg, Poinsett County, Ark. (?) (collected by L. W. Stephenson). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge, U. S. Nat. Mus. No. 2490).

Collections.—U. S. National Museum; New York Botanical Garden.

Juglans berryi Knowlton.

Juglans rugosa. Hollick (in part) (not Lesquereux) in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 35, fig. 2 (not fig. 1), 1899.

Juglans Berryi. Knowlton, U. S. Geol. Survey Prof. Paper, MS.

Description.—Knowlton's description is as follows:

> Leaflets membranaceous in texture, the terminal leaflet ovate, equal sided, broadest near the middle, whence it narrows in about the same degree to both base and apex. Margin entire, petiolule short, slender; secondaries 10 to 12 pairs, mainly alternate, considerably curved upward, camptodrome; lateral leaflets larger, ovate-lanceolate, strongly unequal sided; margin slightly undulate; petiolule slender; secondaries about 14 pairs, alternate, camptodrome; nervilles mainly unbroken, oblique to the secondaries.

This species is common in the Raton formation of Colorado. Incomplete specimens, identical with the more perfect material from Colorado, occur at several localities within the Wilcox formation.

Occurrence.—Wilcox group, a quarter of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum; New York Botanical Garden.

Genus ENGELHARDTIA Leschen.

Engelhardtia (Oreomunnea) mississippiensis Berry.

Plate XVII, figure 1.

Engelhardtia mississippiensis. Berry, Am. Jour. Sci., 4th ser., vol. 31, p. 494, pl. 2, 1911; Plant World, vol. 15, pp. 234–238, pls. 3, 4, 1912.

Description.—Involucre large, trilobate, and somewhat reflexed. Alæ widely spread, the angle between the median and lateral wings being 70° to 80°. Sinuses correspondingly open, rather straight sided, rounded at the angle, which is 1.5 centimeters from the extreme base of the specimen. The median wing is the longest of the three and is equilateral, spatulate or oblanceolate in outline, expanding gradually distad from a basal width of 8 millimeters to a width of 13 millimeters, where the distal portion is broken off, 5 centimeters above the base. Since this apical part is missing, the total length is estimated at 6.5 centimeters, which is a minimum rather than a maximum estimate. Lateral wings slightly inequilateral, the outer part of the lamina being a trifle wider than the inner. Apex rounded. Length 5 centimeters. Greatest width, which is above the middle, 11 millimeters. Least width proximad, 7 millimeters. Primaries three in number, one median primary being present in each wing. The primaries are relatively very stout and continue with but slight attenuation to the tips of the wings. No subordinate primaries or discordantly directed secondaries are present, as in some of the European Tertiary species. Secondaries numerous, thin, more or less parallel, about 12 to 15 pairs to each wing, alternate. The secondaries branch from the midvein at a wide angle, which becomes progressively less distad, where they are placed at shorter intervals and are more regularly curved, camptodrome throughout. Tertiaries extremely fine, forming small arches just inside the margin and more or less rectangular meshes within the spaces bounded by the secondaries. Margins strictly entire throughout. The essential portion of the fruit is poorly preserved and partly broken away, as is the rule in the fossil species of this genus. It appears to have been of considerable consistency, and the whole fruit having fallen face downward the reflexed wings raised the peduncular portion, which either rotted away before fossilization or more probably was broken off when the specimen was collected.

Among previously described Tertiary forms this species is most similar to *Engelhardtia brongniarti* Saporta,[1] a species recorded from Spain, France, Italy, Germany, and Austria-Hungary and supposed to range from the Oligocene to the Pliocene. The American species is somewhat larger than most specimens of *Engelhardtia brongniarti*, although Unger has figured forms of that species from Sotzka, in Styria, which are not much different in size. The wings are more spreading and the outlines are much more elegant in the present species. In the European form the wings are rounded apically as in the American, but they have approximately the same width throughout and do not taper downward as in *Engelhardtia mississippiensis*. The secondaries, instead of being regular and camptodrome as in *Engelhardtia mississippiensis*, are less numerous and more irregular in position, several in each wing ascending from the base for considerable distances approximately parallel with the midvein, as in our Claiborne species.

Among the existing species with which it has been compared *Engelhardtia mississippiensis* is very similar to most of the described oriental forms, perhaps resembling *Engelhardtia spicata* Blume more closely than the others. This species ranges from the northwestern Himalayan region through Burma to Java and other East Indian islands. Comparative material of Oreomunnea is very scarce. A single fruit in the National Herbarium is closer to the fossil than are any of the Asiatic species, but in the absence of more material the limits of variation in Oreomunnea are unknown.

In a general way the fruits of Engelhardtia are not unlike those of Carpinus. There seems to be little occasion for confusion, however, even in poorly preserved fossil material. The fruit proper is decidedly different, although this is seldom well enough preserved in fossils to be decisive. The involucre is also markedly different in the two genera. The involucres of Carpinus are generally smaller and the median wing much wider and longer than the lateral wings and with somewhat different venation. The margins are also toothed, whereas in Engelhardtia they are invariably entire. I have examined fruits of all the existing species of Carpinus and experience no difficulty in readily distinguishing them from those of Engelhardtia, the American species of Carpinus being especially different in appearance from those of Engelhardtia. I have seen involucres of the Old World *Carpinus betulus* from trees cultivated in this country in which the margins of the wings were entire or nearly entire, but the aspect of the specimens as a whole, because of their different proportions and venation, was markedly unlike Engelhardtia, and if they had been found as fossils no competent paleobotanist would have been at a loss regarding their botanic affinity for a single instant.

The leaves described under the name of *Engelhardtia ettingshauseni* Berry are found in association with these fruits and also at other localities in the Wilcox group, where the fruits are absent, but they probably represent the same species. A second species of Engelhardtia based on fruits is found in the Wilcox, and a third species occurs in the lower Claiborne deposits of southern Arkansas.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by W J McGee).

Collection.—U. S. National Museum.

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 343, pl. 12, fig. 5, 1865.

Engelhardtia puryearensis Berry, sp. nov.

Plate XVII, figures 6 and 7.

Description.—Involucre small to large, trilobate. Alæ widely spread, diverging from each other at angles of about 70°. Sinuses correspondingly open and nearly straight sided. The whole organ ranges from 4 to 7 centimeters in length and from 4.4 to 6.25 centimeters in maximum width from tip to tip of the lateral wings. Nucellus of medium size, ovate to spherical. Median wing oblong, very much larger than the lateral wings, ranging from 3.5 to 6 centimeters in length and from 1 centimeter to 1.7 centimeters in maximum width at a point about halfway to the tip, narrowed to the bluntly rounded tip. Lateral wings nearly equilateral, straight sided, with broadly and abruptly rounded tips, ranging from 2 to 4 centimeters in length and from 6.5 to 11 millimeters in maximum width. Margins strictly entire and subparallel. Each wing has a relatively stout midrib centrally placed and straight in its course. On each side of each midrib at a distance approximately halfway to the margin a relatively stout vein runs from the extreme base parallel with the midrib nearly to the tip of the respective wings; these subordinate primaries are somewhat less stout than the midribs but stouter than the rest of the venation. In the larger specimens subordinate primaries run from the base part way to the tips. Thin obliquely curved nervilles connect the lateral primaries of each wing with the midrib. From the outer side of the outer lateral primaries thin branches diverge to form a camptodrome marginal areolation; in the median wing they diverge at acute angles, but in the lateral wings their angle of divergence is very open.

Species founded on fruits of Engelhardtia are perhaps not entirely free from suspicion, since in a single spike of a modern Engelhardtia there is more or less variation in the relative sizes of the wings. Nevertheless the present form is strikingly different from the contemporaneous *Engelhardtia mississippiensis* Berry and is represented by several specimens, both large and small, so that no course is possible but to describe it as a distinct species. Some of these differences are worthy of enumeration: In *Engelhardtia puryearensis* the median wing is much larger instead of being about the same size as the lateral wings; the margins are subparallel and not conspicuously narrowed toward the base or apex; the lateral wings are equilateral and generally diverge at more open angles; the tips are more broadly and bluntly rounded; the nucellus is relatively somewhat smaller; the sinuses are more deeply cleft and more angular. The secondaries are not numerous or regular and subparallel, but conspicuous lateral pseudoprimaries run from the extreme base. A third American species of fruit described by me as *Engelhardtia claibornensis* occurs in the lower part of the overlying Claiborne group in Arkansas. Though not as large as some of the forms of this species or as *E. mississippiensis* it is much more robust and has subequal pointed wings, less deeply cleft sinuses, and a much larger nucellus.

Among the Engelhardtia fruits described from the European Tertiary, the present species greatly resembles some of the forms included by Saporta [1] in *Engelhardtia brongniarti* which come from the Oligocene of southeastern France. Our species may be compared with that species as shown in Saporta's figure 5c of Plate XII. Other forms associated with this specimen and referred to this species are not at all closely comparable and I have no doubt that the Wilcox form is specifically distinct. From their rare occurrence in the Wilcox flora, which is essentially a coastal one, it may be inferred that in the Eocene as in the existing flora the Engelhardtias were upland trees, so that only occasionally did their bouyant winged fruits float down the rivers to the coastal area of sedimentation.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Engelhardtia ettingshauseni Berry, n. sp.

Plate XIX, figures 1, 3, and 5.

Sapindus dubius. Lesquereux (part), U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888.

Description.—Leaves pinnate. Leaflets sessile, ovate-lanceolate, more or less inequilateral in outline, slightly falcate, with a narrowed, bluntly pointed or narrowly rounded apex, and a pointed inequilateral base. Length 5.5 to 9 centimeters. Maximum width 2 to 3 centimeters, in the middle part of the leaflet. Mar-

[1] Saporta, G. de, op. cit., vol. 2, p. 343, pl. 12, fig. 5.

gins entire, somewhat undulate, as in the existing *Engelhardtia spicata* Blume. Texture coriaceous. Midrib stout and generally curved. Secondaries rather stout, prominent on the lower surface of the leaflets, 10 to 12 opposite to alternate, subparallel camptodrome pairs; they branch from the midrib at angles of 30° to 60°, and pursue a relatively straight course to the marginal region, where they curve upward close to and subparallel with the margin. Tertiaries thin, mostly percurrent.

This species is associated with the fruits described as *Engelhardtia mississippiensis* Berry [1] at Early Grove, Miss., and *E. puryearensis* Berry at Puryear, Tenn., and was probably the foliage of one or the other of these Eocene trees. Until this can be demonstrated it seems wisest to describe the foliage under a distinctive name, the one selected being in honor of the late Baron von Ettingshausen, who was the first to point out the true botanic position of the Engelhardtia fruits, so common in the European Oligocene, which previously were referred to the genus Carpinus.

The species shows considerable variation in size and relative proportions, the narrower leaflets having more ascending secondaries, but no specific differences are discernible. The limits of variation are well shown by the specimens figured. They resemble *Engelhardtia spicata* Blume of the Asiatic region except in the acuminate leaflets of that species. They are still more like *Engelhardtia chrysolepis* Hance of the southeastern Asiatic region, which has petiolulate leaflets with entire margins, blunt tips, and inequilateral outlines, exactly like the fossil. The leaflets are not as large as those of *E. spicata* and the secondaries are more ascending, in both of these features approaching nearer to the fossil form. Other modern species have leaflets with toothed margins—a character in which there is much variation among the Juglandales, both recent and fossil. The present species occurs in the Raton formation of the southern Rocky Mountain province, a horizon slightly older than the Wilcox. A specimen from Wickliffe that was referred to *Sapindus dubius* by Lesquereux is unquestionably a leaf of this species, which was also collected from the locality by L. C. Glenn. A previously described fossil which is very close to if not identical with the present species, and which I consider a species of Engelhardtia, is described by Engelhardt [2] as *Tapiria lanceolata* (Anacardiaceæ). It comes from the Tertiary of Ecuador.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry); Holly Springs sand, Early Grove and Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Wilcox group (common but fragmentary), Benton, Saline County, Ark. (collected by R. E. Call). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge and L. C. Glenn).

Collections.—U. S. National Museum.

Genus **PARAENGELHARDTIA** Berry, n. gen.

This genus has the characters of the type and only known species. It is evidently allied to Engelhardtia and probably represents a survivor of the ancestral stock from which Engelhardtia was derived.

PARAENGELHARDTIA EOCENICA Berry, n. sp.

Plate XVII, figures 2–5.

Description.—The present genus and species are based on bracteate fruits, which may be described as follows: Involucre entire, not tripartite, orbicular in general outline, with a short stout stalk. The distal margin has a shallow, broadly rounded sinus on each side of the apex, dividing the wing into three broadly rounded or shortly pointed lobes. Base rounded or decurrent to the peduncle. Apex broadly rounded or, though preserving its broadly rounded outline, it may be mucronate pointed. Lateral lobes broadly rounded or in some specimens pointed; the specimen shown in Plate XVII, figure 4, is pointed on one side and rounded on the other. The smallest specimen figured was complete when collected and was of the exact form indicated by the dotted line; that is, all the lobes were rounded. It was abraded during transit from the field and now appears as shown by the photograph. Height ranges from 1.6 to 2.75 centimeters. Maximum width ranges from 2.2 to 3.2 centimeters. Margins entire. Substance thin but somewhat coriaceous. Venation thin and reticulate.

[1] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 31, p. 494, fig. 1, 1911.

[2] Engelhardt, H., Senckenbergische naturf. Gesell. Abh., vol. 19, p. 15, pl. 9, fig. 4, 1895.

About 15 somewhat flabellate, distally forked, and anastomosing veins radiate from the essential part of the fruit, which is large and spherical and is situated at the top of peduncle. No primaries are differentiated, but a vein runs to the tip of each marginal lobe. Within the meshes a system of still finer anastomosing veinlets forms a four or five sided indistinct areolation. The essential part of the fruit is more or less globular, 5 to 8 millimeters in diameter, and is adnate to the involucre at its base at the top of the peduncle.

This species represents an undescribed type. The specimen shown in Plate XVII, figure 4, suggests a ligneous scale comparable with some coniferous scale, but in reality it is an unthickened wing. These specimens, which are not rare, have been compared with all the existing families which have winged fruits that are known to me. They are more nearly comparable with certain existing members of the Amentiferæ and are especially suggestive of Engelhardtia, which is represented in the Wilcox flora by perfectly characteristic winged fruits as well as leaves. The essential part of the fruit appears to be identical in both genera, but in Paraengelhardtia the involucre is entire and has only faint indications of the lobation characteristic of Engelhardtia, besides it lacks the differentiated venation of that genus. It is easy to understand that with the progressive elongation of the incipient lobes of Paraengelhardtia, necessary to a better dissemination of these fruits, the main vascular bundle to the tip of each lobe would become stouter and be gradually transformed into midribs. This hints at the genesis of the Engelhardtia type of fruit from ancestral forms with small bracts like the bracts of Juglans or Hicoria, which became in the course of time concrescent and subsequently deeply trilobate.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus HICORIA Rafinesque.

HICORIA ANTIQUORUM (Newberry) Knowlton.

Carya antiquorum. Newberry, New York Lyc. Nat. Hist. Annals, vol. 9, p. 72, 1868.

Newberry, Illustrations of Cretaceous and Tertiary plants, pl. 23, figs. 1–4, 1878.

Newberry, U. S. Geol. Survey Mon. 35, pl. 31, figs. 1–4, 1898.

Carya antiquorum. Lesquereux, U. S. Geol. and Geog. Survey, Terr. Ann. Rept. for 1871, p. 294, 1872.

Lesquereux, idem for 1872, p. 402, 1873.

Lesquereux, The Tertiary flora, p. 289, pl. 57, figs. 1–5; pl. 58, fig. 2, 1878.

Carya antiqua. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Hicoria antiquorum (Newberry). Knowlton, U. S. Geol. Survey Bull. 152, p. 117, 1898.

Description.—Lesquereux's description, published in 1878, is as follows:

> Leaflets large, broadly oval or ovate-lanceolate, acuminate, rounded or broadly cuneate to the petiole; base inequilateral; borders minutely denticulate; lateral nerves close, parallel, simple, curved in ascending toward the borders.
>
> The leaflets of this species are very large, except those of the lowest pair, whose size is, as in species of Juglans, generally diminutive. * * * The substance of these leaflets is subcoriaceous and rigid, the surface generally polished, though deeply cut by numerous lateral nerves and nervilles; the borders, crenulate or denticulate, become entire toward the more or less inequilateral base, of which one side is generally rounded, the other straight. The petiole of the lateral leaflets is short; that of the terminal ones longer. * * * The lateral nerves are close, twenty to twenty-five pairs in the large leaflets, under a broad angle of divergence, 50° to 60°, mostly simple, closely following the borders in simple bows, connected with the teeth by minute short nervilles. * * * The generic relation of the species can not be definitely considered as long as the fruit is not known. As the North American species of Juglans and Carya can be used only as points of comparison by the characters of their leaves, these characters, especially the generally simple secondary nerves in our species of Juglans more generally divided in those of Carya, seem to refer this fine species, whose lateral nerves are not at all divided, to the first genus. The size of the leaflets, however, has more likeness to those of *Carya alba*, though all the fossil leaflets of Carya published by European authors are narrow and linear, and also the branching of the nerves is quite as distinct in *Juglans rupestris* as in the species of Carya.

The foregoing quotation is somewhat abridged from Lesquereux's description of this species, which is found in considerable abundance in the Wilcox at Campbell's quarry, La. The form is widely distributed in the basal and Fort Union Eocene of the Rocky Mountain province, extending northward into the Northwest Territory and British Columbia, according to Penhallow, whose records I have not quoted in the synonymy because of the extreme unreliability of most of his unillustrated determinations.

With regard to the generic reference of these leaves to Hicoria, I believe it to be entirely unsatisfactory but have not ventured on a change, since that would obscure the geologic value of this widespread form. The species is certainly very close to the widespread Wilcox species described in the present work as *Euonymus splendens* Berry if not identical with it, and it shows in its broad form, large size, simple secondaries, and the like, more of the characters of this genus than it does those of Hicoria.

Occurrence.—Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson).

Collection.—U. S. National Museum (No. 2443, 11 specimens).

Order MYRICALES.

Family MYRICACEÆ.

Genus MYRICA Linné.

MYRICA ELÆANOIDES Lesquereux.

Plate XVIII, figure 2.

Myrica elæanoides. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 12, pl. 4, fig. 5, 1888.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Lesquereux's description, written in 1888, is as follows:

Leaf long, linear-lanceolate, entire, gradually tapering at base and somewhat decurring upon a short petiole, acute or acuminate (point broken); secondaries close, numerous, oblique, camptodrome; tertiaries intermediate, more inclined, anastomosing at right angles on both sides, reticulation very small, quadrate.

This species was described by Lesquereux, who compared it with Salix and with *Quercus elæna* Unger of the European Tertiary, the specific name chosen being in allusion to its resemblance to that species. Though he notes its similarities to various Lauraceæ he finally decides in favor of Myrica, pointing out its resemblance to the European *Myrica aquensis* Saporta and *Myrica hakeæfolia* Saporta.

Myrica elæanoides, if it is a Myrica, must have been rare in the Wilcox flora or else an inhabitant of areas remote from fossilization, for it has been detected only twice in the large collections subsequently made. There is some resemblance to the larger leaves of the Wilcox species *Nectandra pseudocoriacea* Berry, but the two forms are believed to be perfectly distinct.

In the existing flora the family Myricaceæ is represented by the genera Myrica and Comptonia. Myrica comprises between 30 and 40 species of shrubs and small trees of wide geographic distribution throughout the temperate and subtropical portions of both the Eastern and Western hemispheres. Comptonia is a monotypic genus of eastern North America. Both genera have an extended geologic history, from the middle Cretaceous to the Pliocene, and both had a wide range and very many species during the Tertiary.

Many of the existing species are coastal forms, inhabiting either deep swamps or areas of sand dunes, and it is probable that *Myrica elæanoides* had a habitat comparable with that of the modern wax myrtle, *Myrica cerifera* Linné, which ranges along the Atlantic coast from southern New Jersey to Texas and also grows in Bermuda and the Bahama Islands as well as on several of the Antilles.

Though the type of this species has always been credited to Wickliffe, the specimen which is preserved in the United States National Museum (No. 2572) is obviously from Boaz. A thin marginal vein, which was not noticed by Lesquereux, unites the secondaries. Some of the later collections are much smaller than the type, the smallest specimen measuring 9 centimeters in length by 1.5 centimeters in maximum width.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard). Lagrange formation (in beds of Wilcox age), Boaz, Graves County, Ky. (collected by R. H. Loughridge), and 1¼ miles east of Grand Junction, Hardeman County, Tenn. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

MYRICA WILCOXENSIS Berry, n. sp.

Plate XVIII, figure 1.

Description.—Leaves of small size, lanceolate in general outline, the tip somewhat abruptly pointed and the base narrowly cuneate. Length about 5.5 centimeters. Maximum width, slightly above the middle of the leaf, about 1.1 centimeters. Margins entire in the basal half of the leaf; the upper half shows remote, irregularly spaced, small serrate teeth. Texture coriaceous. Petiole short or lacking. Midrib stout, prominent on the lower surface of the leaf. Secondaries relatively stout and prominent, numerous and unequally spaced; some of those in the upper part of the leaf enter marginal teeth in a craspedodrome manner, others send short branches into the teeth, but the intermediate ones and those in the lower half of the leaf are camptodrome. Tertiary system well marked and duplicating the characters found in recent species of Myrica, namely, that stout, more or less flexuous tertiaries between and subparallel with the secondaries send out oblique branches and form a coarse and stout Tertiary areolation, connected with a finer isodiametric ultimate areolation. The fossil leaves, which have considerable substance preserved as a thin ferruginous sheet of lignite, show unmistakable evidence of a punctate character, exactly comparable with that which obtains in recent species of the genus.

This species, though not abundant, is especially well marked and readily distinguishable from the other members of the Wilcox flora. It is almost identical with a number of existing species, as for example *Myrica cerifera* Linné, which ranges along the Atlantic coast from Cape May, N. J., to Texas and is also found on the Bermuda and Bahama islands and several of the Antilles. *Myrica cerifera* is most common and vigorous in sandy swamps along the South Atlantic and Gulf coasts, and its habitat may be legitimately compared with that of *Myrica wilcoxensis*. It is also close to the existing Eurasiatic *Myrica gale* Linné. A large number of fossil species are closely comparable with the present form, especially those rather numerous species of the upper Eocene and lower Oligocene of Mediterranean Europe. Among American fossil species it shows considerable resemblance to *Myrica nigricans* Lesquereux of the Claiborne group in the embayment area and may be an ancestor of that form.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Order FAGALES.

Family FAGACEÆ.

Genus DRYOPHYLLUM Debey.

Leaves broad and long pointed with prominent aquiline-serrate teeth .... *Dryophyllum amplum.*
Leaves broad and short pointed (elliptical-lanceolate) with shallow regular serrate teeth... *Dryophyllum moorii.*
Leaves narrow and elongated (linear-lanceolate), more or less prominently toothed:
  Petiole short, secondaries thin and irregularly spaced. *Dryophyllum anomalum.*
  Petiole long, secondaries stout, more closely and regularly spaced:
    Alternate secondaries camptodrome, teeth irregularly spaced .... *Dryophyllum puryearensis.*
    Secondaries closer, craspedodrome, teeth closer and more regularly spaced. *Dryophyllum tennesseensis.*

DRYOPHYLLUM ANOMALUM Berry, n. sp.

Plate XXIV, figures 2 and 3.

Description.—Leaves of medium or large size, elongate, and oblong-lanceolate in outline, the apex narrowed and extended, acuminate, and the base narrowly cuneate and decurrent. Length ranges from 15 to 25 centimeters. Maximum width, at or below the middle, ranges from 2.5 to 3 centimeters. Margins entire below, somewhat undulate and revolute, variously toothed for the upper three-fourths of their length. Teeth remote, irregularly spaced, serrate, ranging from forms in which they are greatly reduced, like the smaller figured specimen, to forms like the larger figured specimen in which they are very prominent, directed outward, incurved or recurved and separated by rounded inequilateral sinuses. Leaf substance very thick and coriaceous. Petiole short and stout, tumid proximad, about 1.25 centimeters in length, the narrowly decurrent leaf margins reaching nearly to the base. Midrib very stout, prominent on the lower surface of the leaf. Secondaries very thin and immersed in the leaf substance, remote and irregularly spaced, alternate, invariably camptodrome. They diverge from the midrib at wide angles, curve upward in different degrees, are accentuated in the marginal region, and send a thin tertiary outward to each marginal tooth. Tertiaries mostly obsolete; where seen they are percurrent.

This species is distinguishable from all the other Wilcox species of Dryophyllum by its thin camptodrome venation. In outline and general appearance it is very similar to the larger forms of *Dryophyllum puryearensis* Berry. The specimens show marked textural differences, however, and *Dryophyllum puryearensis* has rather regular stout craspedodrome secondaries.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

DRYOPHYLLUM MOORII (Lesquereux).

Plates XXII, figure 1, and XXIII, figures 1–3.

Quercus Moorii. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 415, pl. 16, figs. 1–3, 1869.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 31, 1888.

Knowlton in Glenn, L. C., U. S. Geol. Survey Water-Supply Paper 164, p. 38, 1906.

Knowlton in Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 73, pp. 60, 61, 1911. (Eocene near Susanville, Lassen County, Cal.)

Description.—Lesquereux, in 1869, gave the following description:

Q. foliis coriaceis, oblanceolatis, vel obovatis oblongis, elongatis, subobtusis, margine remote, breviter serratis; nervis secundariis, sub angulo latiore egredientibus, curvatis, craspedodromis.

This handsome species has not been found in any recent collections made by me from the embayment area and is consequently represented by Lesquereux's figured specimens, by one or two additional fragments fortunately preserved in the Hilgard collection, and by a few specimens collected by Prof. Glenn at Wickliffe, Ky., and by Dr. Vaughan at Old Port Caddo Landing, Tex. The specimens represented by Lesquereux's figures 1 and 2 have been photographed and reproduced in Plate XXIII, and a third figure of the lower part of a medium-sized leaf has been reproduced to give some idea of the general outline of the leaf whose upper half is shown in Lesquereux's figure 3. The species may be somewhat more fully characterized as follows:

Leaves very broadly elliptical-lanceolate in outline, differing in size, the length ranging from 14 to 28 centimeters, and the maximum width from 4.5 to 12 centimeters. Widest near the middle, the lateral margins being full and tapering rather abruptly to the pointed apex and cuneate base. Texture coriaceous. Margins entire for a short distance above the petiole, elsewhere set with remote shallow serrate teeth, one at the terminus of each secondary, separated by shallow inequilateral, nearly straight sinuses. Midrib stout, rigid, not out of proportion to the size of the leaves nor as stout as indicated in Lesquereux's figures 2 and 3. Secondaries numerous, approximately parallel, usually opposite or subopposite, branching from the midrib at regular intervals at angles of about 45°. Their angle of divergence is more open in the median part of the leaf as well as in broader specimens, and may be said to range from 40° to 65°. There are about 15 pairs of stout secondaries, prominent on the lower surface of the leaf. They are nearly straight in larger specimens, but curve more or less distad in the smaller forms. They terminate craspedodromely in the marginal teeth, generally by a slight bending outward, and are camptodrome in the basal, entire-margined portion of the leaf. Tertiaries thin but clearly seen, numerous, regular, and percurrent.

This species is well characterized and is markedly distinct from other species of Dryophyllum, which are abundant in the Wilcox. It is also distinct from the forms described from other areas but shows marked similarities to some of the European early Eocene species. In referring briefly to other Wilcox species of Dryophyllum, it may be noted that *Dryophyllum puryearensis* Berry is relatively much more slender and elongate, the apex and base gradually narrowed, and the base entire for a considerable distance. The marginal teeth are more prominent, the intervening sinuses more curved, and the secondaries much less numerous and more regularly curved. The midrib is relatively much stouter; both it and the secondaries are prominent below, but the tertiaries are obsolete, possibly indicating a more coriaceous leaf.

Dryophyllum tennesseensis Berry is somewhat variable in outline and some specimens of this exceedingly abundant species approach *Dryophyllum moorii* in appearance. They are, however, more lanceolate in outline, being relatively much longer and more slender, and have more numerous, stouter, curved secondaries and more prominent teeth.

The genus Dryophyllum is exceedingly well developed in the early Eocene of Europe and a number of these European forms are similar to the present species, the most similar being perhaps *Dryophyllum levalense* Marty [1] from the Paleocene (Montian) of Hainaut in Belgium. This species shows even greater variations in size than *Dryophyllum moorii.* It has the same broad, abruptly pointed leaves and iden-

[1] Marty, Pierre, Mus. hist. nat. Belgique, Extrait Mém., vol. 5, p. 15, pls. 2–7, 1907.

tical venation, the principal point of difference being the prominent dentate teeth of the Belgian species. *Dryophyllum moorii* also shows some resemblance to the early Eocene species *Dryophyllum aquamarum* Ward,[1] from Black Buttes, Wyo.

Dryophyllum moorii is found in the flora of the Raton formation of the southern Rocky Mountain province, a formation slightly older than the Wilcox.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard); Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn). Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan).

Collections.—U. S. National Museum; State University, Oxford, Miss.

DRYOPHYLLUM TENNESSEENSIS Berry, n. sp.

Plates XIX, figure 6, XX, figures 1–3, XXI, figures 1, 4, and 5, and XXII, figure 2.

Quercus crassinervis. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859.
Lesquereux, Geology of Tennessee, p. 427, pl. K, fig. 1, 1869. (Not *Quercus crassinervia* Göppert, 1852.)
Loughridge, Report on the geologic and economic features of the Jackson's purchase region, p. 196, fig. 1, 1888.
Quercus cf. *cuspidata* (Rossm.) Ung. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 12, 1888.

Description.—Leaves predominantly lanceolate in outline, meriting the term ovate-lanceolate in a few broader specimens. Length 6 to 25 centimeters, average about 20 centimeters. Maximum width ranges from 7.5 millimeters to 6 centimeters; averages about 3.5 centimeters midway between the apex and the base or somewhat nearer the base. From the region of maximum width the leaf curves gradually to the extended slender tip and the narrowly cuneate base. Margin entire for a short distance proximad. Above this portion it is beset with more or less prominent, aquiline serrate teeth, directed upward and separated by shallow inequilateral sinuses. Petiole very stout, enlarged at the point of attachment, tapering upward, from 3 to 5 centimeters in length. Midrib relatively very stout, prominent on the lower surface of the leaf. Secondaries stout, very numerous, regularly spaced at intervals of 3 to 6 millimeters, parallel, craspedodrome, opposite to alternate. They diverge from the midrib at different angles, dependent on the width of the leaf, but the average is about 45°; they are prominent on the lower surface of the leaf, curve upward slightly, the curve becoming more pronounced distad, and terminate in the marginal teeth. Tertiaries fine but well marked, percurrent. Texture coriaceous.

This species is very abundant in the clays of Henry County, Tenn. It shows considerable variation in size and relative slenderness, some of the specimens approaching *Dryophyllum puryearensis* Berry in the latter character. It is less variable in size than *Dryophyllum moorii* (Lesquereux) Berry, despite its much greater abundance in the collections studied, and is readily distinguished from both *Dryophyllum moorii* and *Dryophyllum puryearensis.* The normal form can never be confused with *Dryophyllum puryearensis* and the more slender forms may be distinguished by their stouter, more numerous secondaries, their more numerous and less prominent teeth, and by the tendency in *Dryophyllum puryearensis* for a large portion of the lower margins to be toothless and to have camptodrome secondaries. Its more important differences when compared with *Dryophyllum moorii* are mentioned in the description of that species. A single fragment of this species was collected by Safford many years ago near Somerville, Tenn., and was described by Lesquereux[2] as *Quercus crassinervis* Unger. As far as I am aware Unger never applied the name *crassinervia* to any species of Quercus of which he was the original describer, and Lesquereux undoubtedly referred to *Quercus crassinervia* described by Göppert from the upper Miocene of Silesia (Tortonian). The plant from Tennessee differs decidedly from this European Miocene species, which Ettingshausen[3] subsequently referred to *Castanea atavia* Unger and which Schimper[4] referred to *Castanea kubinyi* Kovats. *Quercus crassinervia* Göppert[5] has much more prominent, outwardly directed teeth, with deeper and more angular sinuses, and is a less elongated leaf than *Dryo-*

[1] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 26, pl. 10, figs. 2–4, 1887.

[1] Lesquereux, Leo, in Safford, J. M., Geology of Tennessee, p. 427, pl. K, fig. 1, 1867.
[2] Ettingshausen, C. von, K. Akad. Wiss. Wien Sitzungsber., Bd. 65, Abth. 1, p. 160, 1872.
[3] Schimper, W. P., Paléontologie végétale, vol. 2, p. 610, 1872.
[4] Göppert, H. R., Deutsche geol. Gesell. Zeitschr., vol. 4, p. 491, 1852; Die tertiäre Flora von Schossnitz, p. 16, pl. 8, fig. 1, 1855.

phyllum tennesseensis. It may be the leaf of a Castanea.

The present species may be compared with a number of early Eocene species described from European localities, as, for example, *Dryophyllum palæocastanea* Saporta from Sézanne, France,[1] *Dryophyllum curticellense* (Watelet) Saporta and Marion, an Ypresian species,[2] and *Dryophyllum dewalquei* Saporta and Marion[3] from Gelinden, Belgium. *Dryophyllum palæocastanea* is perhaps most like *Dryophyllum tennesseensis* but has larger and less pointed teeth and more nearly horizontal secondaries. *Dryophyllum dewalquei* is also much like the Wilcox species but is widest near the base and much elongated and narrowed distad; the teeth are much more prominent and rounded.

The medium-sized leaves of *Dryophyllum tennesseensis* are much like those described by Watelet from the Ypresian of the Paris Basin as *Castanea saportæ*,[4] and the smaller leaves may be compared with forms described by this author from the Thanetian of the Paris Basin as *Myrica roginei*.[5]

The deposits from which the fragment of this species came near Somerville were referred to the Pleistocene by Lesquereux, but they are in fact beds of Grenada or upper Wilcox age.

Occurrence.—Holly Springs sand, ravine at Oxford, Lafayette County, Miss. (collected by E. W. Berry), and Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Wilcox group, 4 miles southwest of Boydsville, Clay County, Ark. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age): Somerville, Fayette County, Tenn. (collected by J. M. Safford); Puryear (abundant) and Henry (Breedlove pit), Henry County, Tenn. (collected by E. W. Berry); Boaz, Graves County, Ky. (collected by R. H. Loughridge, 5 specimens, No. 2573); and Wickliffe, Ballard County, Ky. (collected by L. C. Glenn). Wilcox group, $1\frac{3}{4}$ miles west, $2\frac{3}{4}$ miles southeast, 3 miles east, 5 miles southeast, and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Dryophyllum puryearensis Berry, n. sp.

Plate XXI, figures 2 and 3.

Description.—Leaves linear-lanceolate in outline, very different in size, the length ranging from 15 to 25 centimeters and the maximum width, which is midway between the apex and the base, ranging from 1 centimeter to 2.5 centimeters. Apex and base equally elongated and gradually narrowed to a point. Margins entire below for distances that differ in different specimens, amounting to one-fourth the length in some specimens; above this region strong but slightly produced serrate teeth are directed outward and separated by rounded sinuses. The marginal teeth are commonly spaced irregularly and are lacking in some of the secondaries. Midrib very stout and prominent below, generally more or less curved. Secondaries stout, considerably curved, diverging from the midrib at angles in excess of 45°; not parallel, since in general every other secondary is craspedodrome and terminates in a marginal tooth; the alternating secondaries diverge at a wider angle and are camptodrome, as are also the secondaries in the basal part of the leaf, where the margins are entire. Tertiaries immersed. Texture coriaceous.

This is a well-marked species, and some of the characters by which it may be distinguished from the preceding species of Dryophyllum have been mentioned in the discussion of those species. It may be compared with the same group of European early Tertiary species of Dryophyllum, of which several have already been mentioned.

The larger leaves of the present form are not likely to be mistaken for anything else, but some of the smaller specimens, like the smaller one figured, may be confused with the Wilcox species of Banksia, especially with the not uncommon species of Banksia described by Lesquereux as *Quercus saffordi*,[6] but that

[1] Saporta, G. de, Prodrome d'une flore fossile des travertins anciens de Sézanne, p. 61 (349) pl. 5, figs. 4-6, 1868. (Also recorded from Italy by Squinabol, Riv. ital. Paleont., vol. 7, p. 71, 1901.)

[2] Saporta, G. de, and Marion, A. F., Essai sur l'état de la végétation à l'époque des marnes heersiennes de Gelinden, p. 42, pl. 1, fig. 5, 1873; Revision de la flore heersienne de Gelinden, p. 53, pl. 7, figs. 6-8, 1878. (Also recorded from Saxony by Friedrich, Beiträge zur Kenntniss der Tertiär flora der Provinz Sachsen, p. 209, pl. 6, figs. 14, 15, 1883.

[3] Saporta, G. de, and Marion, A. F., Essai sur l'état de la végétation à l'époque des marnes heersiennes de Gelinden, p. 37, pl. 2, figs. 1-6; pl. 3, figs. 1-4; pl. 4, figs. 1-4; Revision de la flore heersienne de Gelinden, p. 50, pl. 7, figs. 4, 5; pl. 8, figs. 1-7. (Recorded from Saxony by Friedrich, op. cit., pp. 22, 101, pl. 1, figs. 3, 6; pl. 9, fig. 6.)

[4] Watelet, A., Description des plantes fossiles du bassin de Paris p. 142, pl. 38, figs. 4, 5, 1866.

[5] Idem, p. 127, pl. 33, figs. 10, 11.

[6] Lesquereux, Leo, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859. (For other citations see *Banksia saffordi* in the present work.)

species differs in its general form, being widest and entire proximad; in its much extended and narrow apex, with relatively larger produced teeth; and in its minute isodiametric areoles.

The present species is less common than the preceding Wilcox species of Dryophyllum.

The larger leaves of *Dryophyllum puryearensis* are closely simulated in appearance by the associated leaves of *Dryophyllum anomalum* Berry, which, however, can be readily distinguished by their thin and invariably camptodrome secondaries. The smaller leaves are much like the French Ypresian species *Dryophyllum curticellense* (Watelet) Saporta and Marion[1] and the French Thanetian species *Myrica roginei* Watelet.[2] The leaves of *Myrica roginei* are also much like *Quercus linearis* Knowlton of the Raton formation of the southern Rocky Mountain province.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe (No. 2571), Ballard County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

DRYOPHYLLUM AMPLUM Berry, n. sp.

Plate CXVII, figures 1–4.

Description.—Leaves large, lanceolate in general outline, with an acuminate apex and a cuneate base. Length ranges from 20 to 30 centimeters. Maximum width, in the middle part of the leaf, ranges from 5 to 7 centimeters. Texture coriaceous. Margins entire in the basal fourth of the leaf, above which they are beset with widely spaced, prominent, aquiline-serrate teeth, one at the termination of each secondary vein. The petiole is missing in all the specimens. The midrib is stout and prominent on the lower surface of the leaf. Secondaries stout, regularly and widely spaced, about a dozen pairs, varying from alternate to opposite, craspedodrome; they diverge from the midrib at angles of 50° to 60°, pursue a nearly straight ascending course, and terminate in the marginal teeth. Tertiary venation very thin, forming a fine angular mesh, with no differentiation between nervilles and the ultimate areolation. In the teeth straight tertiaries run directly to the margin and there is no intramarginal series of arches as there usually is in Castanea or Quercus.

This large and characteristic species is common in the clay ironstone in the vicinity of Naborton. It is larger than the leaves of any of the Wilcox species of Dryophyllum except occasional leaves of *Dryophyllum moorii* (Lesquereux), which is relatively shorter and broader and has more numerous secondaries and very feeble marginal teeth. None of the other Wilcox forms has nearly so prominent or aquiline teeth as *Dryophyllum amplum,* the only one with large teeth being the narrow form *Dryophyllum anomalum,* in which they are different in shape and the secondaries are thin and camptodrome. Among foreign species *Dryophyllum dewalquei* Saporta and Marion[3] from the Heersian (Thanetian) of Belgium is perhaps most similar to the present form.

Occurrence.—NW. ¼ sec. 9 and SE. ¼ NE. ¼ sec. 13, T. 12 N., R. 12 W., near Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Order URTICALES.

Family ULMACEÆ.

Genus PLANERA J. F. Gmelin.

PLANERA CRENATA Newberry (?).

Planera crenata. Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 508, 1882.

Newberry, U. S. Geol. Survey Mon. 35, p. 81, pl. 57, fig. 3, 1898.

Description.—Newberry gave the following description in 1882:

> Leaves oblong, ovate; short petioled; 5 centimeters long by 25 millimeters wide; base rounded; summit blunt-pointed; margins coarsely crenate; nervation simple, delicate, six simple branches on each side of the midrib terminating in the crenations of the margin.

This species was described by Newberry from apparently scanty material collected by Hayden from the Eocene of Tongue River, Mont. Only a single specimen was figured. A single imperfect leaf from the Grenada formation resembles this species more closely than it does any other described form. It is the same

[1] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 127, pl. 34, figs. 1–3, 1866.

[2] Idem, p. 127, pl. 33, figs. 10, 11.

[3] Saporta, G. de, and Marion, A. F., op. cit.

in size and outline, has identical venation, and differs merely in a more cuneate base and slightly less prominent teeth. The material is entirely insufficient for certain identification or proper diagnosis, and it is therefore referred tentatively to this species, with which, in so far as the materials in hand go, it is practically identical.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Family MORACEÆ.

Genus ARTOCARPOIDES Saporta.

ARTOCARPOIDES WILCOXENSIS Berry, n. sp.

Plate CIX, figure 5.

Description.—Leaves of medium size for this tribe, elliptical in general outline, widest in the middle and about equally pointed at the apex and base. The base is slightly incurved, however, and decurrent. Margins entire. Texture coriaceous. Length about 13 centimeters. Maximum width about 6.3 centimeters. Petiole short and very stout. Midrib stout and straight, very prominent on the lower surface of the leaf. Secondaries mediumly stout but mostly immersed in the leaf substance; they diverge from the midrib at very irregular intervals at angles of about 50°, pursue a prevailingly straight ascending course, and become much attenuated distad, where they are camptodrome a considerable distance from the margins. Tertiaries thin, variable; branches from the secondaries and from the midrib together form an open, prevailingly quadrangular network.

This species is not abundant in the Wilcox and is confined to the Puryear locality. It was a handsome form with symmetric rigid coriaceous smooth leaves. With regard to its botanic affinity it appears to be congeneric with the species of Artocarpoides described by Saporta from the Paleocene of Sézanne, France. Schenk [1] considers these to be forms of Juglandites, but I fail to see any foundation for his contention. It is possible that the Wilcox leaf is not congeneric with the Sézanne leaves, but should be referred to the tropical American genus Brosimum Swartz (which includes about 8 existing species in tropical America, ranging from Mexico and the West Indies to Brazil), especially as it differs in certain particulars from the modern entire-leafed species of Artocarpus. It is certainly not related to Juglans but is as certainly a member of the Moraceæ, recalling in everything except its venation numerous forms that have been referred to Ficus.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Schenk, A., Palaeophytologie, pp. 451, 477, 1890.

Genus ARTOCARPUS Förster.

ARTOCARPUS LESSIGIANA (Lesquereux) Knowlton.

Plate XXVI, figure 1.

Myrica? Lessigiana. Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 386, 1875 (1876).
Lesquereux U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 312, 1876.
Myrica? Lessigii. Lesquereux (not Lesquereux, 1888), The Tertiary flora, p. 136, pl. 64, fig. 1, 1878.
Artocarpus lessigiana. Knowlton, Science, vol. 21, p. 24, 1892.
Knowlton, U. S. Geol. Survey Bull. 152, p. 42, 1898.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 281, pl. 37, 1899.

Description.—Leaves large, 30 centimeters in maximum length by 20 centimeters in maximum width; oblong in general outline; pinnately and more or less deeply four to eight lobed. The lobes differ in form, are oblong-lanceolate in outline, and are separated by narrow to broad, rounded sinuses. The lower lobes are directly lateral, and they become more ascending distad, being directed upward in the apical part of the leaf. Midrib very stout. Lateral primaries stout but much less prominent than the midrib, subopposite to alternate, branching from the midrib at a wide angle in the lower part of the leaf and at more acute angles toward the apex, one traversing each lobe and terminating in its acute tip. Secondaries thin, camptodrome, one or more intercalated between successive secondaries and generally several from the lateral primaries. As a rule one runs directly to the sinus and joins a vein that constitutes a marginal hem to the sinus. In some specimens the secondary misses the sinus and continues as a margin of its upper limb. Tertiaries largely immersed. The type specimen which I have had the pleasure of seeing in the National Museum collection is admirably depicted by Lesquereux.[1] The finer venation comes out better in this specimen than in most examples of the species, showing marginal festoons and internal quadrangular or polygonal reticulation. Texture coriaceous.

These large leaves, at first described as gigantic leaves of a Comptonia (Myrica), are obviously allied to the modern species of Artocarpus, especially to *Artocarpus incisa* Förster. This is rendered a certainty by the association of fossil fruits characteristic of the breadfruit with leaves of this type, not only in the far north (western Greenland) but also in Europe, as well as by petrified wood of Artocarpus from the Tertiary of Antigua. The existing species number about two score oriental forms, ranging from Ceylon throughout Indo-Malaysia to China, and now represented by cultivated forms in all tropical countries. The fossil record extends back to the Upper Cretaceous, Nathorst[2] having described a fine species, represented by both fruit and leaves, from beds of this age in Greenland (latitude 70° north). The same sagacious student of fossil plants first pointed out the botanic affinity of our American forms. The genus is represented by *Artocarpus? quercoides* Knowlton[3] in the Fort Union of the Yellowstone Park, by *Artocarpus californica* Knowlton[4] from the Eocene and Miocene of the Pacific coast (California and Oregon), by a new species or variety in the Alum Bluff formation of Florida, and by another in the early Eocene of the Rocky Mountain district. In Europe several species range from the Upper Cretaceous to the Pliocene. Their extinction in that continent is not surprising, as it has numerous parallels, but it is rather remarkable that Artocarpus did not survive in the American Tropics, for the modern forms become readily acclimatized.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, and Vineyard Bluff, Cross Bayou, Caddo Parish, La. (collected by G. D. Harris).

Collections.—U. S. National Museum; New York Botanical Garden.

[1] Lesquereux, Leo, The Tertiary flora, pl. 64, fig. 1, 1878.
[2] Nathorst, A. G., Kgl. Svenska Vetens.-Akad. Handl., vol. 24, pp. 1-10, pl. 1, 1890.
[3] U. S. Geol. Survey Mon. 32, p. 716, pl. 92, fig. 1, 1899.
[4] Science, vol. 21, p. 24, 1892.

ARTOCARPUS PUNGENS (Lesquereux) Hollick.

Plates XXV, figure 1, XXVII, figure 1, and XXIX, figure 1.

Aralia pungens. Lesquereux (not Lesquereux, 1888), The Cretaceous and Tertiary floras, p. 123, pl. 19, figs. 3, 4, 1883.

Artocarpus pungens (Lesquereux). Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 38, figs. 1, 2, 1899.

Description.—Leaves large, estimated to have been at least 30 centimeters in length by as much in width from tip to tip of the lateral lobes; pinnately lobate, the lower lobes obliquely ascending, the upper directed upward. Lobes long, linear, acute, separated by more or less broad rounded sinuses. Margins entire. Texture coriaceous. Midrib stout and straight. Lateral primaries stout, subopposite, branching from the midrib at angles of 45° below and less above, one running to tip of each lobe. Secondaries distinct, one running directly to each sinus and joining the marginal hem that is almost invariably present. Tertiaries mostly obsolete.

The species differ from *Artocarpus lessigiana* (Lesquereux) Knowlton, with which it is often confused by its more orbicular general form and in the great elongation and narrowness of the lobes, which are also more ascending and are separated by more open sinuses.

The present form was described from the Denver formation of Colorado by Lesquereux in 1883 as a species of Aralia. It was subsequently referred to Artocarpus by Knowlton, who united it with *Artocarpus lessigiana,* from which, however, it is clearly distinct, as may be readily seen by a comparison of my figures of the two species.

This form is rather common in the friable sandy clays exposed about 1 mile northwest of Benton, but it was impossible to obtain any but fragmentary specimens, the most complete being the one shown in Plate XXIX, figure 1, reproduced from a careful sketch made at the pit, since it was feared that the specimen would become broken during shipment, which subsequently happened. It is also represented by a nearly complete leaf from Coushatta, La., contained in the collections of the New York Botanical Garden, which I am enabled to figure through the courtesy of Dr. Arthur Hollick, as well as by considerable fragmentary material.

Occurrence.—Grenada formation, Grenada (?), Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, 1 mile northwest of Benton on Military road (Hyten pit), Saline County, Ark. (collected by E. W. Berry); one-fourth mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch); sec. 11, T. 12 N., R. 12 W. (collected by L. C. Chapman); and 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collections.—U. S. National Museum; New York Botanical Garden.

ARTOCARPUS DUBIA Hollick.

Plates XXIX, figure 2, and CXIII, figures 1 and 2.

Artocarpus dubia. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report of the geology of Louisiana, p. 281, pl. 38, fig. 3, 1899.

Description.—Leaves relatively small, broadly ovate, variable in size and outline, normally trilobate through the development of a narrow oblique lateral sinus in the middle part of the leaf on each side, which extends about half the distance to the midrib and is narrowly rounded proximad, with approximately parallel sides. In some specimens this sinus is not developed on one side, which is then entire. Terminal lobe very broadly ovate in outline, inequilateral, acutely pointed. Basal lateral lobes unsymmetric, but slightly produced, directed outward and upward, with short, slightly curved distal margins and long and fully rounded outside margins, their tips bluntly pointed or rounded. Length ranges from 11 to 14 centimeters. Maximum width, from tip to tip of the lateral lobes, 5 to 10.5 centimeters. Apical lobe from 7 to 9 centimeters in length and from 3.5 to 6 centimeters in maximum width. Base broadly cuneate. Leaf margin as a whole entire but irregularly undulate. Midrib stout and prominent on the lower surface of the leaf. Secondaries thin, 10 to 12 pairs, branching from the midrib at angles of 45° or more and nearly straight except near the margins. A craspedodrome secondary runs to the tip of each lateral lobe, and the others are camptodrome, becoming normally attenuated and almost imperceptibly merging in the tertiary areolation. Tertiary system more or less obscured; where seen it shows nearly straight percurrent nervilles with straight cross nervilles, together forming approximately rectangular areolæ.

This leaf is much smaller than most leaves that are referred to Artocarpus and it may possibly represent a young or small leaf of *Artocarpus lessigiana* (Lesquereux) Knowlton, with which it is usually associated, or it may be an abnormal leaf of that species. The present form is not abundant and is confined to the western Gulf region and consequently to the upper Wilcox. It is represented by several specimens and it preserves its essential features from locality to locality so that if not a true botanical species it is a form readily recognizable wherever found.

Occurrence.—Wilcox group, left bank of Red River, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); 1½ miles southeast of Naborton (collected by O. B. Hopkins) and sec. 11, T. 12 N., R. 12 W. (collected by L. C. Chapman), De Soto Parish; and Shreveport, Caddo Parish, La. (collected by O. B. Hopkins).

Collections.—U. S. National Museum; New York Botanical Garden.

Genus PSEUDOLMEDIA Trécul.

PSEUDOLMEDIA EOCENICA Berry, n. sp.

Plates XXVII, figure 3, and XXVIII, figure 2.

Description.—Leaves oblong-lanceolate in outline, ranging from 7 to 12 centimeters in length and from 1.75 to 2.25 centimeters in maximum width, which is in the middle part of the leaf. Base narrowly cuneate pointed. Apex gradually narrowed and produced as an elongate acumen. Margin entire, more or less undulate, partly because more or less revolute. Midrib very stout. Secondaries stout, numerous, at intervals of 3 to 5 millimeters, diverging from the midrib at wide angles, almost 90°, pursuing a straight course to the marginal region, where their tips are connected by flat arches. Texture coriaceous.

This species has leaves of a type ordinarily referred to the genus Ficus, some forms of which it greatly resembles, as, for example, the existing *Ficus cuspidata* Blume of the East Indies. It also resembles the leaves of several species of the allied genus Olmedia but is most similar to the closely related genus Pseudolmedia Trécul, especially the West Indian species *Pseudolmedia spuria* Grisebach, which has leaves exactly like those of the fossil species, with the same stout right-angled secondaries, flat lateral arches, and tertiary venation. The apical point has the same shape as in the fossil and is similarly extended, but the ultimate point is not as acute as in the fossil. The genus Pseudolmedia comprises about 5 species in the existing flora, which inhabit the West Indies, Central America, and tropical South America.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus FICUS Linné.

Broad leaves palmately veined:
- Very large:
  - Over 15 centimeters in width........... Ficus sp.
  - Less than 15 centimeters in width. *Ficus neoplanicostata.*
- Under 12 centimeters in width:
  - Primaries 5, basilar........ *Ficus pseudopopulus.*
  - Primaries 3, basilar............. *Ficus harrisiana.*
  - Primaries 3, suprabasilar:
    - Large leaves...... *Ficus planicostata maxima.*
    - Small leaves.............. *Ficus occidentalis.* *Ficus cinnamomoides.*

Narrower and more elongated leaves with pinnate venation:
- Leaves broadest below the middle:
  - Not over 7 centimeters wide:
    - Secondaries remote .... *Ficus schimperi.*
    - Secondaries closer .... *Ficus denveriana.*
  - Over 7 centimeters wide:
    - Outline regular, secondaries numerous. *Ficus monodon.*
    - Constricted medianly, secondaries remote. *Ficus vaughani.*
- Leaves broadest medianly, tapering to both ends:
  - Nearly as wide as long........ *Ficus artocarpoides.*
  - Much longer than wide, pointed at both ends:
    - Large leaves with numerous subparallel secondaries less than 5 millimeters apart. *Ficus eolignitica.*
    - Linear-lanceolate, tip more pointed than base, secondaries close, conspicuous marginal veins............... *Ficus myrtifolius.*
    - Lanceolate or oblong-lanceolate, equally pointed at both ends:
      - Secondaries close....... *Ficus wilcoxensis.*
      - Secondaries remote:
        - Large leaves. *Ficus puryearensis elongata.*
        - Small narrow leaves:
          - Oblong-lanceolate. *Ficus pseudolmediafolia.*
          - Acuminate-lanceolate. *Ficus pseudocuspidata.*

FICUS PSEUDOCUSPIDATA Berry, n. sp.

Plate XXVIII, figure 1.

Description.—Leaves small, lanceolate in general outline, widest in the middle and acuminate at both ends. Margins regular and entire. Texture subcoriaceous. Length about 10 centimeters. Maximum width about 2 centimeters. Petiole short and very stout, not over 5 millimeters in length. Midrib stout and straight, prominent on the lower surface of the leaf. Secondaries stout, prominent on the lower surface of the leaf, widely but regularly spaced, alternate except in the base of the leaf; they diverge from the midrib at wide angles, approximately of quite 90°, pursue a straight course, and have their ends connected by broad flat camptodrome arches. Tertiaries obsolete.

This characteristic little species is named from its resemblance to the existing oriental *Ficus cuspidata* Blume. It may also be compared with a number of existing species of northern South America. Among the members of the Wilcox flora it resembles *Pseudolmedia eocenica* Berry but is readily distinguishable, especially in its venation characters, as is obvious when the figures of the two are compared.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

FICUS OCCIDENTALIS (Lesquereux) Lesquereux.

Plate XXVIII, figure 3.

Dombeyopsis occidentalis. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 380, 1873.

Ficus occidentalis (Lesquereux). Lesquereux, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.

Description.—This species was described by Lesquereux in the following terms:

> Leaves comparatively thick, coriaceous, truncate-cordate at the base, narrowed upward into an obtuse acumen, palmately triple nerved; lateral veins equidistant, parallel, camptodrome.

The species is found in the Denver formation at Golden, Colo., and occurs sparingly in the Ackerman formation of northern Mississippi. The leaves of the form from Mississippi are somewhat smaller than those from the Rocky Mountains, averaging about 8 centimeters in length by 6 centimeters in maximum width, and the two forms may represent distinct species, although they are identical except in size. The venation is prominent.

The present species is closely related to *Ficus planicostata* Lesquereux, as well as to the Wilcox species *Ficus harrisiana* Hollick, which is widest in the middle instead of at the base and narrows both distad and proximad. The venation, though of the same general character, shows well-marked differences of detail.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Ficus denveriana Cockerell.

Ficus spectabilis. Lesquereux (now Kunth and Bouché, 1847), U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 379, 1873.

Lesquereux, The Tertiary flora, p. 199, pl. 33, figs. 4–6, 1878.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Laurus utahensis. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.

Ficus goldiana. Lesquereux, idem, p. 25 (specimen No. 2471).

Ficus denveriana. Cockerell, Torreya, vol. 10, p. 224, 1910.

Description.—This species was described by Lesquereux from the Denver formation and was based in the first instance on the large leaf shown in Plate XXXIII, figure 5, of "The Tertiary flora." Subsequently leaves of all sizes and showing a considerable range of variation were referred to this species. It is present in considerable abundance in the western half of the Mississippi embayment area and may be recharacterized as follows: Leaves ranging from 6 to 15 centimeters in length and from 2.25 to 8.5 centimeters in maximum width, which is at or more commonly below the middle; broadly ovate in outline, with a somewhat extended acuminate tip and a broadly rounded, slightly decurrent base. Margins entire. Texture coriaceous. Midrib stout, prominent on the lower surface of the leaf. Secondaries of medium size, numerous, opposite to alternate, close or somewhat remotely placed, generally subparallel, diverging from the midrib at angles of about 45°, camptodrome in the marginal region. The lower pair may be opposite and somewhat stouter, with outside lateral camptodrome branches, thus simulating a palmately triveined leaf. This is true in some of the Louisiana material as well as in some of the type material from the Denver formation. More commonly the secondaries are all similar and subparallel.

This species makes its appearance in the Midway (?) formation at Earle, Tex., as well as in the basal Eocene of the Rocky Mountain province (Raton formation). It continues throughout the Wilcox group in Arkansas and Louisiana and in beds of Wilcox age in Kentucky but has not been detected in the eastern Gulf area.

Occurrence.—Wilcox group, Scarboroughs, Clay County, Ark. (collected by J. C. Branner), Campbell's quarry, Cross Bayou, Caddo Parish, La.; McLees, 2 miles north of Mansfield, De Soto Parish, La. (collected by L. C. Johnson); and one-fourth of a mile above Coushatta, Red River Parish, La. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

Ficus cinnamomoides Lesquereux.

Ficus cinnamomoides. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 417, pl. 17, fig. 8, 1869.

Description.—Lesquereux in 1869 gave the following description:

F. foliis late ovatis, basi rotundatis, integerrimis, irregulariter trinerviis; nervo medio arcuato, nervis secundariis crassis, angulo acuto sinu obtuso egredientibus, subtus ramosis.

This species was founded on a single incomplete specimen collected by Hilgard about 1860 and since lost. I have been unable to correlate it with any of the forms in the large collections from the Wilcox that have been studied by me.

Occurrence.—"Soft white clay, Lafayette County, Miss." This means that it was from the Holly Springs sand at Oxford or the Ackerman formation at Raglands Branch, southeast of Oxford (collected by E. W. Hilgard).

Collection.—Type lost; formerly at the State University, Oxford, Miss.

Ficus neoplanicostata Knowlton.

Plate CXIV, figure 1.

Description.—This species was identified for me by F. H. Knowlton, who has fully described it in his unpublished paper on the Raton Mesa flora.

Occurrence.—Wilcox group, sec. 11, T. 12 N., R. 12 W. (collected by L. C. Chapman), and sec. 13, T. 12 N., R. 12 W. (collected by G. C. Matson and O. B. Hopkins), De Soto Parish, La.

Collections.—U. S. National Museum.

Ficus planicostata maxima Berry, n. var.

Plate XXXIV, figure 3.

Ficus planicostata. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 393, 1873.
Lesquereux, The Tertiary flora, p. 201, pl. 31, figs. 1–8, 10–12, 1878.
Hollick in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 282, pl. 36.
Ettingshausen, Roy. Soc. London Proc., vol. 30, p. 232, 1880.

Description.—Lesquereux in 1878 described this species as follows:

Leaves of medium size, subcoriaceous, entire, elliptical or broadly oval, slightly acuminate or obtuse, rounded to a short, thick petiole, palmately three-nerved from the top of the petiole, rarely from a short distance above the base; primary and secondary nerves broad, flat, all camptodrome, as well as their divisions.

As remarked by Lesquereux, and as is well shown by his figures, this species is extremely variable. To it Hollick referred a leaf from Louisiana that is identical with the western leaves except that it is larger, having an estimated length of 15 centimeters and a maximum width of 11 centimeters, which has prompted me to give it the varietal name of *maxima*. Lesquereux states that the largest leaf in his abundant western collections was 12 centimeters in length and 7 centimeters in maximum width.

The type material was abundant at Black Buttes, Wyo., occurring also at Point of Rocks, Wyo., and in the Denver formation at Golden, Colo. It is not an abundant form in the Wilcox flora and is very likely to be confused with *Ficus vaughani* Berry; in fact it is not certain that the two do not represent the foliage of a single species of Ficus, although I consider this very doubtful. It was recorded by Ettingshausen from the Ypresian of Alum Bay, but as the specimens were neither described or figured the determination can not be verified, although it is not inherently improbable.

Occurrence.—Wilcox group, Slaughter Pen Bluff, Cross Bayou, Caddo Parish, La. (collected by A. C. Veatch); sec. 7, T. 12 N., R. 11 W., De Soto Parish, La. (collected by G. C. Matson and E. H. Finch); and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—Western types, U. S. National Museum. Wilcox figured specimen, New York Botanical Garden.

Ficus planicostata latifolia Lesquereux.

Ficus planicostata latifolia. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept., 1872, p. 393, 1873.
Lesquereux, The Tertiary flora, p. 202, pl. 21, fig. 9, 1878.
Ficus latifolia (Lesquereux). Knowlton, U. S. Geol. Survey Bull. 152, p. 102, 1898.

Description.—This form was described by Lesquereux from two specimens which differed from the associated and abundant *Ficus planicostata* in their somewhat larger size, relative shortness, greater width, and their truncate or subcordate base. The material from the Wilcox is considerably larger in size and may be characterized as follows: Leaves of medium to large size, orbicular or transversely elliptical in general outline. Character of the apex unknown. Base broadly truncated or slightly cordate. Margins entire, full and evenly rounded. Texture coriaceous. Length ranges from about 8.5 to 12 centimeters. Maximum width ranges from 10 to 13 centimeters. Petiole very stout. Midrib stout, prominent on the lower surface of the leaf, A stout lateral primary diverges from the midrib on either side at its extreme base at angles of about 40° to 50°. These primaries curve upward and are camptodrome in the marginal region; they are prominent on the lower surface of the leaf but are not as stout as the midrib; they give off, at regular intervals on the outside, stout camptodrome secondaries, which increase in curvature distad, the lowest pair being subparallel with the basal margins and diverging from the primary only about 5 millimeters above the midrib, a less distance than in the specimens from Golden, Colo. Secondaries from the midrib stout, ascending, camptodrome, two or three subopposite prominent pairs. Tertiaries thin, percurrent, typical of the *Ficus planicostata* type of leaf.

Thus far these leaves have only been found in the later Wilcox of the western embayment. That they, as well as several other forms, are not represented in the very large collections from the Wilcox deposits of the eastern embayment would seem to indicate a slightly different floral facies to the westward and also an apparently freer intermigrational communication with the Rocky Mountain province.

Knowlton in 1898 raised this variety of Lesquereux to specific rank, but it seems to me to differ from *Ficus planicostata* merely in a varietal way. *Ficus planicostata* is certainly a variable form and it may possibly be polymorphous. I would not be surprised if the Wilcox variety *maxima* represented the western type, whose larger size and more robust form merely reflected the optimum conditions along the Wilcox coast, since it differs from the western *planicostata* in the same respect that the Wilcox *latifolia* differs from the *latifolia* of Colorado.

Occurrence.—Wilcox group, Shreveport, Caddo Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

FICUS ARTOCARPOIDES Lesquereux?

Plate XXXIV, figure 2.

Ficus artocarpoides. Lesquereux, The Cretaceous and Tertiary floras, p. 227, pl. 47, figs. 1–5, 1883.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 281, pl. 35, fig. 4, 1899.

Description.—Leaves large, elliptical, subcoriaceous, rounded distad and broadly rounded or subcordate proximad; midrib thick; secondaries numerous, thin, curved, ascending, camptodrome; and tertiaries numerous, fine, percurrent.

This species was doubtfully determined from Louisiana by Hollick in 1899. No new material has been collected, so that the species is included in the present work with a query, although as far as the incomplete material goes it is identical with the western specimens, which come from the "Badlands of Dakota," now known to be in the Fort Union formation. It also occurs in the Raton formation.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La., (collected by A. C. Veatch).

Collection.—New York Botanical Garden.

FICUS PSEUDOPOPULUS Lesquereux.

Plates XXXVII, figures 3–5; CXIII, figure 3.

Ficus pseudopopulus. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 313, 1876.
Lesquereux, The Tertiary flora, p. 204, pl. 34, figs. 1, 2, 1878.
Knowlton, U. S. Geol. Survey Prof. Paper (MS.).

Description.—Palmately veined leaves of medium size, broadly ovate in general outline, narrowed and acuminate at the apex, broadly rounded or truncate, and more or less decurrent at the base. Length about 12 or 13 centimeters. Maximum width, at or below the middle, about 6 to 7 centimeters. Margins entire. Texture subcoriaceous. Petiole stout, curved, about 1.5 centimeters in length. Primaries three, curved, the midrib stouter than the laterals. Lateral primaries, one on each side, diverging from the midrib just above the top of the petiole at angles of about 20°, ascending, and camptodromely joining a secondary two-thirds or more of the distance from the base to the tip. Secondaries from the upper half of the midrib, four or five alternate curved pairs, diverging from the midrib at acute angles, becoming subparallel with the lateral margins distad, and arching along them in a camptodrome manner. Secondaries from the outer side of the lateral primaries, about seven on each side, thin and camptodrome, the lowest on each side longer, stouter, and more ascending than the others, diverging at or just above the top of the petiole. Tertiaries thin, percurrent at right angles to primaries and secondaries.

This well-marked species of Ficus was described by Lesquereux from Evanston, Wyo., and is very abundant in the Raton formation of the southern Rocky Mountain province. It is markedly distinct from the other figs known from the Wilcox group, the only remotely similar form being *Ficus planicostata maxima* Berry, recorded from Caddo Parish, La. It is, however, a type common in the lower Eocene of the Rocky Mountain province, where it is represented by *Ficus occidentalis* Lesquereux [1] and by some of the forms of *Ficus spectabilis* Lesquereux [2] and *Ficus planicostata clintoni* (Lesquereux) Knowlton.[3] The Wilcox species

[1] Lesquereux, Leo, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.
[2] Idem, p. 199, pl. 33, figs. 4–6.
[3] Idem, p. 202, pl. 33, figs. 1–3.

is, however, more elongated and more distinctly triveined. Among foreign species it is closely comparable with *Ficus micheloti*, which is described by Watelet [1] from the Thanetian of the Paris basin.

The Wilcox material from Hatchie River near Shandy is preserved in clay ironstone and is very fragmentary; the complete leaf figured is a composite of drawings of several incomplete specimens. It is also found in a fragmentary condition in the clays at Puryear.

Occurrence.—Wilcox group, 1½ miles northeast of Mansfield, sec. 28, T. 13 N., R. 12 W. (collected by L. C. Chapman), and 1¾ miles west, 2¾ miles southeast, 5 miles southeast, and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Lagrange formation (in beds of Wilcox age), Puryear, Henry County (collected by E. W. Berry), and Hatchie River near Shandy, Hardeman County, Tenn. (collected by L. C. Johnson).

Collections.—U. S. National Museum.

Ficus harrisiana Hollick.

Plate XXXIV, figure 1.

Ficus goldiana Lesquereux. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Ficus Harrisiana. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 281, pl. 46, fig. 2, 1899.

Description.—Hollick in 1899 gave the following description:

Leaf about 3½ inches long by 3½ inches broad across the middle; constricted to a blunt (?) apex and wedge-shaped at the base; margin entire and wavy; three-nerved from the base and with two pairs of prominent subopposite secondaries above; midrib strongest, basal nerves branched from the lower side; all nervation finally thinning out and inosculating near the margin, tertiary nervation mainly at right angles to the primaries, secondaries, and subsecondaries, but broken in places by finer cross reticulations.

I fully share Hollick's doubts regarding the reference of this leaf to Ficus, although it is not unlike *Ficus occidentalis* Lesquereux [2] and *Ficus planicostata clintoni* (Lesquereux) Knowlton [3] from the Denver formation at Golden, Colo. *Ficus planicostata clintoni* is a slightly more elongate and coarser leaf. Hollick compares the material from Louisiana with Aralia and Hedera, and I would suggest the possibility that it represents a form of the family Leguminosæ, so strikingly represented in the Wilcox flora. It may also be compared with certain species of the genus Buttneria Linné of the Sterculiaceæ.

Two specimens (U. S. National Museum Nos. 2471, 2472) collected by L. C. Johnson on Cross Bayou were referred by Lesquereux to *Ficus goldiana*.[4] Neither specimen belongs to that species, which is now known as *Ficus spectabilis clintoni*.[5] No. 2471 is nothing like *Ficus goldiana* and is referable to *Ficus spectabilis* Lesquereux. No. 2472, though much like the Denver species with which it was confused, is referable to *Ficus harrisiana* species. It is of interest to note that Lesquereux's label reads "*Ficus goldiana* var."

Occurrence.—Wilcox group, Vineyard Bluff, Cross Bayou (collected by O. B. Hopkins and A. C. Veatch); Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson); 1 mile northeast of Rockdale Church; and sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum; New York Botanical Garden.

Ficus monodon (Lesquereux).

Plates XXXII, figure 2, and XXXIII, figure 2.

Populus monodon. Lesquereux (not Lesquereux, 1878), Am. Philos. Soc. Trans., vol. 13, p. 413, pl. 15, figs. 1, 2, 1869.

Description.—Lesquereux in 1869 published the following description:

P. foliis longis, latisque, lamina sexpolicari et ultra, deltoideo acuminatis, margine undulatis, vel parce irregulariter obtuse lobatis, nervo medio crasso, nervis lateralibus apertis, arcuatis.

This species was described from the two specimens figured by Lesquereux in 1869, the larger of which (shown in Lesquereux's fig. 1) has been available for study by the present writer. Subsequently Lesquereux [6] referred specimens from the Raton Mountains, N. Mex., to this same species. These specimens were not identical with the type material, as Knowlton has pointed out,[7] and he divides the material from New Mexico which Lesquereux identified

[1] Watelet, A., Descriptions des plantes fossiles du bassin de Paris, p. 157, pl. 44, figs. 4, 5, 1866.
[2] Lesquereux, Leo, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.
[3] Idem, p. 202.
[4] Idem, pl. 33, figs. 1-3.
[5] Knowlton, F. H., U. S. Geol. Survey Bull. 152, p. 103, 1898.
[6] Lesquereux, Leo, op. cit., p. 180, pl. 24, figs. 1, 2, 1878.
[7] Knowlton, F. H., op. cit., p. 178.

as *Populus monodon* between *Populus mutabilis ovalis* Heer[1] and *Ficus uncata* Lesquereux.[2]

Unlike most of the forms figured in Lesquereux's paper of 1869 those referred to Populus are very poorly drawn, and their describer failed to describe or figure the incurving of the lateral margin on the right, as shown in the present figure, which is a photograph of the type of Lesquereux's figure 1, or that the base of the leaf was present immediately to the left of the midrib. These two additional features serve admirably to indicate the basal characters of this species, which is undoubtedly a Ficus, and which may be more fully described as follows: Leaves large, 17 to 18 centimeters in length by 12 centimeters in maximum width, which is in the basal half, elliptical-ovate in outline, with a markedly undulate margin, narrowed and acuminate apex, and broadly rounded, truncated base, which may perhaps have been slightly cordate in some specimens. Texture coriaceous but the leaf substance thin. Midrib very stout, 3 millimeters in diameter at the base, longitudinally lined. Secondaries relatively thin, numerous, subopposite to alternate, mostly alternate, rather evenly spaced and subparallel, diverging from the midrib at angles of about 65°, the lower but slightly curved until they approach the margins, the upper more curved, all camptodrome. Tertiary venation immersed, percurrent where seen.

The present species has the same outline as the associated but smaller *Ficus schimperi* Lesquereux, with a much more immersed venation, however, and a great many more secondaries, subtending much wider angles. It also resembles *Ficus spectabilis* Lesquereux[3] of the Denver basin Eocene in outline, but is slightly larger and relatively broader and lacks the outer lateral tertiaries which spring from the basal secondaries in the Colorado species. It is the same type of leaf as *Ficus uncata* Lesquereux[4] of the basal Eocene in the Rocky Mountain region, but the tip is more extended, the base more truncated, and it lacks the camptodrome tertiaries from the outer ends of lower secondaries present in *Ficus uncata*.

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 22, pl. 1, figs. 1, 2, etc., 1856.

[2] Lesquereux, Leo, The Tertiary flora, p. 197, pl. 35, figs. 1, 1a, 2, 1878.

[3] Idem, p. 199, pl. 33, figs. 4–6, 1878.

[4] Idem, p. 197, pl. 35, figs. 1, 1a, 2, 1878.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard, E. N. Lowe, and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Ficus wilcoxensis Berry, n. sp.

Plate XXVII, figure 6.

Sapindus falcifolius Alexander Braun. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 12, pl. 4, fig. 4, 1888.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Sapindus dubius. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888 (part).
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaves relatively small, symmetrically elongate-lanceolate in outline, with the apex and the base equally narrowed and acuminate. Length about 7 centimeters. Maximum width, in the middle part of the leaf, about 1.8 centimeters. Margins regularly curved, entire. Texture coriaceous. Petiole short and rather stout, about 7 millimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, numerous, subparallel, mostly immersed in the leaf substance; they diverge from the midrib at wide angles, 60° to 70°, at intervals generally of about 2 millimeters, and pursue a nearly straight course to the marginal region, where they curve abruptly upward to form camptodrome arches subparallel with the margins.

This characteristic species in its form, texture, and venation is a typical Ficus, although specimens that have more remote secondaries suggest some lauraceous leaf, as well as some of the described species of Apocynophyllum. It is the smallest of the Wilcox species of Ficus and greatly resembles numerous recent and fossil figs that have small lanceolate, pinnately veined leaves. The existing *Ficus americana* Aublet has somewhat similar leaves, although they are a little larger and have less numerous secondaries. Among fossil forms the present species resembles the narrower forms of the

European *Ficus jynx* Unger, especially the forms of this species described by Ettingshausen from the Oligocene of the Tyrol.[1]

It is not an especially common form in the Wilcox flora. A single somewhat distorted leaf collected by R. H. Loughridge at Boaz, Ky., was referred by Lesquereux to *Sapindus falcifolius* Alexander Braun, a species widespread in the European Miocene. It is perhaps needless to add that the American form is not identical with that from Europe.[2] Other forms in the old collections from Wickliffe were identified as *Sapindus dubius* by Lesquereux.

Occurrence.—Lagrange formation (in beds of Wilcox age): Puryear, Henry County, Tenn. (collected by E. W. Berry); Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge); and Boaz, Graves County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

Ficus vaughani Berry, n. sp.

Plates XXXII, figure 1, XXXIII, figure 1, and XCII, figure 1.

Description.—Leaves relatively large, irregularly elliptical in general outline. Length about 15 centimeters. Maximum width, in the basal half of the leaf, 8 to 10 centimeters. Apex bluntly pointed. Base broadly cuneate or slightly decurrent. Margins entire but very irregularly undulate. Texture thin but coriaceous. The shape of these leaves is variable. As a rule the lower lateral margins are full and rather evenly rounded; about midway to the tip they curve inward on one or both sides to form a rounded sinus, curving upward to form the apical half of the leaf, which is thus usually narrower than the basal half, giving such leaves a somewhat trilobate appearance. In the leaf from Puryear shown in Plate XXXII, figure 1, the lamina is constricted in this manner only on the left side. Petiole stout, terete, its length not determinable. Midrib stout, terete, and very prominent on the lower surface of the leaf. Secondaries relatively thin, also very prominent on the lower surface of the leaf, six to eight subopposite to alternate pairs, somewhat irregularly spaced, diverge from the midrib at various angles, the average for a single leaf being about 45°; camptodrome in the marginal region. Tertiaries thin but well marked, camptodrome in the marginal region, percurrent in the usual Ficus fashion internally. Areolation open, quadrangular or pentagonal.

This species is represented by considerable material, mostly fragmentary, from scattered localities. It represents, however, a characteristic form, readily recognized by its irregularly undulate margins and variable outline, generally more or less constricted, enough to be differentiated into apical and basal halves.

It resembles the form from Cross Bayou identified as *Ficus planicostata* Lesquereux, but I think the two are perfectly distinct.

It is named for T. W. Vaughan, who collected it in eastern Texas more than a score of years ago. It is also represented in the museum collections by a specimen (No. 8605) collected by Prof. John C. Branner in northeastern Arkansas in 1889. The recently collected material comes from Puryear, Tenn., where the species is fairly common and from the railroad cut at Oxford, Miss., where all the plant remains are very much macerated. A single small form from Wilson County, Tex., is somewhat doubtfully referred to this species.

Occurrence.—Wilcox group, Hardys Mill near Gainesville, Greene County, Ark. (collected by J. C. Branner), and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Holly Springs sand, Oxford, Lafayette County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum.

Ficus eolignitica Berry, n. sp.

Plate XXXI, figure 4.

Description.—Leaves large, elliptical-lanceolate in general outline, texture very coriaceous, and surface polished. Length about 15 centimeters. Maximum width, in the middle part of the leaf, about 6.25 centimeters. Margins entire, slightly irregularly undulate, full, curving to the narrowed and obtusely pointed tip. Basal part of the leaf fuller than apical part, the margins incurving slightly to the somewhat decurrent, pointed base. Petiole not

[1] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 41, pl. 10, figs. 6, 8, 1855.

[2] For illustrations of this European species see Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 61, pl. 119; pl. 120, figs. 2–8; pl. 121, figs. 1, 2, 1859.

preserved, obviously stout. Midrib stout and prominent. Secondaries very thin, numerous, closely and regularly spaced at intervals of about 3 millimeters. They diverge from the midrib at wide angles of about 65° and pursue a nearly straight course, curving slightly in the marginal region, where they are abruptly camptodrome. They become almost obsolete in the thick leaf substance and their ultimate course is seen with difficulty. Tertiaries obsolete.

This species is a splendid Eocene example of the type of Ficus foliage exemplified by the existing *Ficus elastica* Linné. It differs from that species and from numerous very similar existing forms in its more tapering outline, both distad and proximad. The modern forms are usually oblong-elliptical. It has the typical texture and venation of this type of Ficus and is very distinct from the rather numerous Wilcox species as well as from any described species from the North American Tertiary, although it is not unlike some of the European Tertiary forms.

Occurrence.—Wilcox group, Hardys Mill, Greene County, Ark.

Collection.—U. S. National Museum.

Ficus schimperi Lesquereux.

Plate XXXI, figures 1–3.

Ficus Schimperi. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 417, pl. 18, figs. 1–3, 1869.

Description.—Lesquereux in 1869 gave the following description:

F. foliis membranaceis, ovato lanceolatis, acuminatis, basi rotundatis vel subtruncatis, integris, undulatis, tri subquinque nerviis, inæqualibus; nervis secundariis camptodromis, nervulis distantibus, continuis.

This species occurs in abundance in the clay ironstone at Hurleys, from which it was collected by Hilgard and described by Lesquereux in 1869, and many of the specimens, including the originals of Lesquereux's figures 1 and 2, are still in the Hilgard collection. The species is not abundant at other localities in the Wilcox group. It may be more fully described as follows: Leaves of variable size, broadly ovate-acuminate in general outline with a broadly rounded, somewhat truncated base and a usually narrowed acuminate tip. Length ranges from 5 to 13 centimeters, averaging about 9 or 10 centimeters. Maximum width, in the basal half of the leaf, ranges from 2.2 to 6 centimeters, averaging about 5 centimeters. Margins entire, generally gently undulate. Leaf substance apparently very thin but of considerable consistency. Petiole absent in all the specimens. Midrib stout, curved. Secondaries stout, four to six, subopposite to alternate pairs; they branch from the midrib at angles that average about 45° and curve upward, coming to be approximately parallel with the margins, camptodrome. The lower pair are usually opposite and in some specimens suggest lateral primaries, although the species is distinctly pinnately veined throughout. There is considerable variation in their spacing as shown in the specimens figured. Tertiaries thin, percurrent within the secondary system and forming arches in the marginal region.

In some respects the present species suggests *Ficus monodon* (Lesquereux) Berry, which has larger, relatively broader, and thicker leaves, with more numerous and divergent secondaries. It may be compared with a great variety of fossil and recent species. Among the recent species I might mention *Ficus populiformis*, *F. ferruginea*, and *F. venosa*.

It seems probable that the two broken specimens described by Lesquereux as *Celtis brevifolia* [1] are referable to *Ficus schimperi*, but as they were so very incomplete and have since been lost they are not recognized in the present report. *Ficus schimperi* is present in the Raton formation of the southern Rocky Mountain province, a formation slightly older than the Wilcox.

A similar homotaxial form is described by Watelet [2] from the Ypresian of the Paris Basin as *Ficus cuspidata* (not related to the recent species of this name).

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss., very common (collected by E. W. Hilgard, E. N. Lowe, and E. W. Berry). Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex., common (collected by T. W. Vaughan); and Coushatta, Red River Parish, La. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn., rare (collected by E. W. Berry), and Baughs

[1] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, p. 416, pl. 20, figs. 4, 5, 1869. This specific name is preoccupied, having been used by Miquel for an existing species of tropical America.

[2] Watelet, A., Descriptions des plantes fossiles du bassin de Paris, p. 156, pl. 44, fig. 3, 1866.

Bridge, Wolf River near La Grange, Fayette County, Tenn. (collected by L. C. Johnson).

Collections.—U. S. National Museum.

Ficus myrtifolius Berry, n. sp.

Plate XXX, figures 1–3.

Ficus multinervis Heer. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 11, pl. 4, figs. 2, 3, 1888.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaves narrowly elongate-lanceolate, slightly inequilateral in outline, tapering upward to an acuminate tip, and broadly pointed proximad. Length ranges from 10 to 18 centimeters, the acuminate tips usually broken off before fossilization. Maximum width, in the middle or basal portion of the leaf, 1.7 to 3.5 centimeters. Margins entire, irregularly undulate. Texture subcoriaceous. Petiole very stout, straight or curved, tumid proximad, about 1 centimeter or slightly more in length. Midrib stout, straight or curved, prominent on the lower surface of the leaf. Secondaries numerous, thin, diverging from the midrib at wide angles, many of them fully 90°, at intervals of 2 or 3 millimeters, generally a little under 2 millimeters, pursuing a nearly straight course, their tips joined by a slightly arched marginal vein, parallel with and about 1 millimeter distant from the margin.

This is a well-marked species of a narrowly lanceolate and in some specimens slightly falcate Ficus, readily distinguishable from the other rather numerous Wilcox species of Ficus. It resembles in a general way certain fossil and existing species in the families Apocynaceæ and Myrtaceæ but can be readily matched with the leaves of several existing species of Ficus. Among previously described American fossil species it is most like *Apocynophyllum scudderi* described by Lesquereux[1] from shales supposed to belong to the Green River formation of Wyoming. Specimens collected by Loughridge at Boaz, Ky., were identified by Lesquereux with the European Miocene species *Ficus multinervis* Heer,[2] to which they show considerable similarity. The American species is, however, a much more elongated leaf.

Occurrence.—Holly Springs sand, Holly Springs and Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn), and at Boaz, Graves County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

Ficus pseudolmediafolia Berry, n. sp.

Plate XXVII, figure 2.

Description.—Leaves small, lanceolate in outline, base pointed, slightly decurrent, and apex acuminate. One large specimen has the tip narrowly rounded. Length ranges from 9 to 10.5 centimeters. Maximum width, in middle part of the leaf, ranges from 2 to 3 centimeters. Margins entire. Texture coriaceous. Petiole short. Midrib stout, prominent on the lower surface of the leaf. Secondaries slender, immersed in the leaf substance, 10 to 12 pairs, rather remote and irregularly spaced, diverging from the midrib at wide angles, straight at first, curving upward abruptly in the marginal region to form flat camptodrome arches. Tertiaries mostly obsolete except for laterals parallel with and between most of the adjacent secondaries.

This lanceolate Ficus appears to be distinct from previously described fossil species. It resembles a number of recent species as well as the leaves of the genus Pseudolmedia Trécul, a genus that comprises about five species living in the West Indies, Central America, and tropical South America. It is very close to a form described by Knowlton from the Raton formation of the southern Rocky Mountain province as *Laurus ratonensis*. A very similar form, *Ficus laqueata*, has been described by Engelhardt[3] from the Tertiary of Colombia.

Occurrence.—Wilcox group, Bolivar Creek, 3½ miles north of Harrisburg, Poinsett County, Ark. (collected by L. W. Stephenson). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Ficus puryearensis Berry, n. sp.

Plates XXVII, figures 4 and 5, XXVIII, figure 5, and XXX, figures 4 and 5.

Description.—Leaves of medium size, smooth and coriaceous, oblong-lanceolate in outline.

[1] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 172, pl. 45A, figs. 1-5, 1883.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 63, pl. 81, figs. 6-10; pl. 82, fig. 1, 1856.

[3] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 26, pl. 3, fig. 22, 1895.

Apex shortly pointed. Base broadly rounded, slightly cordate or very broadly pointed. Length ranges from 9 to 11 centimeters. Maximum width ranges from 3.3 to 5 centimeters at or somewhat below the middle. There is considerable variation in the appearance of these leaves, well illustrated in the specimens figured. The widest leaf has full, regularly curved margins and is shortly and broadly pointed distad and still more broadly pointed proximad. From this extreme the leaves vary toward forms that have a rounded, almost truncate base and a somewhat extended tip. The extreme form as regards the extended tip has a slightly cordate base, with full and rounded lower lateral margins, nearly straight sides, and an elongated narrowed tip. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries relatively thin, 10 to 12 subopposite to alternate pairs, remote and somewhat irregularly spaced, diverging from the midrib at wide angles, nearly 90°, nearly straight until they reach the marginal region, where they turn abruptly upward and form a wide arch to the secondary next above. Tertiaries mostly obsolete. Margins entire.

This well-marked species is distinct from previously described forms. It appears to have been not uncommon in the upper part of the embayment area in Wilcox time and suggests by its outline the leaves of Cordia. The venation, however, is typically that of a Ficus. A number of existing species resemble this fossil form, as, for example, *Ficus ferruginea* and *Ficus angustifolia*. It is represented in the lower Claiborne by a closely allied species, *Ficus unionensis* Berry.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Ackerman formation, Hurleys, Benton County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Ficus puryearensis elongata Berry, n. var.

Plate XXVIII, figure 4.

Description.—Leaf oblong-lanceolate, with acuminate tip and narrowly cuneate base. Length generally about 12 centimeters, ranging to 15 centimeters. Maximum width, in middle part of the leaf, generally about 3.5 centimeters or slightly less, ranging to 5.65 centimeters. Margins entire. Texture subcoriaceous. Petiole short and very stout, about 7.5 centimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, diverging from the midrib at wide angles, camptodrome to a considerable distance from the margins.

Ficus puryearensis is a variable type, grading from elliptical to elongate outlines. *Ficus puryearensis elongata* differs from *Ficus puryearensis* in its narrower, more elongate outline and in the narrowly cuneate or only slightly rounded instead of the conspicuously rounded base. Venation very close to the type.

In the maximum-sized forms of this variety the leaves are very coarse and both the midrib and the secondaries are extremely stout.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Ficus sp.

Plate XXIV, figure 1.

Description.—Leaves of large size and ample width, either entire or more or less trilobate. Length at least 20 centimeters. Maximum width about the same as the length. Margin not preserved. Leaf substance subcoriaceous. Venation open, not stout, tripalmate from a point at or near the base. Lateral primaries the same caliber as the midrib. Secondaries subopposite and subparallel. Tertiaries numerous, regular, subparallel, percurrent. Areolation open, largely quadrangular.

This large-leafed species is represented by fragments, the largest of which has been figured. Though it appears to represent a new species it is too incomplete for specific characterization. It resembles a number of existing and fossil large-leafed species of the genus Ficus, but it is not certainly a Ficus although it is clearly a member of the family Moraceæ. It also suggests the allied genus Cecropia Linné, which comprises from 30 to 40 existing species in tropical America, ranging from Mexico to Brazil. Ettingshausen referred a fossil form from the Aquitanian of Bohemia to this genus, describing it as *Cecropia heerii*,[1] which, in so far as comparisons are possible, is very close to the form under discussion. Another species has been described by this author from the same horizon, and he also records [2] a species of Cecropia from the lower Eocene (Ypresian) of Alum Bay, England, which unfortunately was never described or figured.

The present form appears to be represented by similar fragmentary material in the Midway (?) formation of Earle, Tex.

Occurrence. — Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order PROTEALES.

Family PROTEACEÆ.

Genus PALÆODENDRON Saporta.

PALÆODENDRON AMERICANUM Berry, n. sp.

Plate XXXVIII, figure 1.

Description.—Leaves oblanceolate in outline, apex obtusely pointed, and base narrowed and decurrent. Texture very thick and coriaceous. Length about 7 centimeters. Maximum width, in the middle part of the leaf, about 1.5 centimeters. Margins entire. Petiole not present as a distinct unit below the narrowly decurrent basal margins of the lamina. Midrib wide and channeled, curved. Secondaries thin, immersed in the thick leaf substance; about 10 irregularly spaced pairs, diverging from the midrib at wide angles, 60° to 80°, curving slightly outward and then upward, relatively straight to the vicinity of the margins, where they curve upward to form a flat arch, approximately parallel with the margins, joining the adjacent superior secondary. Tertiaries obsolete.

This species has a very distinct individuality and closely resembles the supposed proteaceous leaves described by Saporta from the Tertiary of southeastern France. It is especially like *Palæodendron gypsophilum* Saporta[3] of the Sannoisian of Aix, which that author compares with the living *Protea caulescens* and with the fossil *Conospermum macrophyllum* of Ettingshausen. Saporta[4] subsequently redescribed this species as *Quercus palæophellos*, a disposition in which I can not at all concur. It is unlike any of the other members of the Wilcox flora, and though it may possibly represent a type still living in the American Tropics I have failed to discover such a one and have felt constrained to refer it to Saporta's genus, with which it is so closely allied.

Occurrence.—Holly Springs sand, ravine at Oxford, Lafayette County, Miss. (collected by E. W. Berry). Wilcox group, Bolivar Creek, 3½ miles north of Harrisburg, Poinsett County, Ark. (collected by L. W. Stephenson).

Collections.—U. S. National Museum.

Genus PROTEOIDES Heer.

PROTEOIDES WILCOXENSIS Berry, n. sp.

Plate XXXV, figures 4-6.

Description.—Leaves of different sizes, lanceolate and commonly falcate in general outline, tapering abruptly from about the middle to the narrowly acuminate tip and to the equally narrowly pointed decurrent base. Length ranges from 6.5 to 11 centimeters. Maximum width, about halfway between the apex and the base, ranges from 1.2 to 3 centimeters. Margins entire, full and in some specimens undulate and unsymmetric. Texture coriaceous, the substance of the leaf commonly preserved. Petiole short and very stout, winged by decurrent lamina of leaf almost or entirely to the thickened base. Midrib very stout, especially proximad, generally curved, rather prominent on the lower and channeled on the upper surface of the leaf. Secondaries numerous, thin, diverging from the midrib at a wide angle, camptodrome, as a rule almost obsolete by immersion in the substance of the leaf.

This species is common at both the Grenada and the Puryear localities, where it occurs in all sizes. Its affinities appear to be with the Proteaceæ, and it is similar to and probably filiated with some of the Upper Cretaceous species of Proteoides described from southeastern North America. Its generic relationships among the recent Proteaceæ is not determinable with certainty and it is therefore referred to the form genus Proteoides. Ettingshausen[5] records a species based on a fruit from the Ypresian of the Isle of Sheppey, and the leaves of another species from this same horizon at Alum Bay, England.[6]

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[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 1, p. 82, pl. 27; pl. 28, fig. 7, 1866.

[2] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, p. 232, 1880.

[3] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 97, pl. 8, fig. 1, 1863.

[4] Idem, vol. 3, pt. 2, p. 36, pl. 6, figs. 9-12, 1867.

[5] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 29, p. 394, 1879.

[6] Idem, vol. 30, p. 233, 1880.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 2¾ miles and 3½ miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Genus KNIGHTIOPHYLLUM Berry, n. gen.

KNIGHTIOPHYLLUM WILCOXIANUM Berry, n. sp.

Plate XXXV, figures 1–3.

Description.—Leaves of different sizes, ovate in general outline, widest at or slightly below the middle and narrowing gradually to the obtusely pointed apex and rather abruptly to the acuminate base. Length ranges from 8 to 14 centimeters. Maximum width ranges from 3 to 5 centimeters. Margins entire near the base, above which they are beset with irregularly spaced, large, recurved, outwardly directed or aquiline teeth, which in the tip of the leaf become reduced to dentate points and ultimately disappear. Texture coriaceous. Petiole long and stout, about 3.5 to 4 centimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries rather stout, numerous, somewhat irregularly spaced; they diverge from the midrib at angles of about 60°, curving but slightly in their outward course until they curve upward in a camptodrome manner some distance from the margin. A few secondaries pursue a craspedodrome course, but in general a tertiary branch proceeds to the tip of the large teeth. There are some tertiaries intermediate between the secondaries and subparallel with them, and a few percurrent tertiaries that except for their reduced caliber might be considered forks of the secondaries. The finer areolation is obsolete by immersion in the leaf substance.

This very characteristic leaf is represented by a considerable amount of material and is distinguished at once by the peculiar large marginal teeth, which resemble more or less those of some species of Quercus, Ceratopetalum, Panax (*Panax arboreum* Förster), and Clerodendron (*Clerodendron serratum* Sprengel). The present species is practically identical in all of its characters with the leaves of the existing *Knightia excelsa* R. Brown, and it is therefore made the basis of the form genus Knightiophyllum, which indicates its probable botanic affinity without implying actual generic identity with the recent species of Knightia, which are confined to Australia and New Zealand, but seem to be represented in the European Tertiary.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus BANKSIA Linné fils.

BANKSIA SAFFORDI (Lesquereux) Berry.

Plate XXXVI, figures 5 and 6.

Quercus Saffordi. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1869.

Lesquereux in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 319, pl. 6, fig. 3, 1860.

Lesquereux in Safford, J. M., Geology of Tennessee, p. 427, pl. K, figs. 2a–c, 1860.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 13, pl. 5, figs. 1–3, 1888.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, pp. 196, 198, figs. 2a–c, 1888.

Knowlton, in Glenn, L. C., U. S. Geol. Survey Water-Supply Paper 164, p. 38, 1906.

Description.—Leaves linear-lanceolate in outline, widest in the basal half; base more or less entire, gradually attenuated, and decurrent; apex greatly extended and gradually narrowed, more or less prominently toothed, and acuminate. Size variable, the average form having a length of about 16 centimeters and a maximum width below the middle of about 1 centimeter. A specimen from Wickliffe, Ky., shows the basal part of a larger leaf, which is 1.5 centimeters wide, and another specimen from the same locality, not positively identified, is 2.4 centimeters in maximum width. Lesquereux, in his description of this species in 1869, says: "Rarely an inch broad, 4 to 6 inches long," thus rather overestimating the width and underestimating the length. The average size as given above is based on a considerable number of specimens of uniform size and appearance from areas as remote as La Grange, in southern Tennessee, and Wickliffe, in northwestern Kentucky. The texture is coriaceous and the leaves were obviously more or less rigid in life, since they also have a thick prominent midrib. Petiole short and stout, about 1 centimeter in length on the average-sized leaves, like the one figured. Secondaries thin, numerous, more or less subparallel, branching from the midrib at angles between 40° and 45° at intervals of 2 to 4 millimeters, curving upward, camptodrome or caspedodrome, depending on the character of the margin; in the region where the margin is toothed a secondary ends in each tooth, and there are one or two, and in some places more, camptodrome secondaries between each craspedodrome one. The areolation is made up of tiny isodiametric, four, five, or six sided areoles. The margins are entire for a considerable distance below, about one-third of their whole length; above this point they show irregularly spaced, serrate teeth, which become more prominent and aquiline-serrate in the upper, narrower part of the leaf.

This species is strikingly distinct when represented by complete specimens. Fragments, however, are likely to be confused with contemporary species of Dryophyllum, Myrica, Fraxinus, and the like. The attenuated terminal portions of the leaves of *Banksia saffordi* may be confused with *Banksia tenuifolia* Berry, but where the margins are toothed and not entire they may be distinguished by their much more prominent aquiline teeth.

Lesquereux first described this species from Somerville, Tenn., and, as he imagined that he was dealing with a Pleistocene instead of a lower Eocene flora, he naturally sought for similar forms among recent species of Quercus, Asa Gray having furnished him with the leaves of certain modern species for comparison. No very similar modern species were found, however. In his paper published in 1888 he compares it with *Quercus furcinervis* (Rossmässler) Unger, a widespread Tertiary species of Europe, which appears for the first time in the Sannoisian and which is markedly distinct from the American form.

This misconception with regard to the Pleistocene age of the specimen caused Lesquereux to fail to recognize the very obvious and close relationship between his *Quercus saffordi* and the numerous European older Tertiary species of Banksia described by Ettingshausen, Saporta, and others, and so elaborately compared with the existing species of Banksia by the first of these authors. It will be profitable to compare the present species with some of these forms. Fossil species of Proteaceæ are exceedingly common in Europe, and numerous genera characterize the Oligocene floras. Most of these forms appeared in the later Eocene and many of them survived the close of the Oligocene, but they were especially prominent during that epoch. *Banksia saffordi* greatly resembles a group of these European species, which includes *Banksia ungeri* Ettingshausen,[1] *Banksia haeringiana* Ettingshausen,[2] *Myricophyllum gracile* Saporta,[3] and *Myricophyllum zachariense* Saporta.[4] These forms abound in the upper Eocene gypsiferous deposits of southeastern France and in the lower Oligocene in the leaf beds of Monte Promina, Dalmatia, Haering in the Tyrol, Sagor in Carniola, and in the lignites of Styria, where Sotzka is the most famous fossil plant locality.

Most of the European forms are somewhat smaller than *Banksia saffordi* and some are less acuminate distad. Saporta's enlargement [5] of *Myricophyllum gracile*, which is about twice natural size, is almost exactly like *Banksia saffordi* in outline, margin, and venation. Another fossil form which shows considerable resemblance to the present species is *Myrica banksioides*, described by Engelhardt [6] from the Tertiary of Bolivia. On the whole, *Banksia haeringiana* Ettingshausen is most like the American plant. Numerous existing species of Banksia in the Australian region are similar to these fossil species, among which might be mentioned *Banksia spinulosa*, *B. collina*, *B. littoralis*, *B. attenuata*, *B. marginata*, and *B. serrata*.

A few American specimens have been identified with European species of Banksia, but the only undoubted representatives of this genus on this continent are this and the follow-

[1] Ettingshausen, C. von, Die Proteaceen der Vorwelt, p. 23, 1851. For figures of this species see Unger, F., Die fossile Flora von Sotzka, pp. 30, 39, pl. 6, figs. 3, 4; pl. 7, figs. 2–6, pl. 20, figs. 1–6, 1850; and Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 54, pl. 17, figs. 1–22, pl. 18, figs. 1–6, 1852.

[2] Ettingshausen, C. von, Die Proteaceen der Vorwelt, p. 23, pl. 2, figs. 17, 18, 1851; Die tertiäre Flora von Häring in Tirol, p. 54, pl. 16, figs. 1–23, 1853; Die eocene Flora des Monte Promina, p. 17, pl. 7, fig. 16, 1854, and numerous other publications.

[3] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 102, pl. 10, fig. 1, 1863.

[4] Idem, vol. 1, pp. 176, 220, pl. 8, fig. 2, 1863; vol. 2, p. 99, 1866.

[5] Idem, vol. 1, pl. 10, fig. 1a.

[6] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1887, p. 36, pl. 1, figs. 10, 14; idem, 1894, p. 5, pl. 1, figs. 6, 7, 14, 17.

ing species of the Gulf States. It would seem that southeastern North America during the first half of the Eocene afforded the closest botanic parallel with southern Europe during the later Eocene and early Oligocene.

Banksia saffordi is not uncommon at a considerable number of localities and horizons in the Wilcox group. It is most common in the upper embayment area—that is, north of the boundary between Tennessee and Mississippi. The locality between Grand Junction and La Grange is at least 150 feet above the base of the Wilcox, since the wells of that depth at Grand Junction fail to penetrate the underlying Porters Creek clay. As shown by well records the Wickliffe plant bed is about 450 feet above the base of the Wilcox and the plants from Boaz are probably from about the same level. Somerville is nearer the top of the Wilcox and Grenada is at the extreme top. A single specimen was found from Boaz on the reverse of one collected by Loughridge and labeled *Quercus elæna* Unger by Lesquereux.[1] The species is not known from the Ackerman formation.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age): Somerville, Fayette County, Tenn. (collected by J. M. Safford); 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn and E. W. Berry); Puryear, Henry County, Tenn. (collected by E. W. Berry); Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge and L. C. Glenn); and Boaz, Graves County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

BANKSIA TENUIFOLIA Berry, n. sp.

Plate XXXVI, figures 1–3.

Description.—Leaves linear in outline and variable in size, ranging from 12 to 30 centimeters in length and from 2 to 7 millimeters in maximum width, which is near the middle of the leaf but somewhat nearer the base. Apex very gradually narrowed to an acuminate tip. Base similarly and gradually narrowed. Margins entire for the basal third of their length, and in many specimens entire for considerable distances in the distal two-thirds of their course, or with irregularly spaced and scattered teeth. As a rule, however, the margins above the entire basal portion are regularly toothed. The teeth are placed singly at the ends of secondaries and range from dentate points directed outward and separated by shallow equilaterally rounded sinuses, as shown in Plate XXXVI, figures 1 and 3, to rather prominent, serrate teeth, directed somewhat upward and separated by inequilateral sinuses, rounded below and straighter above, as in figure 2. Petiole very short, practically lacking, since the lamina starts from the extreme base. Midrib stout, relatively very stout, and straight, slightly curved distad in some of the narrower specimens, occupying one-third of the total width and prominent on the lower surface of the leaf. Secondaries numerous, thin, subparallel, branching from the midrib at angles of 55° to 65° and curving slightly upward, craspedodrome and terminating in the marginal teeth, or camptodrome near the margin in the entire parts of the leaf. Areolation minute, more or less isodiametric, composed of four, five, or six sided meshes. Texture very coriaceous. The texture and thick midrib indicate that these leaves were very rigid in life, and they were also slightly revolute, since the margins are sharply and broadly impressed in casts of the lower surface.

This handsome species, though clearly congeneric with *Banksia saffordi*, which it resembles in numerous details of its structure, is readily distinguishable, even in small fragments, by its narrow linear and greatly elongated form and less produced teeth. Though it differs considerably in size, its appearance is unchanged, since the relative proportions are the same in leaves of all sizes, from the small forms, not over 2 millimeters in maximum width with nearly entire margins, to the larger forms, at least 30 centimeters in length with regularly toothed margins distad.

This is one of the most striking forms in the Wilcox flora and must have been a considerable element of the flora toward the head of the embayment since it has not been collected south of Henry County, Tenn. It is much like a number of existing Australian species of Banksia and Dryandra. Perhaps *Banksia spinulosa* R. Brown is most like the American form. Though similar in the bulk of its characters to numerous European Oligocene species, *Bank-*

[1] Specimen No. 2574, U. S. National Museum, which was recorded as *Quercus neriifolia* Alexander Braun by Lesquereux in U. S. Nat. Mus. Proc., vol. 11, p. 12, 1888.

sia tenuifolia is more slender and seems to represent the extreme of elongation in the fossil leaves of this genus. The most similar fossil species known seems to be *Banksia longifolia* Ettingshausen,[1] which is recorded from a large number of European localities, ranging in age from the upper Eocene through the Oligocene and into the basal Miocene.

Unger's Plate VII, figure 1, especially the smaller specimen in this figure, from Sotzka, Styria, and Ettingshausen's specimens from Monte Promina in Dalmatia, figured on his Plate VIII, show how closely this somewhat later European form approaches its American prototype. Unger referred this species to Myrica in 1850, although he recognized its proteaceous resemblances. Ettingshausen was the leading exponent of the proteaceous affinity of this and numerous other Tertiary types. Controversy was at one time quite heated, and among others Bentham in England went so far as to doubt the ability of anyone to recognize a fossil leaf of the Proteaceæ. I think anyone who takes the trouble to look into the subject will find it difficult not to see proteaceous affinities in these forms, and opinion of late years has been practically unanimous that this modern antipodean type was a cosmopolitan Tertiary type. This logical conclusion has been fortified by the discovery of abundant and characteristic fruits of several of the genera.

Banksia tenuifolia is extremely abundant at Puryear, Tenn., and occurs also near the head of the embayment both in northeastern Arkansas and western Kentucky.

Occurrence.—Wilcox group, 4 miles southwest of Boydsville, Clay County, Ark (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by R. H. Loughbridge and L. C. Glenn).

Collections.—U. S. National Museum.

BANKSIA PURYEARENSIS Berry, n. sp.

Plate XXXVI, figure 4.

Description.—Leaves of different sizes, lanceolate to oblong-lanceolate and most of them falcate in general outline, widest at or below the middle, from which point they taper gradually upward to the acuminate tip and downward to the narrowly cuneate base. Length ranges from 5.5 to 11 centimeters. Maximum width ranges from 1.2 to 1.5 centimeters. Margins entire in the lower half of the leaf, with very fine, remote, irregularly spaced, serrate teeth above the middle. Texture subcoriaceous. Petiole short and stout, about 6 to 8 millimeters in length. Midrib stout, prominent, and curved. Secondaries thick, numerous, diverging from the midrib at angles of more than 45°, pursuing a rather straight course; those in the lower half of the leaf are joined at their ends by flat camptodrome arches subparallel with the leaf margin; some of those in the upper part of the leaf are craspedodrome, running to the marginal teeth. Tertiaries immersed in the leaf substance.

This species presents some of the features of Myrica, to which genus it may belong. It seems, however, to be more closely allied to the two species of Banksia that are so abundant in the Wilcox. It is much less elongated and relatively wider than either *Banksia tenuifolia* Berry or *Banksia saffordi* (Lesquereux) Berry, differing widely from the greatly elongated, narrowly linear, toothed leaves of *tenuifolia*, and with much finer teeth, shorter petiole, and thinner texture than *saffordi*. It is not unlike certain European Tertiary and modern Australian species of Banksia.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order ARISTOLOCHIALES.

Family ARISTOLOCHIACEÆ.

Genus ARISTOLOCHIA Linné.

ARISTOLOCHIA WILCOXIANA Berry, n. sp.

Plate XXXVIII, figure 3.

Description.—Fruit a large capsule, oblong-elliptical in lateral view, as shown in the figure, presumably nearly circular in transverse section, the surface marked with obscure longitudinal ridges, of which three are indistinctly shown in the figured specimen. Evenly and broadly rounded distad, somewhat narrowed proximad, where it is broken away from the peduncle.

The present form appears to represent the fruit of a Wilcox species of Aristolochia.

[1] Ettingshausen, C. von, Die Proteaceen der Vorwelt, p. 22, pl. 2, fig. 19, 1851; Die tertiäre Flora von Häring in Tirol, p. 53, pl. 15, figs. 11-26, 1853; Die eocene Flora des Monte Promina, p. 33, pl. 7, figs. 12-14, pl. 8, 1855. Unger, Franz, Die fossile Flora von Sotzka, p. 29, pl. 6, fig. 2; pl. 7, fig. 1, 1850.

Leaves, recognizable as such, are not known from the Wilcox, but a species of Aristolochia is represented by leaves in the embayment area toward the top of the Claiborne group (*Aristolochia claiborniana* Berry, unpublished) and a smaller fruit has been recognized by Knowlton from the lower Eocene of New Mexico (Raton formation).

The genus Aristolochia is represented in the existing flora by more than 200 species, chiefly vines, which are commonly of great length, living in temperate but mostly in tropical countries. The fruits are many seeded generally six-celled capsules, and a large number of the modern species have fruits very similar to this fossil species.

There are more than a dozen described fossil species of Aristolochia based on both foliage and fruit, the oldest remains of the fruit being a species described by Bayer[1] as *Aristolochia tecomæcarpa* from the Upper Cretaceous (Cenomanian) of Bohemia. The present fruit is not very different from *Aristolochia œningensis* Heer[2] from the Swiss Miocene, which was also identified by Lesquereux from the Tertiary lignites of Brandon, Vt.[3] A large number of fruits referred to Aristolochites have been described from these lignites.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order POLYGONALES.

Family POLYGONACEÆ.

Genus COCCOLOBIS P. Browne.

COCCOLOBIS EOLIGNITICA Berry, n. sp.

Plate XXXVIII, figure 4.

Description.—Leaves obovate or elliptical in general outline, with a broadly rounded or slightly emarginate apex and a broadly cuneate or slightly decurrent base. Length about 9 centimeters. Maximum width, in the middle part of the leaf, about 4.6 centimeters. Margins entire, slightly undulate. Texture coriaceous. Petiole stout, about 1.5 centimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, distant, irregularly spaced, about six alternate pairs. They diverge from the midrib at angles ranging from 45° to 60° and pursue a somewhat irregular, more or less curved, and slightly flexuous course, the lower ones continuing upward parallel with the lateral margins, the upper shorter and more strongly curved, a type of secondary venation ordinarily found in Cornus, Rhamnus, and Berchemia. Tertiaries obsolete.

This fine leaf is obviously unlike any other member of the Wilcox flora. It resembles in a general way the somewhat smaller leaves of Bourreria P. Browne, a tropical American genus of the Boraginaceæ, one species of which, *Bourreria havanensis* Miers, reaches the keys of southern Florida. On the whole the fossil has more of the characters of Coccolobis and may be compared with the leaves of the existing *Coccolobis laurifolia* Jacquin, the pigeon plum, which is such an abundant seacoast tree of the Florida Keys, of the Bahamas and many of the Antilles, as well as of Venezuela. The genus Coccolobis is confined to America in the existing flora and comprises more than 120 species, which are distributed from southern Florida through the West Indies to Brazil and from Mexico and Central America to Peru. This or a closely allied genus is represented in the Upper Cretaceous Tuscaloosa flora of northwestern Alabama, and several species of Coccoloba have been described by Ettingshausen[4] from the Aquitanian of Europe. A small leaf of questionable affinities from Carbon, Wyo., was also described by Lesquereux as *Coccoloba lævigata*,[5] and Engelhardt has described[6] a form from the early Tertiary (Eocene or Oligocene) of Coronel, in Chile, which he calls *Phyllites coccolobæfolia*.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

COCCOLOBIS UVIFERAFOLIA Berry, n. sp.

Plate LXXXVII, figure 5.

Description.—Leaves subsessile, elliptical to orbicular in general outline, with a broadly

[1] Bayer, E., K. böhm. Gesell. Wiss. Sitzungsber., 1899, No. 26, p. 29, text figs. 10, 10a, pl. 1, figs. 7, 8, 1900.

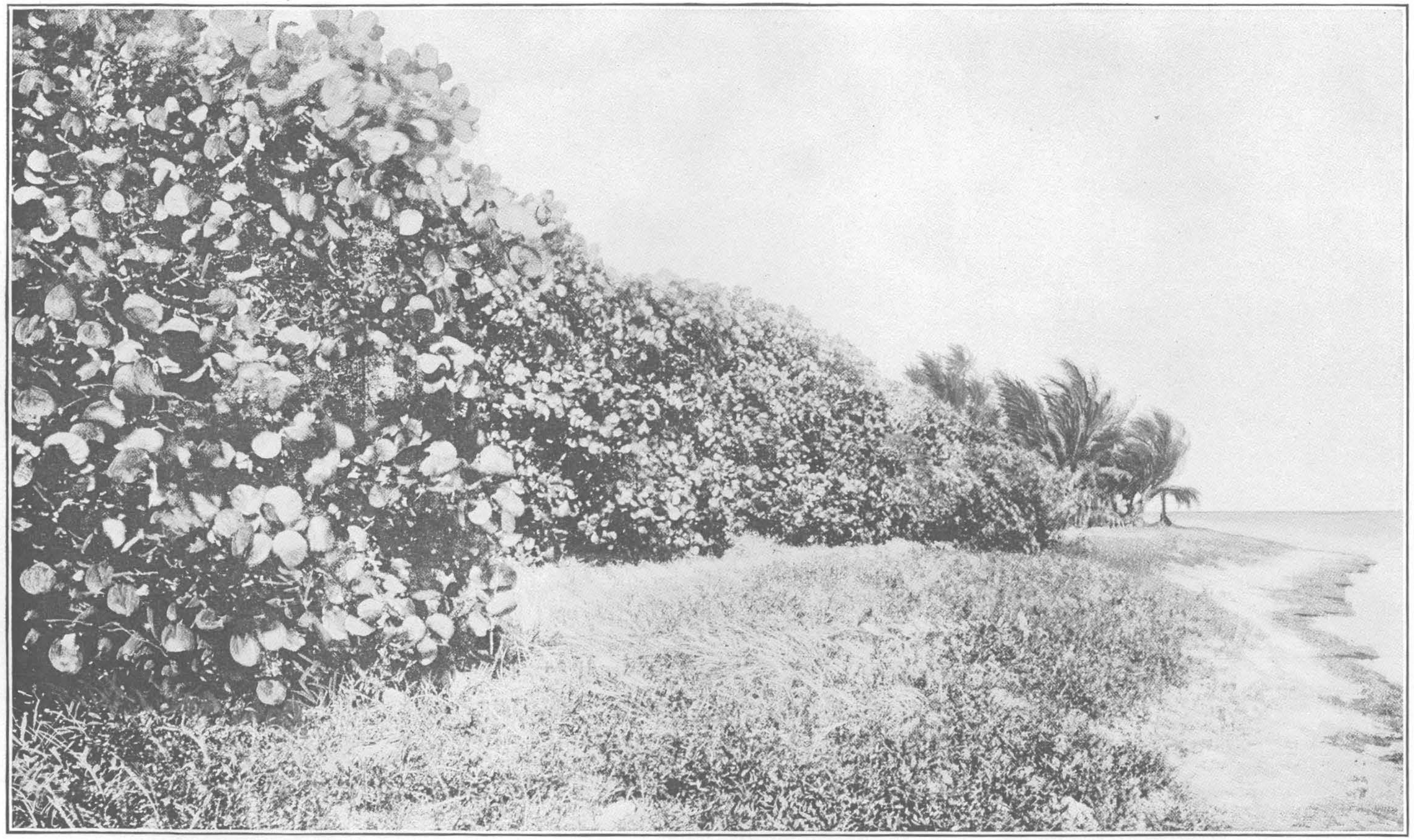
[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 104, pl. 100, fig. 11b, 1856.

[3] Lesquereux, Leo, Geology of Vermont, vol. 2, p. 715, fig. 134, 1861.

[4] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 1, pp. 88, 89, pl. 30, figs. 1, 2, 1866.

[5] Lesquereux, Leo, The Tertiary flora, p. 208, pl. 35, fig. 7, 1878.

[6] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 16, pt. 4, p. 683, pl. 4, fig. 8b; pl. 12, fig. 6, 1891.



ROCKY SHORE OF ST. CROIX, DANISH WEST INDIES, SHOWING COCCOLOBIS ASSOCIATION.
Courtesy of Augustana Book Concern.

rounded apex and a cordate base. Length about 8.5 centimeters. Maximum width, midway between the apex and the base, about 7.5 centimeters. Margins entire, full and undulate. Texture coriaceous. Petiole short and broad, practically wanting. Midrib stout, prominent, curved. Secondaries stout, four or five subopposite pairs, the lower pairs diverging from the midrib at wide angles, the upper one or two pairs at acute angles, all pursuing extended, somewhat flexuous, sweeping, curved courses, eventually parallel with the margin along which they arch.

The present well-marked species is named from its resemblance to the existing *Coccolobis uvifera* Jacquin, which inhabits tidal shores and beaches from Mosquito Inlet and Tampa Bay southward along the coast of peninsular Florida and is common in the Bermuda and Bahama Islands, in the Antilles, and along the South American coast from Colombia to Brazil. The fossil leaves are somewhat smaller than those of the existing species, but otherwise they agree closely in all of their characters. A characteristic view of the habitat of the modern species is shown on Plate VIII.

Coccolobis uviferafolia differs from the other Wilcox species, *Coccolobis eolignitica* Berry, in about the same way that the existing *Coccolobis uvifera* Jacquin differs from the other Florida species, *Coccolobis laurifolia* Jacquin. It is an interesting fact that these two modern types of the Florida Keys and tropical America should be associated along the Wilcox coast in western Tennessee.

There are likewise two species in the flora of the overlying Claiborne group, one of which, *Coccolobis columbianus* Berry, greatly resembles the present species.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order CHENOPODIALES.

Family NYCTAGINACEÆ.

Genus PISONIA Linné.

PISONIA EOLIGNITICA Berry, n. sp.

Plate XXXVIII, figures 5 and 6.

Description.—Leaves small and sessile, oblanceolate to obovate in general outline, the apex rounded or obtusely pointed and the base narrowly cuneate or slightly decurrent. Length ranges from 2.6 to 3.1 centimeters. Maximum width, at or above the middle of the leaf, ranges from 7.5 to 12 millimeters. The narrower leaves are thus somewhat spatulate in appearance. Margins entire, full, and rather evenly rounded, except where they straighten to form the cuneate base, decidedly revolute. Texture thick and coriaceous, the venation, except for the midrib, being entirely immersed and obsolete. The midrib is stout, nearly straight, and prominent on the lower surface of the leaf. This feature is well shown in the larger of the two figured specimens, which represents a leaf with its substance preserved, the under side being exposed and showing, in addition to the stout, prominent midrib, the revolute character of the very entire margin. The midrib is not at all prominent on the upper surface of the leaf and is scarcely discernible, even toward the base, in the smaller specimen figured, which is a narrow form of this species that is preserved with the upper surface exposed.

This is a well-marked species, readily distinguished by the absence of a petiole and by its broad tip, narrow base, thick substance, and revolute margins, all features that serve to separate it from the following associated species. It is very similar to several existing American species of Pisonia, for example *Pisonia longifolia* Sargent, which extends northward from Brazil through the West Indies to the Florida Keys as far as Cape Canaveral. *Pisonia longifolia* is a fair-sized tree with an erect or inclined trunk, an inhabitant of sea beaches and the shores of salt-water lagoons. Its most striking difference from the fossil is in the petiolate character of the leaves, the petioles being about 1.25 centimeters in length. Other comparable existing American forms are *Pisonia floridana* Britton and *Pisonia macranthocarpa* Donnell Smith.

Guppy states that the seeds of the Polynesian species have no buoyancy, but that the fruits are sticky and are distributed by their property of adhering to the plumage of birds.

The modern species of Pisonia are numerous and occur chiefly in the Tropics in both hemispheres, but mostly in America. About a dozen fossil species are known and there are several different forms in the European Tertiary, some of them represented by fruits as well as leaves. Pisonia makes its appearance in the Upper

Cretaceous of both America and Europe (North Carolina and Bohemia). In addition to the species described below *Pisonia claibornensis* Berry is found in the flora of the Claiborne group in Georgia and Louisiana, and *Pisonia jacksoniana* occurs in deposits of Jackson age in Arkansas.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

PISONIA CHLOROPHYLLOIDES Berry, n. sp.

Plates XXXVII, figure 1, and XLII, figure 1.

Quercus chlorophylla. Lesquereux (in part, not Unger), Am. Philos. Soc. Trans., vol. 13, p. 416, pl. 17, fig. 7 (not figs. 5, 6), 1869.

Description.—Leaves relatively large, obovate in general outline, the apex rounded and the base cuneate and decurrent. Length about 6 centimeters. Maximum width, slightly above the middle, about 2.8 centimeters. Median lateral margins full and rounded. From the region of maximum width the margins curve inward rapidly distad to the broadly rounded tip. They likewise curve inward proximad, curving outward in the basal region to form the decurrent base. Margins entire, slightly irregular. Texture coriaceous. Petiole missing in the type specimen, evidently short and stout. Midrib very stout proximad, becoming thin distad, curved, prominent on the lower surface of the leaf. Secondaries thin, mostly immersed in the leaf substances, six or seven pairs, diverging from the midrib at angles of about 50° to 55° and camptodrome in the marginal region. Tertiaries entirely obsolete.

This species is much larger than the associated Wilcox species of Pisonia, which it resembles in a general way. It approaches the Claiborne species *Pisonia claibornensis* Berry [1] but is abundantly distinct. Among previously described fossil species it is most similar to *Pisonia eocenica* Ettingshausen,[2] a common European species that makes its appearance at the base of the Oligocene.

There are several existing American species that are much like *Pisonia chlorophylloides*, the most similar being probably *Pisonia aculeata* Linné, the type of the genus.

[1] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 140, pl. 28, fig. 3, 1914.

[2] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 43, pl. 11, figs. 1-22, 1853.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard).

Collection.—University of Mississippi.

PISONIA PURYEARENSIS Berry, n. sp.

Plate XXXVIII, figure 7.

Description.—Leaves small, elliptical in general outline, the margins slightly incurved distad to form the narrowly rounded apex. Base about equally rounded, but basal margins evenly rounded and not incurved to match the apex. Length about 3.2 centimeters. Maximum width, in the middle part of the leaf, about 1.2 centimeters or slightly less. Margins entire. Texture coriaceous but leaf substance not nearly as thick as in the preceding species. Petiole stout and curved, about 3 millimeters in length. Midrib rather stout, much thinner than in *Pisonia eolignitica* Berry, slightly curved toward its tip. Secondaries thin, mostly immersed, ascending, curved, camptodrome.

This species has thinner, petiolate, and more elliptical leaves than *Pisonia chlorophylloides*, from which it is readily distinguishable. Superficially it approaches some of the leaflets of the Cæsalpiniaceæ and Mimosaceæ of the Wilcox flora, as, for example, those of the genus Cassia, which are, however, as a rule, thinner and have short or no petiolules and different venation. It is not unlike several existing American species of Pisonia, with which comparisons have been made. A similar fossil form from the Tertiary of Ecuador is referred to the genus Vochysia Jussieu by Engelhardt [3] and compared with the existing Brazilian *Vochysia elliptica* Martius.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order RANALES.

Family MAGNOLIACEÆ.

Genus MAGNOLIA Linné.

MAGNOLIA ANGUSTIFOLIA Newberry.

Magnolia attenuata. Lesquereux (not Weber), The Tertiary flora, p. 250, pl. 45, fig. 6, 1878.

Magnolia angustifolia. Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 513, 1882 (1883).

[3] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 15, pl. 1, fig. 6, 1895.

Magnolia lanceolata. Hollick (not Lesquereux), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 282, pl. 40, 1899.

Description.—Leaves large, lanceolate in general outline, with a pointed tip and a narrowly cuneate, slightly decurrent base. Length ranges from 19 to 30 centimeters. Maximum width, about midway between the apex and the base, ranges from 5.25 to 7.5 centimeters. Margins entire. Texture subcoriaceous. Petiole stout, its whole length not preserved. Midrib stout and straight, prominent on the lower surface of the leaf. Secondaries relatively thin, remote, about 10 opposite to alternate pairs. They diverge from the midrib at angles of about 50°, curving upward somewhat abruptly two-thirds of the distance to the margin, and ascending along it in a camptodrome manner.

This fine large species was described by Newberry in 1882, but not figured, the only published figure being the lower half of a leaf from the type locality at Fishers Peak, N. Mex. (Raton formation), identified by Lesquereux four years earlier as *Magnolia attenuata* Weber. It is obviously distinct from that species. Its occurrence in the Wilcox flora is thus far limited to the large specimen from Coushatta identified by Hollick as *Magnolia lanceolata* Lesquereux,[1] a single nearly complete leaf from Puryear, Tenn., collected by me, and fragmentary specimens from the vicinity of Naborton, La. Though the general form and size are similar to *Magnolia lanceolata* the two are perfectly distinct. *Magnolia angustifolia* has much fewer secondaries, at a different angle of divergence and curving upward more abruptly in the marginal region. It is also more lanceolate rather than oblanceolate. It is a form abundant in the recent Lee collections from the Raton region of New Mexico, which have been described by Knowlton, and adds another link in the correlation of the Rocky Mountain lower Eocene with that of southeastern North America.

Occurrence.—Wilcox group, Coushatta, Red River Parish, La. (collected by G. D. Harris), and 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

[1] Lesquereux, Leo, Mus. Comp. Zool. Mem., vol. 6, no. 2, p. 24, pl. 6, fig. 4, 1878.

MAGNOLIA LEEI Knowlton.

Plate XLIII, figures 1 and 2.

Magnolia Leei. Knowlton, U. S. Geol. Survey Prof. Paper (MS.).

Description.—Leaves medium sized to large, ranging from 13 to 30 centimeters in length and from 5.5 to 8 centimeters in maximum width, the larger leaves being relatively much narrower than the smaller leaves. The maximum width of most of the material is very close to 7 centimeters. There is considerable difference in the form of the leaves. The shorter are slightly obovate in general outline, the maximum width being just above the middle. From this point the fully rounded lateral margins curve slightly inward proximad to the gradually narrowed and decurrent base; distad they curve inward somewhat more abruptly and are then more or less greatly extended and acuminate. The larger leaves are more nearly oblong-lanceolate in outline, for though the region of maximum width is still above the middle, it is distinguished by the narrower form of the leaf and the nearly equal narrowing of the apex and the base. Margin entire, but as a rule slightly undulate, its shallow waves following closely the distal bowing of the camptodrome secondaries. Texture relatively thin for such large leaves, apparently stiff but not at all meriting the term coriaceous. Petiole short and stout. Midrib stout, somewhat curved in all the material examined, prominent on the lower surface of the leaf. Secondaries relatively thin and distant for leaves of this size, prominent, 8 to 15 pairs, ranging in position from alternate to subopposite, branching from the midrib at angles, ranging from 55° to 62° in the median region of the leaf, from 43° to 63° in the distal region, and from 46° to 67° in the proximal region.

The spacing of the secondaries at their origin from the midrib ranges from 14 to 26 millimeters in the median region of a single specimen. Where the interval is wider an unusually large tertiary branches from the midrib in the upper half of the space, at a wider angle than the secondaries, and runs with but slight curvature to the lower secondary. The secondaries are all regularly curved upward, arching along and close to the margin, eventually and finely camptodrome. Tertiaries, with the exception of the enlarged ones just described, very thin, largely percurrent.

The large and more lanceolate specimen figured is superficially unlike the smaller one figured and may be thought to be distinct from it by some students. These two extremes are so closely connected by gradations that the conclusion is irresistible that they represent the limits of variation in leaf form of a single species.

It was recently described from the Raton formation of the southern Rocky Mountain province in Colorado and New Mexico, a slightly earlier horizon, where it is exceedingly abundant and varied. Several fine large specimens have the apex extended as a strikingly slender acumen.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Family ANONACEÆ.

Genus ANONA Linné.[1]

ANONA WILCOXIANA Berry, n. sp.

Plate XLI, figures 1 and 2.

Description.—Leaves of medium size, elliptical in general outline, the tip somewhat narrowed and rounded and the base rounded or slightly pointed. Length about 12 centimeters. Maximum width, in the middle part of the leaf, about 4.25 centimeters. Margins entire. Texture coriaceous. Petiole short and extremely stout, about 1.25 to 1.5 centimeters long. Midrib very stout and prominent. Secondaries stout, eight or nine alternate, rather distant pairs; they diverge from the midrib at angles of 50° to 80°, and sweep upward in broad, subparallel curves, becoming parallel with the lateral margins, along which they arch for considerable distances, especially in the lower half of the leaf. Tertiaries thin but well marked, nearly straight and percurrent transverse to the long axis of the leaf.

This species is well marked, as may be seen from the figured specimens, which have been chosen to show the range of variation in the character of the base. Remains referable to the genus Anona have not been found in any great abundance in North America. Lesquereux many years ago described a species from the Dakota sandstone of Kansas and another from the lower Eocene of Colorado. Recently Cockerell has described a third American species from the Miocene of Florissant, Colo. More than 10 species, based on both seeds and fruits, ranging in age from the Eocene to the Pliocene, have been described from the European Tertiary. Ettingshausen [2] mentions two new species of Anona leaves in the Alum Bay clays (Ypresian).

The existing species, many of which are economically valuable, number about 60, all of them American except two or three forms of Africa and tropical Asia. Several forms are widely cultivated in all tropical countries, and their original home has been a matter of dispute, since the cultivation of some species probably antedated the discovery of America. This is indicated by the description of *Anona squamosa* Linné, written by Oviedo as early as 1535.

A. de Candolle,[3] after his extensive systematic studies of the Anonaceæ, reached the conclusion that Anona was of American origin and that the ancestors of the cosmopolitan cultivated forms probably came from the West Indies or from the neighboring part of the American continent. This is unquestionably true not only of the cultivated forms but of the genus as a whole, the present and associated species furnishing early Eocene ancestors of the modern forms.

Among fossil species *Anona wilcoxiana* Berry may be compared with *Anona elliptica* Unger [4] from the European Miocene, a form with very similar leaves. Among recent forms it is scarcely to be distinguished from *Anona glabra* Linné, the only species that reaches southern Florida—a stout tree of dense growth, commonly with buttressed roots, that grows in shallow ponds, swampy hammocks, and low stream borders near the coast, associated with ferns of the genera Meniscium, Acrostichum, and Dryopteris. It is found on both coasts of tropical America and extends through the Bahamas and many of the Antilles. It also occurs on the west coast of Africa, having possibly been spread by the very light branches

[1] The name of the genus is often spelled Annona.

[2] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, p. 234, 1880.

[3] Géographie botanique, p. 859, 1855.

[4] Unger, Franz, Sylloge plantarum fossilium, pt. 3, p. 43, pl. 14, figs. 1, 2, 1866.

with fruit which were transported by currents. Most of the species are coastal forms of different habitats. Guppy mentions quantities of seeds of *Anona paludosa* in the drift of the Guayaquil River estuary, many of them in a germinated condition. Safford mentions that *Anona reticulata* is readily naturalized in Guam and other parts of the oriental Tropics, where it occupies a prominent place in the scrub of the inner beaches. It seems probable that this and the other Wilcox species of Anona inhabited the low shores of coastal lagoons or the lower and more or less swampy reaches of the tributary streams. No seeds referable to Anona have been discovered in the clays of the Wilcox group, but Lesquereux many years ago recorded seeds from Oxford, Miss., which he described as *Asimina leiocarpa*.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry); bed of Mobley Creek, 4 miles southwest of Trenton, Gibson County, Tenn. (collected by Bruce Wade). Wilcox group, 2 miles and 5 miles southeast of Naborton and sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Anona eolignitica Berry, n. sp.

Plate XLII, figures 2–4.

Description.—Leaves of medium size, oblong-elliptical in general outline, the apex and base rounded or bluntly pointed. Length ranges from 10 to 16 centimeters. Maximum width, in the middle part of the leaf, ranges from 4.25 to 5.5 centimeters. Margins entire, very slightly undulate on some specimens. Texture coriaceous. Short and stout, enlarged proximad, about 6 millimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries stout but immersed in the leaf substance, about 10, evenly spaced, opposite to alternate pairs, diverging from the midrib at angles of 70° to 80°, curving regularly upward and camptodrome. Tertiaries largely obsolete.

This species is smaller, relatively more elongated, and more robust than *Anona ampla* Berry. It is much like *Anona wilcoxiana* Berry and may possibly be a variant of that species, although it is more narrowed distad, has less prominent venation, and in spite of its larger size has a much slenderer midrib.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, sec. 28, T. 13 N., R. 12 W., 4½ miles and 5 miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Anona ampla Berry, n. sp.

Plates XXXIX, figure 1; XL, figure 1; and XLI, figure 3.

Description.—Leaves relatively large, elliptical in general outline, ranging from 17 to 22 centimeters in length by about 8 to 8.5 centimeters in maximum width, at or slightly below the middle. Apex narrowed, rounded or bluntly short pointed. Base rounded. Margins entire. Leaf substance thin for so large a leaf. Petiole stout, not preserved for its whole length, at least 1 centimeter long. Midrib stout, less so than in *Anona wilcoxiana* Berry, and narrower as well as rounder. Secondaries relatively thin, about nine subopposite to alternate, rather evenly spaced pairs, diverging from the midrib at angles of 70° to 80° and curving regularly upward, camptodrome in the marginal region. Tertiaries of a similar character to those of the preceding species but very thin and visible only with magnification.

This is the largest of the three Wilcox species of Anona. It is less robust in texture and venation than either of the others, both of which it greatly resembles in general form and character of venation. It appears to be the least common of the three and may possibly represent a variant of *Anona eolignitica* Berry due to especially favorable conditions of growth such as a shady humid habitat.

Occurrence.—Wilcox group, Hardys Mills, Greene County, Ark. (collected by J. C. Branner); sec. 13, T. 13 N., R. 12 W., and 1½ miles southeast of Naborton, De Soto Parish, and Shreveport, Caddo Parish, La. (collected by G. C. Matson and O. B. Hopkins). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus ASIMINA Adanson.

ASIMINA LEIOCARPA Lesquereux.

Asimina leiocarpa. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 422, pl. 15, fig. 8, 1869.

Description.—Lesquereux in 1869 wrote the following description:

A. seminibus oblongo ovalibus, une apice truncatis, altero acutis, lævibus, pollicem longis, vix semi-latis.

This supposed seed is included in the present enumeration of the Wilcox flora on the authority of Lesquereux's description and figure cited above. It was described from the red shale at Hurleys and compared with the seeds of the existing *Asimina triloba* Don.

I have been unable to find the type in the Hilgard collections.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard).

Family MENISPERMACEÆ.

Genus MENISPERMITES Lesquereux (sensu lato).

MENISPERMITES WILCOXENSIS Berry, n. sp.

Plates CXV, figures 1 and 2, and CXVI, figures 2 and 3.

Description.—Leaves of variable size and appearance, broadly or narrowly ovate in outline, widest in the basal half and tapering upward to an acute tip, which is produced in the smaller and more narrow leaves. Length ranges from 10 to 19 centimeters. Maximum width, below the middle, ranges from 4.5 to 12 centimeters. Margins entire. Texture subcoriaceous. Base ranges from truncate in the smaller leaves to cordate and slightly inequilateral in the larger. These leaves are uniformly inequilateral, with a slightly curved midrib and with the secondaries on one side slightly stouter than on the other. This inequilaterality is shown more by the difference in outline than by measurement. For example, in the smaller leaves one side of the lamina is only about a millimeter narrower than the other, but in the larger leaves this difference may amount to 5 to 8 millimeters. The petiole is stout and curved; only its distal part is preserved in the material collected. The midrib is stout and prominent on the lower surface of the leaf. There are about seven pairs of mostly alternate secondaries, more prominent on one side of the midrib than on the other; they are somewhat irregularly spaced and diverge from the midrib at angles ranging from 20° to 70°, the angles of divergence becoming progressively more acute in passing downward toward the base of the midrib. The basal pair of secondaries are subopposite and simulate primaries, especially the one on the more robust side of the leaf. The distal secondaries are of the normal camptodrome type; the lower three or four pairs divide and subdivide by repeated forks or false dichotomies; all are ultimately camptodrome. The tertiary system is thin and subpercurrent, the areolæ being open and unequal.

The genus Menispermites is used for this Wilcox species as a form genus for unaligned forms referable to the family Menispermaceæ and not in the sense as defined originally by Lesquereux,[1] who, though never modifying his generic diagnosis, subsequently referred forms with a camptodrome venation similar to the present species to this genus and it seems to me unnecessary to multiply form genera of this kind.

The Wilcox form does not resemble any previously described species in this family, although some of the larger leaves do suggest fossil forms that have been referred to the genus Ficus as well as other forms referred to the family Tiliaceæ. Some of the existing species of Cissampelos, Odontocarya, and Anamirta are very similar to the fossil form, but it has been found impossible to allocate it more definitely.

Occurrence.—Southeast corner sec. 28, T. 13 N., R. 12 W., near Naborton, De Soto Parish, La. (collected by G. C. Matson).

Collection.—U. S. National Museum.

Order PAPAVERALES.

Family CAPPARIDACEÆ.

Genus CAPPARIS Linné.

CAPPARIS EOCENICA Berry, n. sp.

Plates XLIV, figures 1–3, and LII, figure 5.

Description.—Leaves evergreen and coriaceous, oblong-lanceolate in outline, the apex and base equally and obtusely pointed, especially in the larger leaves. Length as a rule 4.5 to 6 centimeters, averaging near the larger figure. Width, which is greatest halfway between the apex and the base, 7.5 to 12 milli-

[1] Lesquereux, Leo, The Cretaceous flora, U. S. Geol. Surv. Terr. Report, vol. 6, p. 94, 1874.

meters. Petiole short and stout, about 5 millimeters in length. Midrib stout and straight, prominent on the lower surface of the leaf. Secondaries numerous and regular, rather prominent on the lower surface of the leaf, about 14 pairs, branching from the midrib at angles that average between 55° and 60°, pursuing a slightly curved outward course to the vicinity of the margin, where they curve upward in a camptodrome manner. Tertiaries numerous, at approximately right angles to the secondaries.

This well-marked species belongs to a type often referred to the genus Quercus by paleobotanists and somewhat similar forms have also been referred to Sapindus. To be sure, they are not unlike the existing *Quercus phellos* Linné or *Quercus brevifolia* Sargent, and if found in a more recent flora or in one showing a temperate facies, such an identification would perhaps be proper. As, however, they occur in this early Eocene flora associated with elements that even the most captious critic can not dispute, it seems desirable to look in some other family for their nearest living representative, particularly as the venation offers minor contrasts to that of Quercus.

Extended search shows that these Eocene leaves can scarcely be distinguished from those of *Capparis domingensis* Sprengel of the Capparidaceæ, a family which comprises about 35 genera that are widely distributed in the warmer parts of both hemispheres. The genus Capparis embraces more than 100 species of shrubs or small trees, chiefly tropical, and although found also in the Eastern Hemisphere, most of the species occur in the American Tropics, particularly in Central and South America. *Capparis domingensis* is a small Antillean tree and its leaves are rather smaller than most of the members of the genus. Several of the West Indian forms, as, for example, *Capparis ferruginea* Linné, *C. amygdalina* Lamarck, and *C. cynophallophora* Linné, are shrubs or small trees of the strand flora, the first being especially common in such an environment. The fossil species is somewhat similar to a form described by Engelhardt[1] from the Tertiary of Bolivia as *Capparis multinervis*, which is compared with the existing *Capparis angustifolia* Humboldt, Bonpland, and Kunth of southern Mexico, *Capparis jacobinæ* Moricand of Brazil, and *Capparis longifolia* from the Antilles. Unger[2] many years ago described *Capparis ogygia* from the middle Miocene of Parschlug, Styria, but Schimper[3] referred that species to the Phaseoleæ. In addition Schenk has described petrified material from the Tertiary of Egypt as Capparidoxylon and F. von Müller has described two or three species of fruits of the genera Dieune and Plesiocapparis from the late Tertiary of Australia. Plesiocapparis is said to be most closely related to the section Busbeckia of Capparis.

A fine large specimen of the present species from Puryear measures 8 centimeters in length and 1.75 centimeters in maximum width.

Occurrence.—Holly Springs sand, Holly Springs, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Order ROSALES.

Family HAMAMELIDACEÆ.

Genus PARROTIA C. A. Meyer.

PARROTIA CUNEATA (Newberry) Berry.

Viburnum cuneatum. Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 511, 1882 (1883).

Newberry, U. S. Geol. Survey Mon. 35, p. 130, pl. 57, fig. 2, 1898.

Description.—Leaf obovate in general outline, the apex broadly pointed and the base narrowly cuneate. Length, about 11 centimeters. Maximum width, above the middle, about 4.5 centimeters. Margins entire from the region of maximum width to the base; distad they are strongly and massively dentate toothed. The teeth are large and six or seven on each side; they are directed upward and are separated by curved sinuses. The texture is coriaceous. Petiole, stout. Midrib very stout proximad, becoming attenuated in the tip of the leaf. Secondaries rather stout, about eight opposite to alternate pairs; they diverge from the midrib at angles of 10° to 30° and pursue a rather straight, ascending, unbranched course; the basal two or three pairs are camp-

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 7, pl. 1, fig. 18.

[2] Unger, Franz, Genera et species plantarum fossilium, p. 443, 1850.

[3] Schimper, W. P., Paléontologie végétale, vol. 3, p. 350, 1874.

todrome and the remainder are craspedodrome, one terminating at the apex of each marginal tooth. Tertiaries immersed in the leaf substance.

This remarkable species heretofore confined to the type locality in Wyoming is represented by two reasonably complete specimens from the strata near the base of the beds of Holly Springs sand (middle Wilcox age) in Tennessee. The type was referred to the genus Viburnum by Newberry, who, however, was very uncertain regarding its affinities. It has not the characters of any living or fossil Viburnums with which I am familiar, and in my judgment is certainly referable to the family Hamamelidaceæ, more particularly to the subfamily Hamamelidoideæ-Parrotieæ, such genera as Parrotia C. A. Meyer and Fothergilla Linné furnishing the closest comparisons. I have referred it to the genus Parrotia, which has one or two existing species of the southwestern Asiatic region and six or seven fossil species. The genus makes its appearance in the Upper Cretaceous and *Parrotia grandidentata* Lesquereux [1] of the Dakota sandstone of Kansas might well serve as the ancestor of the present Eocene species. The genus has not heretofore been recognized in the American Tertiary, but is present in the Arctic Eocene and is represented in the European Oligocene, Miocene, and Pliocene by several not uncommon forms.

Occurrence.—Lagrange formation (in beds of Wilcox age), Hatchie River near Shandy, Hardeman County, Tenn. (collected by L. C. Johnson).

Collection.—U. S. National Museum.

Family ROSACEÆ.

Genus CHRYSOBALANUS Linné.

CHRYSOBALANUS EOCENICA Berry, n. sp.

Plates XLIV, figures 4 and 5, and CXII, figures 8–10.

Description.—Fruit a drupe with a large stone, about twice as wide as long, pointed at the base and rounded distad, more or less angled with longitudinal ridges. Size ranges in the collected material from 1.1 to 1.5 centimeters in length and from 5 to 7 millimeters in diameter. Flesh adherent, either thin in life or greatly shrunken and dried, with a hard skin.

These fruits differ from each other somewhat in size. They are not uncommon in the clays at Puryear, Tenn., but are not especially well preserved, though very similar both in size and appearance to the dried fruits of *Chrysobalanus icaco* Linné, as preserved in herbarium material. From this it is probably to be inferred that in life these fruits were more nearly globose and the pulp was of considerable thickness. They may represent the fruits of the same species whose foliage is described as *Chrysobalanus inæqualis* (Lesquereux) Berry.

Chrysobalanus is a tropical and subtropical genus of the Rosaceæ represented in the existing flora in the South Atlantic States by a low shrubby species that ranges from Georgia to Alabama along the coast and by a second species, more like the present fossil form, which as a shrub or small tree (the cocoa plum) inhabits the shores and keys of southern Florida and is widely distributed throughout the maritime regions of tropical America, through the West Indies to southern Brazil, and also is found on the west coast of Africa from Senegambia to the Kongo Free State. The African occurrences are frequently segregated to form a third species. As in Laguncularia the distribution of *Chrysobalanus icaco* would suggest dissemination by ocean currents, a point well worthy of the investigation of some botanic student. A Pliocene species, *Chrysobalanus præ-icaco*, is recorded by Ettingshausen [2] from the State of Bahia in Brazil, and the same author records a Miocene species from Croatia.[3]

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

CHRYSOBALANUS INÆQUALIS (Lesquereux) Berry.

Plate XLIV, figures 8–10.

Elæagnus inæqualis. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859.

Lesquereux, in Safford, J. M., Geology of Tennessee, p. 428, pl. K, fig. 7, 1869.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 196. fig. 7, 1888.

[1] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 140, pl. 39, figs. 2–4, 1892.

[2] Krasser, F., K. Akad. Wiss. Wien Sitzungsber., Bd. 112, Abt. 1, p. 859, 1903.

[3] Ettingshausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Radoboj, p. 894, 1870.

Description.—Leaves of medium size, elongate-elliptical in general outline, with a somewhat narrowed and rounded, in some specimens slightly emarginate apex, and rounded basal margins to the broadly cuneate base. Length about 8 to 9 centimeters. Maximum width, midway between the apex and the base, about 3 to 4 centimeters, averaging about 3.5 centimeters. Margins entire, regularly and evenly rounded. Leaf substance thick and texture coriaceous. Petiole short and stout or else obsolete. Midrib very stout, as a rule slightly curved, prominent on the lower surface of the leaf. Secondaries stout and rather prominent, eight or nine opposite to alternate, in general regularly spaced pairs; they diverge from the midrib at angles of 50° to 70° and pursue a slightly curved course as far as the marginal region, where they curve regularly upward and are camptodrome. Tertiary venation prominent, identical in character with that shown in the two existing species of Chrysobalanus.

This species in its form, texture, and venation is strictly congeneric with the leaves of the existing species and stands about halfway between the two in the sum of its characters. It is larger and relatively wider, and has more numerous secondaries than *Chrysobalanus oblongifolius* Michaux (Pl. XLIV, fig. 11) and is narrower and relatively more elongated than *Chrysobalanus icaco* Linné (Pl. XLIV, figs. 6 and 7). It seems quite likely that it may represent the same Wilcox species whose fruits are described as *Chrysobalanus eocenica* Berry. It includes the form from Somerville, Tenn., which was referred to the genus Elæagnus by Lesquereux in 1859, and is common at the Puryear locality.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Somerville, Fayette County, Tenn. (collected by J. M. Safford), and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus PRUNUS Linné.

Prunus nabortensis Berry, n. sp.

Plate CXVI, figure 1.

Description.—Stone subglobose, somewhat compressed, broadly elliptical in outline, slightly acuminate distad and rounded proximad. Length 10.5 millimeters, maximum width 8.75 millimeters. Thickness 6.5 millimeters. Surface slightly rugulose, prominently pitted.

This specimen is the only one of its kind found in the deposits of the Wilcox group, nor are there any remains of foliage known from this horizon that can be legitimately referred to Prunus, although the stone (pit) is readily distinguishable from those of other genera with somewhat similar roughened stones, as, for example, Grewia, Zizyphus, and Celtis. The genus Prunus is used in the broad sense, as including the nine sections into which Baillon segregated it or the seven sections adopted by Focke in his contribution to the Natürlichen Pflanzenfamilien on this subject, although there can be little doubt that several of these are entitled to generic rank. Without a very extensive series of authenticated recent material it would be impossible to make any valuable comparisons with recent forms, more particularly as some of the modern sections of the genus have rough and smooth stones, and the same is true for Celtis, Zanthoxylon, and probably other recent genera, showing that little significance can be attached to this character. This is further shown among cultivated American species of Prunus, where there seems to be an increased rugosity of the stone correlated with an increase in size of the fruits and especially shown in horticultural hybrids. Judging only from the figures in Wright's recent account [1] of North American species of Prunus the Wilcox form is most similar to *Prunus umbellata* Elliott, especially to forms of this species figured from Lake County, Fla. This species is a small tree growing on dry sandy soils, mainly in the coastal region from South Carolina to western Louisiana.

The genus is widely distributed throughout the North Temperate Zone and extends southward into southern Asia and into tropical America. Most of the species are small, many being scarcely arborescent, and grow naturally scattered in open situations, more rarely within forests, so that the Wilcox form may probably be regarded as a small tree of coastal sand flats growing in open places along the margins of the beach jungle or in similar situations and thus not abundant in any one locality.

[1] Wright, W. F., U. S. Dept. Agr. Bull. 179, 1915.

The geologic history of Prunus is as yet but little understood. About 70 fossil species have been described and most of these are based on leaf remains, although the stones are common in the German and other lignitic deposits. Upper Cretaceous forms are known from the Raritan and Dakota formations in this country and from the Emscherian of Silesia, and the Eocene records include Alaska and Greenland. In later Tertiary time Prunus grew on all the great land masses of the Northern Hemisphere and during Miocene time its range apparently was somewhat greater than its present range. For example the stones of 9 species are found in the Pliocene deposits of Holland,[1] representing 1 European, 2 oriental, and 2 entirely extinct species.

Among previously described fossil forms *Prunus nabortensis* seems most similar to *Prunus deperdita* Heer, so elaborately described by Laurent [2] in his recent work on the flora of the Sannoisian of Menat in the Auvergne.

Occurrence.—About 3½ miles southeast of Naborton (NW. ¼ NE. ¼ sec. 19, T. 12 N., R. 11 W.), De Soto Parish, La. (collected by G. C. Matson).

Collection.—U. S. National Museum.

Family MIMOSACEÆ.

Section PHYLLODINEÆ.

Genus ACACIA Willdenow.

ACACIA WILCOXENSIS Berry, n. sp.

Plate LV, figures 1 and 2.

Description.—Phyllode oblanceolate in general outline, the apex broadly rounded, mucronate pointed, and the base gradually narrowed and pointed. Length about 5 centimeters. Maximum width, in apical region, about 9.5 millimeters. Margins entire. Texture thin and somewhat membranaceous or scarious. Petiole short and stout, 1 to 2 millimeters in length. Venation consists of a single fairly stout midvein and a very fine lateral system, scarcely visible without magnification, composed of long and narrow polygonal meshes, the long axis parallel with the lateral margins.

This species is based on the single specimen figured on Plate LV, which in its size, outline, apex, and venation is closely comparable with the phyllodes of numerous existing species of Acacia. The genus Acacia comprises about 450 tropical and subtropical species in the existing flora and these are largely confined to Africa and Australia. The section Phyllodineæ, with which *Acacia wilcoxensis* shows the closest similarity, includes about 280 existing species confined to Australia and Oceanica. Among these are numerous forms suggestive of the present species, as, for example, *Acacia oblunata* Cavanilles, which is somewhat smaller, and *Acacia pycnantha* Bentham, which is somewhat larger than the fossil. Many other similar existing species might be enumerated if it were worth while. Fossil species with the foliage reduced to phyllodes are not common. Ettingshausen has described four such species, *Acacia coriacea*,[3] *A. mimosoides* [4] *A. proserpinæ*,[5] and *A. dianæ*,[6] from the lower Oligocene (Sannoisian) of Haering in the Tyrol. The last of these, though somewhat smaller, is otherwise very similar to *Acacia wilcoxensis*.

Occurrence.—Holly Springs sand; ravine at Oxford, Lafayette County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus INGA Willdenow.

INGA MISSISSIPPIENSIS Berry, n. sp.

Plate XLV, figure 1.

Prunus caroliniana. Lesquereux (not Michaux), Am. Jour. Sci., 2d ser., vol. 27, p. 363, 1859.
Lesquereux, in Safford, J. M., Geology of Tennessee, p. 427, pl. K, fig. 6, 1869.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 196, fig. 6, 1888.

Description.—Leaflets ovate-lanceolate in outline. Apex narrowed and prolonged into an acuminate point. Base markedly inequilateral; outer side full and rounded; inner side nearly straight and ascending, forming an angle of 45° or less with the midrib. Length about 5.5 to 6 centimeters. Maximum width about 1.75 centimeters. Margins entire, straight and approximately parallel in the median region of the leaflet, narrowing rather suddenly distad. Petiolule very short and

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[1] Reid, Clement and E. M., The Pliocene floras of the Dutch-Prussian border, pp. 101-103, pl. 9, figs. 21-36, 1915.

[2] Laurent, Louis, Mus. hist. nat. Marseille Annales, Géologie, vol. 14, pp. 152-160, pl. 13, figs. 9, 10, pl. 14, figs. 1-4, 6-10, 1912.

[3] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 93, pl. 29, fig. 47: pl. 30, figs. 51, 52, 1853.

[4] Idem, p. 93, pl. 30, figs. 60, 61.

[5] Idem, p. 94, pl. 30, figs. 53, 54.

[6] Idem, p. 94, pl. 30, figs. 58, 59.

stout, only about 1 millimeter in length. Midrib slender but well marked, curved. Secondaries thin but well marked, about five alternate pairs. The lower pairs diverge from the midrib at acute angles, ascending in long, somewhat irregular curves, camptodrome; the upper pairs diverge at a wide angle and are nearly straight in their course to the point where they turn upward to form camptodrome arches. Tertiary venation fine but distinctly marked, as shown in the specimen figured.

This well-marked species is clearly unlike previously described forms but not unlike several existing American species of Inga. Among fossil forms the only one that approaches it closely is an undescribed species from the Claiborne group of Arkansas, which has the same general form but is slightly larger and has a stouter venation, immersed tertiaries, and a more coriaceous texture. It seems to be genetically related to this Wilcox species.

The fossil species of Inga are few. *Inga cretacea* Lesquereux of the Upper Cretaceous is abundant in the clays of the Tuscaloosa formation of northwestern Alabama and is somewhat suggestive of the present species but is larger, more regularly lanceolate, and carries more numerous secondaries. Engelhardt[1] has described a small-leafed species, *Inga ochseniusi*, from the Tertiary of Bolivia.

The existing species of Inga number more than 150. They are confined to the Tropics and subtropics of America and are common in the West Indies but fail to reach the United States.

Inga mississippiensis is very close to the small leaf from Carbon, Wyo., figured by Lesquereux[2] as a form of his *Ficus oblanceolata*, a reference that will be questioned by most students.

A specimen of *Inga mississippiensis* was collected by Safford at Somerville, Tenn., many years ago and was identified by Lesquereux as a leaf of the living *Prunus caroliniana* Michaux. It does not at all resemble that species and the determination was largely influenced by the idea that the deposits were very recent and probably Pliocene.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Somerville, Fayette County, Tenn. (collected by J. M. Safford).

Collections.—U. S. National Museum.

INGA PURYEARENSIS Berry, n. sp.

Plate LI, figure 12.

Description.—Leaflets oblong-lanceolate, inequilateral and slightly falcate in outline, abruptly narrowed to the inequilateral bluntly pointed apex and to the inequilateral cuneate base. Length about 6.5 centimeters. Maximum width, at or below the middle, about 2.2 centimeters. Margins entire, slightly undulate, the outer longer, fuller, and more curved than the inner. Texture subcoriaceous. Petiolule wanting. Midrib stout, somewhat curved, especially distad, prominent on the lower surface of the leaflet. Secondaries relatively stout and prominent, five or six irregularly spaced and generally remote, opposite to alternate pairs; they diverge from the midrib at different angles, which are acute in the lower part of the leaflet but more open toward its tip. The lower secondaries are slightly curved, elongated, ascending subparallel with the lower lateral margins and eventually camptodrome. Their angles of divergence range from 30° to 50°. The upper two or three secondaries diverge at angles of about 60° and describe short, even, camptodrome curves. Tertiaries thin, relatively straight, percurrent at nearly right angles to the midrib.

Although several species of Inga are known from the Wilcox group, they are chiefly represented by a few leaflets, which are generally detached. The present species is most like *Inga mississippiensis* Berry but is larger and coarser and has a more prominent venation and fewer secondaries, the apex is much more abruptly pointed, and the basal lamina is fuller on the inner instead of on the outer side of the midrib. It is very much larger, less coriaceous, less inequilateral, and more oblong in form than *Inga wickliffensis* Berry, which also has more numerous, much thinner, and much less ascending secondaries. It is much smaller and less inequilateral than *Inga laurinafolia* Berry and has less numerous and much more ascending secondaries, which are also more prominent. It is much like several existing species of Inga of the American Tropics.

Inga puryearensis closely resembles and is possibly ancestral to *Inga arkansensis* Berry of

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 11, pl. 1, figs. 39, 40.

[2] Lesquereux, Leo, The Tertiary flora, pl. 28, fig. 9 (not figs. 10-12), 1878.

the upper Claiborne of Arkansas, which is relatively longer, has a more gradually narrowed and more pointed tip and more numerous thinner secondaries.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

INGA LAURINAFOLIA Berry, n. sp.

Plate XLVIII, figure 8.

Description.—Leaflets opposite, large, markedly inequilateral in outline, ovate in form. Length about 9 centimeters. Maximum width, at or below the middle, about 2.75 centimeters. Apex bluntly pointed. Base acute, very inequilateral. No distinct petiolule developed but upper margin of midrib naked for a distance of about 1 centimeter. Margins entire, slightly irregular. Leaf substance thick and texture coriaceous. Midrib stout, considerably curved, prominent. Secondaries thin, about ten opposite to alternate pairs, diverging from the midrib at angles of about 60°, curving slightly outward and then upward, camptodrome in the marginal region. Tertiaries thin, mostly immersed and obsolete.

This species is much larger than the other Wilcox species of Inga and is perfectly distinct from them. It has a very characteristic outline. At the apex the inner lamina is fuller and wider than the outer; halfway to the base the two margins are about equidistant from the midrib; from this point the inner (upper) margin curves gradually inward, becoming decurrent and terminating on the upper side of the midrib at an acuminate angle about a centimeter above the base. The outer (lower) margin continues full and rounded, curving broadly inward and then acutely decurrent, its maximum distance from the midrib measuring 1.7 centimeters, whereas the maximum width of the inner lamina is 1.2 centimeters, and at the level where the outer lamina reaches 1.7 centimeters the inner lamina is only 8 millimeters in width.

The present species is extremely close to the leaves of the common West Indian species *Inga laurina* Willdenow,[1] and many leaves of that species which could be selected would be indistinguishable from its Eocene representative. In general the modern species has a more prominent venation and lacks the falcate form of the fossil, the midrib being straight in spite of the inequilateral lamina.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

[1] This species is also present in Central America.

INGA WICKLIFFENSIS Berry, n. sp.

Plate L, figure 8.

Description.—Leaflets opposite, sessile, small, ovate, and markedly inequilateral in outline. Length about 3.5 centimeters. Maximum width, in the middle part of the leaflet, about 1.1 centimeters. Apex gradually narrowed. Base acute, very inequilateral, the lamina on the distal side of the midrib having its lower margin recurved and excavated to such an extent that the midrib is practically naked and has only a slight wing for a distance of 2 to 4 millimeters on this side; the lamina on the proximal side is full and rounded, being widest at a point where the distal lamina commences to narrow abruptly. Margins entire. Texture coriaceous. Petiolule wanting. Midrib very stout and prominent to its extreme tip, slightly curved toward the apex of the leaf. Secondaries very thin and immersed in the leaf substance; about eight subopposite to alternate unequally spaced pairs diverge from the midrib at wide angles of 65° to 80°, those in the distal half of the lamina more open than those in the proximal half; the secondaries pursue nearly straight courses to the marginal region, where their ends are joined by broad flat arches. Tertiaries thin, forming open, isodiametric, quadrangular or polygonal meshes.

In the sum of its characters this species is very similar to *Inga laurinafolia* Berry, and it may be merely a variety of that species. It is, however, only about one-third the size of that species and is blunter and more coriaceous, and the margins are more evenly rounded.

It is very close to several existing American species of Inga. As far as may be judged from the rather large collections of Wilcox plants that have been made it is not a common form in the coastal flora of that time.

Occurrence.—Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collection.—U. S. National Museum.

Genus PITHECOLOBIUM Martius.

PITHECOLOBIUM EOCENICUM Berry, n. sp.

Plate XLV, figure 2.

Description.—Leaves even-pinnate, with several pairs of opposite leaflets, increasing in size distad. Leaflets asymmetric-elliptical in outline, the apex rounded or bluntly pointed and the base cuneate, inequilateral, sessile. Length about 3 centimeters. Maximum width, which is in the middle part of the leaflet, about 1.6 centimeters. Margins entire. Texture coriaceous. Petiolules wanting, the leaflets being seated directly and obliquely on the rachis. Midrib stout, somewhat curved, becoming thin distad. Secondaries thin, six or seven subopposite to alternate pairs, branching from the midrib at angles of about 50° and pursuing a rather straight course to the marginal region where they curve upward and are camptodrome. Areolation fine but distinct, composed of four or five sided meshes.

This species is based on detached leaflets and hence the leaf habit is conjectural and is drawn from the existing species, with the leaflets of some of which the fossil is identical. A comparison with the foliage of the existing rain tree, *Pithecolobium saman* Bentham, endemic from Nicaragua to Brazil and widely planted as a shade tree in tropical America and even in Asia, will show the very great similarity between the Eocene species and this and other of the existing species. I have figured alongside the fossil the leaflets of two existing species which illustrate in a most striking way the parallelism between this lower Eocene form and its existing descendants. *Pithecolobium unguis-cati* (Linné) Bentham, shown in Plate XLV, figure 4, is a small tree that forms thickets on the Florida Keys, and is widely distributed throughout the Antilles to Venezuela and Colombia. *Pithecolobium dulce* Bentham, shown in Plate XLV, figure 5, is a large tree which ranges from southern Mexico through Central America to Colombia and is naturalized in many tropical countries.

The genus Pithecolobium belongs to the tribe Ingeæ of the Mimosaceæ and is more or less closely related to the genus Inga of Willdenow. More than 100 existing species are known, all confined to the Torrid Zone, where many of them are large trees. Three-fourths of the existing forms are American, and there are more than a score in tropical Asia and a few in tropical Australia and Africa. With the exception of *Pithecolobium tertiarum*, described by Engelhardt [1] from the Tertiary of Bolivia, and *Pithecolobium tenuifolium* described by the same author [2] from the Tertiary of Colombia, the genus has not previously been recognized in the fossil state. The second of these species is very similar to *Pithecolobium eocenicum* Berry and is compared by Engelhardt [2] with the existing *Pithecolobium glomeratum* of Colombia, Guiana, and Brazil.

This species resembles somewhat *Sophora palæolobifolia* Berry, a somewhat smaller form that has a narrower apex and a more slender, straighter midrib.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

PITHECOLOBIUM OXFORDENSIS Berry, n. sp.

Plate XLV, figure 3.

Description.—Leaflets small, asymmetric-ovate in outline, the apex narrowly rounded and the base inequilateral, cuneate. Length about 2.5 centimeters. Maximum width, which is below the middle, about 1.1 centimeters. Margins entire. Texture coriaceous. Petiolules wanting, the leaflets being sessile and oblique. Midrib stout, curved below, straight distad. Secondaries thin, more or less immersed, six or seven subparallel pairs, camptodrome.

This species, which is based on detached leaflets, differs from *Pithecolobium eocenicum* in its much more asymmetric form, more narrowed apex and base, and obsolete tertiary system. It is also considerably smaller. It is close to a number of existing species of Pithecolobium, and among fossil forms it may be compared with the lower Oligocene species of Europe that are usually referred to the genus Palæolobium of Unger, especially with the numerous leaflets of *Palæolobium haeringianum* Unger,[3] figured from Haering in the Tyrol by Ettingshausen.[4]

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 12, pl. 1, fig. 33.

[2] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 37, pl. 3, fig. 21, 1895.

[3] Unger, Franz, Die fossile Flora von Sotzka, p. 56, pl. 41, figs. 8-10, 1850.

[4] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 88, pl. 29, figs. 10-17, 1855.

The present species is sparingly represented at the single locality enumerated below.

Occurrence.—Holly Springs sand, Oxford ravine, Fayette County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus MIMOSITES Bowerbank.

Apex rounded:
- Leaflets inequilateral and with a short petiolule. *Mimosites inequilateralis.*

Apex pointed:
- Base about equally pointed, leaflet nearly equilateral and sessile.................. *Mimosites lanceolatus.*
- Base rounded, leaflet nearly equilateral and sessile. *Mimosites acaciafolius.*
- Base pointed, petiolulate, inequilateral. *Mimosites variabilis.*

MIMOSITES INEQUILATERALIS Berry, n. sp.

Plate XLV, figure 12.

Description.—Leaflets elongate-elliptical in outline, markedly inequilateral basally, with a short petiolule. Apex broadly rounded. Base in some specimens slightly narrower than the apex and somewhat angular. Margins entire. Texture subcoriaceous. Petiolule thick, about 1 millimeter in length. Midrib stout and straight, prominent on the lower surface of the leaflet. Secondaries thin and mostly obsolete, branching from the midrib at a wide angle, considerably curved upward, camptodrome.

This species is much like *Mimosites variabilis* Berry, especially the larger leaflets of that species, which, however, have an acute apex and base and a longer petiolule. *Mimosites inequilateralis* well deserves its name; for, though the width of the lamina is about the same on both sides of the midrib, the outline is markedly different, the apex and base being almost equally inequilateral. It is similar to many existing and fossil species of Mimosaceæ.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MIMOSITES LANCEOLATUS Berry, n. sp.

Plate XLV, figure 13.

Description.—Leaflets lanceolate in outline, the apex and base nearly equally acute, sessile, nearly equilateral. Margins entire. Length about 2.5 centimeters. Maximum width about 7 millimeters, about halfway between the apex and the base. Midrib stout, prominent on lower surface of the leaflet, slightly curved. Secondaries thin, mostly obsolete, about eight pairs, diverging at an angle of about 70°, their tips joined by arches. Texture subcoriaceous.

This characteristic species of Mimosites is distinguishable from the other species of Mimosites found in the Wilcox as well as from the associated Cæsalpiniaceæ by its strictly lanceolate, nearly equilateral form.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MIMOSITES ACACIAFOLIUS Berry, n. sp.

Plate XLV, figure 14.

Description.—Leaflets of different sizes, lanceolate in outline, nearly equilateral and sessile, the apex sharply pointed and the base broadly rounded. Length ranges from 1.3 to 2 centimeters. Maximum width, in middle part of leaf, ranges from 3 to 5 millimeters. Texture subcoriaceous, but the finer venation is more distinct than in the other species of Mimosites. Margins full and entire. Midrib stout and prominent on the lower surface of the leaflets. Secondaries very thin but distinct, numerous, branching from the midrib at angles of about 45°, curving upward and merging insensibly in the similar camptodrome tertiary system.

This species is much like *Mimosites variabilis* Berry in appearance but may be distinguished by the absence of a petiolule, by the rounded base, and by the more equilateral form. *Mimosites inequilateralis* Berry differs in having a rounded apex, a short petiolule, and an inequilateral form. *Mimosites lanceolatus* Berry, though equilateral and sessile, has an equally pointed apex and base.

In a number of characters *Mimosites acaciafolius* resembles small leaflets of *Gleditsiophyllum eocenicum* Berry. This is especially true of the venation. *Gleditsiophyllum eocenicum* is, however, comparatively more elongated and in general slightly falcate, more inequilateral, and has a considerable petiolule; its smaller leaflets, which approach *Mimosites acaciafolius* in size, have an acute instead of a rounded base.

A detailed comparison with similar existing and fossil Mimosaceæ can throw but little light on the ecology of this fossil form.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Mimosites variabilis Berry, n. sp.

Plate XLV, figures 6–11.

Description.—Leaflets of different sizes, elongate-elliptical or lanceolate in outline, as a rule markedly inequilateral, but this feature is only slightly developed in some narrow leaflets. Length ranges from 6 millimeters to 3 centimeters, averaging about 1.6 centimeters. Maximum width ranges from 2 to 7.5 millimeters, averaging about 5 millimeters in the middle part of the leaflet. Margins entire, more or less parallel, curving inward to form the generally similarly pointed apex and base. In all the numerous specimens the lamina is narrower and more acute at both the apex and the base on one side and broader and more rounded on the other. If anything the upper part of the leaflet is slightly narrower than the lower part. Petioles are invariably present, but these are short and stout, not over 1.5 millimeters in length, rugosely wrinkled and as a rule much curved. Midrib relatively very stout throughout its length, rather prominent on the lower surface of the leaflet, straight or curved. Secondary venation obsolete on both surfaces of the leaflets in all except the largest specimens, in which rather numerous thin secondaries diverge from the midrib at angles slightly more than 45°. Texture smooth and very coriaceous. A specimen from Puryear shows a row of six closely placed leaflets.

This species is characteristic and common at several localities and embraces both the largest and the smallest Wilcox leaflets of Mimosites. It is in many ways very similar to the other Wilcox species of Mimosites, but may be distinguished by its thicker texture and obsolete venation. *Mimosites inequilateralis* Berry has a conspicuously rounded apex and generally a rounded base and a shorter petiolule. *Mimosites spatulatus* Berry also has a rounded apex and the leaflets are sessile, and both *Mimosites acaciafolius* Berry and *Mimosites lanceolatus* Berry have sessile leaflets, and *lanceolatus* is equilateral or nearly so.

This and the preceding species of Mimosites represent forms mostly identified as species of Acacia (as, for example, in the paleobotanic work of Heer, Ettingshausen, and other eminent students) which may be properly referable to Acacia or Mimosa or to other genera of the Mimosaceæ—in other words, forms which are referable to this family with great certainty but whose exact generic alignment is more or less uncertain. Among these I might mention *Acacia uninervifolia* described by Engelhardt[1] from the Tertiary of Bolivia and compared with the phyllodes of the modern *Acacia paradoxa* De Candolle. The Wilcox species represents a leaflet of a compound leaf and not a phyllode, and it may be that this is also the nature of Engelhardt's species.

Both Acacia and Mimosa are very large genera in the existing flora, Acacia containing more than 400 and Mimosa more than 300 species. Acacia is largely African and Australian but is found through Oceanica, South and Central America, and the West Indies. Mimosa, on the other hand, is mostly confined to tropical and subtropical America, though a few species live in Asia, Africa, and Australia. Since the Eocene flora of southeastern North America is made up to such a large extent of ancient types, still chiefly American, it would seem that Mimosites as used in this paper indicates a more probable affinity with Mimosa than with Acacia.

Mimosites variabilis may be compared with numerous existing American species of Mimosa. Among the described fossil species it suggests *Mimosites palæogæa* Unger,[2] *M. haeringiana* Ettingshausen,[3] *M. cassiæformis* Ettingshausen,[4] and *Acacia sotzkiana* Unger.[5]

Occurrence.—Grenada formation, Grenada, Grenada County (collected by E. N. Lowe and E. W. Berry). Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry); 1½ miles west of

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 11, pl. 1, figs. 10, 11, 20.

[2] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 92, pl. 30, figs. 21, 22, 1855.

[3] Idem, figs. 23–37.

[4] Idem, figs. 38–50.

[5] Idem, figs. 55, 56.

Grand Junction in Fayette County, Tenn. (collected by L. C. Glenn, also by E. W. Berry); and Wickliffe, Ballard County, Ky. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Family CÆSALPINIACEÆ.

Genus CERCIS Linné.

CERCIS WILCOXIANA Berry, n. sp.

Plate XLIX, figure 1.

Description.—Leaves almost circular or slightly cordate in outline, about 11 centimeters in length by 9.5 centimeters in maximum width. Base truncate and very slightly decurrent or somewhat cordate. Margins entire, full and rounded, curving upward at the apex to form a slightly extended and bluntly pointed tip. Primaries, generally five, diverge at acute angles from the thickened top of the petiole. The midrib is the stoutest and the outer laterals the thinnest. The laterals curve slightly outward and then upward in broad sweeping lines and ultimately become thin and are united with a short outward branch. True secondaries, two or three camptodrome pairs, in apical part of the leaf. The branches from the primaries are more transverse and less distinctly forked than in the existing species, and the flat camptrodome arches which join their ends in the marginal region are more distinctly continuations of the outer primaries than they are in the existing species.

With these trifling modifications *Cercis wilcoxiana* is almost identical with the larger leaves of the existing *Cercis canadensis* Linné (Pl. XLIX, fig. 2), which ranges from Ontario to Florida and Texas and which is so commonly cultivated under the names of redbud or Judas tree. This tree is common in the rich soil of stream borders in the midland zone of Maryland, but its requirements are better satisfied in our Southern States, where it is a common riverside tree, mostly away from the coast and where the banks are not too low.

In the existing flora the genus consists of 5 or 6 species of the warmer temperate parts of America, Europe, and Asia. About 15 fossil species have been described, ranging in age from the base of the Eocene throughout the Tertiary and with several of the still existing species appearing in the Pleistocene.

There is a strong generic likeness among all the fossil species and the pods as well as the leaves are found as fossils. *Cercis wilcoxiana* is larger than the fossil forms with which it may be compared and is perfectly distinct from the previously described forms from either Europe or America. It is remotely like *Cercis deperdita* described by Watelet[1] from the Ypresian of the Paris Basin (grès de Belleu).

In partial confirmation of the assumption that it was a form of the rich woods of the Eocene uplands and not a strand or coastal form it is very rare at the two localities in the Wilcox where it occurs, as if it had been brought down from these uplands by some stream to the area of sedimentation along the coast.

Occurrence.—Holly Springs sand, Vaughns, near Lamar, Benton County (formerly part of Tippah County), Miss. (collected by L. C. Johnson). Lagrange formation (in beds of Wilcox age), 1 mile south of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus CASSIA Linné.

Based on legumes, leaflets unknown:
- Pods long and slender............*Cassia bentonensis.*
- Pods short and broad.........*Cassia mississippiensis.*

Based on leaflets or leaflets and legumes:
- Leaflets sessile:
  - Large with rounded or emarginate tips. *Cassia wilcoxiana.*
  - Small, pointed at both ends..*Cassia tennesseensis.*
- Leaflets petiolulate:
  - Petiolule long (over 5 millimeters), leaflets emarginate.......................*Cassia emarginata.*
  - Petiolule medium (3 to 4 millimeters):
    - Leaflets small, pointed....*Cassia fayettensis.*
    - Leaflets very large, ovate-lanceolate. *Cassia puryearensis.*
  - Petiolule short (less than 3 millimeters):
    - Leaflets small, pointed, inequilateral, slightly falcate..............*Cassia marshallensis.*
    - Leaflets medium sized, narrowed to both ends, approximately equilateral. *Cassia glenni.*
    - Leaflets large, ovate.....*Cassia glenni major.*
    - Leaflets large, elliptical, approximately equilateral................. *Cassia colignitica.*
    - Leaflets lanceolate to ovate.....*Cassia lowii.*

CASSIA TENNESSEENSIS Berry, n. sp.

Plate XLIX, figures 3 and 4.

Description.—Leaves evenly pinnate. Rachis stout. Petiole 2.5 centimeters in length. Leaflets oblique and opposite, small and sessile, or

[1] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 241, pl. 58, fig. 9, 1866.

very minutely petiolulate, attached obliquely, ovate-lanceolate and slightly falcate in outline. Length about 3 to 3.5 centimeters. Maximum width about 1.1 centimeters, in the middle part of leaflet. Margins entire, full and rounded, curving inward to the equally pointed apex and base, or the apex very slightly more slender than the base. Petiolule relatively stouter than in *Cassia fayettensis* Berry, prominent on the under side of the leaflet, slightly curved. Secondaries thin, six or seven camptodrome pairs, more ascending than in *Cassia fayettensis* and leaflets also of a thicker texture than in that species.

This species is well marked, and though in its general appearance it suggests a small variety of *Cassia fayettensis*, the nearly sessile leaflets with their more coriaceous texture and different venation serve to indicate its distinctness. It is very similar to the somewhat smaller species *Cassia marshallensis* Berry, which is more coriaceous and has more numerous open secondaries and a relatively long petiolule. It resembles numerous existing and European Tertiary species of Cassia. It is somewhat similar to a form from the Tertiary of Bolivia described by Engelhardt [1] as *Cassia membranacea* and compared with the existing *Cassia lævigata* Willdenow, which ranges from Mexico to Brazil.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Cassia eolignitica Berry, n. sp.

Plate XLVIII, figures 2-4.

Description.—Leaflets elliptical in general outline with a rounded apex and a slightly narrowed base. Length ranges from 5 to 7 centimeters. Maximum width, about midway between the apex and the base, ranging from 2.5 to 3 centimeters. Margins full and entire, slightly irregular. Petiolule short and stout, widened and rugose, ranging from 1.5 to 3 millimeters in length according to the size of the leaflet. Midrib slender. Secondaries very thin but distinct, five or six opposite to alternate pairs, unequally spaced, diverging from the midrib at angles of about 45°, rather straight proximad but curved and camptodrome toward the margins. Tertiaries very fine but distinct in the smaller leaves, forming camptodrome arches in the marginal region and large pentagonal meshes internally, mostly obsolete in the larger leaflets. Leaf substance thin.

The general form and details of venation ally this species with the genus Cassia. Among the Wilcox species it is closest to *Cassia wilcoxiana* Berry but is relatively broader and petiolulate. It may be distinguished from the Wilcox species of Sophora, which resemble it in outline, by its texture and venation. A relatively shorter and broader specimen, collected by McGee at Early Grove, is in the United States National Museum collections. The largest forms come from the locality between Grand Junction and La Grange. The species is rare at the outcrops where it has been found but evidently had a considerable range and was probably more common than the collected material indicates.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by W J McGee). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and 1½ miles west of Grand Junction in Fayette County, Tenn. (collected by E. W. Berry). Wilcox group, 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Cassia bentonensis Berry, n. sp.

Plate L, figure 1.

Description.—Pods of medium size, elongated, linear, flat, unsegmented, with fine transverse forked and more or less anastomosing veinlets. Length about 7 centimeters and width about 1 centimeter. Seeds numerous, compressed.

This species is based on incomplete specimens, the largest being that figured. The only foliage of Cassia associated with it is represented by the leaflets described as *Cassia fayettensis* Berry, and the specimens may well be the pods of this or of one of the other numerous Wilcox species of Cæsalpiniaceæ. They resemble numerous existing Cassia fruits

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 9, pl. 1, figs. 31, 32.

as well as those of several previously described Tertiary species, for example, the pods which Heer refers to the widespread *Cassia berenices* Unger.[1] Though the similarity of foliage and fruit among the numerous existing species of this very large genus renders detailed comparisons of less value than in other genera, the similarity of the present species to the pods of the existing *Cassia apouconita* Aublet is, however, worth pointing out. *Cassia apouconita* ranges from Rio de Janeiro northward to the Caribbean Sea in tropical South America, and its pods, its size, shape, margin, veining, and the like are practically identical with *Cassia bentonensis*.

Occurrence.—Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum.

Cassia puryearensis Berry, n. sp.

Plate LI, figures 13 and 14.

Description.—Leaflets relatively large, equilateral and petiolulate, ovate-lanceolate in general outline; the tip gradually narrowed, extended, and acuminate and the base cuneate or slightly decurrent. Length about 8 centimeters. Maximum width, in the lower half of the leaflet, about 2.4 centimeters. Margins entire, full below and regularly curved. Leaf substance of medium thickness and smooth surface, not coriaceous. Petiolule stout, about 4 millimeters in length. Midrib stout, straight, prominent on the lower surface of the leaflet. Secondaries thin, more or less immersed in the lamina; eight to ten pairs diverge from the midrib at angles of 45° to 55°, curving regularly upward in a subparallel manner and camptodrome. Tertiaries obsolete.

This species is clearly distinct from the contemporaneous species of Cassia, differing in its larger size, its ovate-lanceolate outline, and extended acumen. It is very similar to several species of Cassia of the European Tertiary, such as *Cassia berenices* Unger, and it is also practically indistinguishable from several existing species, for example, *Cassia lævigata* Willdenow, *Cassia corymbosa* Lamarck, and other species of Central and South America. Among antecedent forms it is remarkably close to several Upper Cretaceous species, such as *Cassia vaughani* Berry, which is common in the lower Tuscaloosa flora of western Alabama.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Cassia wilcoxiana Berry, n. sp.

Plate L, figures 2–5.

Description.—Leaves compound. Leaflets sessile, ovate-elliptical in outline, the apex broadly rounded, in some specimens slightly emarginate, and the base bluntly pointed. Length about 5.5 centimeters. Maximum width, in the middle part of the leaflets, 2 centimeters. Margins entire, slightly wavy in some specimens. Midrib stout. Secondaries thin, about nine alternate to opposite pairs. They branch from the midrib at angles of 50° to 55°; their course is rather straight at first, but toward the margin they curve upward in broad camptodrome arches. Tertiaries thin, arched along the margin, internally forming large four or five sided open meshes. Pods small, elliptical and flat, about 3 centimeters or slightly less in length by 1.2 or 1.3 centimeters in maximum width, rounded at both ends, the distal end more broadly rounded. The pods show oblique thin subparallel anastomosing curved veins and were few seeded.

These leaves and pods are characteristically those of some species of Cassia. They were not found in organic union, however, and are described under a single specific name since they are commonly found associated. A comparison with the modern forms of Cassia has resulted in the restoration shown in figure 13. The leaf arrangement is after that of the existing *Cassia tora* Linné and the arrangement of the pods is like that of the existing *Cassia acutifolia* Delpino. These characters do not indicate any especially close filiation, for the leaf and fruiting characters are very similar throughout the vast number of existing forms, which embrace between 300 and 400 herbs, shrubs, and trees, found on all the continents in the warmer temperate and tropical zones, and especially abundant in tropical America. The leaflets in the present species are considered to have been in three pairs, hence the leaves were evenly pinnate and probably alternate.

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, pl. 137, fig. 55, 1859.

The pods are arranged in a raceme, as was of course the inflorescence, and were tardily dehiscent.

This species might be compared with a great many existing and fossil species of Cassia, but in view of the great similarity in foliage and fruiting characters throughout the genus little weight can be attached to resemblances to individual species. If it is thought that an unwise course has been followed in referring both the leaflets and pods to a single species, it should be remembered that in any event they belong to closely related contemporaneous species and both show unmistakably that they are properly referred to the genus Cassia. There is no danger of confusing the present species with the numerous other Wilcox species of Cæsalpiniaceæ. It is, however, liable to be mistaken for *Sophora wilcoxiana* Berry, which is more coriaceous with more numerous straighter secondaries and more perfectly elliptical outline.

The pods are much like those from the lower Oligocene (Sannoisian) of southern France, described by Saporta as *Micropodium oligospermum*.[1] They are also much like the pods of Heer's genus Podogonium,[2] but differ, as does also Micropodium, in having more than a single seed and in lacking the long stalk which is present in Podogonium. They may be compared also with a form from the Tertiary of Bolivia described by Engelhardt [3] as *Dalbergia antiqua*.

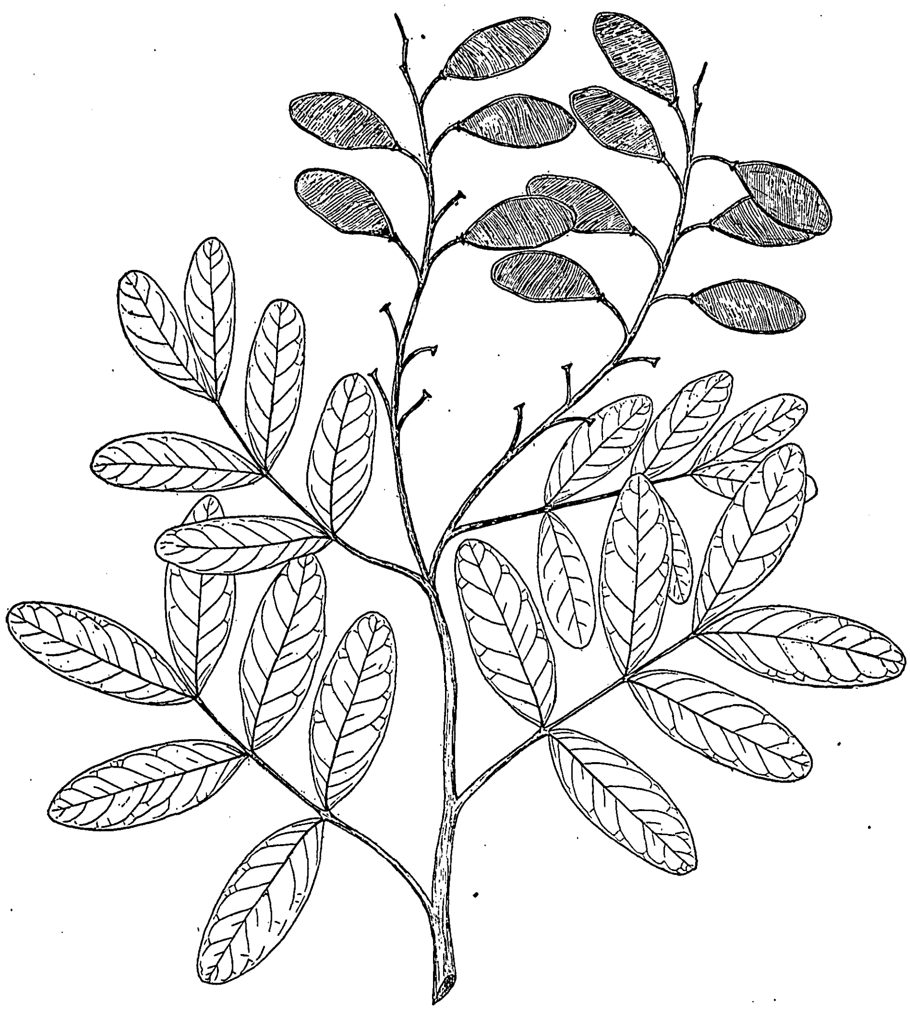

FIGURE 13.—Restoration of *Cassia wilcoxiana* Berry. (One-half natural size.)

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 137, pl. 14, fig. 8, 1863; idem, vol. 3, pl. 18, fig. 1, 1867.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 113, 1859.

[3] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 8, pl. 1, fig. 23.

CASSIA MARSHALLENSIS Berry, n. sp.

Plate L, figures 6 and 7.

Description.—Leaflets relatively small, lanceolate, somewhat falcate in outline, more or less inequilateral, the apex obtusely pointed, in some specimens slightly emarginate, and the base broadly pointed and in some specimens quite inequilateral. Length as a rule about 2.5 centimeters. Maximum length observed 3.5 centimeters. Maximum width 1.1 centimeters, midway between the apex and the base. Margins entire and fully and regularly curved. Texture coriaceous. Petiolule stout, about 2.5 millimeters or less in length, much curved. Midrib stout, prominent, and curved. Secondaries thin, eight or nine rather regularly spaced, subopposite to alternate, subparallel, camptodrome pairs, branching from the midrib at angles of about 60° or more.

This species shows all the characters of the genus Cassia. It is the smallest of the Wilcox forms referred to that genus, but may be compared with numerous similar species of Cassia, both living and fossil. It is somewhat close to *Cassia tennesseensis* but is readily recognizable and is named from the occurrence of the type in Marshall County, Miss.

It is much like a form from the Tertiary of Bolivia described by Engelhardt[1] as *Cassia ligustrinoides*.

Occurrence. — Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction in Fayette County, Tenn. (collected by L. C. Glenn), and Wickliffe, Ballard County, Ky. (collected by E. W. Berry).

Collections.—U. S. National Museum.

CASSIA FAYETTENSIS Berry, n. sp.

Plate XLIX, figures 5–8.

Description.—Leaflets petiolulate, ovate-lanceolate in outline, very slightly inequilateral, 3.5 to 4.5 centimeters in length by about 1.7 centimeters in maximum width at or slightly below the middle of the leaflet. Margins entire and fully rounded, so full in some specimens that they become repand. Basally the margins come inward with regular full curves to the pointed, slightly inequilateral base; distad they are regularly curved, the curves being flatter than at the base; hence this part of the leaflet is more slender than the base. Apex narrowly rounded. Petiolules stout rugose, 3 or 4 millimeters in length, apparently without exception much curved. Midrib stout and generally straight, prominent on the lower surface of the leaflet. Secondaries not raised, very thin but distinct, eight or nine alternate pairs, unequally spaced, branching from the midrib at angles of more than 60°, at first straight and then curving upward in a broad arch some distance from the margin to join the secondary next above. Outside of these rather flat arches are small straight laterally directed tertiaries, also arched from tip to tip approximately parallel with the margins. Texture thin and membranaceous.

These leaves in their outline, texture, and the very characteristic venation are clearly referable to Cassia and approach somewhat closely the more lanceolate forms of the associated *Cassia glenni* Berry. They are invariably smaller, but in spite of this fact they have a much longer petiolule, and they have not been observed to show any tendency toward an emargination of the tip. They resemble somewhat the two smaller species *Cassia marshallensis* Berry and *Cassia tennesseensis* Berry, both of which differ in their venation, *Cassia tennesseensis* being sessile and not petiolulate.

The present species is similar to a number of existing species of Cassia, the South American *Cassia stipulacea* Aiton, to mention but one. It is also similar to a number of European Tertiary species, for example, *Cassia feroniæ* Ettingshausen[2] from the lower Oligocene of the Tyrol, or the very wide ranging *Cassia lignitum* Unger,[3] which not only occurs all over Europe but has been recorded in considerable abundance from the early Tertiary of eastern Asia by Heer.[4]

Occurrence.—Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call). Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry), and Vaughns, near Lamar, Benton County, Miss. (collected by L. C. Johnson). Lagrange formation (in

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1887, p. 37, pl. 1, fig. 16; idem, 1894, p. 10, pl. 1, fig. 27.

[2] Ettingshausen, C. von, Die tertiäre Flora von Häring, p. 91, pl. 30, figs. 9–11, 1855.

[3] Compare with figures in Ettingshausen, C. von, idem, pl. 29, figs. 40–42, and Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 121, pl. 138, figs. 22–28, 1859.

[4] Heer, Oswald, Flora fossilis arctica, vol. 5, pt. 4, p. 55, pl. 15, figs. 6–8, 1878.

beds of Wilcox age): Puryear, Henry County, Tenn. (collected by E. W. Berry), 1½ miles west of Grand Junction in Fayette County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

CASSIA EMARGINATA Berry, n. sp.

Plates XLV, figure 17b, and XLVIII, figure 5.

Description.—Leaflets of medium size, slightly inequilateral, ovate in general outline, with a broadly rounded or narrowed, emarginate apex, and a narrowed and rounded or broadly cuneate base. Length about 4.7 to 5.5 centimeters. Maximum width, in the middle part of the leaflet, 1.5 to 2.75 centimeters. Margins entire, slightly irregular. Leaf substance thin. Petiolule long and stout, about 7 millimeters in length. Midrib stout. Secondaries very thin, 10 to 12 opposite to alternate, irregularly spaced pairs; they diverge from the midrib at wide angles, curving upward in varying arcs, and are regularly camptodrome in the marginal region. Tertiaries fine, but distinct, forming large, irregularly quadrangular meshes.

This fine species closely resembles some of the leaflets of *Cassia glenni* Berry and *Cassia wilcoxiana* Berry in size, outline, texture, and venation. It is especially close to some of the emarginate leaflets of *Cassia glenni*, but may be readily distinguished from both species, which are practically sessile, by its relatively long petiolule.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

CASSIA GLENNI Berry, n. sp.

Plates XLV, figures 15, 16, 17a, 18, and LII, figure 6.

Andromeda vacciniifoliæ affinis. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859.

Lesquereux, in Safford, J. M., Geology of Tennessee, p. 428, pl. K, figs. 4a, 4b, 1869.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 196, figs. 4a, 4b, 1888.

Description.—Leaflets different in size and outline, ovate-lanceolate to elliptical-lanceolate, with a cuneate base and an equally and regularly narrowed, bluntly pointed apex; or the distal part of the leaflet may be gradually narrowed and more or less extended and the tip narrowly rounded; or the tip may be and commonly is emarginate. Length ranges from 3.75 to 6 centimeters, averaging about 4.75 centimeters. Maximum width, at or generally below the middle, ranges from 1.75 to 2.5 centimeters, averaging about 1.95 centimeters. Petiolule short, not over 1.5 millimeters in length, so that leaflets are practically sessile. Leaf substance thin and membranaceous. Blade slightly inequilateral. Margins normally full and entire, abnormally undulate like one specimen figured. Midrib relatively stout and prominent. Secondaries thin, six or seven subopposite to alternate pairs, branching from the midrib at angles of more than 45°, pursuing a rather straight course, at length upward and camptodrome.

This species is very common at the locality discovered halfway between Grand Junction and La Grange, Tenn. The species is named for Prof. L. C. Glenn, of Vanderbilt University, who collected the type material in 1903. It is quite variable and the figured material illustrates this variability, which, however, is not at all confusing, since the narrow rounded or more or less emarginate tip and the thin stiff texture, together with the sharply impressed but very fine tertiary venation, only visible with a lens, give the leaflets a perfectly characteristic appearance.

It may be matched by a number of the abundant existing species of Cassia from the American tropics. Among fossil forms it shows great similarity to certain European Tertiary species, especially to the abundant and widespread *Cassia berenices* Unger [1] and *Cassia hyperborea* Unger,[2] both so common in the Oligocene of southern Europe. Some of the forms of these species, especially the suite of *Cassia berenices* figured by Heer [3] from the Swiss Miocene, only lack the slight emargination of the tip to be identical with *Cassia glenni* in all its variations. It also suggests a form from the Tertiary of Bolivia described by Engelhardt [4] as *Sweetia tertiaria* (Mimosaceæ), but is larger and not generically identical.

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[1] Unger, Franz, Die fossile Flora von Sotzka, p. 58, pl. 43, figs. 4-10, 1850.
[2] Idem, pl. 43, figs. 1-3.
[3] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, pl. 137, figs. 42-56, 1859.
[4] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1887, p. 38, pl. 1, fig. 11; idem, 1894, p. 9, pl. 1, fig. 26.

Among the contemporary species of Cassia in the Wilcox group, the species under discussion resembles more or less the smaller lanceolate-pointed species, *Cassia fayettensis*, *Cassia marshallensis*, and *Cassia tennesseensis*, but is perfectly distinct from these. It is somewhat similar to *Cæsalpinites mississippiensis*, which is, however, a much smaller, coriaceous form with more prominent venation. *Cassia wilcoxiana* averages about the same size, but has less full margins and a broadly rounded instead of a narrowed apex. *Sophora wilcoxiana* is generally elliptical in outline and has more numerous secondaries and a more coriaceous texture. *Cassia glenni* is very similar to *Cassia sapindoides* Knowlton of the flora of the Raton formation in the southern Rocky Mountain province. Two fine specimens were figured from Tennessee by Lesquereux in 1869 and referred to Andromeda.

Occurrence.—Holly Springs and Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age); Somerville, Fayette County, Tenn. (collected by J. M. Safford); 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn (U. S. National Museum, No. 3455) and E. W. Berry); bed of Mobley Creek, 4 miles southwest of Trenton, Gibson County, Tenn. (collected by Bruce Wade); and Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

Cassia glenni major Berry, n. var.

Plate CXI, figure 4.

Description.—Leaflets relatively large, ovate and approximately equilateral in general outline, the base broadly cuneate and the tip gradually narrowed but eventually rounded. Margins entire. Leaf substance thin but apparently rigid. Length ranges from 6 to 8 centimeters. Maximum width, in the lower part of the leaflet, ranges from 2.2 to 2.8 centimeters. Petiolules stout, expanded, about 2 millimeters in length. Midrib stout, prominent, slightly curved. Secondaries thin, equally spaced, diverging from the midrib at angles of about 45°, regularly curved, camptodrome. Tertiaries thin but well marked.

This species greatly resembles some of the leaflets of *Cassia glenni* Berry as well as those of *Cassia emarginata* Berry, both of which are normally much smaller. It differs from *Cassia glenni*, to which it appears to be most closely allied, not only in size but in the development of a petiolule and the prominence of the tertiary venation. The figured type shows two superposed leaflets, which if they are from a single leaf, as seems probable, exhibit considerable variation in size.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Cassia lowii Berry, n. sp.

Plate LII, figures 7–9.

Description.—Leaflets differing in size and outline, grouped as a single species because of their intimate association in the rocks and the exact agreement in venation of the different forms. Outline ranges from lanceolate to ovate as a rule slightly inequilateral. Tips range from narrowly pointed through broadly pointed to emarginate forms. Bases rather uniformly cuneate pointed. Length ranges from 4.5 to 7 centimeters. Maximum width at or generally slightly below the middle, ranging from 1.5 to 2.75 centimeters. Margins entire. Leaf substance thin. Petiolule short, greatly enlarged, in many specimens curved, 2 to 3 millimeters in length. Midrib stout throughout its length, slightly prominent, generally curved, longitudinally striated. Secondaries thin, scarcely differentiated from the tertiaries; they diverge from the midrib at angles ranging from 30° to 45° and curve in long ascending camptodrome curves subparallel with the lower lateral margins. Tertiaries very fine but well marked, forming an ascending anastomosing network. Areolation fine, mostly pentagonal.

This species, which is common in the Grenada formation of Grenada, Miss., shows similarities in some of its variable forms to certain other Wilcox species of Leguminosæ, and possibly it should be segregated into two species, thus placing the emarginate leaflets in a distinct category. All the specimens, however, are closely related by identical characters of texture and venation, and as very many modern species show similar variations from acute to emarginate tips it has seemed better to regard these forms as constituting a single species, especially as their common characters of venation set them apart from all the other numerous species of Wilcox Leguminosæ. A few of these forms which are similar in outline to some of the varieties of the present species are the following: *Cassia puryearensis* Berry is suggestive of the larger ovate-lanceolate form; *Cassia wilcoxiana* Berry is similar to the emarginate form, and *Cassia tennesseensis* Berry and *Cassia fayettensis* Berry suggest the smaller lanceolate forms. As previously remarked, however, and without taking the space to enumerate the minor differences, *Cassia lowii* has much more ascending secondaries and a well-marked venation, unlike all the species enumerated above. It may be compared with a large number of recent species of Cassia.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by Lowe and Berry).

Collection.—U. S. National Museum.

Cassia mississippiensis Berry, n. sp.

Plate LI, figures 10 and 11.

Description.—Pods short, wide, and compressed, the peduncle stout and the tip acuminate. Widest at or below the middle and tapering somewhat distad, distinctly margined all around. Texture very coriaceous. Veins transverse, very faint and immersed. Length 3.5 to 4.5 centimeters. Maximum width 1.6 to 1.8 centimeters. Seeds few and of large size.

This species is clearly distinct from the other forms of pods found in the Wilcox group, and it therefore becomes necessary to give it a specific name, although it probably represents the fruits of one of the numerous species of Cassia described from the leaflets. These pods resemble somewhat those of *Cassia wilcoxiana* Berry, but are wider, more regularly rounded, more distinctly margined, more acuminate, and more coriaceous, and the venation is much less prominent.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CÆSALPINIA Linné.

Cæsalpinia wilcoxiana Berry, n. sp.

Plate L, figures 9–12.

Description.—Leaflets elliptical in outline and of different sizes, ranging from 1 to 2 centimeters in length and from 4 to 8 millimeters in maximum width at or below the middle of the leaf. Apex slightly narrower than the base, broadly rounded. Base rounded, slightly inequilateral. Margins entire and full. Texture coriaceous. Petiolule stout, straight, as a rule from 1.5 to 2 millimeters in length. Midrib stout and straight, impressed on the upper side and prominent on the lower side of the leaflets. Secondaries thin and mostly immersed, eight or nine pairs, branching from the midrib at a wide angle, camptodrome but merging in the tertiary areolation toward the margin. A leaflet of this species from Puryear, which measures 8 millimeters in length, has a petiolule 4.5 millimeters long.

This species, though the specimens differ in size, is rather uniform in outline and is readily distinguished from associated forms of Mimosaceæ and Cæsalpiniaceæ by its coriaceous texture, its Cæsalpinia venation, which is stronger than in Mimosites, its relatively long petiolule and its symmetric appearance, although the leaflets are really more or less inequilateral.

The existing species of Cæsalpinia number about two score forms of the Tropics of both hemispheres, none of which reach the United States except two or three species of the Florida Keys which are often referred to the allied genus Poinciana Linné. The leaflets of *Cæsalpinia wilcoxiana* can be closely matched by those of several existing West Indian and tropical American species, for example, *Cæsalpinia bahamensis* Lamarck, and this resemblance is so close that the present form is referred without hesitation to the genus Cæsalpinia and not to the somewhat less definite form genus Cæsalpinites, which is used for allied forms referable to the family Cæsalpiniaceæ, whose generic affinity can not be positively settled.

Guppy [1] discusses the three oriental strand species—*C. nuga* (Aiton), *C. bonducella* (Flem-

[1] Guppy, H. B., Observations of a naturalist in the Pacific, vol. 2, Plant dispersal, p. 183, 1906.

ing), and *C. bonduc* (Roxburg). The second of these is cosmopolitan and its seeds float uninjured for months. There are a number of records of their occurrence in the drift on the Irish and Scandinavian coasts. Robert Brown recorded a plant raised from a West Indian seed washed up on the Irish coast, and these features of distribution are discussed by Hemsley, Schimper, Guppy, and Sernander.

The fossil species of Cæsalpinia are numerous, numbering more than a score, besides about an equal number of forms of Cæsalpinites. They are largely represented in the European Tertiary, commencing with the upper Eocene. In this country our previously known Eocene floras have been of a rather different type, and leguminous forms have not been discovered in them in great quantities.

A few fossil forms that resemble the present species are *Leguminosites calpurnioides* Saporta[1] from the French Oligocene, which is practically identical with the larger leaflets of the American Eocene form except that the French form has a shorter petiolule. *Cæsalpinites colligendus* Saporta[2] from the lower Oligocene of France is practically identical with the smaller forms of the present species, *Copaifera relicta* Unger[3] from Radoboj in Croatia is also almost exactly like the larger leaflets of the present species. Other similar forms from the Tertiary of Bolivia are described by Engelhardt as *Platipodium potosianum*[4] and *Drepanocarpus frankei*[5] and are supposed to represent these two allied genera of papilionaceous trees, which in the existing flora are confined to the American Tropics. Another fossil species which closely resembles the larger leaflets of *Cæsalpinia wilcoxiana* Berry is described by Engelhardt[6] as *Cassia longifolia*. It is from the Tertiary of Ecuador.

Cæsalpinia wilcoxiana was apparently common throughout Holly Springs time. Northward it appears to have been replaced by species of Mimosites.

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, p. 189, pl. 7, fig. 7, 1867.

[2] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, p. 121, pl. 19, fig. 24, 1889.

[3] Unger, Franz, Sylloge plantarum fossilium, vol. 2, p. 32, pl. 11, fig. 11, 1862; Die fossile Flora von Radoboj, p. 154, pl. 3, fig. 10, 1869.

[4] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 12, pl. 1, fig. 41.

[5] Idem, p. 8, pl. 1, figs. 36–38.

[6] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 19, pl. 2, figs. 15 and 16, 1895.

Occurrence.—Holly Springs sand, Early Grove and Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, and Pinson, Madison County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus CÆSALPINITES Saporta.

CÆSALPINITES PINSONENSIS Berry, n. sp.

Plate L, figure 13.

Description.—Leaflets small and sessile, attached somewhat obliquely, broadly elliptical in outline, about 7 millimeters in length by 4.5 millimeters in maximum width in the basal half. Apex broadly rounded, with a mucronate point at the end of the midrib. Base broadly rounded, somewhat inequilateral, and broader than the apex. Margins entire. Texture coriaceous. Venation immersed, even the midrib scarcely discernible.

This small, almost orbicular leaflet is clearly allied to Cæsalpinia. It is sparingly represented at Pinson and the material collected shows only the upper surface of the leaflets, so that the venation characters can not be made out. It is much smaller than most of the forms of Cæsalpiniaceæ and Mimosaceæ described from the Wilcox deposits and is not close to any previously described forms. It suggests somewhat *Cæsalpinia sellardsi* Berry, a true Cæsalpinia, which comes from the Alum Bluff formation of Florida, and in which the leaflets were more inequilateral at the base and consequently borne at a more oblique angle on the rachis.

A number of species described from later Tertiary horizons of Europe are similar to the form under discussion, for example, the lower Oligocene forms (Stampian) of *Cæsalpinia townshendi* Heer.

Cæsalpinites pinsonensis comes from the basal sands of Holly Springs or middle Wilcox age near the eastern boundary of Madison County, Tenn., and is of especial interest on that account. It is very close but somewhat larger than a form from the Tertiary of Bolivia described by Engelhardt[7] as *Desmodium ellipticum*.

[7] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 8, pl. 1, figs. 42–44.

Occurrence.—Lagrange formation (in beds of Wilcox age), Pinson, Madison County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Cæsalpinites bentonensis Berry, n. sp.

Plate L, figure 14.

Description.—Leaflets elliptical in general outline, the apex sharply emarginate and the base rounded or broadly pointed. Margins entire, slightly undulate. Texture coriaceous. Length about 3 centimeters or slightly less. Maximum width 1.5 centimeters, in the basal half of the leaflet. Apical ears directed upward, rather uniformly and broadly rounded. Midrib stout and straight. Secondaries thin, ascending, camptodrome, insensibly merging into the tertiary areolation in the upper part of the leaflet. Tertiaries form small arches in marginal region.

This species is unfortunately based on the single incomplete fragment figured, and were it not for its striking unlikeness to the other members of the Wilcox flora it would be unsafe to form the basis of a new species. It resembles a number of recent species of Cæsalpinia and also the fossil form described by Heer as *Tephrosia europæa*.[1] It is not unlike some of the forms of *Podogonium lyellianum* Heer.[2] It may be distinguished from Dalbergia, Colutea, Bumelia, Sapotacites, and other genera with retuse or emarginate tips, not only by the venation but by its being narrower distad than proximad, whereas these genera have leaves or leaflets which are usually narrowly pointed at the base and widest above the middle.

Occurrence.—Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call).

Collection.—U. S. National Museum.

Cæsalpinites mississippiensis Berry.

Plate L, figure 16.

Description.—Leaflets ovate-lanceolate in outline, the base broadly rounded, nearly equilateral, sessile, and the apex narrowed and bluntly rounded. Length about 2.2 centimeters. Maximum width about 8 millimeters, in the basal half of the leaflets. Margins entire, regularly and full curved. Texture coriaceous. Midrib stout, prominent. Secondaries thin, about 10 pairs, branching from the midrib at angles of about 45°, curving upward, camptodrome, more or less merging with the fine but distinct tertiary areolation.

This species closely resembles the larger leaflets of *Cæsalpinia wilcoxiana* Berry, but is narrowed upward and also unlike that species in the absence of a petiolule. It may be compared with a number of very similar fossil and existing species of Acacia, Cæsalpinia, Mimosa, and allied genera.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Cæsalpinites (Parkinsonia ?) aculeatafolia Berry, n. sp.

Plate L, figure 15.

Description.—Leaflets small, equilateral, and sessile or minutely petiolulate, obovate-lanceolate in outline, the apex broadly rounded and the base somewhat narrowed and pointed. Length 5 or 6 millimeters. Maximum width about 2.5 to 3 millimeters, above the middle. Margins entire. Texture subcoriaceous. Midrib relatively stout, curved, prominent on the under side of the leaflet. Secondaries for the most part merged with the tertiary areolation and indistinguishable from it. Two or three pairs of secondaries stand out slightly as ascending, gently curved, and camptodrome.

This species is the smallest form thus far known from the Wilcox flora and is clearly distinct from the associated species of Cæsalpiniaceæ or Mimosaceæ. Though much smaller and relatively shorter and broader, it suggests *Mimosites spatulatus* Berry of the overlying Claiborne group. Among Recent forms it suggests the leaflets of Parkinsonia, especially *Parkinsonia aculeata* Linné, the so-called horse bean, so widely planted throughout the West Indies and other tropical countries and indigenous in low moist spots from the lower Rio Grande to Lower California.

The genus Parkinsonia contains only three or four existing species in the warmer parts of North America and South Africa. I am only acquainted with one fossil form, *Parkinsonia recta* Laurent[3] from the Tongrian of France. The leaflets of that species are very similar

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 101, pl. 133, figs. 1-3, 1859.

[2] Idem, p. 117, pl. 136, figs. 22-52.

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

to those of *Cæsalpinites (Parkinsonia?) aculeatafolia* and are authenticated by their association with the characteristic seeds and torose pods. No such certainty exists regarding the Wilcox form, which may be only a small obovate form of Cæsalpinites. Forms from the European Oligocene and Miocene referred to the genus Edwardsia Salisbury, of the Papilionaceæ (Sophoreæ), recent species of which inhabit New Zealand and South America, are not unlike the present species. This is especially true of *Edwardsia parvifolia* Heer [1] from the Aquitanian of Switzerland. Another similar fossil form is one from the Tertiary of Bolivia, described by Engelhardt [2] as *Hedysarum bolivianum* (Papilionaceæ) and compared with the existing *Hedysarum falcatum* De Candolle, a species ranging from Mexico through Central America to Brazil and Peru.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry.)

Collection.—U. S. National Museum.

Genus GLEDITSIOPHYLLUM Berry.

GLEDITSIOPHYLLUM EOCENICUM Berry, n. sp.

Plate XLVI, figures 1–7.

Description.—Leaves compound, odd-pinnate, thereby differing from the modern species of Gleditsia. Petiole rather stout, slightly enlarged proximad, about 3 centimeters in length, without a petiolar gland. Leaflets subopposite to alternate, 1.5 to 2.5 centimeters apart, differing in size, ovate-lanceolate to lanceolate in outline, more or less inequilateral, the apex bluntly pointed or more or less rounded and the base pointed and more or less inequilateral. The arrangement is opposite to alternate, as in Gleditsia. Terminal leaflet does not differ from the lateral leaflets except that it is slightly larger in many specimens. Length ranges from 3.5 to 6.35 centimeters and averages about 4.5 to 5 centimeters. Maximum width, which is below the middle, ranges from 7 to 13.5 millimeters and averages about 8 millimeters. Margins entire, but minutely undulate in some specimens. Leaf substance consistent, comparable with that of *Gleditsia triacanthos* Linné. Leaflets petiolulate. Petiolules stout, recurved, about 2 millimeters in length, reticulately wrinkled, as in modern forms. Midribs stout, somewhat curved, prominent on the lower surface of the leaflet. Secondaries generally 9 or 10 subopposite pairs, thin but distinct. They branch from the midrib at angles of about 45°, curving upward, camptodrome. Tertiary venation nearly as prominent as the secondary. It consists of branches from the midrib that parallel the secondaries and help to form the internal polygonal meshes and marginal branches which arch in that region.

This species, which ranges from about the middle to the top of the Wilcox, shows a considerable diversity in the size and outline of its leaflets, which are not, however, as dissimilar in this respect as the leaflets on a single leaf of the existing *Gleditsia triacanthos.* Some of the leaves of *Gleditsiophyllum eocenicum* are decidedly inequilateral, the base being nearly straight and narrowly cuneate on one side of the midrib and broad and fully rounded on the other side. Some of the leaflets are narrow and somewhat falcate, with pointed tips, and others are broad, with rounded tips. Narrow leaflets may have rounded tips and broad leaflets pointed tips. Most of these variations are shown in the specimens figured, in several of which the leaflets are still attached to the leaf stalk. The species is well characterized, however, the sharply impressed thin venation being sufficient for its identification. It is represented by an abundance of material, which in many respects is very similar to modern species of Gleditsia. Naturally it resembles numerous allied modern genera with this type of foliage, and there are numerous allied fossil forms with which it may be compared. It differs from Gleditsia in its odd-pinnate character, which is also a feature that serves to distinguish it from Cassia, as does also the absence of a petiolar gland.

Gleditsiophyllum eocenicum bears a general resemblance to the genus Podogonium,[3] several species of which are so common in the later Tertiary of Europe and also present in North America. Podogonium generally has, however, a broadly rounded apex and inequilateral

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 107, pl. 133, fig. 41, 1859.

[2] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 7, pl. 1, figs. 62, 63.

[3] Heer, Oswald, op. cit., p. 113.

venation in the basal region of its leaflets. Saporta [1] figures a leaf from the lower Oligocene of southern France, which he refers to the larger-leafed species *Diospyros varians*, a form almost identical in size, outline, and venation with the species under discussion.

I established the genus Gleditsiophyllum [2] for an Upper Cretaceous species of Cæsalpiniaceæ from the Coastal Plain of North Carolina, which is much like the present species, especially the larger-leafed forms. It may bear an ancestral relationship to this lower Eocene form which is so exceedingly common at the Puryear locality.

The most similar fossil forms are the abundant leaves from the Oligocene of Haering in the Tyrol described by Ettingshausen as *Cassia zephyri* [3] and *Cassia pseudoglandulosa*.[4] *Cassia pseudoglandulosa* in particular is extremely close to this American Eocene species.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen); 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Gleditsiophyllum ovatum Berry, n. sp.

Plate LI, figure 1.

Description.—Leaflets small, ovate in general outline, the tip broadly rounded and the base narrowly cuneate. Length about 1.5 centimeters. Maximum width, midway between the apex and the base, about 6 millimeters. Margins entire. Texture subcoriaceous. Petiolule not preserved. Midrib stout throughout, curved, not especially prominent, secondaries thin, ascending, scarcely differentiated from the tertiaries, dictyodrome.

This small form is distinct from those forms of similar outline referred to Mimosites, Cæsalpinia, and Cæsalpinites. It suggests Dalbergia, but because of its uncertain generic relationship it is referred to the form genus Gleditsiophyllum, with the other forms of which its venation is practically identical. It is rare and may represent an abnormal leaf of *Gleditsiophyllum eocenicum* Berry.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Gleditsiophyllum constrictum Berry, n. sp.

Plate LI, figure 4.

Description.—Leaflets oblong-lanceolate in general outline, the tip bluntly pointed and the base cuneate, constricted to the midrib in the apical region to form an oblong basal portion 2.5 centimeters long and 8 millimeters in maximum width in the middle. Both apical and basal portions are slightly inequilateral. Margins entire, regularly curved. Texture subcoriaceous. Petiolule not preserved. Midrib curved, stout. Secondaries numerous, thin, ascending, curved, dictyodrome, scarcely differentiated from the tertiary areolation.

The general character of these leaflets allies them with *Gleditsiophyllum eocenicum*, and their rarity at a locality where that species is very abundant lends some ground to the theory that they represent abnormal leaflets of *eocenicum*. As this theory is incapable of verification, they are given a specific name in allusion to the constriction that divides the lamina into a small distal and a larger proximal segment, a character which serves at once to distinguish the present from all the other forms of leguminous leaflets found in the Wilcox.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Gleditsiophyllum ellipticum Berry, n. sp.

Plate LI, figures 2 and 3.

Description.—Leaflets small, somewhat irregularly elliptical in general outline, widest at the middle, and about equally rounded at the apex and base. Length about 6.5 millimeters. Maximum width about 5 millimeters. Margins entire, regularly rounded. Texture relatively subcoriaceous for so small a form. Petiolule long and stout, curved, about 4 millimeters in length. Midrib stout, straight, and prominent. Second-

[1] Saporta, G. de, Études de la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 107, pl. 6, fig. 4, 1866.
[2] Berry, E. W., Torrey Bot. Club Bull., vol. 37, p. 197, 1910.
[3] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 90, pl. 30, figs. 1–8, 1855.
[4] Idem, p. 89, pl. 29, figs. 48–55.

aries very thin, scarcely differentiated from tertiaries, and more or less obsolete by immersion.

This apparently rare species is of uncertain generic affiliation and it is therefore referred to the form genus Gleditsiophyllum. It may be distinguished at once from the other species referred to this genus by its relative shortness and from all the Wilcox forms in this genus or other leguminous genera by the relatively long petiolule.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Gleditsiophyllum minor Berry, n. sp.

Plate LI, figures 5 and 6.

Description.—Leaflets very small, lanceolate in general outline, tapering from about the middle and equally pointed at both ends, petiolulate. Length about 1.75 centimeters. Maximum width, in the middle part of the leaflet, about 3 millimeters. Margins entire. Texture coriaceous. Petiolule stout, relatively elongated, about 2.5 millimeters in length. Midrib relatively stout and prominent, straight. Secondaries scarcely differentiated from the tertiaries, thin, few in number, diverging from the midrib at acute angles, curved, ascending subparallel with the lateral margins for long distances, camptodrome. Tertiaries thin, forming fine meshes.

This tiny-leafed species is closely allied to *Gleditsiophyllum eocenicum* Berry. It is much less abundant and differs in its much smaller size, being only half as large as the smallest known leaflet of that species. It also differs in its equilateral form and in being widest medianly instead of in the lower half of the leaflet; in its relatively more coriaceous texture; longer petiolule; and in its less numerous, less differentiated, and more ascending secondaries.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Gleditsiophyllum hilgardianum Berry, n. sp.

Plate LI, figure 9.

Description.—Pods short, wide, and flat. About 6.5 centimeters in length by about 2 centimeters in maximum width. Both ends bluntly pointed. Venation thin, oblique, and anastomosing. Substance thin and wrinkled, having a septate appearance between the seeds. Seeds numerous, relatively small for the size of the pod, orbicular, lenticular.

It is obviously futile to endeavor to determine the botanic affinity of this pod, which is clearly referable to the Leguminosæ and as clearly distinct from the other forms of pods described from the Wilcox group. It is therefore referred to the form genus Gleditsiophyllum and named in honor of E. W. Hilgard, who discovered this fossiliferous locality more than half a century ago.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Gleditsiophyllum fructuosum Berry, n. sp.

Plate LI, figure 7.

Description.—Indehiscent, many seeded, nonseptate, flat pods of large size. Outline oblong linear and ends bluntly rounded. The base is missing, but was probably somewhat more pointed than the apex. Texture coriaceous but not ligneous, showing no veins. Length probably variable, as in the modern *Gleditsia triacanthos*. The specimens do not show their whole length, owing to the jointing of the clay and not to the breaking of the pods before fossilization. Estimated length, 10 to 15 centimeters. Width 2.25 to 2.50 centimeters. The margins are approximately straight and parallel and are not appreciably thickened. Seeds lenticular, obovate, 1.5 to 2 centimeters long and about 1 centimeter wide.

This species strongly suggests the variable pods of our common honey locust, *Gleditsia triacanthos* Linné, but it can not be correlated with certainty with this genus, since it is equally close to the pods of several more or less closely related genera, and a number of fossil pods of similar characters have been referred to Acacia, for example, *Acacia microphylla* Unger[1] from Sotzka, Styria, which is

[1] Unger, Franz, Die fossile Flora von Sotzka, p. 59, pl. 46, figs. 11, 12, 1850.

very similar except for its smaller seeds; *Gleditsia wesseli* Weber,[1] from the Miocene of Switzerland and Germany, which also has smaller seeds; *Acacia brongniarti* Watelet,[2] from the Ypresian of the Paris Basin, which is similar in size and form and in the size of the seeds, but has more pointed ends.

Gleditsiophyllum fructuosum is not abundant and is only known from the one locality at Holly Springs, Miss., where such a variety of pods have been collected. It is referred to the form genus Gleditsiophyllum rather than to any modern genus. Leaflets described as *Gleditsiophyllum eocenicum* Berry are very abundant in the deposits of Wilcox age, at Puryear, Tenn., but none of these have been found in association with these pods.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

GLEDITSIOPHYLLUM ENTADAFORMIS Berry, n. sp.

Plate LIV, figure 5.

Description.—Indehiscent pods of large size, oblong-elliptical in outline, of a leathery or ligneous consistency, several-seeded. Apex inequilaterally and bluntly pointed. Base missing. Seeds large, orbicular, lenticular. Length unknown. Width about 3 centimeters. Margins nearly parallel, slightly constricted between the seeds. The single specimen shows traces of partitions between the seeds and very strongly suggests a relationship with the genus Entada Adanson (often and perhaps more properly named Lens, a name proposed by Stickman in 1754), which in the existing flora has several species known as sea beans or snuffbox sea beans in the strand flora of tropical America and Asia. They are distributed by ocean currents. Fossil species are rare. Unger described two species many years ago, *Entada polyphemi*,[3] from Sotzka in Styria, and *Entada primogenita*,[4] from Radoboj in Croatia. *Entada primogenita* shows considerable resemblance to the present species but has smaller seeds. Watelet described a somewhat doubtful species, *Entada dubia*,[5] from the Ypresian of the Paris Basin, which is even smaller than the present Wilcox species.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family PAPILIONACEÆ.

Genus SOPHORA Linné.

Leaflets inequilateral, bluntly pointed at both ends, petiolulate.................... *Sophora palæolobifolia.*
Leaflets elliptical, approximately equilateral:
- Sessile, emarginate at apex and base. *Sophora henryensis.*
- Slightly emarginate apex, pointed base, long petiolulate.......................... *Sophora lesquereuxi.*
- Rounded at both ends, oblong-elliptical. *Sophora wilcoxiana.*
- Somewhat narrowed apex, repand. *Sophora repandifolia.*
- Conspicuously mucronate.......... *Sophora mucronata.*
- Ovate-elliptical, pointed....... *Sophora puryearensis.*

SOPHORA WILCOXIANA Berry, n. sp.

Plate XLVII, figures 1-13.

Description.—Leaves pinnate, rachis stout, and leaflets opposite at intervals of about 1.5 centimeters. Leaflets differ greatly in size, elliptical, and nearly equilateral in outline. The apex is broadly rounded, and the base is broadly rounded, or in some specimens broadly cuneate and slightly inequilateral. Length ranges from 2 to 6 centimeters, averaging between 3 and 4 centimeters. Maximum width, which is about midway between the apex and the base, ranges from 8 millimeters to 2.5 centimeters, averaging about 1.75 centimeters. Margins entire, full, and generally almost evenly rounded. Apex broadly rounded and generally equilateral; in some specimens almost truncate, in others narrowed somewhat and slightly inequilateral, with a tiny mucronate point. Base as a rule broadly rounded, but like the apex ranging from broadly pointed, through narrowly rounded, to broad and truncate forms; some specimens not perceptibly inequilateral but others distinctly so. Petiolules very small and thickened. Midrib very stout and straight, prominent on the lower surface of the leaflet, forming a small mucronate point at the apex of the leaf. Secondaries seven or eight, thin, subopposite to alternate pairs, branching from the midrib at angles of about 45° or slightly more,

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 108, pl. 133, figs. 55-59, 1859.

[2] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 246, pl. 60, figs. 1-3, 1866.

[3] Unger, Franz, Sylloge plantarum fossilium, vol. 2, p. 36, pl. 11, fig. 23, 1862.

[4] Idem, pl. 11, fig. 22.

[5] Watelet, A., op. cit., p. 245, pl. 60, fig. 5.

rather straight at first and then curving upward, camptodrome. Texture coriaceous.

This fine species is indisputably allied to Sophora in all of its characters. It is very abundant in Henry County, Tenn., and though decidedly variable in size preserves its essential characters with remarkable uniformity and is readily distinguishable from associated forms by its texture alone. The leaflets have almost invariably been found detached, but in several specimens they lie side by side in the clays in a manner indicating their pinnate arrangement along the petiole of a compound leaf, and in one specimen several are attached to the rachis. They average larger and are narrower than most of the other Wilcox species of Sophora. The smallest specimens resemble somewhat the larger leaflets of *Cæsalpinia wilcoxiana* Berry, which have, however, a relatively long petiolule. They also resemble those from the Tertiary of Bolivia described by Engelhardt[1] as *Dalbergia chartacea*. They average about the same size and have the same outline as the leaflets of *Cassia wilcoxiana* Berry, but are more coriaceous in texture and have more numerous and straighter secondaries and in general a more perfectly elliptical form. The mucronate point at the apex of the midrib serves to readily distinguish them from associated forms.

Sophora wilcoxiana may rightfully be considered to be the ancestral form of a closely allied species, *Sophora claiborniana* Berry, of the middle Eocene of the Mississippi embayment region, which is almost identical with the smaller leaflets of *Sophora wilcoxiana*. In general, however, *Sophora wilcoxiana* averages very much larger and wider and has a more prominent venation and a mucronate tip.

There are about 25 existing species of shrubs and small trees referred to the genus Sophora, which are scattered over the warmer parts of both hemispheres and are found on all tropical seashores. Two arborescent forms occur along our western Gulf coast where they show a preference for moist calcareous soils along streams. One of these Texan species, *Sophora secundiflora* De Candolle, the coral bean, has leaflets very similar to those of *Sophora wilcoxiana*. Other existing species are likewise very similar to this species, as for example *Sophora tomentosa* Linné, a cosmopolitan tropical strand plant. The dry pods float for a week or two and then decay, liberating the buoyant seeds, which float uninjured for several months, according to the experimental evidence of both Schimper and Guppy.[2]

The genus is well represented in European Tertiary floras from the Eocene to the Pliocene but has not been previously recognized in North America, somewhat similar leaves from our western Tertiaries being usually referred to the genus Quercus. Among the described fossil forms *Sophora wilcoxiana* greatly resembles *Sophora europæa*, which was compared by Unger, its original describer, with the existing *Sophora tomentosa* Linné. *Sophora europæa* has been identified by numerous students at a large number of European localities. It is a later form, extending from the Oligocene through the Miocene. It is exceedingly variable and is more like the Wilcox species *Sophora henryensis* Berry, only the more elongate leaflets are like the present species, and then they are usually more inequilateral.[3] Plate XLVII well illustrates the character and variations of *Sophora wilcoxiana*.

Occurrence.—Wilcox group, Atchison clay pit, Perla, near Malvern, Hot Spring County, Ark. (SW. ¼ sec. 24, T. 4 S., R. 17 W.) (collected by R. E. Call in 1891); Bolivar Creek, 3½ miles north of Harrisburg, Poinsett County, Ark.(?) (collected by L. W. Stephenson); and 2¾ miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (very common) (collected by E. W. Berry), and 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

Sophora puryearensis Berry, n. sp.

Plates LII, figure 3, and CIX, figure 3.

Description.—Leaflets ovate or elliptical and somewhat inequilateral in general outline, broadly rounded at the base, narrowing for their

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 8, pl. 1, fig. 25.

[2] Guppy, H. B., Observations of a naturalist in the Pacific, vol. 2, Plant dispersal, pp. 147, 579, 1906.

[3] Unger, Franz, Die fossile Flora von Sotzka, p. 57, pl. 42, figs. 1-5, 1850.

upper third to an ultimately blunt point. Length ranges from 3.75 to 6.5 centimeters. Maximum width, midway between the apex and the base, about 1.75 to 2.25 centimeters. Margins entire, slightly revolute. Texture subcoriaceous. Petiolule rather stout, curved, about 4 millimeters in length. Midrib stout, prominent. Secondaries stout but more or less immersed in the leaf substance; about six to eight irregularly spaced pairs diverge from the midrib at angles of about 55° or more, curve regularly and are camptodrome some distance from the margins. Tertiaries obsolete.

This species, which apparently is rare, is well differentiated among the rather numerous species referred to Sophora in the Wilcox flora. It may be compared with several existing species in Sophora and allied genera.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Sophora henryensis Berry, n. sp.

Plate LII, figure 2.

Description.—Leaflets short and broadly elliptical in outline, the apex and base broadly rounded slightly emarginate, sessile. Length about 2.75 centimeters. Maximum width, which is halfway between the apex and the base, about 1.75 centimeters. Margins entire and full. Texture coriaceous. Midrib stout and somewhat flexuous, relatively slender as compared with *Sophora wilcoxiana* Berry or *Sophora palæolobifolia* Berry. Secondaries five to seven pairs, thin but distinct, somewhat irregularly spaced, branching from the midrib at angles of about 60°, rather straight, ultimately curved, and camptodrome. Tertiaries forming small arches in the marginal region and internally four or five sided, small meshes.

This species is very similar to some of the shorter and wider forms of *Sophora wilcoxiana* Berry, but is readily distinguished by its sessile habit, emarginate apex and base, thinner midrib, and more prominent tertiary venation. It may be distinguished from *Sophora palæolobifolia* Berry by its equilateral form and sessile habit. It greatly resembles some of the variants of *Sophora europæa* Unger, for example, the leaflet figured by Ettingshausen[1] from Haering in the Tyrol. It is represented by a very similar but slightly larger species in the flora of the Raton formation in the southern Rocky Mountain province, a formation slightly older than the Wilcox.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Sophora palæolobifolia Berry, n. sp.

Plate LII, figure 1.

Description.—Leaflets elliptical in outline, markedly inequilateral, slightly petiolulate, relatively small, about 2.5 to 3 centimeters in length by 1.3 centimeters in maximum width, in the middle part of the leaf. Margins entire. Texture subcoriaceous. Apex bluntly pointed, inequilateral. Base equally pointed and inequilateral. Petiolule stout, about 1 millimeter in length. Midrib stout, prominent, and usually slightly curved. Secondaries thin, 5 to 7 alternate pairs, branching from the midrib at angles of about 55° and curving regularly upward, camptodrome.

This species is readily distinguished from the other Wilcox species of Sophora by its size and outline. It resembles somewhat the leaflets of the contemporaneous species of Pithecolobium. It may be distinguished from *Pithecolobium eocenicum* Berry by the larger size, more rounded apex, and by the stouter, more curved midrib of that species; and from *Pithecolobium oxfordensis* Berry by the very asymmetric leaflets of that species and their more coriaceous texture and obsolete venation. It also greatly resembles some of the leaflets from Haering in the Tyrol, which Ettingshausen[2] refers to the genus Palæolobium, which has suggested the specific name that has been adopted. It may also be compared with the leaflets of the widespread *Sophora europæa*, figured from Radoboj in Croatia by Unger,[3] and with a form from the Tertiary of Bolivia described by Engelhardt[4] as *Lonchocarpus obtusifolius*.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction,

[1] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, pl. 29, fig. 20, 1855.

[2] Idem, figs. 10-19.

[3] Unger, Franz, Die fossile Flora von Radoboj, pl. 3, fig. 18, 1869.

[4] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 7, pl. 1, fig. 22.

in Fayette County, Tenn. (collected by L. C. Glenn and E. W. Berry).

Collection.—U. S. National Museum.

SOPHORA REPANDIFOLIA Berry, n. sp.

Plate XLVIII, figures 6 and 7.

Description.—Leaflets of different sizes, elliptical in general outline, the base broadly rounded, and the apex somewhat narrowed and rounded. Length ranges from 4 to 8 centimeters. Maximum width, at or below the middle, ranges from 2.5 to 3.5 centimeters. Petiolule short and wide, spreading at the point of attachment, about 1 to 2 millimeters in length. Midrib stout and prominent. Secondaries thin, 9 or 10 opposite to alternate unequally spaced pairs, diverging from the midrib at angles of about 50°, curving regularly upward, subparallel, camptodrome. Tertiaries obsolete. Leaf substance subcoriaceous.

This species may be distinguished at once by its repand margins. It is larger than any of the other Wilcox species of Sophora, although the larger leaflets of *Sophora wilcoxiana* Berry are as large as the smaller leaflets of this species. It may be differentiated from *Sophora wilcoxiana* by its repand margin, broader form, narrowed apex, and by the flattening and widening of its petiolule. It is found in association with that species but is considerably less abundant.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

SOPHORA LESQUEREUXI Berry, n. sp.

Quercus myrtifolia. Lesquereux (not Willdenow), Am. Jour. Sci., 2d ser., vol. 27, p. 363, 1859.
Lesquereux, in Safford, J. M., Geology of Tennessee, p. 427, pl. K, fig. 3, 1869.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 196, fig. 3, 1888.

Description. — Leaflets shortly elliptical, approaching orbicular in general outline, slightly inequilateral. Apex slightly emarginate. Base pointed, slightly decurrent. Length about 3 centimeters. Maximum width, in the middle part of the leaflet, about 1.75 to 2 centimeters. Margins entire, regularly rounded. Texture coriaceous. Petiolule long, stout, curved, about 4 millimeters in length. Midrib stout and curved. Secondaries thin, about four alternate, unequally spaced pairs; they diverge from the midrib at angles of about 55°, curve regularly upward in a subparallel manner, and are camptodrome in the marginal region; those on the narrower side of the lamina are slightly more ascending than those of the opposite side. Tertiaries immersed in the leaf substance.

When Lesquereux studied this material in 1859 the deposits from which it came were thought to be of Pliocene age, and he naturally searched the still existing flora of temperate North America for a similar form and identified the present species with the scrub oak, *Quercus myrtifolia* Willdenow, a small tree ranging from South Carolina to Louisiana near the coast. This form is really not especially like the fossil, being generally larger, obovate in outline, with a decidedly different secondary venation, and a well-marked and characteristic querciform tertiary areolation. If Lesquereux had extended his comparisons to the existing flora of tropical America he would have found numerous similar leaflets in the genus Sophora, so common in modern strand floras of the Tropics.

The present species is at once distinguishable from the associated Wilcox species of Sophora by its relatively long petiolule. It is relatively much shorter and broader than the abundant *Sophora wilcoxiana* Berry and much less inequilateral than *Sophora palæolobifolia* Berry. It is closest to *Sophora henryensis* Berry but is more inequilateral, has fewer and more ascending secondaries, and of course is readily distinguishable by its long petiolule.

Occurrence.—Lagrange formation (in beds of Wilcox age), Somerville, Fayette County, Tenn. (collected by J. M. Safford).

Collection.—Location of type unknown. Not contained in any of the recent collections.

SOPHORA MUCRONATA Berry, n. sp.

Plate LII, figure 4.

Description. — Leaflets of medium size, oblong-elliptical and somewhat inequilateral in general outline. Length about 4.5 centimeters. Maximum width, at or slightly below the middle, about 1.6 centimeters. Tip evenly and broadly rounded, the midrib being produced as a slender mucro about 2 millimeters in length. Base rounded or in many specimens broadly cuneate. Margins entire. Texture subcoriaceous. Petiolule long, broad, and flat, about 6 millimeters in length. Midrib stout, as a rule slightly curved, prominent on the lower surface of the leaflet. Secondaries thin, largely immersed in the leaf substance; about seven opposite to alternate, regularly spaced pairs diverge from the midrib at angles of 45° to 50°, curving slightly in their ascending subparallel courses, eventually camptodrome. Tertiaries obsolete.

Among the numerous Wilcox species of Sophora this species greatly resembles the medium-sized leaflets of *Sophora wilcoxiana* Berry, the specific differences being the relatively long, flat petiolule, *Sophora wilcoxiana* having practically sessile leaflets, and the extended bristle-like mucro of the tip. It is possible that some of the leaflets referred to *Sophora wilcoxiana* are leaflets of *Sophora mucronata* from which the mucro and the petiolule have been broken off, since the outline and venation of the two species are practically identical. There is no danger of confusing the present species with any of the other Wilcox species. Among recent forms of Sophora, species with foliage like that of *Sophora mucronata* are not uncommon in the American tropical and subtropical zones. Among foreign Tertiary species attention should be called to the resemblance between this species and one from Sagor in Carniola described by Ettingshausen [1] as *Styphnolobium europæum*.[2]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus DALBERGIA Linné fils.

DALBERGIA EOCENICA Berry, n. sp.

Plate LIII, figures 1 and 2.

Description.—Leaflets oblong or obovate in general outline, sessile. Apex emarginate. Margins more or less parallel, entire, curving inward to form the broadly pointed base. Length, 2.2 centimeters. Maximum width, 8 or 9 millimeters, extending over the upper half or two-thirds of the leaflet. Midrib very stout and prominent on the lower surface of the leaflet, straight or somewhat curved. Secondaries thin but distinct, especially on the lower surface of the leaflet, six or seven pairs, branching at an acute angle (30° or less), camptodrome or more or less obsolete by anastomosing to form the tertiary marginal areolation. The texture is coriaceous and the venation is entirely obsolete, except for the well-marked midrib, on impressions showing the upper surface of the leaflet. The distal ears are symmetrically rounded and directed upward, and the leaflet is as broad at this height as it is lower down.

The modern species of Dalbergia number about eighty, distributed throughout the oriental and occidental tropics, and there is a strong generic similarity in their foliage, a number being practically identical with this Wilcox species. It is also very similar to a number of previously described fossil species, for example, *Dalbergia bella* Heer,[3] *Dalbergia affinis* Saporta,[4] *Dalbergia retusæfolia* Heer,[5] and *Dalbergia cuneifolia* Heer.[6] These and numerous other species range from the upper Eocene into the Pliocene of Europe. Although several Upper Cretaceous species are described from North America the Tertiary occurrences are few. Lesquereux [7] has identified *Dalbergia cuneifolia* Heer from the Miocene of Colorado, and I have recorded *Dalbergia calvertensis* Berry from the Miocene of Virginia. Perhaps the most similar species to the present form is the widespread *Dalbergia bella* Heer, which differs in being petiolulate, whereas *Dalbergia eocenica* is sessile and has more nearly parallel margins. *Dalbergia bella* is represented in the late Eocene flora of Greenland.

Among unrelated existing genera the common coastal species *Reynosia septentrionalis* Urban (Rhamnaceæ) of the West Indies has small, coriaceous, emarginate leaves that are identical with those of *Dalbergia eocenica* in outline, differing merely in their venation, Reynosia having regularly spaced, camptodrome secondaries, diverging at an invariably wide angle of more than 90°.

Another similar, somewhat larger form is described by Friedrich as *Dalbergia oligocænica*.[8]

[1] Ettingshausen, C. von, Die fossile Flora von Sagor in Krain, pt. 2, p. 49, pl. 19, figs. 9–11, 1877.

[2] Engler and Prantl treat the genus Styphnolobium Schott as a synonym of Sophora.

[3] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 104, pl. 133, figs. 14–19, 1859.

[4] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, pl. 1, fig. 12, 1889.

[5] Heer, Oswald, op. cit., pl. 133, figs. 9–11.

[6] Idem, pl. 133, fig. 20.

[7] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 200, pl. 34, figs. 6, 7, 1883.

[8] Friedrich, Paul, K. preuss. geol. Landesanstalt Abh. Geol. Specialkarte, Preussen und den Thüringischen Staaten, vol. 4, p. 231, pl. 29, figs. 17–19, 1883.

It comes from the Oligocene of Doerstewitz, Saxony.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Dalbergia wilcoxiana Berry, n. sp.

Plates LIII, figure 7, and LIV, figures 1 and 2.

Description.—Leaflets small, obovate in general outline, petiolulate. Apex broadly rounded, conspicuously emarginate, the apical lobes separated by the width of the relatively very broad midrib. Sides full and evenly rounded, becoming straighter and narrowing from above the middle to the narrowly cuneate base. Length about 12 millimeters. Maximum width, slightly above the middle, about 5.5 millimeters. Margins entire. Texture relatively coriaceous. Petiolule relatively long and stout, about 3.5 to 4 millimeters in length. Midrib very stout and prominent, slightly curved. Secondary system consists of four or five alternate pairs of secondaries, relatively thin and but slightly differentiated from the tertiary system, with which they tend to merge; they diverge from the midrib at angles of about 45°, curving upward subparallel with the lateral margins, and are camptodrome. Tertiary system comprises veins parallel with the secondaries that anastomose by dichotomous forking, joined by still finer transverse nervilles, more or less immersed in the leaf substance.

This species may be compared with the same fossil forms as *Dalbergia eocenica* Berry. It differs from that species in its smaller size, long petiolule, more differentiated and fewer secondaries, and in lacking the oblong form of that species. It is not common in the large amount of material collected and may have been uncommon along the Wilcox coast.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Dalbergia monospermoides Berry, n. sp.

Plate LIV, figure 3.

Description.—Pods of small size, ovate in outline, pointed at both ends, pedunculate, compressed, with a single mature seed. Length exclusive of peduncle about 2.3 centimeters. Maximum width, about midway between the apex and the base, about 1.3 centimeters. Peduncle stout and straight, about 4 millimeters in length. These small pods are inequilateral in side view, the dorsal suture being less full and curved than the ventral side, keeled. Ventral margin thickened. Surface indistinctly veined with close anastomosing transverse nervilles. Texture subcoriaceous. The single mature seed is centrally located, about 7 millimeters in diameter.

This species, represented by a few mostly imperfect pods at the Puryear locality, seems clearly referable to the genus Dalbergia and is closely comparable with the pods of several existing species characterized by their relatively small legumes. It very likely represents one or the other Wilcox species which have been referred to this genus on the basis of their foliage, but since this can not be demonstrated it is given a specific name. Among previously described fossil forms it may be compared with *Dalbergia phleboptera* Saporta [1] and *Dalbergia microcarpa* Saporta [2] of the lower Oligocene of southeastern France, both of which are even smaller than the Wilcox species but otherwise very similar.

This species suggests that ocean currents played a part in the distribution of the Wilcox Dalbergias, for, according to Schimper, the pods of the very similar existing *Dalbergia monosperma* are buoyant. Guppy [3] found these pods in the drift of the Rewa estuary and states that they will float uninjured for months.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Dalbergia tennesseensis Berry, n. sp.

Plate LIV, figure 4.

Description.—Leaflets relatively large, markedly inequilateral, elliptical, or obovate in general outline, the apex rounded or emarginate, inequilateral, and the base cuneate, nearly equilateral. Length about 2.5 centimeters. Maximum width, in the middle part of the leaflet, about 11 or 12 millimeters. Mar-

[1] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, p. 116, pl. 18, fig. 18, 1889.

[2] Idem, p. 117, pl. 18, fig. 19.

[3] Guppy, H. B., Observations of a naturalist in the Pacific, vol. 2, Plant dispersal, p. 529, 1906.

gins entire. Petiolule relatively long, stout, and curved, about 4 or 5 millimeters in length. Midrib rather stout, much curved. Secondaries well marked, about six opposite to alternate pairs, diverging at different angles, camptodrome. Tertiaries thin but well marked, rather straight, forming a relatively open areolation. The lamina is about one-fifth wider on one side of the midrib, and the secondaries are more ascending on the narrower side.

Dalbergia is represented by three species of leaflets and a pod in the Wilcox flora. The present species is somewhat larger than the other two Wilcox species of Dalbergia leaflets and has more numerous and relatively stouter secondaries, more prominent tertiaries, and a much more inequilateral outline. It is readily matched by the leaflets of some of the existing species of Dalbergia.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus DALBERGITES Berry, n. gen.

This genus is proposed as a form genus for leaflets which possess distinctive characters that ally them with the genera of the subfamily Dalbergieæ without, however, showing characters that enable a decision to be reached in favor of one genus to the exclusion of the others. The name Dalbergites is not intended to indicate any closer botanic affinity to Dalbergia than to Pterocarpus or any other genus of this subfamily, which is my reason for proposing this present name instead of Dalbergiophyllum, which is already in the literature.

In the modern flora the subfamily consists of about 350 species in 27 genera, which are segregated to form four tribes. Of these tribes the Anomalæ are exclusively African and not known in the fossil state, but the other three are largely American and tropical, and of these the tribe Pterocarpinæ seems to be the one most strongly suggested by the following species.

DALBERGITES ELLIPTICIFOLIUS Berry, n. sp.

Plate LIV, figure 10.

Description.—Leaflets small, equilateral, and elliptical in general outline, the tip slightly mucronate. Length about 3.75 centimeters. Maximum width, midway between the apex and the base, about 2 centimeters. From the point of greatest width the full entire margins curve evenly to the apex and the base. Texture subcoriaceous. Petiolule absent. Midrib stout and straight, not prominent. Secondaries thin but well marked; six or seven pairs, scarcely differentiated from the tertiaries, diverge from the midrib at angles of about 25° to 30°, long ascending and but slightly curved, camptodrome in the marginal region, where they can scarcely be distinguished in caliber from the tertiaries. Tertiaries thin but well marked, the anastomosing veinlets forming the characteristic acutely angular areolæ of this family.

This species is readily distinguishable from the other Wilcox species of Leguminosæ. It is somewhat suggestive of Sophora, but the mucronately pointed tip serves at once to differentiate it, as does also the venation. It is somewhat like the extinct genus Palælobium Unger of this subfamily, and also suggests certain existing species of the genus Machærium Persoon, which comprises more than three score species that are confined to the American Tropics, though the genus is also recorded from the European Tertiary. It may also be compared with existing species in the genera Dalbergia, Drepanocarpus, and Pterocarpus.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

DALBERGITES OVATUS Berry, n. sp.

Plate LIV, figure 11.

Description.—Leaflets relatively large, ovate in general outline, widest below the middle and tapering upward to the gradually narrowed, eventually abruptly and obtusely pointed tip and downward to the broadly cuneate base. Length about 7.5 centimeters. Maximum width, in the lower half of the leaf, about 3.25 centimeters. Margins entire, slightly undulate. Leaf substance thin. Petiolule lacking. Midrib stout throughout, slightly curved, longitudinally striated, apparently flat and not prominent. Secondaries thin, scarcely visible on the upper surface of the leaflet; about a dozen pairs, scarcely differentiated from the tertiaries, diverge from the midrib at irregular intervals at angles averaging about 35°, pursue an ascending but slightly curved course, and by forking merge with the tertiary system in the marginal region. The basal two or three pairs of secondaries originate close together at the base of the leaf, and one pair, generally the third, are somewhat stouter, more ascending, and longer than any of the others, giving the leaflets a palmately triveined appearance, as in so many lauraceous and other genera. These veins are not lateral primaries, however, and the sum of the characters of the specimens indicates their leguminous nature. The tertiary veins are thin but well marked and inosculate to form the typical papilionaceous venation of this species.

In its outline this species suggests various Wilcox Leguminosæ, from all of which it differs in its venation characters, especially in its triveined appearance. It may be compared with existing species of Machærium, Drepanocarpus, Pterocarpus, and the like, as well as certain members of the Phaseoleæ.

Occurrence.—Grenada formation, Gre ada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus CANAVALIA Adanson.

CANAVALIA EOCENICA Berry, n. sp.

Plate LIII, figures 3-6.

Description.—Stem elongated, probably trailing or scandent. Leaves trifoliate. Leaflets variable in size, elliptical in outline, the apex broad, emarginate or retuse, and the base rounded or very broadly and obtusely pointed. Petiole stout, about 1.5 centimeters in length, slightly tumid proximad. Petiolules stout, with narrow and thick marginal wings, constricted at base of leaflets, 4 to 12 millimeters in length. Leaflets range in size from 4.5 to 8 centimeters in length and from 2.3 to 4.7 centimeters in maximum width, which is midway between the apex and the base. Midribs stout and prominent on lower surface of the leaflets, appearing narrow on the upper surface. Secondaries thin, remote, five or six subopposite to alternate pairs, diverging from the midrib at angles of about 45° or more, curving regularly upward, subparallel and camptodrome. Margins entire. Texture coriaceous.

This fine species is entirely distinct from previously described fossil forms. The detached leaflets are common in the clays of Henry County and might readily be confused with sapotaceous leaves like those of Mimusops or with Sophora, Chrysobalanus, or Capparis. I was fortunate enough, however, to find a complete specimen, which had all three leaflets intact. This is shown in Plate LIII, figure 6, after the terminal leaflet was destroyed in transit. When the petiolule is not broken off, the detached leaflets may be distinguished from unrelated genera with similar leaves by the enlarged lateral margins of their petiolules.

Among existing species this Eocene form is unquestionably closely allied to *Canavalia obtusifolia* (Lamarck) De Candolle, a widely distributed tropical strand plant common in the West Indies, creeping over the beach ridges and climbing in the thickets in the beach jungle, comparable in its abundance, range, and habitat with *Ipomœa pes-capræ.*

This modern species is identical in character with the fossil form, except that its leaflets are relatively slightly broader, the petiole is somewhat longer, and the rachis extends a short distance above the point of attachment of the opposite lateral leaflets. The size, texture, and venation are exactly comparable, and some of the broader leaflets, like the larger one figured, are identical in outline. The leaves of the recent form are not deciduous, but the leaflets commonly absciss after repeated wetting, and a similar habit would account for the presence of the commonly detached leaflets in the clays of Wilcox age in Tennessee.

Another existing species, *Canavalia cubensis* Grisebach, has leaflets relatively narrower than those of *Canavalia obtusifolia.* They are elliptical and identical with the average of those of the fossil species but are as a rule merely obtuse and not emarginate distad. *Canavalia cubensis* is a common high climber of the mountains of Cuba but in some places clambers over coral rock at sea level along the coast.

At least three of the existing species are littoral and are dispersed by ocean currents. The pods and seeds of *Canavalia obtusifolia* float well and the seeds retain their vitality after prolonged immersion in sea water,[1] so that the wide dispersal of this species is undoubtedly largely due to this habit.

An unrelated modern form with trifoliate leaves, and leaflets identical in outline with

[1] Guppy, H. B. op. cit., p. 145.

Canavalia eocenica, is *Bombax mucronatum* Schumann, an inhabitant of Brazil. The fossil species may be distinguished from this recent form by its fewer and much more ascending secondaries.

Canavalia eocenica is so positively identified that it affords a very satisfactory addition to the Wilcox flora, enabling us to form so definite a picture of the plant grouping along the sandy parts of the shore of the Wilcox Mississippi Gulf.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Canavalia acuminata Berry, n. sp.

Plate CX, figures 4 and 5.

Description.—Leaves trilobate (?). Leaflets of medium size, ovate-lanceolate in outline, nearly equilateral, the base broadly rounded and tapering from about the middle to a short, sharp point. Length 5 to 6 centimeters. Maximum width, below the middle, 2 to 2.5 centimeters. Margins evenly rounded and entire. Texture subcoriaceous. Petiolules short, flat, and very much expanded, transversely striated. Midrib stout and prominent on the lower surface of the leaflets. Secondaries thin; six to eight pairs diverge from the midrib at angles that average about 50°, curving upward in a subparallel manner and camptodrome in the marginal region. The tertiary venation is thin but well marked, the angular areolation being characteristic of the genus.

No complete leaves of this species have been found, so that its identification is not as conclusive as that of *Canavalia eocenica* Berry. It is slightly smaller than that species and is readily distinguished by its ovate-lanceolate leaflets as against the broadly elliptical or retuse leaflets of *Canavalia eocenica*, and it is also less common than *Canavalia eocenica*.

It somewhat resembles the numerous leaflets from the Tertiary of Colombia described by *Engelhardt*[1] as *Inga reissi*.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus LEGUMINOSITES Bowerbank.

Leguminosites prefoliatus Berry, n. sp.

Plate XLVIII, figure 1.

Description.—A small unexpanded leaf of an Acacia-like form occurs in the collection from the clays of Wilcox age at Puryear. It represents an incomplete leaf of conduplicate vernation, preserved for a length of 2 centimeters. The stipe is stout and the immature leaflets are numerous, numbering about a dozen pairs in the portion preserved. They are small, linear-lanceolate, sessile, and about 5 or 6 millimeters in length and 1 millimeter in maximum width, inserted obliquely, and apparently somewhat falcate. They are much smaller than most of the described species of Mimosites and Cæsalpinites of the Wilcox flora, but had obviously not attained their mature size.

The specimen is not unique, since Heer described an almost exactly similar specimen from the Swiss Miocene as *Cassia concinna*[2] and Lesquereux has figured a specimen from the lower Eocene of Evanston, Wyo., that is almost exactly similar to the Swiss form as well as to the present Wilcox form. This he identifies as *Cassia concinna* Heer,[3] an obviously rash proceeding when the nature of the remains and the wide interval, both geographic and geologic, between the two occurrences is taken into consideration. Lesquereux's form may be the same as that from Tennessee, since they are identical in appearance and come from horizons that are not remotely different in age, but such evidence is hardly sufficient to establish actual identity, and I prefer to keep them separate.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Leguminosites arachioides (Lesquereux) Lesquereux.

Plate XLVIII, figure 9.

Carpolithes arachioides. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 403, 1873.

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 36, pl. 8, figs. 1, 2; pl. 9, fig. 8, 1895.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, pl. 138, fig. 41, 1859.

[3] Lesquereux, Leo, The Tertiary flora, p. 299, pl. 59, figs. 8, 8a, 1878.

Leguminosites? arachioides. Lesquereux, The Tertiary flora, p. 301, pl. 59, figs. 13, 14, 1878.
Dawson, Geol. Survey Canada Rept. Progress for 1877–78, p. 186b, 1878.

Description.—Much material of these strange leguminous fruits has come to light during late years, and Lesquereux's diagnosis may be considerably amplified, as well as corrected in several particulars, as follows:

Pods in compound clusters, arranged alternately in pairs on stout flexuous stems, subsessile, of a ligneous consistency, full and evenly rounded, inflated, about 2.5 centimeters in length and about 1 centimeter wide across the middle, pointed at both ends, mucronate distad, several-seeded, dehiscent. Surface striated; in general there are two series of striæ, wrinkles, or corrugations, one set approximately longitudinal and the other transverse. These striations are to a certain extent the result of compression, since a good many of the pods show rounded bases evidently due to deformation.

Lesquereux compared these forms, which are very common in the early Eocene of the Rocky Mountain region (Raton, Fort Union, Denver, and the like) with the existing *Arachis hypogæa* Linné, a very remote analogy it seems to me. Their most curious feature is the absence of the persistent calyx that is such a widespread feature of leguminous fruits, and their well-marked habit of occurring in pairs, a feature not observed by Lesquereux, who also speaks of the specimen shown in figure 14 as terminating in a tendril. This is not the case but is an oversanguine interpretation of the material. *Leguminosities arachioides* was either a low straggling plant of the sandy beaches, comparable perhaps with the modern forms of Baptisia or Crotalaria, or else it was a vine like the modern species of Abrus.

Occurrence.—Wilcox group, 3 to 4 miles below Hamilton on Sabine River, Sabine County, Tex., very common in a grayish sandstone (collected by A. C. Veatch); and 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collection.—New York Botanical Garden. Much western material in U. S. National Museum.

LEGUMINOSITES WICKLIFFENSIS Berry, n. sp.

Plate LI, figure 8.

Description.—Small legume, ovate in general outline, compressed but somewhat full and rounded on the margin opposite the keel, apparently indehiscent. Length about 2 centimeters. Maximum width, about halfway between the ends, about 7 millimeters. Proximad the pod tapers to a stout peduncle. Distad it is narrowed and obtusely pointed. The keeled and opposite margins are about equally curved, giving the pod an approximately equilateral form. The pod is, however, angled along the well-marked keel and rounded along the opposite side. The texture appears to have been coriaceous, but this may be partly due to the lignified nature of the remains. The surface is nearly smooth but has slight transverse ridges. Close-set thin transverse veins, almost completely immersed in the substance, are faintly discernible. The seeds appear to have been several in number, small and compressed.

This form was collected from the lower lignite bed in the railroad cut just south of Wickliffe, for which locality it is named. It is entirely distinct from the other pods which have been discovered in the lower Tertiary, and though it may very likely represent the pod of one of the numerous species of Leguminosæ that have been described from the Wilcox on the basis of their leaflets, there is no clue to this relationship, and the remains are of necessity given a distinct specific name. With regard to their exact botanic affinity they offer no decisive characters for generic diagnosis and are therefore referred to the form genus Leguminosites. The texture is similar to that of our common Robinia, and the size and outline suggest numerous existing species of Cassia as well as certain other genera of the Cæsalpiniaceæ and some genera of the Papilionaceæ. My impression is that they appertain to the first of these families, but this is incapable of verification. Almost identical remains from the Oligocene of southern France are described by Saporta [1] as *Cercis ameliæ.*

Occurrence.—Lagrange formation, lower lignite bed (of Wilcox age), in a cut on the Illinois

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, p. 117, pl. 14, fig. 12, 1867.

Central Railroad 1 mile south of the depot at Wickliffe, Ballard County, Ky. (collected by E. W. Berry).

Collection.—U. S. National Museum.

LEGUMINOSITES RENIFORMIS Bowerbank (?).

Leguminosites reniformis. Bowerbank, History of the fossil fruits and seeds of the London clay, p. 135, pl. 17, figs. 29, 30, 1840.

Description.—Small seed, reniform, about twice as long as broad, with a smooth testa. A few seeds in the deposits at Puryear are indistinguishable from this species, which was described by Bowerbank from the pyritized remains in the London clay (Ypresian) of the Isle of Sheppey.

As remains of this sort present few specific characters the occurrence is queried, although it is not at all unlikely that identical or closely related species of Leguminosæ with similar seeds flourished in North America and Europe during the early Eocene.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

LEGUMINOSITES SUBOVATUS Bowerbank (?).

Leguminosites subovatus. Bowerbank, History of the fossil fruits and seeds of the London clay, p. 125, pl. 17, figs. 1, 2, 1840.

Description.—Subovate leguminous seeds about 8 millimeters in length, 6 millimeters in width, and 4 millimeters in thickness are found at Puryear. Though slightly smaller they are otherwise identical in outline and surface with this species, described by Bowerbank from the Ypresian of the Isle of Sheppey. The Wilcox identification is queried because of the uncertainty attending the recognition of specific characters in isolated seeds.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order GERANIALES.

Family RUTACEÆ.

Genus FAGARA Linné.

FAGARA PURYEARENSIS Berry, n. sp.

Plate LIV, figure 8.

Description.—Leaflets broadly elliptical in general outline, apex and base equally rounded. Length about 4 centimeters or slightly less. Maximum width, midway between the apex and the base, about 3 centimeters or slightly less. Margins entire, evenly rounded. Texture subcoriaceous. Petiolule practically lacking, not more than 1 millimeter in length. Midrib narrow, straight, and prominent. Secondaries thin but well marked; four or five opposite to alternate pairs diverge from the midrib at irregular intervals at wide angles and sweep upward in full, even, subparallel curves, arching camptodromely subparallel with the margins. Tertiaries thin, mostly percurrent.

This present species is readily distinguishable from the other Wilcox species of Fagara. It resembles somewhat certain forms of Rhamnaceæ and is very close to *Fagara vicksburgensis orbiculata*, a form of Fagara which is abundant in the deposits of the Vicksburg group, but does not show the characteristic punctate markings of that species.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

FAGARA EOCENICA Berry, n. sp.

Plate LV, figure 6.

Description.—Leaves compound. Leaflets small, orbicular or broadly elliptical in general outline, as a rule more or less inequilateral, apex and base equally rounded. Length about 3.5 centimeters. Maximum width, midway between the apex and the base, about 2.25 centimeters. Margins more or less prominently and somewhat irregularly crenate. Texture subcoriaceous. Petiolule short and relatively very stout, curved, about 2 millimeters in length. Midrib stout, inclined to be slightly flexuous. Secondaries relatively stout, generally five alternate, irregularly spaced pairs; they diverge from the midrib at angles of about 50°, are rather straight in their courses at first, though they differ in this feature, curve upward in the marginal region, and are camptodrome. Tertiaries obsolete.

This is a characteristic species clearly allied to the leaflets of the existing Rutaceæ, particularly of the genera Xanthoxylum Linné and Fagara Linné. The former genus consists of about 10 species of shrubs and small trees in the existing flora, distributed between Asia and North America and extending northward in North America as far as Canada. The genus

Fagara, on the other hand, embraces a large number of existing species of shrubs and trees (between 100 and 150), cosmopolitan in tropical and subtropical countries. Fossil forms of the type of *Fagara eocenica* are as a rule referred to the genus Xanthoxylum, no well-established fossil species of Fagara being known. More than a score of post-Cretaceous fossil forms have been referred to Xanthoxylum, but few of these are from North America, the majority occurring in the European Oligocene. This species is referred to Fagara rather than to Xanthoxylum, since although the leaves are exactly alike in the two genera (the absence of a calyx in Xanthoxylum being practically the only difference between the two), it seems very probable that Xanthoxylum is derived from Fagara through the loss of the floral calyx and by adaptation to cooler and otherwise slightly different climatic requirements and was not differentiated in Eocene times. The present species resembles numerous existing forms with crenate margins. Except for its larger size it is very close to *Fagara fagara* Small of our present Gulf coast.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Fagara hurleyensis Berry, n. sp.

Plate LIV, figure 9.

Description.—Leaves pinnate. Leaflets small, elliptical and somewhat inequilateral in general outline, widest in the upper half of the leaflet. Apex and base rounded, the base inequilateral. Length about 2.7 centimeters. Maximum width, above the middle, about 8 millimeters. Margins entire. Texture coriaceous; the glandular punctate character of the foliage is well shown in the type specimen. Petiolule short and broad, oblique, about 1 millimeter in length. Midrib stout and straight, prominent on the lower surface of the leaflets. Secondaries thin, immersed in the leaf substance; about five pairs diverge from the midrib at acute angles, ascending in long sweeping curves and becoming camptodrome in the marginal region. Tertiaries obsolete.

This well-marked species shows many similarities to leaflets of the Mimosaceæ, Cæsalpiniaceæ, and Papilionaceæ, but its obviously punctate character renders its reference to Fagara almost certain. It is entirely unlike the other Wilcox species but may be matched among the numerous existing tropical species.

Occurrence.—Ackerman formation, Hurleys, Benton County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus CITROPHYLLUM Berry.

Citrophyllum wilcoxianum Berry, n. sp.

Plate LV, figure 3.

Description.—Leaves small, ovate in outline, the apex rounded or bluntly pointed and the base rather narrowly cuneate. Length about 3.5 to 4 centimeters. Maximum width about 1.4 centimeters, halfway between the apex and the base. Margin irregularly crenate. Texture very coriaceous. Petiole stout, about 5 millimeters in length, with a lateral wing on each side constricted at the top, where there appears to be an abscission line. Midrib stout, more or less curved and immersed in the thick lamina. Secondaries thin, five alternate to opposite pairs, branching from the midrib at angles of about 45°, curving upward, camptodrome, immersed in the leaf substance. Tertiaries obsolete.

This species is clearly different from the earlier Cretaceous *Citrophyllum aligerum* (Lesquereux) Berry and from the later Claiborne species *Citrophyllum eocenicum* Berry. It approaches very close, however, to some of the modern forms of Citrus and its allies.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family SIMARUBACEÆ.

Genus SIMARUBA Aublet.

Simaruba eocenica Berry, n. sp.

Plate LIV, figure 7.

Description.—Leaves pinnate, long petioled, leaflets opposite to alternate, sessile. Leaflets slightly inequilateral, oblong-obovate in outline, rounded or slightly emarginate at the apex and cuneate at the base. Length about 4 to 4.5 centimeters. Maximum width, at or above the middle, about 1.7 centimeters. Margins entire, evenly curved. Texture coriaceous. Petiolule stout, reduced to not more than 1 millimeter in length, so that the leaflets are practically sessile. Midrib stout and curved, prominent on the lower surface of the leaflets. Secondaries thin, largely immersed in the leaf substance; five or six subopposite pairs diverge from the midrib at angles of about 50°, curving upward and camptodrome in the marginal region. Tertiaries obsolete by immersion in the leaf substance.

This form clearly represents a Wilcox species of the genus Simaruba (or Simarouba as it is often spelled, the Carib name of one of the species). The genus contains a few existing species, confined to tropical America and distributed from southern peninsular Florida through the West Indies to Guatemala and Brazil. The fossil species is very close to *Simaruba glauca* De Candolle, the paradise tree or bitterwood, which is the only species that reaches Florida from the West Indies. It is a tree of considerable size and lives near the coast throughout the West Indies, and also in Nicaragua and northern Brazil. The fossil may also be compared with the existing *Simaruba officinalis* De Candolle. It also resembles some of the existing and fossil species of the Papilionaceæ, such as Dalbergia; the Rhamnaceæ, such as Reynosia, and the Sapotaceæ, such as Bumelia.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family MELIACEÆ.

Genus CARAPA Aublet.

CARAPA EOLIGNITICA Berry, n. sp.

Plates LV, figure 4, and LX, figure 4.

Description.—Leaves digitately compound. Leaflets large, elongate-elliptical in outline. Length ranges from 12 to 20 centimeters. Maximum width, at a point midway between the apex and base, ranges from 3.5 to 5.5 centimeters. Margins slightly undulate. Texture coriaceous. Apex narrowly rounded. Base a counterpart of the apex or slightly broader. Midrib stout, slightly flexuous. Secondaries stout, numerous, subparallel, somewhat irregularly spaced, about 13 alternate pairs; they diverge from the midrib at wide angles, curve regularly upward, and are camptodrome parallel with the margins and close to them. Tertiaries mostly obsolete; where seen they are thin and percurrent.

This striking form resembles existing species in several families. It suggests some Combretaceæ and numerous Magnoliaceæ, such as *Magnolia fœtida* Sargent, of our Southern States. Among recent forms with which it has been compared it is most similar to *Carapa guianensis* Aublet, an inhabitant of the West Indies and tropical South America (Venezuela, Guiana, and Brazil). The genus Carapa has not, so far as I know, been previously recorded in the fossil state. In the existing flora it comprises only 4 or 5 species, which are confined to tropical America and tropical western Africa.[1]

The present species has only been observed in my collections from one locality, where it is not abundant. It is contained in collections made by Loughridge at Wickliffe, Ky., and labeled *Sapindus dubius*. It was also collected at that locality by Glenn.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge and L. C. Glenn).

Collection.—U. S. National Museum.

Genus CEDRELA Linné.

CEDRELA WILCOXIANA Berry, n. sp.

Plate LVI, figure 1.

Description.—Leaflets small, lanceolate in outline, the apex narrowed and acute, and the base slightly less narrowed and acute. Length about 2.2 centimeters. Maximum width, in the middle part of the leaf, about 6 millimeters. Margins entire. Leaf substance thick. Texture coriaceous. Petiolule short and stout, curved, about 2 millimeters in length. Midrib stout, channeled on the upper surface, and prominent on the under surface of the leaflet. Secondaries thin, immersed in the leaf substance, seven or eight opposite to alternate pairs, irregularly spaced, the angles of divergence generally wide, the course at first straight, curving abruptly in the marginal region to form broad camptodrome arches, subparallel with the margins.

This species is the smallest of the three species of Cedrela that have been recognized in

[1] The oriental mangrove, *Carapa obovata* Blume, and the beach plant, *Carapa moluccensis* Lamarck, are referred by Harms to the allied genus Xylocarpus Koenig.

the Wilcox flora. It differs from *Cedrela puryearensis* Berry, the one that it most resembles, in its narrower form, thicker leaf substance, more obsolete venation, more numerous secondaries, and shorter petiole. *Cedrela mississippiensis* Berry, another Wilcox species, is not likely to be confused with the present form, since it is a larger, slightly inequilateral leaf, widest proximad, and has a coarse prominent venation. It resembles somewhat certain Wilcox species of leaflets of Cæsalpiniaceæ and Mimosaceæ.

The genus Cedrela is no longer represented in the United States, its nine or ten existing species being confined to tropical America, mostly on the mainland. Unger many years ago described two species of Cedrela (*C. europæa* and *C. radobojana*) from the Miocene of Radoboj in Croatia. The supposed rutaceous *Protamyris radobojana* [1] of Unger is also referable to Cedrela, according to Ettingshausen,[2] who enumerated but never described *Cedrela primigenia* from the Eocene of Alum Bay, England (Ypresian).

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

CEDRELA MISSISSIPPIENSIS Berry, n. sp.

Plate LV, figure 5.

Description.—Leaflets small, ovate-lanceolate in outline, the apex somewhat abruptly pointed and the base rounded, decidedly inequilateral. Length about 4.5 centimeters. Maximum width, at a point below the middle, about 1.1 centimeters. Margins entire, regularly and fully rounded. Texture coriaceous. Petiolule not enlarged, about 3 to 4 millimeters in length. Midrib very stout, curved, very prominent on the lower surface of the leaflet. Secondaries stout, prominent on the lower surface, somewhat unequally spaced and irregularly curved; about eight prevailingly alternate pairs diverge from the midrib mostly at wide angles, 60° to 80°. They are rather straight at first and then sharply curved upward to form camptodrome arches subparallel with the margins. Tertiaries relatively prominent, forming small marginal arches and internal three, four, or five sided relatively large meshes.

This is larger than the preceding Wilcox species of Cedrela, and is readily distinguishable from the others by the characters already enumerated. It is more like a leaflet of the Cæsalpiniaceæ than either of the other small species, and greatly resembles several Wilcox species of Cæsalpinites, to which, however, it is believed to be unrelated, as it is certainly perfectly distinct. It is much like the existing *Cedrela fissilis* Velloso of northern South America.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CEDRELA PURYEARENSIS Berry, n. sp.

Plate LVI, figure 2.

Description.—Leaflets small, lanceolate in outline, the apex narrowed, acute, and the base somewhat rounded, pointed, and equilateral. Length about 3.5 centimeters. Maximum width in the middle part of the leaflet about 1 centimeter. Margins entire. Texture coriaceous. Petiole relatively long and stout, about 7 millimeters in length. Midrib stout, curved, and prominent. Secondaries thin, about five, distant, subopposite pairs; they diverge from the midrib at wide angles and may be straight at first, but as a rule curve slightly upward to a point about two-thirds of the distance to the margin, where the curvature is rapidly accelerated to form wide camptodrome arches subparallel with the lateral margins.

The figured specimen of this species has a large insect gall at the top of the petiolule, which has caused some abnormality, but not enough to obscure the essential characters of the leaflet. It was chosen for illustration instead of a perfectly normal leaflet, since the gall adds an item to our knowledge of the Wilcox biota.

This species is somewhat similar to *Cedrela wilcoxiana* Berry, but is larger, relatively as well as actually wider, thinner, and has fewer secondaries and more prominent venation. It differs from *Cedrela mississippiensis* Berry in its smaller size, equilateral lanceolate form, longer petiole, and less stout venation.

[1] Unger, Franz, Sylloge plantarum fossilium, pt. 1, p. 47, pl. 21, fig. 16, 1859.

[2] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, p. 235, 1880.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CEDRELA ODORATIFOLIA Berry, n. sp.

Plate LVII, figure 7.

Description.—Leaflets large, elongate-ovate in general outline, the base abruptly pointed, inequilateral, and the tip extended, gradually narrowed, and eventually bluntly pointed. Length about 13 centimeters. Maximum width, in the lower half of the leaflet, about 2.25 centimeters. Margins entire, somewhat irregularly curved. Texture subcoriaceous. Midrib stout and prominent proximad, becoming thin in the tip of the leaf. Secondaries numerous, subopposite to alternate; more than 20 pairs diverge from the midrib at wide angles, averaging about 60°. They are regularly curved and camptodrome. Tertiaries obsolete.

This well-marked species of Cedrela is very much larger than the other three Wilcox species, with which there is no danger of confusing it. Among existing species it is very close to the Antillean *Cedrela odorata* Linné, which resemblance has suggested the name of the fossil species, whose leaflets are somewhat narrower than those of the existing species. It is practically identical with an unnamed existing species of Cedrela figured by Ettingshausen.[1]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family HUMIRIACEÆ.

Genus VANTANEA Aublet.

VANTANEA WILCOXIANA Berry, n. sp.

Plate LIV, figure 6.

Description.—Leaves small, broadly lanceolate and slightly inequilateral in general outline, widest near the middle, margins full and incurved to the narrowed but obtusely pointed tip and to the decurrent base. Length about 5 centimeters or slightly more. Maximum width about 2 centimeters. Margins entire. Texture coriaceous. Petiole short and stout, not produced beyond the decurrent limbs of the lamina. Midrib stout and ligneous, becoming thin distad, not especially prominent, somewhat flexuous. Secondaries thin but prominent, about nine subopposite to alternate pairs, diverging from the midrib at angles of 45° to 55°, pursuing a rather straight course until they reach the marginal region, where they curve upward in a brachiodrome manner. Tertiaries well marked, comprising some branches from the midrib parallel with the secondaries, curved transverse nervilles, and finer connecting nervilles, forming open, isodiametric, four or five sided meshes.

This species is correlated with the genus Vantanea, which contains five or six existing species in Brazil and Guiana, the one most similar to the fossil being *Vantanea paniculata* Urban. The family Humiriaceæ is much reduced in the modern flora and comprises but 3 genera and about 20 species of shrubs and trees, which with the exception of one species of West Africa are confined to northern South America.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 3½ miles southeast of Ñaborton, De Soto Parish, La. (collected by G. C. Matson).

Collections.—U. S. National Museum.

Family MALPIGHIACEÆ.

Genus BANISTERIA Linné.

BANISTERIA PSEUDOLAURIFOLIA Berry, n. sp.

Plates LVI, figures 6 and 7, and CX, figures 1 and 2.

Description.—Leaves of variable size, ovate-lanceolate in outline, the apex narrowly pointed and the base broadly pointed. Length ranges from 8 to 12.5 centimeters. Maximum width ranges from 2.4 to 4.8 centimeters, in the basal half of the leaf. Margins entire, full, and rather evenly rounded; toward the tip they may recurve slightly and the tip may be slightly extended. Petiole stout, generally curved, about 1 centimeter in length. Midrib stout. Secondaries thin, 9 or 10 opposite to alternate pairs, somewhat irregularly and widely spaced; they branch from the midrib at wide angles, averaging about 60°, curving upward, camptodrome. Tertiaries largely obsolete, arching in the marginal region and forming rather open, mostly polygonal, meshes internally. Texture coriaceous.

This species is characteristic and rather common in the upper part of the Mississippi

[1] Ettingshausen, C. von, Blatt-skelete der Dikotyledonen, pl. 55, fig. 7, 1861.

Gulf. It may be distinguished from the associated *Banisteria wilcoxiana* Berry by its larger size and more broadly rounded base. It is named from its very great resemblance to the existing Central American *Banisteria laurifolia* Linné.[1] The genus comprises between 70 and 80 species, exclusively American, the majority climbing shrubs, and largely developed in tropical South America, being most numerous in Brazil.

Several Tertiary species are known from the European area, where they are represented by both the foliage and the characteristic fruits. These species, with the exception of *Banisteria juglandoides* Watelet [2] from the Ypresian of the Paris Basin, a horizon homotaxial with the Wilcox, are all somewhat younger than the Wilcox species, the oldest other species being *Banisteria vasseuri* Laurent [3] from the Tongrian of France, which is somewhat larger than *Banisteria pseudolaurifolia* but is identical in outline and secondary venation, though it differs in its tertiary venation. Another very similar Oligocene species is *Banisteria sotzkiana*, which is described by Ettingshausen [4] from the Styrian lignites and compared with the existing *Banisteria laurifolia*. It is a trifle more slender, and has somewhat more ascending secondaries than the Wilcox form. A third and strictly congeneric form was described by Heer [5] from the Aquitanian of Switzerland as *Banisteria helvetica*. It is very similar to the present species. There are still other fossil species, based on both leaves and fruit.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry); and Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

BANISTERIA REPANDIFOLIA Berry, n. sp.

Plate LVI, figures 3 and 4.

Description.—Leaves of medium size, oblong-ovate in general outline. Apex narrowed, sharply pointed, generally produced as a narrow and more or less elongated acumen. Base broadly rounded. Length about 12 centimeters. Maximum width, in the middle part of the leaf, 4 to 4.5 centimeters. Margins entire, more or less strongly repand, and in many specimens slightly revolute. Leaf substance thick and coriaceous. Petiole short and stout, expanded and more or less alate, about 1 centimeter in length and about 3 millimeters in maximum width, in the middle portion. Midrib stout and straight, becoming somewhat thinner and curved in the acumen, prominent on the lower surface of the leaf. Secondaries thin, alternate, widely spaced, more or less immersed in the thick leaf substance; 8 to 10 pairs diverge from the midrib at angles of about 55°. They are irregularly spaced, of varying but mostly slight degrees of curvature until the marginal region is reached, where they curve abruptly to form broad camptodrome arches subparallel with the margins. Tertiaries thin but distinct on the lower surface of the leaf, forming marginal camptodrome arches and internal, generally quadrangular meshes. Areolation fine, mainly quadrangular. Leaf substance either minutely punctate or scurfy. A small leaf of this species, measuring 8 centimeters in length by 3.5 centimeters in maximum width, has a stout, longitudinally striated petiole 1.3 centimeters in length.

This species is not at all like the associated species, *Banisteria wilcoxiana* Berry, but resembles more or less the other Wilcox species, *Banisteria pseudolaurifolia* Berry. Points of difference are its broadly rounded base, peculiar alate petiole, produced tip, subparallel lateral margins, and textural characters. There is some question whether or not the smaller specimen figured is identical with the larger specimen, which is less repand and has its secondaries arching farther from the margins. The two specimens may represent distinct but closely related forms. As interpreted they are taken to represent variations of a single species.

This species is not unlike other and unrelated members of the Wilcox flora, for example *Cordia eocenica* Berry and some of the leaves of *Ficus puryearensis* Berry. It may be distinguished from both of these superficially similar species by its more oblong form, peculiar petiole, acuminate tip, repand margins, general texture, and details of venation.

[1] Referred to the genus Heteropterys Kunth by Hemsley in his Flora of Central America (vol. 1, p. 150, 1888). It ranges from southern Mexico through the West Indies and Central America to Colombia.

[2] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 226, pl. 56, fig. 6, 1866.

[3] Laurent, Louis, Flore des calcaires de Célas, p. 124, pl. 13, figs. 3, 4, 1899.

[4] Ettingshausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Sotzka, p. 68, pl. 3, fig. 5, 1858.

[5] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 65, pl. 121, fig. 8, 1859.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

BANISTERIA WILCOXIANA Berry, n. sp.

Plate LVI, figure 5.

Sapindus dubius. Lesquereux (part), U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888.

Loughridge (part), Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaves broadly lanceolate in outline. Apex narrowly pointed. Base somewhat more broadly pointed than the apex. Length about 8 centimeters. Maximum width about 2.5 centimeters, at a point about halfway between the apex and the base. Margin entire. Texture coriaceous. Petiole stout, curved, less than 1 centimeter in length, tumid proximad. Midrib stout and prominent on lower surface of the leaf. Secondaries thin, 8 to 10 subopposite pairs, branching from the midrib at angles of about 55°, rather straight at first, then curving upward and camptodrome. Tertiaries mostly obsolete.

This species is much like the preceding species but differs in its smaller size, more lanceolate form, and straighter secondaries. It is much like *Banisteria laurifolia* of the American tropics and very similar to the Oligocene form, *Banisteria sotzkiana*, described by Ettingshausen[1] from Sotzka, Styria. It is apparently less common in the Wilcox than the preceding species. Specimens collected from Wickliffe many years ago were identified by Lesquereux as *Sapindus dubius*.

Occurrence.—Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge), and 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

BANISTERIA FRUCTUOSA Berry, n. sp.

Plate LVI, figures 8 and 9.

Description.—Small winged fruit or samara, about twice as long as high, the lower margin evenly rounded, the column straight and thickened and the upper margin undulate, the oblique tip rounded. Essential part of the fruit small. Wing of considerable consistency, showing about 16 veins, curving subparallel with the lower margin, in places forked or anastomosing but mostly free, terminating in the upper margin.

These fruits show the usual resemblance to the winged fruits and seeds of a variety of modern forms, particularly to certain genera of the family Proteaceæ. They are not referable to this family, however, since their true affinities are with the subtribe Banisteriinæ of the Malpighiaceæ, especially the genera Banisteria Linné, Heteropteris Jussieu, Stigmatophyllon Jussieu, Schwannia Endlicher, Janusia Jussieu, and the like. The tribe contains many species and is almost confined to tropical and subtropical America in the existing flora, making its greatest display in northern South America.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus HIRÆA Jacquin.

HIRÆA WILCOXIANA Berry, n. sp.

Plates LVII, figure 8, and CIX, figure 6.

Description.—Leaves ovate-lanceolate and more or less falcate in general outline, widest below the middle, tapering to the cuneate base and more gradually upward to the narrowly extended acuminate tip. Length about 10 centimeters or slightly more. Maximum width about 3.3 centimeters. Margins entire. Texture subcoriaceous. Petiole very stout, curved, channeled, about 1 centimeter in length. Midrib curved, very stout and prominent on the lower surface of the leaf, channeled on the upper surface. Secondaries relatively thin, not prominent; about 10 to 12 subopposite to alternate pairs diverge from the midrib at angles of about 55°. They are relatively straight until they approach the margins, where they curve more abruptly and are camptodrome. Tertiaries thin and largely obsolete, mostly close and percurrent, their prevailing course nearly at right angles to the midrib.

This species is closely comparable with the leaves of the existing species of Hiræa. The modern forms are exclusively American. They number more than a score and range from Mexico and the Antilles throughout northern South America to Peru. Ettingshausen[2] has

[1] Ettingshausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Sotzka, p. 68, pl. 3, fig. 5, 1858.

[2] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, p. 235, 1880.

recorded a fossil form from the Ypresian of Alum Bay, England.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family EUPHORBIACEÆ.

Genus DRYPETES Vahl.

DRYPETES PREKEYENSIS Berry, n. sp.

Plate LVIII, figure 4.

Description.—Leaves elliptical in general outline, the apex and base broadly cuneate or rounded. Length about 6 to 7 centimeters. Maximum width, midway between the apex and the base, about 3 centimeters. Margins entire. Texture coriaceous. Petiole short and stout. Midrib stout, flexuous, prominent on the lower surface of the leaf. Secondaries rather stout, about 10 subopposite pairs; they diverge from the midrib at angles of 60° to 80°, and curve irregularly upward, forming camptodrome arches in the marginal region. Tertiaries thin but distinct, forming marginal arches and internally large three, four, or five sided meshes.

The present species is named from its resemblance to *Drypetes keyensis* Urban (*Drypetes diversifolia* Krug and Urban), a stout tree of dry, sandy soils, ranging from the extreme southern Florida Keys through the West Indies. The genus Drypetes, which contains 2 species in the Wilcox flora, is confined to tropical America in the existing flora and comprises about a dozen species that range from southern Florida through the West Indies to northern Brazil.

The present species is readily distinguished from the lanceolate-leafed *Drypetes prelateriflora* Berry of the Wilcox flora.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

DRYPETES PRELATERIFLORA Berry, n. sp.

Plate LVIII, figure 3.

Description.—Leaves ovate-lanceolate in general outline, tapering equally both proximad and distad, the apex acuminate and the base sharply decurrent. Length about 6.5 centimeters. Maximum width, midway between the apex and the base, about 2.1 centimeters. Margins entire, rounded, slightly undulate. Texture coriaceous. Petiole short, stout, and curved, about 3 millimeters in length, Midrib stout, more or less curved, prominent on the lower surface of the leaf, becoming attenuated in the slender tip. Secondaries rather stout, about seven or eight subopposite to alternate arcuate pairs, diverging from the midrib at angles of 50° to 60°, forming camptodrome arches in the marginal region. Tertiaries thin.

This species is named from its resemblance to the leaves of the Guiana plum, *Drypetes lateriflora* (Swartz) Urban, a small tree of the Florida Keys, the Bahamas, and several of the Antilles. It is relatively much narrower and is otherwise readily distinguished from *Drypetes prekeyensis* Berry, a related form in the Wilcox flora.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CROTONOPHYLLUM Velenovsky.

CROTONOPHYLLUM EOCENICUM Berry, n. sp.

Plate LVIII, figure 2.

Description.—Leaves of medium size, oblong-ovate in general outline, the tip narrowed and acuminate, and the base broadly rounded. Length about 12 centimeters. Maximum width, in the basal part of the leaf, about 4 centimeters. Margins entire below, but above the entire portion they show irregularly spaced, rather distant, and variably shaped and directed dentate teeth, some prominent, others very faint. Texture coriaceous. Petiole stout, not preserved for its entire length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, numerous, subparallel, about 18 pairs, diverging from the midrib at angles ranging from 60° in the upper part of the leaf to 80° in the lower part; they are but slightly curved and are camptodrome close to the margins. Tertiary venation obsolete.

This species is entirely unlike previously described fossil forms, although it resembles somewhat closely some of the leaves described by Ettingshausen from Sagor in Carniola as

Quercus decurrens.[1] Its botanic affinities are uncertain, although its sum of characters seem to indicate its reference to the family Euphorbiaceæ. In this family it is most successfully compared with some of the modern species of Croton, for example, *Croton eluteria* (Linné) Bennett of the Bahama Islands. Croton comprises more than 600 species of herbs and shrubs in the existing flora, widely distributed in the warmer parts of both hemispheres and especially abundant in tropical America. The leaves are in general variable and somewhat protean and polymorphous in character. To avoid undue definiteness I have referred the species here described to Crotonophyllum.

The genus Crotonophyllum was proposed by Velenovsky for leaves from the Cenomanian of Bohemia constituting the single species *Crotonophyllum cretaceum.*[2] Recently I have added a second Upper Cretaceous species, *Crotonophyllum panduræformis* from the Middendorf arkose member of the Black Creek formation of South Carolina.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CROTONOPHYLLUM APPENDICULATUM Berry, n. sp.

Plate LVIII, figure 1.

Description.—Leaves medium sized or small, oblong-ovate in general outline, consisting of a somewhat inequilateral, oblong-elliptical basal portion, and a small ovate-lanceolate terminal portion separated from the basal portion by a narrow sinus on each side which extends to the midrib. Length of the lower segment about 41 centimeters. Maximum width, in the middle part, about 2 centimeters. Length of the somewhat falcate upper segment about 1.5 centimeters. Maximum width about 4 millimeters. Margins entire, somewhat undulate. Texture coriaceous. Petiole missing. Midrib stout. Secondaries thin, subparallel, more or less immersed in the leaf substance, camptodrome.

This remarkable leaf with its apical appendage may be abnormal, but its regularity and the common occurrence of leaves of some of the existing Euphorbiaceæ with somewhat similar constrictions tend to give it a specific character of its own.

It is referred to the form genus Crotonophyllum and resembles the two known Upper Cretaceous species that are referred to this genus, but differs decidedly from the associated Wilcox species referred to this genus.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus EUPHORBIOPHYLLUM Ettingshausen.

EUPHORBIOPHYLLUM FAYETTENSIS Berry, n. sp.

Plate LVII, figure 1.

Description.—Leaves of small size, long-petiolate, narrowly cuneate in general outline, the tip acuminate and a shallow emargination at the base. Length ranges from 2 to 3 centimeters. Maximum width, at or below the middle, 1.5 to 2 centimeters. Margins entire, regularly curved. Texture not coriaceous. Petiole stout, slightly curved, about 8 millimeters in length. Midrib stout. Secondaries well marked; four or five equally spaced subopposite pairs diverge from the midrib at angles ranging from 30° in the uppermost pair to 60° in the lowest pair. Tertiaries thin but well marked, closely spaced, and irregularly percurrent. Areolation obsolete.

This rare small-leafed species is referred to the form genus Euphorbiophyllum since it appears to belong to the Euphorbiaceæ and is not certainly referable to any one genus. It greatly resembles the leaves of several Central American species of Omalanthus, of South American species of Stillingia, and, except for its somewhat smaller size, more narrowed apex, and strictly entire margins, it might represent a leaf of the monotypic genus Hippomane Linné, which frequents sea beaches and sandy knolls from the southern Florida Keys through the West Indies and the Antilles to the northern coast of South America and both coasts of Central America. Though I have not ventured to identify the fossil form as a species of Hippomane, it may be exactly matched by the small, more acuminate terminal leaves of *Hippomane mancinella* Linné. Ettingshausen[3]

[1] Ettingshausen, C. von, Die fossile Flora von Sagor in Krain, pt. 1, p. 180, pl. 5, figs. 5-7 (cf. fig. 7), 1872.

[2] Velenovsky, J., Květena českého cenomanu, p. 20, pl. 5, figs. 4-11, 889.

[3] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 29, p. 394, 1879.

has recorded a species of Euphorbiophyllum from the Ypresian of the Isle of Sheppey.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order SAPINDALES.

Family ANACARDIACEÆ.

Genus HETEROCALYX Saporta.

Fruit a single-seeded drupe with an accrescent, scarious, normally three-parted, abortively two-parted, or rarely four or five parted, netted-veined calyx. This genus was founded by Saporta in 1867 [1] to replace the term Trilobium proposed by him in 1861.[2] The type and only species was *Heterocalyx ungeri* Saporta, with which were identified *Getonia petreæformis* Unger [3] and *Elaphrium antiquum* Unger.[4]

This species occurs at Aix, Sused, Sotzka, Radoboj, and Celas, thus ranging from the base of the Oligocene (Sannoisian) into the Miocene. It was compared by Saporta with the genera Astronium, Mangifera, Anasillis, Melanorrhea, and Loxostylis, especially with the first and last of these, which are Brazilian genera of the Anacardiaceæ. It was compared by Engler with Parishia, a Malayan genus of this same family. A single species of Heterocalyx is present in the Wilcox flora.

HETEROCALYX SAPORTANA Berry, n. sp.

Plate LIX, figure 1.

Description.—Fruit small, probably a drupe, elliptical in side view, about 2.5 millimeters in length by about 1 millimeter in diameter, attached to a persistent calyx consisting of three or four elliptical scarious sepals about 3.5 millimeters in length by about 1.5 millimeters in maximum width, which is in the middle part. Venation very thin and faint, consisting of a scarcely discernible midvein and one or two illy defined laterals connected with the midvein by fine transverse nervilles. Margins entire.

This fruit is much smaller than *Heterocalyx ungeri* Saporta, the illustration, which is enlarged four times, being about the same size as that species. It also fails to show any trace of the long slender pedicle of *Heterocalyx ungeri*, but this is commonly missing in the French specimens. The sepals are less pointed than those of the European type, and the venation is less prominent; the latter feature is probably correlated with the much smaller size of the American species, which is also geologically much older than the type of the genus.

The species is based on the single specimen figured, although this can not be taken as an indication of the rarity of the form, as its small size would in a measure cause it to be overlooked in the field unless it were present in great abundance.

Occurrence. — Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus METOPIUM P. Browne.

METOPIUM WILCOXIANUM Berry, n. sp.

Plates LVII, figures 2 and 3, and CXI, figure 5.

Description.—Leaflets relatively small, petiolulate, broadly elliptical or suborbicular in general outline, rounded or broadly cuneate at the base, somewhat narrowed distad to the broadly rounded or slightly emarginate tip. Length ranges from 5 to 6.5 centimeters. Maximum width, at or below the middle, ranges from 3 to 3.55 centimeters. Margins entire, slightly irregular. Texture coriaceous. Petiolule relatively long and stout, expanded proximad, about 8 millimeters in length. Midrib stout and prominent. Secondaries numerous, nearly straight, subparallel, camptodrome; about nine alternate pairs diverge from the midrib at angles of about 55°.

This species appears to be confined to the upper part of the Wilcox.

The only Wilcox species which *Metopium wilcoxianum* at all closely resembles is *Anacardites metopifolia* Berry, a form that is generally much smaller, relatively more elongate and ovate, and has more numerous secondaries and a shorter petiolule.

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, suppl. 1, p. 110, 1867.

[2] Saporta, G. de, Examen analytique des flores tertiaires de Provence, p. 32, 1861.

[3] Unger, Franz, Chloris protogæa, p. 139, pl. 47, figs. 1, 2; Die fossile Flora von Sotzka, pl. 23, figs. 1-4, 1850; Sylloge plantarum fossilium, pt. 3, pl. 17, figs, 4, 5, 1865.

[4] Unger, Franz, Sylloge plantarum fossilium, pt. 1, p. 47, pl. 21, figs. 7-22, 1859.

The genus Metopium in the existing flora contains two species of the coastal region of southern peninsular Florida and the West Indies.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan).

Collections.—U. S. National Museum.

Genus ANACARDITES Saporta.

Leaves small, obovate .... *Anacardites minor.*
Leaves short and broad:
  Small, ovate .... *Anacardites metopifolia.*
  Larger, elliptical .... *Anacardites puryearensis.*
Leaves elongated, lanceolate to linear-lanceolate:
  Margins serrate .... *Anacardites serratus.*
  Margins entire:
    Lanceolate with ascending secondaries, *Anacardites grevilleafolius.*
    Linear-lanceolate with laterally directed secondaries:
      Relatively short and bluntly pointed, nearly equilateral ...... *Anacardites marshallensis.*
      Elongated, acuminate, falcate, very inequilateral .... *Anacardites falcatus.*

ANACARDITES FALCATUS Berry, n. sp.

Plate LIX, figure 6.

Description.—Leaflets elongate, linear-lanceolate, falcate, gradually narrowed both proximad and distad to the equally and acutely pointed apex and base. Markedly inequilateral in outline. Length about 10 centimeters. Maximum width, below the middle, about 1.6 centimeters. Margins entire, slightly irregular. Texture coriaceous. Midrib stout, curved, prominent on the lower surface of the leaflet. Secondaries stout, prominent on the lower surface, numerous, subparallel, diverging from the midrib at wide angles, commonly as much as 90°, at intervals of about 2 millimeters, curving slightly, anastomosing and arching in the marginal region. Tertiaries stout, subparallel with the adjacent secondaries, to which they alternately send stout transverse nervilles.

These leaflets are of a distinctive character and markedly inequilateral, especially proximad, as shown by the specimen figured. The tip is recurved and more nearly equilateral. The form and venation are suggestive of certain genera of the Apocynaceæ, but on the whole are more like certain modern forms of Anacardiaceæ. It is a much more elongated and falcate form than the Wilcox species *Anacardites marshallensis* Berry.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ANACARDITES MARSHALLENSIS Berry, n. sp.

Plate LVIII, figure 6.

Description.—Leaflets oblong-lanceolate and slightly falcate in outline, somewhat narrowed distad, the apex and the base about equally and bluntly pointed. Length about 6 centimeters. Maximum width, slightly below the middle, about 1.6 centimeters. Margins entire, slightly and shortly undulate. Leaf substance very thick and coriaceous. Midrib very stout and curved, prominent on the lower surface of the leaflet. Secondaries stout, numerous, about 20, indifferently opposite to alternate pairs; they diverge from the midrib at wide angles, approaching 90°, at intervals of 2.5 to 4 millimeters, curving slightly, and arching in a camptodrome manner close to the lateral margins. Tertiary venation distinct, of numerous transverse and but slightly curved nervilles with cross branches, forming small quadrangular or pentagonal meshes.

This relatively short, blunt leaflet has the characteristic form and venation of numerous modern Anacardiaceæ. It is readily separable from the other Wilcox species, although it resembles somewhat remotely *Anacardites falcatus* Berry. It is a type easily and often confused with the willow-leafed and live oaks, which it resembles in a general way.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ANACARDITES PURYEARENSIS Berry, n. sp.

Plate LVII, figure 6.

Description.—Leaves relatively short and broad, elliptical and somewhat inequilateral in general outline, the apex broadly rounded and the base broad, slightly decurrent. Length about 6 centimeters. Maximum width, above the middle, about 3.25 centimeters. Margins entire, somewhat irregularly curved. Texture coriaceous. Petiole extremely stout, curved, about 1.25 centimeters in length, 3 millimeters in diameter at the enlarged base. Midrib stout throughout, broad and flat, curved. Secondaries stout, numerous, subparallel, more widely spaced in the upper half of the leaf; about 10 subopposite to alternate pairs diverge from the midrib at angles of about 60° to 65°, pursuing a rather straight course to the marginal region, where they are camptodrome. Tertiaries well marked, obliquely percurrent. Areolation rectangular.

This species differs markedly from the other Wilcox species referred to this genus, suggesting some of the Sapotaceæ in its general appearance. It has, however, the venation of the Anacardiaceæ and may be compared with existing genera of that family, especially the genus Anacardium Linné, which comprises 8 species in tropical America. The present species is apparently rare.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ANACARDITES MINOR Berry, n. sp.

Plate LVII, figure 4.

Description.—Leaves or leaflets relatively small, obovate in general outline, the tip broadly rounded, and the base broadly cuneate. Length about 2 centimeters. Maximum width, midway between the apex and the base, about 1.5 centimeters. Margins entire, somewhat undulate. Texture subcoriaceous. Petiole short and much enlarged, about 2 centimeters or slightly less in length. Midrib rather stout, prominent, nearly straight. Secondaries thin, relatively prominent; 5 or 6 subopposite pairs diverge from the midrib at angles of about 50° and pursue a nearly straight course to the margin, where they form single flat camptodrome arches which simulate marginal hems. Tertiaries thin, mainly percurrent. Areolation predominantly quadrangular.

The present species in its size, outline, and marginal venation is clearly differentiated from the other members of the Wilcox flora and as clearly allied with existing members of the Anacardiaceæ. It is apparently rare.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ANACARDITES GREVILLEAFOLIA Berry, n. sp.

Plates LVII, figure 5, and LVIII, figure 5.

Description.—Leaflets small, lanceolate in outline, the apex sharply pointed and the base similarly pointed. Length ranges from 2.5 to 4.5 centimeters. Maximum width, slightly below the middle, ranges from 7 to 11.5 millimeters. Petiolule short and stout, about 1.5 or 2 millimeters in length. Midrib very stout and prominent. Secondaries thin, numerous, close set, diverging from the midrib at acute angles less than 45°. Those in the lower half of the leaflet are curved and ascend subparallel with each other and with the lower lateral leaf margins; those in the upper part are less ascending and subtend wider angles; all are camptodrome. Tertiaries obsolete. Margins entire. Texture coriaceous.

This is the smallest species of Anacardites known in the Wilcox flora and it is thoroughly distinct from the other species, *Anacardites metopifolia* Berry being the only one that approaches it at all, and the two are not close. It is something like *Rhus palæophylla* Saporta [1] of the Sannoisian of France, but the resemblance is not close enough to demand extended comment. It is also more or less like several described Tertiary species usually referred to Rhus.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

ANACARDITES METOPIFOLIA Berry, n. sp.

Plate LVIII, figure 7.

Description.—Leaflets small, ovate in general outline, lateral margins full rounded, narrowing upward to an obtuse tip, basal margins rounded, and base very broadly cuneate or rounded. Length about 4.5 to 5 centimeters. Maximum width, toward the base of the leaf, about 2 centimeters. Margins entire. Texture cori-

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 125, pl. 13, figs. 1, 2, 1863.

aceous. Petiolule short and stout, about 2 millimeters in length. Midrib stout. Secondaries thin, numerous, about 15 pairs, diverging from the midrib at wide angles; rather straight to the marginal region, where they form camptodrome arches parallel with the margins. Tertiaries largely obsolete; intermediate ones diverge from the midrib between and parallel with the secondaries, to which they are connected by very faint nervilles.

This species may be compared with a number of modern forms. It is like the leaflets of numerous species of Rhus, for example *Rhus copallina* Linné. It is named for its resemblance to Metopium P. Browne, a genus represented in the Wilcox flora, and one that contains 2 existing species which are confined to southern Florida, the West Indies, and Honduras. Metopium is often united with Rhus, of which it is the tropical representative. The present species is very similar to the somewhat variable leafed *Metopium metopium* Small (*Rhus metopium*), so abundant along the shores and keys of southern Florida and in the Bahamas, as well as in Cuba, Jamaica, and Honduras.

Occurrence.—Holly Springs sand, Holly Springs and Vaughns, near Lamar, Benton County, Miss. (collected by L. C. Johnson). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by L. C. Glenn), and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Anacardites serratus Berry, n. sp.

Plate LVIII, figure 8.

Description.—Leaflets lanceolate and more or less falcate in general outline, widest above the middle, tapering to a sharp conical point and narrowing gradually to the elongated, acutely pointed base. Length about 8 centimeters. Maximum width about 1.5 centimeters. Margins entire and markedly undulate in the basal half of the leaflet, with closest and inconspicuous serrate teeth in the distal half. Texture coriaceous. Midrib stout, curved. Secondaries of medium size, numerous; about 20 generally subopposite pairs diverge from the midrib at wide angles, curve regularly upward, subparallel, and are camptodrome close to the margins.

This well-marked species is sparingly represented in the collections. It resembles somewhat the Cuban species *Ardisia* (*Icacorea*) *dentata* De Candolle and the fossil form *Ardisia* (*Icacorea*) *lanceolata* Ettingshausen[1] from the Bohemian Tertiary. All things considered, it is believed to represent a Wilcox species of Anacardiaceæ of uncertain generic relationship.

Occurrence.—Lagrange formation (in beds of Wilcox age), $1\frac{1}{2}$ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family ILICACEÆ.

Genus ILEX Linné.

Ilex eolignitica Berry, n. sp.

Plate LIX, figure 7.

Description.—Leaves small, ovate-lanceolate in general outline, the apex gradually narrowed, acuminate, and the base more abruptly narrowed and decurrent. Length about 5.5 centimeters. Maximum width, below the middle, about 2 centimeters. Margins entire. Texture coriaceous. Petiole short and stout, about 4 or 5 millimeters in length, tumid proximad. Midrib stout, curved. Secondaries about eight, rather stout, alternate pairs; they diverge from the midrib at angles of about 50°, curving slightly upward at first and more abruptly in the marginal region, where they are camptodrome. Tertiaries mostly immersed.

The form, texture, and venation ally these leaves with those of numerous modern species of Ilex. The genus Ilex, which is largely American, contains more than 200 existing species found in nearly all tropical and temperate regions of the world and especially abundant in northern South America. The leaves show considerable variation and include forms with entire and variously toothed margins. The genus appears to be but sparingly represented in the Tertiary floras of southeastern North America.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 2, p. 40, pl. 37, fig. 28, 1868.

ILEX VOMITORIAFOLIA Berry, n. sp.

Plate LXIV, figure 6.

Description.—Leaves much reduced, ovate or obovate in general outline, the apex somewhat narrowed and rounded and the base narrowly decurrent. Length about 1.5 centimeters. Maximum width, in the middle part of the leaf, about 5.5 centimeters. Margins entire at the base, above which they are beset with shallow crenulations. Texture subcoriaceous. Petiole obsolete. Midrib rather stout, straight. Secondaries numerous, thin, ascending, camptodrome.

This uncommon species is markedly distinct from the other members of the Wilcox flora and approaches very close to the smaller leaves of the existing *Ilex vomitoria* Aiton, a small tree rarely found far from salt water, ranging from southern Virginia to Cedar Keys, Fla., and west to Matagorda Bay, Tex. It also resembles several small-leafed species in the allied family Celastraceæ.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ILEX? AFFINIS Lesquereux (?).

Ilex? affinis. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, suppl., p. 8, 1872.
Lesquereux, The Tertiary flora, p. 270, pl. 50, figs. 2, 3, 1878.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 285, pl. 44, fig. 2, 1899.

Description.—As described by Lesquereux in 1878 this species shows the following characters:

Leaves coriaceous, oblong-ovate, broadly cuneate to the base, borders irregularly distantly dentate; nervation subcamptodrome.

These leaves, inequilateral at the base, seem like pinnules of a compound leaf. The midrib is thick, the secondary veins numerous, parallel, inequidistant, and at an open angle of divergence either enter the point of the teeth and by thin branches follow the borders in festoons, or are truly camptodrome, with nervilles passing up from the back of the curves into the teeth. This nervation is not in conformity with that of the leaves of the dentate section of Ilex; it is rather analogous to that of some oak leaves. The coriaceous substance of the leaves prevents a reference to Quercus. I find, moreover, in some fossil species of Ilex, *I. stenophylla* Unger, *I. berberidifolia* Heer, a related type of nervation to that of these leaves.

The type material came from the Green River formation at Green River station, Wyo., a formation considerably younger than the Wilcox. In 1899 Hollick doubtfully referred a single incomplete specimen from the Wilcox outcrop at Coushatta to this species. Though the Coushatta specimen resembles the type, this identification is very uncertain; the marginal teeth are smaller, and the secondaries appear to be craspedodrome and suggest a small leaf of *Dillenites macrodentatus* (Hollick) Berry. I have not made any change, however, as the available material is too scanty to warrant any extended discussion of its botanic affinity, although I am inclined to see a resemblance to Dillenites in the material from Louisiana.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

ILEX sp. Hollick.

Ilex sp. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 285, pl. 43, figs. 2, 3, 1899.

Description.—Two fragments of a large leaf with a remotely toothed margin have been identified as a form of Ilex by Hollick. No additional material has been collected and it would be hazardous to attempt to revise or certify this identification. As the specimens appear to differ from all the known members of the Wilcox flora, they are retained as determined by their describer.

Occurrence.—Wilcox group, Slaughter Pen Bluff on Cross Bayou, Caddo Parish, La. (collected by A. C. Veatch).

Collection.—New York Botanical Garden.

Family CELASTRACEÆ.

Genus MAYTENUS Feuillée.

MAYTENUS PURYEARENSIS Berry, n. sp.

Plate LXI, figure 5.

Description.—Leaves small, lanceolate and commonly falcate in general outline, the apex pointed and the base narrowly cuneate and decurrent. Length about 4 centimeters. Maximum width, midway between the apex and the base, about 1 centimeter. Margins entire for a short distance proximad, passing gradually into small close regular crenate teeth. Texture coriaceous. Petiole short and stout. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, about six opposite to alternate pairs, diverging from the midrib at acute angles and curving upward in wide loops to join the adjacent superior secondaries a considerable distance from the margins. Tertiaries very thin, arching in the marginal region.

This well-marked small leaf in its general outline, marginal crenation, texture, and venation is strictly comparable to some of the modern species of Maytenus, especially *Maytenus verticillatus* (Ruiz and Pavon), *Maytenus boaria* Molina, and *Maytenus chilensis* De Candolle of tropical and subtropical South America. It also resembles several West Indian species of the genus Myginda Jacquin. Among fossil forms it may be compared with *Maytenus europæa* Ettingshausen [1] from the Bohemian Tertiary. The genus Maytenus includes about 70 existing species of the West Indies, Central America, and tropical South America.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CELASTRUS Linné.

Leaves small and entire margined:
- Orbicular.................. *Celastrus bruckmannifolia.*
- Lanceolate.......................... *Celastrus minor.*

Larger with toothed margins:
- Relatively small leaves with rounded base and crenate-serrate margins................ *Celastrus eolignitica.*
- Larger, equally pointed at both ends, margin crenate............................. *Celastrus veatchi.*
- Very large and broad, base truncate or subcordate, margin prominently serrate... *Celastrus taurinensis.*

Celastrus bruckmannifolia Berry, n. sp.

Plate LXI, figure 1.

Description.—Leaves small, elliptical or orbicular in outline, many specimens slightly inequilateral. Length about 1.2 centimeters. Maximum width, in the middle part of the leaf, about 1 centimeter. Apex and base about equally and broadly rounded. Margins entire, generally full, and rather evenly rounded. Leaf substance thick. Texture coriaceous. Petiole short and stout, 1 to 2 millimeters in length. Midrib stout, narrowed distad on the upper surface of the leaf, more or less prominent on the lower surface. Secondaries thin, four or five subopposite to alternate pairs; they diverge from the midrib at angles of 45° or more, curving outward and then slightly upward, each forming a camptodrome arch approximately parallel with the margin and close to it. Tertiaries immersed in the leaf substance and obsolete.

This characteristic species, with its small leathery and nearly orbicular short-petioled leaves, resembles a great many unrelated modern forms. It is somewhat suggestive of the Wilcox species *Bumelia pseudohorrida* Berry, which has leaves of this size and more or less orbicular form, but they are slightly narrowed proximad and more or less retuse distad and carry numerous thin ascending lateral veins.

Heer has described a Miocene upland form from Switzerland as *Vaccinium reticulatum*,[2] which has leaves similar to the present species and which because of its coastal habitat in a warm Eocene climatic zone can scarcely be referred to Vaccinium. Another European Miocene type whose leaves are comparable to those of the species under discussion is *Rhamnus brevifolius* Alexander Braun,[3] and I was at first inclined to refer this Wilcox species to Rhamnus, several modern as well as fossil species of which have small elliptical coriaceous leaves. The venation, however, is not that of Rhamnus but rather that of Celastrus, and it may be compared with *Celastrus bruckmanni* Alexander Braun, a widespread form of the European Miocene that also occurs in the Chesapeake group of Atlantic North America. It is as a rule a somewhat larger form and has more ascending secondaries and well-marked percurrent tertiaries. In addition a number of Tertiary species referred to the genus Leguminosites, for example, *Leguminosites derelictus* Saporta,[4] from the Sannoisian of France, resemble *Celastrus bruckmannifolia* to a greater or less degree. The venation and sum of the characters, however, convince me that the present species is not a leguminous leaflet, but a

[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 3, p. 31, pl. 48, figs. 10–13, 1869.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 10, pl. 101, figs. 30a–g, 1859. (See especially fig. 30c.)

[3] Idem, p. 78, pl. 123, figs. 27–30, 1859.

[4] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, pl. 18, figs. 23, 24, 1867.

leaf of Celastrus very like some of the existing entire-margined species of tropical American Celastraceæ. It is named in allusion to its resemblance to the smaller leaves of the widespread and somewhat polymorphous species *Celastrus bruckmanni* Alexander Braun of the later and cooler Tertiary of America and Europe. A very similar species, relatively slightly wider than the Wilcox form, is found in the Tertiary of Bolivia and is described by Engelhardt [1] as *Cæsalpinia gmehlingi.*

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Celastrus minor Berry, n. sp.

Plate LXI, figures 3 and 4.

Description.—Leaves small and variable in size, regularly lanceolate to ovate-lanceolate in outline, the apex and base equally acuminate. Length ranges from 1 to 3 centimeters. Maximum width, midway between the apex and the base, ranges from 5 to 8 millimeters. Margins strictly entire. Texture coriaceous. Petiole short, about 1.5 millimeters in length. Midrib straight, relatively stout and prominent. Secondaries thin, three to six subopposite to alternate pairs, irregularly spaced, diverging from the midrib at angles of about 45°, regularly curved upward and camptodrome. Tertiaries obsolete.

This characteristic little species is entirely unlike any of the known members of the Wilcox flora. The leaves at first might suggest an ericaceous species, for example, some of the Brazilian species of Gaylussacia, but they are more like the leaves of the existing entire-margined species of Celastrus. Celastrus is abundant in the Wilcox flora, and the other species are all larger and their margins are more or less toothed. *Celastrus minor* is something like a form from the Tertiary of Bolivia described by Engelhardt [2] as *Acacia tenuifolia.*

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 9, pl. 1, fig. 29.

[2] Idem, p. 11, pl. 1, figs. 45, 46.

Celastrus eolignitica Berry, n. sp.

Plate LIX, figures 8–11.

Description.—Leaves small, ovate or elliptical in general outline, as a rule more or less inequilateral. Apex rounded, generally narrowed, and somewhat extended. Base broadly rounded, in many specimens pronouncedly inequilateral. Length ranges from 3 to 4 centimeters. Maximum width, at or below the middle, ranges from 1 to 1.75 centimeters. Margins entire proximad, passing upward from faint to increasingly prominent crenate teeth, which gradually become sharply pointed; serrate teeth separated by shallow inequilateral sinuses, their points directed upward and outward; with increasing prominence they become farther apart, the intervals ranging from 1.75 millimeters to 4 centimeters, and become closer again distad. In the smallest leaf figured the points are underdeveloped, giving the leaf a somewhat different aspect. The texture is coriaceous. Petiole relatively long and stout, about 1 centimeter in length. Midrib stout, generally somewhat curved. Secondaries stout but not prominent, six to eight chiefly subopposite pairs; they diverge from the midrib at wide angles, curving regularly upward in a subparallel manner, arching camptodromely in the marginal region. Tertiaries mostly immersed in the thick leaf substance; a few thin percurrent ones are visible toward the margins.

This characteristic species is very different from any of the other known members of the Wilcox or related floras. It is not abundantly represented in the collections, and the leaves as a rule are not well preserved, the maceration preceding fossilization suggesting that possibly they represent an inland species, the leaves of which were brought by streams to the basin of sedimentation from a considerable distance. The few specimens collected exhibit considerable variation in size and outline but especially in appearance. They may represent more than one species, but I consider this very doubtful.

They resemble a number of existing species of Celastrus from the Tropics and subtropics of America, and among fossil species they are much like a number of common Tertiary species described from the European area, for example, *Celastrus noaticus* Unger [1] and *Celastrus splendidus* Saporta.[2]

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Celastrus veatchi Hollick.

Plate LXI, figure 2.

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.

Description.—Hollick's description, published in 1899, is as follows:

> Leaf about 3 inches long by 1⅜ inches broad in the middle, elliptical in outline, tapering about equally to base and apex, obtusely or crenately toothed or the lower portion merely wavy, with a blunt tip at the apex; midrib strong and straight; secondary nervation well defined, curving upward, becoming brochidodrome or subcamptodrome though the tertiary nervation, with fine nervilles extending to the teeth and margin.

This species was compared by Hollick with *Elæocarpus europæus* Ettingshausen of the European Tertiary. It is, however, more like *Elæodendron degener* (Unger) Ettingshausen [3] of the European Oligocene and not greatly unlike some of the leaves of the Fort Union *Elæodendron polymorphum* Ward.[4] It may also be compared with certain ancient and modern forms of Ternstrœmiaceæ. Except for its slightly larger size and crenate instead of serrate teeth it is exactly like the two widespread European Aquitanian species *Celastrus persei* Unger [5] and *Celastrus andromedæ* Unger.[6]

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch). Bed of Mobley Creek, 4 miles southwest of Trenton, Gibson County, Tenn. (collected by Bruce Wade). Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collections.—U. S. National Museum: New York Botanical Garden.

Celastrus taurinensis Ward.

Plate LX, figures 1–3.

Celastrus taurinensis. Ward, U. S. Geol. Survey Bull. 37, p. 79, pl. 34, figs. 5, 6, 1887.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 285, pl. 46, fig. 1, 1899.

Description.—Ward's description in 1887 is as follows:

> Leaves rather thin, large (7 centimeters wide, 12 centimeters long), oblong, slightly heart-shaped, pointed, sharply and coarsely serrate to near the base; nervation pinnate, craspedodrome; midrib rather thin, slightly curved, thickened at the nodes; secondary nerves 9 to 11 on each side, alternate to subopposite, curving upward, forking or branching, occasionally arching and supplying short veinlets to the teeth, lowest pair thin, basilar, and mostly simple; nervilles more or less curved, percurrent or more commonly forked, joining the secondaries at right angles.

Although the venation of this species is that of the Celastraceæ, its original describer expresses doubt regarding its relationship with Celastrus, and suggests that it may be referable to Grewiopsis or Pterospermites. I fully share these doubts, and if I were decribing it anew would be inclined to refer it to Grewiopsis, a genus represented by several similar species in the early Eocene of the Rocky Mountain province. The type area for this species is the Fort Union formation of Montana, where it is not uncommon. It appears to have been a rare element in the Wilcox flora.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris).

Collections.—Types in U. S. National Museum; Louisiana specimens in New York Botanical Garden.

Genus EUONYMUS Linné.

Euonymus splendens Berry, n. sp.

Plates LXI, figure 6, and LXII, figures 1–5.

Description.—Leaves of variable size, broadly ovate-lanceolate in outline, the base broadly cuneate, truncate or rounded, somewhat inequilateral, minutely decurrent. Length ranges from 6 to 25 centimeters, averaging about 15 centimeters. Maximum width 2.8 to 9.5 centimeters, averaging about 5.5 centimeters at a point slightly below the middle of the leaf.

[1] Unger, Franz, Sylloge plantarum fossilium, vol. 2, p. 7, pl. 2, figs. 2, 3, 1862.
[2] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 128, pl. 8, fig. 2, 1866.
[3] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 3, p. 37, pl. 49, figs. 5, 7–10, 1869.
[4] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 84, pl. 38, figs. 1–7, 1887.
[5] Ettingshausen, C. von, Die fossile Flora von Sagor in Krain, pt. 2, p. 31, pl. 16, fig. 1, 1877.
[6] Unger, Franz, Die fossile Flora von Sotzka, p. 67, pl. 30, figs. 2–4, 7, 1850.

From this region the lateral margins as they continue toward the base are full and broadly rounded. Distad the margins are full for a considerable distance, becoming incurved as the apex narrows and curving upward to form the extended, narrowly acuminate tip. Margin regularly and finely dentate, the denticulations approaching the serrate form in some specimens, becoming less pronounced and finally obsolete at the extreme base of the leaf. Texture firm but leaf substance not thick. Petiole relatively long and stout, about 3 centimeters in length in a specimen below the average size. Midrib stout below, becoming thin distad. Secondaries stout proximad, numerous, 10 to 15 pairs, regularly spaced and approximately parallel, subopposite to alternate, becoming farther apart in the apex of the leaf; all camptodrome. They branch from the midrib at a wide angle, which ranges from 55° to 90°, they curve but slightly until they approach the margin, where they sweep upward more or less parallel with the margin in a succession of arches of abruptly diminishing caliber. Tertiary system of thin intermediate veins parallel with some of the secondaries and halfway between them and transverse, mostly percurrent veinlets.

This very handsome species is well marked and perfectly distinct from previously described forms, although it resembles somewhat *Hicoria antiquorum* (Newberry) Knowlton. Its extreme variability in size is well shown in Plate LXII, aside from which its features are relatively constant. The smaller leaves like the one shown in figure 1 are more ovate-lanceolate and symmetric and less extended apically, but the larger are less symmetric, rounded and somewhat inequilateral below, and greatly extended apically, with corresponding changes in the angle of divergence of the secondaries. The species is extremely abundant in all sizes at the locality south of Grand Junction, Tenn., both the smallest and the largest figured specimens having come from this outcrop. It is about equally common and variable in size at the Lamar locality but is less common elsewhere. It is also found in the Raton formation of the southern Rocky Mountain province. A large number of fragments from Bastrop County, Tex., are doubtfully referred to this species. They have identical margins and venation, except that the secondaries are more ascending. Their much broken condition prevents their positive determination.

A number of previously described Tertiary species are close enough to *Euonymus splendens* to come within the limits of this discussion. Among these *Euonymus proserpinæ* Ettingshausen [1] is perhaps most like this Wilcox species. It comes from the Aquitanian of Priesen, Bohemia, and is characterized by its more prominent serrate teeth, fewer secondaries, and less extended tip. Ettingshausen compared it with the modern species *Euonymus acuminatus*, *E. wallichii*, *E. javanicus*, *E. pendulus*, *E. hamiltonianus*, and *E. atropurpureus*, and considered it most like the first, a Mexican species.

A number of other species of Euonymus have been described from the European Aquitanian stage, but they are much smaller leaves, though in other respects much like the foregoing.

American Tertiary species are less numerous than the European. A well-marked early Eocene form (Fort Union) from Montana was named *Euonymus xantholithensis* by Ward [2] and compared with the living American *Euonymus atropurpureus* Jacquin, and the East Indian *Euonymus pendulus* Wallich. It has coarser teeth and lacks the apical elongation of *Euonymus splendens*, but except for its smaller size is rather similar to that species. Another similar American species is *Euonymus flexifolius* Lesquereux,[3] which comes from the Green River Eocene of Wyoming. It is about the size of the average specimens of *Euonymus splendens* and is very similar in general outline and distal elongation but is relatively somewhat narrower, has fewer secondaries, and the teeth are very prominent, upwardly prolonged, and serrate.

About twenty fossil species of Euonymus have been described, ranging in age from the base of the Eocene to the Pleistocene. The existing species number about 65 and are widely distributed throughout the northern hemisphere becoming massed in the southeastern Asiatic region, with many species in the uplands of India and China and throughout Malaysia. There are five indigenous species in

[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 3, p. 30, pl. 48, figs. 6, 7, 1869.

[2] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 82, pl. 37, figs. 1, 2, 1887.

[3] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 183, pl. 38, fig. 13, 1883.

the United States, some of which range northward as far as Canada. There are also five or six species in Central America. The genus is distinctly not a strand plant, but it occurs for the most part in open mesophile forests and broken thickets of the warmer temperate and tropical zones.

Occurrence. — Holly Springs sand, Early Grove, Marshall County, Miss. (not rare) (collected by E. W. Berry), and Lamar, Benton County, Miss., in clay ironstone (collected by L. C. Johnson). Wilcox group, Coushatta, Red River Parish, La. (collected by G. D. Harris), and 1,000 yards below Pope Bend, Colorado River, Bastrop County, Tex. (collected by Alexander Deussen). Lagrange formation (in beds of Wilcox age): 1½ miles west of Grand Junction, in Fayette County, Tenn. (four specimens); 1 miles south of Grand Junction, in Fayette County, Tenn. (very abundant); Puryear, Henry County, Tenn. (rare); (all collected by E. W. Berry); and Hatchie River near Shandy, Hardeman County, Tenn., in clay ironstone (collected by L. C. Johnson).

Collections.—U. S. National Museum.

Family SAPINDACEÆ.

Genus CUPANITES Schimper.

CUPANITES EOLIGNITICUS Berry, n. sp.

Plates LXIV, figures 8 and 9, and LXV, figures 1–3.

Description.—Leaves compound. Leaflets as a rule relatively large, elliptical and more or less inequilateral in general outline, the apex bluntly pointed, and the base broad, inequilateral, and probably sessile. Length about 11.5 centimeters. Maximum width, in the middle part of the leaflet, about 4 centimeters. Margins carry distant and small dentate teeth, separated by wide, shallow, evenly curved sinuses. Texture coriaceous. Midrib stout and very prominent on the lower surface of the leaflet, in many specimens curved distad. Secondaries stout and prominent, irregularly spaced, craspedodrome; they diverge from the midrib at wide angles, ranging from 60° in the upper part of the leaflets to 90° in the basal part; they are nearly straight for two-thirds of the distance to the margin, where they generally fork, one limb curving upward and the other downward and outward and both terminating in marginal teeth. Tertiaries numerous, thin, and percurrent. An exceptionally small leaflet of this species is lanceolate-falcate, has a markedly inequilateral base, and measures 6.5 centimeters in length by 1.75 centimeters in maximum width. Two specimens from Louisiana that are somewhat doubtfully referred to this species measure 13 by 3 centimeters and 9 by 2.1 centimeters, respectively.

The leaflets of this species are not uncommon at Puryear. In general aspect they suggest the leaflets of some species of Juglandaceæ, but they show differences in marginal and venation characters and are on the whole more like the leaflets of the existing species of Cupania, several tropical American species of which are very close to the fossil form.

The genus Cupania Linné comprises more than 30 existing species in the flora of tropical and subtropical America. It is common in the West Indies but no longer lives on the Florida mainland. Fossil species, represented by both leaves and fruits, are represented in certain European Tertiary deposits. Those botanists who doubt determinations based on foliage must regard it as a striking coincidence that the seven species of Cupania leaves reported by Ettingshausen [1] from the clays of Alum Bay (Ypresian) should be represented at the synchronous horizon on the Isle of Sheppey, so famous for its pyritized fruits, by eight characteristic species of Cupania fruits and seeds.[2]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 3½ miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson).

Collections.—U. S. National Museum.

CUPANITES LOUGHRIDGII Berry, n. sp.

Plate LXV, figure 4.

Myrica Copeana. Lesquereux (not Lesquereux, 1874, 1878), U. S. Nat. Mus. Proc., vol. 11, p. 12, 1888. Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaves pinnately compound. Leaflets lanceolate, sessile, inequilateral, somewhat falcate. Length about 13 centimeters. Maximum width, in the middle part of the leaflets, about 3 centimeters. Apex acuminate. Base bluntly rounded, markedly inequilateral. Margins entire at the base, elsewhere bearing

[1] Ettingshausen, C. von, Roy. Soc. London Proc., vol. 30, p. 235, 1880.
[2] Idem, vol. 29, p. 395, 1879.

single or doubly serrate teeth, which increase in size gradually from below upward until they are large and prominent and directed upward. Midrib stout, curved, prominent on the lower surface of the leaflet. Secondaries rather stout, prominent, numerous, subparallel; about 25 subopposite to alternate pairs diverge from the midrib at angles of about 60° to 65°, curving slightly, each ending craspedodromely in a major marginal tooth; they increase in caliber and interval of spacing from below upward, and one or two pairs at the extreme base are camptodrome. Near the tips each sends a branch from its lower outer side to a minor marginal tooth, where the teeth are developed. Tertiaries fine, at approximately right angles to the secondaries, usually straight subparallel and percurrent, largely obsolete by immersion. Texture subcoriaceous.

This species is based primarily on a specimen (U. S. National Museum, No. 2521) collected at Wickliffe, Ky., many years ago by R. H. Loughridge, for whom it is named. It was identified by Lesquereux with *Myrica copeana*, which he had described from Florissant, Colo., in 1874 and 1878.

The plant beds at Florissant are much younger than the Wilcox and are now usually regarded as middle or upper Miocene. The flora which they contain indicates an upland mountain-lake basin. Though the superficial resemblance between *Myrica copeana* Lesquereux and *Cupania loughridgii* Berry is close and each is represented by scanty material, there are certain well-marked differences. *Cupania loughridgii* is more elongated and inequilateral, has a rounded sessile base, less prominent nonaquiline teeth, less curved secondaries, right-angled percurrent instead of oblique tertiaries, and a wider angle of divergence of the marginal branches of the secondaries.

The character of the entire, rounded, inequilateral, and sessile base clearly indicates that it represents a leaflet of a compound leaf, and its size suggests that the leaf was once-pinnate, like those of most of the Sapindaceæ and Juglandaceæ. This at once removes from consideration such genera as Myrica, Quercus, Dryophyllum, and most of the Proteaceæ, which offer superficial resemblances. The craspedodrome secondaries prohibit comparisons with the different genera of the Juglandaceæ or with Fraxinus. There is some resemblance to the proteaceous genus Rhopala and to members of the tropical family Burseraceæ. The Sapindaceæ seem to offer the surest comparisons, and in this family the genera Cupania, Dilodendron, and Thouina deserve especial mention. All are strictly American in the existing flora. Cupania contains 30 to 35 species in the Tropics and subtropics, Dilodendron 1 species in Brazil, and Thouina 14 or 15 species in the West Indies and Mexico.

Occurrence.—Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge and L. C. Glenn).

Collection.—U. S. National Museum.

Genus DODONÆA Linné.

DODONÆA WILCOXIANA Berry, n. sp.

Plate XXXVIII, figure 2.

Description.—Leaves small, lanceolate or oblanceolate in general outline, the apex narrowly rounded or shortly pointed and the base narrowly cuneate. Length about 3 centimeters. Maximum width, at or above the middle, about 0.75 centimeter. Margins entire, somewhat revolute. Texture coriaceous. Petiole short and stout, not enlarged, slightly curved, about 3 millimeters in length. Midrib stout and prominent. Secondaries relatively prominent, about ten, mostly opposite pairs. They diverge from the midrib at wide angles, as large as 80° in the upper part of the leaf, and are either straight or curved, becoming thin and camptodrome close to the margins. Tertiaries fine, but distinct in the fine-grained clay matrix. They are largely percurrent, and have cross nervilles that form quadrangular or pentagonal meshes.

This well-marked species seems clearly referable to Dodonæa, especially in view of the characteristic fruits of *Dodonæa knowltoni*, which occur at Puryear. It is closely similar to the less markedly oblanceolate leaves of the modern *Dodonæa viscosa* Linné as well as to other West Indian species of Dodonæa—for example, *Dodonæa angustifolia* Swartz. It is not unlike a form from the Tertiary of Bolivia described by Engelhardt [1] as *Gaylussacia tertiaria* and compared with the existing Brazilian species *Gaylussacia ledifolia* Martius.

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 6, pl. 1, figs. 8, 9.

There are a number of existing species of Gaylussacia in central Brazil, and Engelhardt's determination is probably correct.

The genus is represented by numerous species, based on both leaves and characteristic fruits in the European Tertiary, and a very similar form, *Dodonæa viscosoides* Berry, is rather common in the succeeding Claiborne flora. The modern species comprise about 50 forms, largely massed in the Australian region but represented in the Tropics of both hemispheres.

Occurrence. — Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

DODONÆA KNOWLTONI Berry, n. sp.

Plate LXIV, figure 3.

Description.—Fruit a septicidal, two-celled, two-winged, reticulated capsule. Outline elliptical. Capsule relatively small, orbicular, about 8 millimeters in diameter, centrally located. Number of seeds not discernible. Wing relatively wide and full, deeply emarginate distad and less deeply emarginate proximad, of considerable consistency; veinlets mostly emersed, reticulating. Margins somewhat flexuous. Total length about 1.6 centimeters. Maximum width, midway between the apex and the base, about 22 millimeters. Peduncle long and slender, about 7 millimeters in length. Named in honor of Dr. F. H. Knowlton, of the United States Geological Survey.

The fruits of the existing species of Dodonæa range from membranous to leathery and are two to six celled. Most of them are three celled, and, as a rule carry two, but exceptionally only a single seed in each cell. A number of species are normally two celled—as, for example, *Dodonæa viscosa* Linné, a common shrub of the woods, thickets, and strand, ranging from Bermuda and peninsular Florida through the West Indies. In its size, general outline, and two-celled character *Dodonæa viscosa* is perhaps most like the fossil species, but differs in its less coriaceous texture and the relatively larger size of the seed cavities and hence has relatively narrower wings. The only other existing species which reaches the United States, *Dodonæa jamaicensis* De Candolle, is a shrub of the hammocks, pineland, and the keys of peninsular Florida, occurring also throughout the West Indies. Its fruits are three celled, three winged, smaller, and more deeply emarginate. Among other existing species that are so similar as to deserve mention are *Dodonæa angustifolia* Swartz, of the West Indies, which has smaller fruits; *Dodonæa canescens* De Candolle, which has somewhat narrower fruits, like those of the oriental species, *Dodonæa candollei* Blum, with which the fossil fruits have also been compared.

It is a source of considerable satisfaction to have the rather abundant remains of unmistakable fruits of this genus preserved in the Wilcox deposits, since they render more certain the identification of the associated leaves described as *Dodonæa wilcoxiana*. It is quite possible that both leaves and fruits belong to a single botanic species.

The fossil fruits of a considerable number of species of Dodonæa have been described, and though there is no especial reason for doubting any of these identifications a number of them are based on rather doubtful material. This is especially true of *Dodonæa prisca* Weber [1] from the Aquitanian of Rhenish Prussia, *Dodonæa orbiculata* Heer,[2] *Dodonæa emarginata* Heer,[3] *Dodonæa ptelexfolia* (Weber) Heer,[4] *Dodonæa allemanica* Heer,[5] which range from the Aquitanian to the Tortonian. The species described by Ettingshausen [6] as *Dodonæa salicites* from the Sannoisian of Häring in the Tyrol, where it is represented by characteristic leaves as well as small, not well preserved fruits, which, however, I regard as correctly determined. They are much smaller and relatively much narrower and longer than the Wilcox species. From the Tongrian of St. Zacharie in southeastern France Saporta [7] has described the fruits of *Dodonæa confusa* and *Dodonæa cycloptera*, both of which I regard as correctly identified. Both are smaller and otherwise unlike the present species. The best preserved fossil species heretofore noted is *Dodonæa saportana*, described by Laurent [8] from the Tongrian of Célas (Gard) France. This is a pedunculate bialate form, showing a

[1] Weber, C. O., Palæontographica, vol. 2, p. 85, pl. 5, fig. 8, 1852.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 65, pl. 121, fig. 17, 1859.

[3] Idem, p. 201, note.

[4] Idem, p. 364, pl. 121, figs. 11, 12.

[5] Idem, pl. 121, fig. 15.

[6] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 68, pl. 23, figs. 36-38, 1853.

[7] Saporta, G. de, Études sur la végétation du sud-est de la France à l' époque tertiaire, vol. 1, pp. 240, 241, pl. 10, figs. 3, 4, 1863.

[8] Laurent, Louis, Flore des calcaires de Célas, p. 127, pl. 13, fig. 9, 1899.

single seed in each cell of the capsule. Its describer compares it with the existing *Dodonæa candollei* Blum of New Caledonia, although it is equally similar to the cosmopolitan *Dodonæa viscosa* Linné. Laurent's species differs from the Wilcox fruit in being longer than wide, not emarginate at the base, and less deeply emarginate at the apex.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus SAPINDUS Linné.

Leaflets relatively large and wide, 2 centimeters or over in maximum width:
- Widest medianly, falcate:
  - Apex and base equally pointed ... *S. pseudaffinis.*
  - Apex blunt and base pointed and decurrent. *S. coushatta.*
  - Base broad and rounded .... *S. oxfordensis.*
- Widest below the middle:
  - Equilateral, tip gradually narrowed and rounded *S. bentonensis.*
  - Inequilateral, acuminate, petiolulate. *S. knowltoni.*

Leaflets small and narrow, more or less falcate:
- Leaflets? .... *S. mississippiensis.*
- Leaflets petiolulate:
  - Linear-lanceolate, elongate, long petiolulate. *S. linearifolius.*
  - Ovate-lanceolate:
    - Petiolules over 4 millimeters, base subequilateral, apex extended and straight sided. *S. formosus.*
    - Petiolules not over 3 millimeters, base inequilateral, apex pointed, margins incurved. *S. eolignіticus.*

SAPINDUS PSEUDAFFINIS Berry, n. sp.

Plate LXVII, figure 6.

Description.—Leaflets large, ovate falcate in outline, inequilateral, the apex abruptly pointed and the base similarly pointed. Length about 0.5 centimeter. Maximum width about 3.3 centimeters, midway between the apex and the base. Margins entire, full and evenly rounded and not becoming incurved at either the apex or the base, the regular curvature of the margins continuing until they join as an abrupt point. Petiolule short or wanting. Midrib very stout and curved. Secondaries much thinner but rather stout, 12 to 14 subopposite to alternate pairs, branching from the midrib at angles of more than 45° and curving upward, subparallel, camptodrome. Tertiary system thin but very distinct, consisting of mostly percurrent nervilles connected by intermediate veinlets resulting in a mostly quadrangular areolation. Leaf substance apparently thin but coriaceous.

This large, handsome species is obviously referable to Sapindus and may be closely matched by a number of existing tropical species, for example *Sapindus inæqualis* De Candolle of tropical America or *Sapindus barak* De Candolle and *Sapindus turczaninowii* Vidol of the East Indies, or the East Indian species figured by Ettingshausen.[1] Among fossil species it resembles *Sapindus grandifoliolus* Ward,[2] from Montana, the principal difference, in addition to the more prominent areolation of the Wilcox species, being the attenuated tip of the Fort Union species. Another similar Fort Union species is the very abundant *Sapindus affinis* Newberry, especially the larger forms like those figured by Knowlton[3] from Yellowstone Park. These specimens are nearly if not quite as large as *Sapindus pseudaffinis* and have the same form and secondary venation. The tertiary areolation is obsolete, however. Knowlton, who has studied hundreds of specimens of *Sapindus affinis*, agrees with me that the Wilcox form is distinct, but is closely related to this Fort Union species. It also greatly resembles a leaf from the French Tertiary (Sannoisian) which is described by Saporta[4] as *Magnolia* (*Michelia?*) *proxima.* Many leaflets of *Sapindus saponaria* Linné of the American tropical strand flora match this fossil species.

Sapindus comprises more than 40 existing species (Radlkofer[5] in his revision of the Sapindaceæ includes only about 10 species in Sapindus), which are widely distributed throughout the Tropics of both hemispheres, but are most abundant in the Asiatic region. Several species like *Sapindus marginatus* Willdenow of our Southern States extend considerable distances into the Temperate Zone. The fossil species are numerous from the middle Cretaceous onward, and the genus is prominently represented in the lower Eocene floras of the Rocky Mountain area.

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[1] Ettingshausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Sotzka, pl. 6, fig. 9, 1858.

[2] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 67, pl. 30, figs. 3–5; pl. 31, figs. 1, 2, 1887.

[3] Knowlton, F. H., U. S. Geol. Survey Mon. 32, p. 736, pl. 102, figs. 1–3, 1899.

[4] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, p. 86, pl. 14, fig. 1, 1889.

[5] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, 1887–1901.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Sapindus coushatta Berry, n. sp.

Plate LXV, figure 5.

Juglans rugosa. Hollick (in part, not Lesquereux), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 35, fig. 1 (not fig. 2), 1899.

Description.—Leaflets relatively large, obovate, and somewhat falcate in general outline. Apex not produced, inequilateral, bluntly pointed. Base inequilateral, pointed, and somewhat decurrent. Length about 7 centimeters. Maximum width, near the middle of the leaflet, about 3.4 centimeters. Margins entire, rather evenly rounded. Texture subcoriaceous. Petiolule missing. Midrib stout, prominent, and curved. Secondaries rather stout, about seven subopposite to alternate pairs; they diverge from the midrib at angles of about 50° to 70°, more open on the side of the midrib where the lamina is widest; they are subparallel and rather straight until they reach the marginal region, where they curve upward and are camptodrome. Tertiaries well marked, mostly forking and inosculating, forming an open, mostly five-sided areolation.

This species is based on one of the two forms from the Wilcox group of Louisiana which are referred by Hollick to *Juglans rugosa* Lesquereux,[1] a form from the lower Eocene of the Rocky Mountain province that is in general much larger, much more elongated, and has a broader base.

The present species is much broader than *Sapindus knowltoni*, *S. mississippiensis*, *S. linearifolius*, *S. formosus*, and *S. eolignitiĉus* of the Wilcox flora. It is much shorter and broader than the two large species, *S. bentonensis* and *S. oxfordensis*. It is not so large as the leaflets of *S. pseudaffinis*, but is more elliptical in outline, more pointed at the base, and differs in the details of the tertiary venation.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch).

Collection.—New York Botanical Garden.

[1] Lesquereux, Leo, The Tertiary flora, p. 286, pl. 54, figs. 5, 14; pl. 55; figs. 1-9; pl. 56, figs. 1, 2, 1878.

Sapindus oxfordensis Berry, n. sp.

Plate LXVII, figure 5.

Description.—Leaflets large, elongate elliptical-lanceolate in outline, falcate, slightly inequilateral, the apex pointed and the base markedly inequilateral, rounded on one side and narrow and straight on the other side. Length about 9 centimeters. Maximum width, in the middle part of the leaflet, about 1.8 centimeters. Margins entire. Petiolule short and stout, tumid, about 3 millimeters in length. Midrib stout and curved. Secondaries thin, about eight subopposite pairs, diverging from the midrib at wide angles, about 50°, curving regularly upward, subparallel and camptodrome. Tertiaries mostly obsolete.

This well-marked species is sparingly represented in the collections from Oxford and Grenada. It is clearly unlike the other Wilcox species of Sapindus. It approaches closest to *Sapindus pseudaffinis* Berry but is smaller, has less regularly curved margins or pointed ends and fewer secondaries, and the tertiary venation is less prominent and different. It is entirely distinct from *Sapindus bentonensis* Berry as well as from the other Wilcox species, which have much smaller leaflets. It is not unlike the Fort Union species *Sapindus grandifoliolus* Ward and the larger leaflets of *Sapindus affinis* Newberry. It is like a number of existing species, including *Sapindus saponaria* Linné of the American tropical and subtropical strand flora, and is especially like the larger leaflets of *Sapindus marginatus* Willdenow, which ranges along the Florida coast northward as far as St. Johns River and Cedar Keys.

Occurrence.—Holly Springs sand, Oxford, Lafayette County, Miss. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Sapindus bentonensis Berry, n. sp.

Plate LXVII, figure 4.

Description.—Leaflets ovate-lanceolate in outline, widest toward the base and taper upward to a narrow blunt or slightly emarginate tip. Length about 10 centimeters. Maximum width, in the lower half of the leaflet, about 2.5 centimeters. Margins entire, undulate.

Texture subcoriaceous. Petiolule not preserved. Midrib very stout proximad but thins considerably distad. Secondaries thin, about 12 irregularly spaced pairs. They branch from the midrib at different angles. In the lower half of the leaflet the angles are about 45° and the secondaries are curved and camptodrome. In the upper part of the leaflet the angles become progressively more open until they reach about 80°. The secondaries are straight to the marginal region, where their ends are joined by a wide flat arch. Tertiaries mostly obsolete.

This species appears to be new. Unfortunately it is represented only by the specimen figured, which was collected many years ago by the Arkansas Geological Survey and is in the United States National Museum (No. 8610), and by another specimen from Wilson County, Tex. The specimen first mentioned was identified as Sapindus sp. by Prof. Ward.

Occurrence.—Wilcox group, east of Benton, Saline County, Ark. (the locality given is sec. 28, T. 2 S., R. 14 W.). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

SAPINDUS KNOWLTONI Berry, n. sp.

Plate LXIII, figure 6.

Description.—Leaflets of medium size, ovate-lanceolate, slightly inequilateral and falcate in general outline, the base broadly rounded and the tip elongated, acuminate. Length about 8.5 centimeters. Maximum width, in the basal half of the leaflet, about 2.1 centimeters. Margins entire, slightly irregular in the evenness of their curvature, opposite at the base and similarly arched on both sides of the midrib, the base, however, being inequilateral in a ratio of 8.5 to 11. Leaf substance relatively thin but texture apparently subcoriaceous. Petiolule enlarged, stout, nearly straight, forming an angle with the midrib, about 6 millimeters in length. Midrib stout, oblique with respect to the petiolule, curved, prominent on the lower surface of the leaflet. Secondaries relatively thin but stouter than in the associated small-leafed species of this genus, about seven or eight alternate, somewhat irregularly spaced pairs; they diverge from the midrib at angles of about 50° and curve gently upward, the curve becoming accelerated in the marginal region, where they are camptodrome. Tertiary system fine but distinct, consisting of small four to six sided isodiametric meshes.

This species, which is named in honor of F. H. Knowlton, of the United States Geological Survey, is distinct from the associated Wilcox species of Sapindus as well as from previously described fossil forms. It resembles several of the Wilcox species, however, especially *Sapindus formosus* Berry and *Sapindus eolignitícus* Berry, both of which are slightly smaller and neither has such a long and stout petiolule. Both of these species are also more coriaceous and have thinner, more regular secondaries, and the areolation is more immersed.

Among existing species of Sapindus the present form can scarcely be distinguished from *Sapindus marginatus* Willdenow, a small coastal tree of the Florida peninsula.

Occurrence.—Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

SAPINDUS MISSISSIPPIENSIS Berry, n. sp.

Plates LXIII, figure 1, LXIV, figure 10, LXVI, figures 1 and 2, and CIX, figure 1.

Sapindus angustifolius Lesquereux. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 286, pl. 35, fig. 5, 1899.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 12, 1888 (not 1873, 1878).

Veatch, U. S. Geol. Survey Prof. Paper 46, pl. 17, fig. 6, 1906.

Description.—Leaves odd-pinnate. Leaflets small, slightly inequilateral, acuminate-lanceolate in outline, invariably more or less falcate. Apex somewhat abruptly narrowed and prolonged as a slender acumen. Base cuneate, in many specimens narrowly pointed and matching the apex. Length ranges from 4 to 6.75 centimeters. Maximum width, halfway between the apex and the base, 1.4 or 1.5 centimeters. Margins entire, rather evenly curved. Texture subcoriaceous. Petiolule generally wanting, stout and 4 centimeters long in one specimen. Midrib stout and curved. Secondaries thin, about eight subopposite to alternate pairs, subequally spaced; they diverge from the midrib at angles of about 45° and pursue a slightly but regularly curved, subparallel course, eventually becoming approximately parallel with the lateral margins and camptodrome. Tertiaries commonly obsolete.

A specimen collected at Wickliffe, Ky., by R. H. Loughridge and identified as *Sapindus angustifolius* by Lesquereux shows the terminal leaflet and one of the lateral leaflets attached to the rachis, indicating that the leaves were odd-pinnate, as in the existing *Sapindus marginatus* Willdenow. The terminal leaflet is slightly larger than the lateral leaflet preserved and has a somewhat different secondary venation, the upper secondaries being continued as a marginal hem, thus resembling a Myrcia or Ficus.

This is a characteristic species of Sapindus of the forms that bear numerous small falcate leaflets. A specimen of it from Louisiana was referred to *Sapindus angustifolius* by Hollick, and several from Kentucky were also referred to that species by Lesquereux. *Sapindus angustifolius* comes from the Miocene of Colorado, and though all the species of Sapindus that bear small falcate leaflets are much alike, this Wilcox form really has nothing in common with *Sapindus angustifolius*, the leaflets of which are widest toward the base and gradually taper upward to a narrow extended tip.

This species may be distinguished from the several other small Wilcox species of Sapindus by the same features that distinguish it from *Sapindus angustifolius* Lesquereux. It survives the Wilcox and is found in the Gosport and Lisbon formations of the Claiborne group and is rather common in the Lisbon formation near Newton, Miss. It is much like the leaves from the Tertiary of Ecuador described by Engelhardt[1] as *Myrciaria tenuifolia*.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by W J McGee). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, Kansas City Southern Railway, 1 mile west of Shreveport, Caddo Parish, La. (collected by A. C. Veatch), and Bolivar Creek, $3\frac{1}{2}$ miles north of Harrisburg, Poinsett County, Ark. (collected by L. W. Stephenson). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge, 2 specimens No. 2699), and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

SAPINDUS LINEARIFOLIUS Berry, n. sp.

Plates LXIII, figures 2–5, and CIX, figure 4.

Salix angusta. Lesquereux (not Alexander Braun or Heer), U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaflets narrow, linear-lanceolate and markedly falcate in outline, the apex gradually narrowed and pointed and the base narrow, acute, and nearly equilateral. Length ranges from 6 to 10 centimeters. Maximum width, which is below the middle, ranges from 7 to 14 centimeters. Margins entire, subparallel for most of their length, somewhat revolute. Leaf substance thick and texture coriaceous. Petiolule long and stout, preserved for a length of 7 millimeters. Midrib stout, considerably curved. Secondaries thin, immersed, and mostly obsolete, 12 to 14 subopposite to alternate pairs, diverging from the midrib at wide angles, rather straight until they reach the marginal region, where they curve abruptly upward to form a broad flat arch, subparallel with the margins. Tertiaries obsolete.

This is a well-marked slender falciform species, not especially close to any of the other Wilcox species and readily discriminated by its narrow elongated falcate form, subequilateral lamina, long petiolule, coriaceous texture, and immersed venation. It is much like a species of Sapindus of the Claiborne group but more linear and may possibly represent an ancestral form.

Lesquereux in 1888 identified three fragments from Wickliffe, Ky., as *Salix angusta* Alexander Braun (U. S. Nat. Mus. No. 2588). They do not resemble that Miocene species, as the texture alone sufficiently indicates, but represent the present species, a single specimen of which was subsequently collected from the same locality by L. C. Glenn.

Occurrence.—Holly Springs sand, Early Grove and Holly Springs, Marshall County, Miss. (col-

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 17, pl. 1, fig. 24, 1895.

lected by E. W. Berry). Wilcox group near Boydsville, Clay County, Ark. (collected by E. W. Berry); 1½ miles northeast of Mansfield and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Lagrange formation (in beds of Wilcox age), at Puryear, Henry County, Tenn. (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge and L. C. Glenn). Bed of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum.

Sapindus formosus Berry, n. sp.

Plate LXVI, figures 3–7.

Sapindus angustifolius. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.

Description.—Leaflets with relatively long petiolules, lanceolate-falcate and slightly inequilateral in outline. Length ranges from 6 to 8.5 centimeters, averaging about 6.6 centimeters. Maximum width, in the lower half of the leaflet, ranges from 1.3 to 1.6 centimeters. Apex gradually narrowed and sharply pointed. Base more shortly and broadly pointed. Margins entire, in some specimens slightly irregular, rounded and full basally, rather straight distad. Texture subcoriaceous. Petiolules stout, curved, prominent on the lower surface of the leaflet. Secondaries thin, about eight subopposite to alternate pairs, diverging from the midrib at angles of about 45° and curving upward somewhat irregularly in some individuals, and camptodrome a considerable distance from the margins. Tertiaries distinct in most specimens; they form marginal arches and internally large pentagonal meshes.

This species resembles the smaller leaves of the Fort Union *Sapindus affinis* Newberry, but is less inequilateral and more regularly falcate. It is also comparable with the Florissant *Sapindus angustifolius* Lesquereux but is readily distinguishable. Among the Wilcox species of Sapindus it is approximately the same size as *Sapindus mississippiensis* Berry and *Sapindus eolignitícus* Berry. It differs from *Sapindus mississippiensis* in being wildest below the middle and in having a straight-sided narrowed tip, a broader base, and a long petiolule. It differs from *Sapindus eolignitica* in being abruptly pointed distad and not rounded proximad, in its less coriaceous texture, relatively narrower form, more ascending secondaries, and longer petiolule.

It is very similar to the smaller leaflets of several existing American species. A specimen of this species was collected at Wickliffe, and a rather large leaf which appears to be referable to it from northwestern Louisiana was identified by Lesquereux as *Sapindus angustifolius* (U. S. National Museum No. 2600½). A specimen was collected at Wickliffe, Ky., many years ago by R. H. Loughridge (U. S. National Museum No. 2571) and four complete specimens were collected recently from this same outcrop by L. C. Glenn. It is abundant in the clays at Puryear, Tenn., and survives the Wilcox, being found in the Lisbon formation of the Claiborne group near Newton, Miss.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson); sec. 11, T. 12 N., R. 12 W., De Soto Parish, La. (collected by L. C. Chapman). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn., abundant (collected by E. W. Berry), and Wickliffe, Ballard County, Ky. (collected by L. C. Glenn).

Collections.—U. S. National Museum.

Sapindus eolignitícus Berry, n. sp.

Plates LXVII, figures 1–3, and CIX, figure 2.

Description.—Leaflets relatively short and wide, ovate in general outline, only slightly falcate. The abruptly acuminate tip is rounded in some specimens and the base is rounded and more or less inequilateral. Length ranges from 5 to 7.5 centimeters. Maximum width, in the lower half of the leaflet, 1.3 to 2 centimeters. Margins entire, slightly and faintly undulate in some specimens, incurved slightly at the tip, full and rounded below, broadly on one side of the midrib and narrowly on the other side. Petiolules short, stout, and curved, not over 3 millimeters in length, which is only about half the length of the petiolules of *Sapindus formosus* Berry. Midrib less stout than in *Sapindus formosus*, straight or slightly curved distad, prominent on the lower surface.

Secondaries thin, about nine subopposite to alternate pairs, diverging from the midrib at angles of more than 45°, and becoming much more open toward the tip of the leaf, irregularly spaced, regularly curved, camptodrome in the marginal region. Tertiaries mostly obsolete. Leaf substance thick. Texture coriaceous.

This species may be compared with the same western species as *Sapindus formosus* Berry. It is much like *Sapindus formosus* in size and general appearance but is readily distinguished by its broader form, shorter tip, more coriaceous texture, less ascending secondaries, broader, more inequilateral base, and shorter petiole. It is common at Puryear, Tenn., and greatly resembles the forms from the Raton formation which are referred by Knowlton to *Sapindus affinis* Newberry.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn., common (collected by E. W. Berry), and Wickliffe, Ballard County, Ky., common (collected by L. C. Glenn).

Collections.—U. S. National Museum.

Order RHAMNALES.

Family RHAMNACEÆ.

Genus ZIZYPHUS Linné.

ZIZYPHUS FALCATUS Berry, n. sp.

Plates LXIX, figure 5, and LXX, figures 1 and 2.

Description.—Leaves of variable size, lanceolate or ovate-lanceolate in outline, invariably falcate, the base decurrent and the tip gradually narrowed, acuminate. Length ranges from 7 to 13 centimeters. Maximum width, which is in the lower half of the leaf, ranges from 1.25 to 3 centimeters. Margins irregularly and as a rule prominently crenate, the teeth becoming obsolete at the extreme base and in the tip; less close set and prominent in the smaller, narrower leaves. Texture coriaceous. Petiole short, stout, and curved, 7 to 12 millimeters in length. Midrib stout, prominent, curved, becoming thin in the tip. Lateral primaries one on each side, subopposite, suprabasilar, relatively stout but much less so than the midrib; they diverge at acute angles, the acuteness depending on the relative width of the leaf, and pursue courses parallel with the respective lateral margins, joining secondaries above the middle of the leaf. The secondaries consist of three categories; an opposite pair diverge from the base of the midrib and pursue a course parallel with the lateral primaries and margins for a varying distance upward; two or three thin camptodrome pairs arise from the midrib in the tip of the leaf; and thin camptodrome secondaries run outward from the lateral primaries. The primaries and midrib are connected by numerous thin, nearly straight, transverse veinlets, largely immersed in the thick leaf substance.

This species is in many respects rather close to *Zizyphus meigsii* (Lesquereux) and may possibly represent variants of that species, whose leaves are notoriously variable. There are abundant grounds, however, for specific differentiation. *Zizyphus meigsii* appears to be invariably much widened below, so that without the acumen its outline would be orbicular, and some individuals have a cordate base. It develops a very long attenuated acumen, and as a rule has large close-set teeth. *Zizyphus falcatus*, on the other hand, is smaller, lanceolate-falcate in form, and no specimens are much widened proximad. The base is cuneate and decurrent, and the tip regularly tapering.

The leaf substance is more coriaceous. The teeth are smaller and more distant in the smaller leaves.

Zizyphus falcatus is nearer to the existing American species of Zizyphus than is the associated *Zizyphus meigsii* and is a typical member of the genus. Among previously described fossil forms it greatly resembles *Zizyphus ungeri* Heer,[1] a species that is exceedingly common in the European Oligocene. Ettingshausen in his account of the flora from Haering in the Tyrol has figured a large number of specimens of this species which admirably illustrate its variations.

Zizyphus falcatus is represented in the subsequent Claiborne deposits of the embayment region by the similar *Zizyphus claibornensis* Berry.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 74, pl. 122, fig. 25, 1859.

ZIZYPHUS MEIGSII (Lesquereux) Berry.

Plate LXX, figures 3-5.

Ceanothus Meigsii. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 419, pl. 19, figs. 5-7, 1869.

Description.—Lesquereux's description, written in 1869, is as follows:

C. foliis petiolatis, late ovatis, basi truncatis, cordatisve, in longum apicem attenuatis, obtuse æquiliter serratis, triplinerviis, nervis secundariis infimis basilaribus, tenuibus, superioribus crassis, nervo primario subæqualibus, arcuatis, extrorsum inferne ramosis, acrodromis imperfectis.

This species is extremely variable, and in the light of the recently collected material the foregoing diagnosis may be considerably amended and amplified. In general these leaves range from ovate-lanceolate to elliptical lanceolate in outline and they appear to be invariably more or less inequilateral. The base ranges from cuneate to very broadly rounded and in some specimens markedly cordate. The apex is rather uniformly narrowed and extended as a much elongated slender acumen, which when the lamina is broad, as in Lesquereux's figure 7, shows an abrupt approach of the margins at the base of the acumen. Recently collected material shows this acumen even longer and more slender than in the figure cited. The marginal teeth are variable, ranging from small crenate teeth, approaching the serrate in form, to large full rounded crenate teeth. The margins as a rule are entire at the base of the leaf and the teeth become obsolete in the acumen. The petiole is stout and enlarged proximad and is 3 centimeters long in the small specimen figured. The midrib is stout and curved in the falcate forms or curved and recurved in some of the broader leaves. The lateral primaries are stout but much less so than the midrib. They are subopposite or opposite and suprabasilar, branching from the midrib at more or less acute angles, curving outward, and finally joining a secondary in the upper region of the broad part of the lamina. There are several pairs of well-marked camptodrome secondaries from the upper midrib, and similarly curved camptodrome secondaries from the outer sides of the lateral primaries, tertiary branches from which enter the marginal teeth. The venation becomes obsolete for the most part as the margin is approached, especially in the upper part of the leaf. Length ranges from 13 to 18 centimeters, the acumen over 5 centimeters long in one specimen. Maximum width 3 to 8 centimeters, generally about 6 centimeters.

Lesquereux recorded this species from the yellow coarse clay of Mississippi and the soft white clay of La Grange, Tenn., the specimens from Mississippi having been collected by E. W. Hilgard and those from Tennessee by J. M. Safford. All these types have totally disappeared. The species has since been found at Safford's original locality or in the immediate vicinity, but there is some uncertainty regarding Hilgard's locality in Mississippi. According to Lesquereux's statement[1] the "yellow coarse clay" was from old Winston County, now a part of Choctaw County, but there is a possibility that it came from Raglands Branch in Lafayette County. After canvassing all the possibilities I have decided that the original locality was the one known as Colemans Mill, near New Prospect, Choctaw County. I have not revisited this locality, since the matrix is sandy and the specimens that I have seen from there are for the most part very poor.

Lesquereux referred the present species to Ceanothus, comparing it with our existing *Ceanothus americanus* Linné and with *Ceanothus tiliæfolius* Unger of the European Tertiary, a species subsequently transferred to Zizyphus by Heer. The American form also appears to be more properly referable to the allied genus Zizyphus, as Schimper first pointed out in 1874. It is widely distributed in the Wilcox but never common. I have seen or collected it at several localities, but by a singular misfortune the specimens have been broken in getting them out or during their transit to Baltimore, so that there is not a single perfect specimen in the collections, some of the most complete being those figured in the present contribution.

This magnificent species is a veritable giant compared with either the fossil or with most of the living species of Zizyphus and allied genera, and none of the described forms are in danger of being confused with it. The existing species number about two score and are largely confined to the Indo-Malayan Tropics, only a single species of the long line of Cretaceous and Tertiary ancestors being left in the American Tropics. Some of the East Indian species are closer to *Zizyphus meigsii* than are the tropical

[1] Am. Philos. Soc. Trans., vol. 13, p. 424, 1869.

American species. For example, *Zizyphus napica* from Java is fully as large if not larger, its basal and marginal characters are identical, and a few individuals have a somewhat produced tip. As a rule, however, the tip is not extended and the primaries are strictly acrodrome.

Zizyphus meigsii (Lesquereux) is a member of the lower Eocene flora of northeastern New Mexico (Raton formation).

Occurrence.—Ackerman formation, Colemans Mill, Choctaw County, Miss. (collected by E. W. Hilgard). Holly Springs sand, ravine at Oxford, Lafayette County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction in Fayette County, Tenn. (collected by L. C. Glenn and E. W. Berry); La Grange, Fayette County, Tenn. (collected by J. M. Safford); and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus PALIURUS Jussieu.

PALIURUS MISSISSIPPIENSIS Berry, n. sp.

Plate LXXI, figure 4.

Description.—Winged fruits, orbicular and disklike in outline, the wing thick, somewhat reticulately wrinkled, and entire margined, and the central seed cavity thickened.

The fruits of this species range in size from 1 centimeter to 1.4 centimeters in diameter. The specimen figured represents the maximum size. It was found in a lignitized condition in the clays near Early Grove, Miss., in 1889 by W J McGee and by him deposited in the U. S. National Museum (No. 3460). When I took up the study of the flora these materials were turned over to me. At that time the single specimen had suffered much from drying and had been broken, but all the parts were intact and a drawing was made of them. Subsequently part of the specimen was lost.

Two or three specimens of the same species occur in the clays at Holly Springs. They are slightly smaller than the form from Early Grove but are otherwise identical with it, although they are not especially well preserved.

The genus Paliurus is represented in the modern flora by but two species—*Paliurus aculeatus* Lamarck, which ranges through southern Europe and Asia to Japan, and *Paliurus ramossimus* Poiret of China and Japan. About 30 fossil species are known and these are based for the most part on leaves. They range in age from the middle Cretaceous to the present and are abundant in North America, extending northward as far as western Greenland, according to Heer. In the absence of the characteristic fruits the leaves alone are likely to be confused with the closely allied genus Zizyphus or even with Ceanothus or with certain species of Rhamnus.

The fruits are unmistakable, however, and have been recorded for several European species ranging from the upper Eocene to the Miocene. The present specimens comprise, so far as known, the first records of fruits of Paliurus from North America and are therefore of interest as collateral proof of the correct identification of some of the species from this continent based on foliage alone. They are also of interest in that they occur in the lower Eocene, the earliest horizon in which fruits have thus far been found.

These fruits are somewhat smaller than those of the existing species, although larger than the fossil fruits of this genus from the European Tertiary, which include *Paliurus thurmanni* Heer[1] from the Miocene, which is smaller and has a crenate margin; *Paliurus tenuifolius* Heer,[2] very similar to the American form but smaller; *Paliurus litigiosus* Saporta,[3] an Oligocene species, which also bore smaller fruits; and *Paliurus favonii* Unger,[4] a very similar but smaller Miocene species.

Leaves which have been referred to several species of Paliurus occur in the Wilcox deposits. One of these leaves is rather sparingly associated with the fruits at the Holly Springs locality. The evidence of identity is uncertain, however, and the two are discussed separately. A restoration of the fruits and the leaves associated with them is shown in figure 14 (p. 281).

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (figured specimen collected by W J McGee; additional specimens collected by E. W. Berry), and Holly

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 76, pl. 122, figs. 27–29, 1859.

[2] Idem, fig. 31.

[3] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 177, pl. 2, figs. 4a, b, b¹, 1863.

[4] Unger, Franz, Chloris protogæa, p. 147, pl. 50, figs. 6–8, 1841–1847; also Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 3, p. 39, pl. 50, figs. 6, 7, 1869.

Springs, Marshall County, Miss. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Paliurus pinsonensis Berry, n. sp.

Plate LXXI, figure 7.

Description.—Leaves rather above the average size for this genus, elliptical in outline, margins full and entire, curving inward at the base and slightly decurrent on the short and stout petiole. The extreme tip of the leaf is missing, but from the way in which the margins bend inward distad it is assumed to have been broadly rounded, although there is the possibility that the margins turned to form a short pointed tip. Length about 4 centimeters. Maximum width about 1.9 centimeters in the middle part of the leaf. Primaries five in number, diverging palmately at acute angles from the extreme base of the leaf; the midrib is no larger or more prominent than the main lateral primaries; the two outer primaries are more slender and shorter, forming a marginal hem for half the length of the margin. Midrib curved, main primaries evenly bowed, acrodrome. Secondaries camptodrome from the outside of the main lateral primaries. Tertiaries very fine, curved, mostly transverse. Texture thin.

This species shows more or less resemblance to a number of described forms, suggesting particularly some of the forms which have been referred to the widespread *Paliurus colombi* Heer,[1] so common in Arctic America and recorded from a number of early Eocene localities in the western part of North America (Rocky Mountain region). *Paliurus pinsonensis* is somewhat larger and more symmetric than the leaves of the modern species, which are usually broadest proximad and pointed distad. Several fossil forms, however, for example, *Paliurus orbiculatus* Saporta,[2] are elliptical or orbicular and have a rounded apex.

The present species somewhat resembles the Cretaceous species *Paliurus ovalis* Dawson[3] and *Paliurus obovatus* Lesquereux[4] and may possibly be a descendant of one of these forms. It resembles somewhat *Cinnamomum vera* Berry, which occurs at Oxford and Holly Springs, Miss., and at Puryear, Tenn., but is a smaller, thinner, more obtuse leaf, with a shorter petiole, and with curved outer secondaries instead of straight transverse veins between the lateral primaries. It is only known from the one locality near the base of beds of Wilcox age, where the small florule has a somewhat different facies from the ordinary Wilcox aspect.

Occurrence.—Lagrange formation (in beds of Wilcox age), Pinson, Madison County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Paliurus angustus Berry, n. sp.

Plate LXXI, figures 5 and 6.

Description.—Leaves of medium size for this genus, relatively narrow, ovate-lanceolate in general outline, about 3.5 centimeters in length by about 1.1 centimeters in maximum width, in the middle part of the leaf. Apex bluntly pointed. Base more acute, decurring to the stout petiole. Margins entire. Leaf substance very thin. Petiole stout, 3 or 4 millimeters in length. Midrib stout, curved. Lateral primaries one on each side, thin, subopposite, suprabasalar, branching from the midrib at an acute angle, joining a lateral branch from the lowest secondaries in the middle part of the leaf. Secondaries four, subopposite to alternate, very thin pairs, curving upward, camptodrome. The tertiaries are not clearly made out; as figured on the accompanying plate the transverse lining is composed in part of transverse veins and is in part due to the wrinkling of the very thin leaf, caused by some slight motion of the matrix.

This present species is not especially close to any described species. It is associated with the fruits described as *Paliurus mississippiensis* at the Holly Springs locality, but in view of the abundance and variety of forms at this outcrop there is no reason for assuming that the leaves and fruits came from the same plant. A restoration of the leaves and the fruits associated with them is shown in figure 14.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Heer, Oswald, Flora fossilis arctica, vol. 1, p. 122, pl. 17, fig. 2d; pl. 19, figs. 2–4, 1868.

[2] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, p. 182, pl. 8, fig. 6, 1867.

[3] Dawson, J. W., Roy. Soc. Canada Trans., vol. 3, sec. 4, p. 14, pl. 4, figs. 4, 8, 1886.

[4] Lesquereux, Leo, The flora of the Dakota group, p. 165, pl. 35, fig. 6, 1892.

Genus REYNOSIA Grisebach.

REYNOSIA PRÆNUNTIA Berry, n. sp.

Plates LXVIII, figure 4, and LXIX, figures 2 and 3.

Description.—Leaves medium sized or small, obovate in general outline, the tip broadly rounded, and the base cuneate. Length ranges from 4.5 to 6 centimeters. Maximum width, in the middle part of the leaf, ranges from 1.5 to 2.5 centimeters. Margins entire with a few irregular undulations. Texture subcoriaceous. The type and figured specimen is slightly inequilateral. It continues its maximum width from the tip to the region well below the middle; there is a shallow sinus on one side about 1 centimeter below the apex and a similar one on the other side about 1.5 centimeters below the apex, the margins being full. The petiole is stout and ranges from 5 to 10 millimeters in length. Midrib stout and curved distad, prominent on the lower surface of the leaf. Secondaries relatively thin, irregularly spaced, about seven to nine opposite to alternate pairs; they diverge from the midrib at angles that average about 45°, the basal opposite pair forming marginal hems for a short distance; all are slightly but regularly curved in their ascending course and are camptodrome close to the margins. Tertiaries not prominent but distinct, rather straight and in the main nearly at right angles to the midrib. Areolæ open, three, four, or five sided.

This species is very similar to the existing species of Reynosia indigenous in the Antillean region, one of which reaches the keys and coast of southern Florida. It is also somewhat similar to *Bumelia pseudotenax* Berry, described from the near-by Wilcox locality at Early Grove. It differs in its slightly larger size, blunter tip, more parallel margins, marginal sinuses, longer petiole, stouter midrib, and more numerous secondaries. The genus Reynosia comprises four species which are confined to the Bahamas, Antilles, and southern Florida, and the fossil receives its name from its probable ancestral relationship. Wood resembling that of the existing *Reynosia septentrionalis* Urban occurs in the Claiborne group of Texas.

The present fossil species is much like a part of the material from the Tertiary of northern South America (Colombia), which Engelhardt[1] described as *Sabicea asperifolia*.

FIGURE 14.—Restoration of *Paliurus angustus* Berry (leaves) and *Paliurus mississippiensis* Berry (fruits). (One-third natural size.)

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 40, pl. 5, fig. 6, 1895.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

REYNOSIA WILCOXIANA Berry, n. sp.

Plate LXV, figures 6 and 7.

Description.—Leaves relatively small, oblong-elliptical and somewhat inequilateral in general outline, the apex broadly rounded or slightly emarginate, narrowed from above the middle to the rather bluntly pointed base. Length about 2.1 centimeters. Maximum width, above the middle, about 1 centimeter. Margins entire, full, inclined to be revolute. Texture coriaceous. Petiole curved, short and stout, about 2 millimeters in length. Midrib stout, prominent, curved. Secondaries thin, largely immersed in the substance of the leaf; about seven pairs diverge from the midrib at different angles; spacing reduced and angle increased toward the upper part of the leaf. Secondaries regularly curved and camptodrome in the marginal region. Tertiaries obsolete.

This species is much smaller and otherwise differs from the other Wilcox species, *Reynosia prænuntia.* Like that species it is very similar to the existing *Reynosia septentrionalis* Urban, a small coastal tree of the Florida Keys and the Bahama Islands.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus RHAMNUS Linné.

Leaves large, oblong-elliptical. Venation very stout. *Rhamnus marginatus.*
Leaves smaller, ovate to lanceolate:
- Apex and base about equally pointed:
  - Secondaries remote........*Rhamnus eolignitiçus.*
  - Secondaries close set..........*Rhamnus cleburni.*
- Base much broader than the apex, secondaries close set.............................*Rhamnus coushatta.*
- Apex cuspidate-acuminate. *Rhamnus marginatus apiculatus.*

RHAMNUS MARGINATUS Lesquereux.

Plates LXXI, figure 1, and LXXII, figure 1.

Rhamnus marginatus. Lesquereux, in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 319, pl. 6, fig. 2, 1860.

Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 420, pl. 22, figs. 3–5, 1869.

Description.—Leaves relatively large, elliptical in general outline, but somewhat variable in both size and form. Apex varies from bluntly pointed to broadly rounded. Base broadly pointed, in many specimens slightly decurrent and in some specimens more or less inequilateral. Length ranges from 10 to 13 centimeters. Maximum width, midway between the apex and the base, ranges from 4 to 6 centimeters. Margins entire. Texture coriaceous. Petiole long, very stout, somewhat curved, enlarging proximad, 3 to 3.5 centimeters in length. Midrib very stout, prominent on the lower surface of the leaf. Secondaries very stout and prominent; eight to ten subopposite to alternate pairs diverge from the midrib at angles of about 40° but curve slightly until the marginal region is reached, where they curve upward camptodromely, parallel with the margins and very close to them. Smaller leaves have subparallel and more closely spaced secondaries than leaves the size of the figured specimen. Tertiaries very thin, numerous, subparallel, comparatively straight, percurrent at approximately right angles with the long axis of the leaf.

This is an exceedingly well marked species of a Rhamnus-like leaf, relatively large and stout, the petiole remarkably stout and relatively long and the venation typically that of Rhamnus. Its chief diagnostic character is the great size of the secondaries and their ultimate course along the extreme margins of the leaf. Experience shows that fragments of leaves an inch or two across can at once be recognized by these features.

There are numerous fossil species of Rhamnus which range in age from the Upper Cretaceous to the present, and it is not surprising, when their abundance in the American Upper Cretaceous is recalled, that the genus should form a prominent element in our Eocene floras. It is, however, much less abundant in southeastern North America, where it comprises only three or four species at most, than it is in the early Eocene of the present Rocky Mountain region. The existing species number about three score and consist of small trees and shrubs, widely distributed in all the temperate and in many of the tropical parts of the world (except Australia and the islands of the Pacific, according to Sargent).

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah

County), Miss. (collected by E. W. Hilgard and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

RHAMNUS MARGINATUS APICULATUS Berry, n. var.

Plate LXIX, figure 1.

Description.—Leaves somewhat smaller than the type, lanceolate to oblong-elliptical and somewhat inequilateral in general outline, widest midway between the apex and the base, tapering equally distad and proximad, and narrowly to widely cuneate at the base. Apex abruptly narrowed and then extended as a narrow cuspidate acumen, which is 5 to 10 millimeters in length and 3 to 4 millimeters in width at the base. Length of leaf ranges from 8 to 10 centimeters. Maximum width ranges from 1.8 to 4 centimeters. Margins entire. Texture apparently coriaceous, but the leaf substance is not thick. Petiole short and stout, much enlarged proximad, ranging from 4 to 8 millimeters in length. Midrib very stout and prominent, as a rule slightly curved. Secondaries stout and very prominent, numerous, regularly spaced, and subparallel; they diverge from the midrib at angles ranging from 20° in the narrowly lanceolate forms to 55° in the elliptical forms, curve regularly upward, and become parallel with the margins and run practically on them in their camptodrome endings. Tertiaries of the typical Rhamnus type—very thin, close set and subparallel, percurrent at approximately right angles to the midrib.

This form is clearly marked in some of its features from the type, but in others the two are identical. In texture and venation they show no appreciable differences. The characters that serve to distinguish the present form are its greatly shortened petiole and its greatly extended, cuspidate tip. The variety is smaller than the type and relatively as well as actually shorter. It is common in the Wilcox deposits at Hurleys.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

RHAMNUS CLEBURNI Lesquereux.

Rhamnus Cleburni. Lesquereux, U. S. Geol. and Geog. Surv. Terr. Ann. Rept. for 1872, p. 381, 1873.
Lesquereux, The Tertiary flora, p. 280, pl. 53, figs. 1–3, 1878.
Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.
Knowlton, U. S. Geol. Survey Bull. 204, p. 80, 1902.

Description.—Leaves medium sized or large, lanceolate in general outline. Apex and base about equally pointed; base in some specimens cuneate instead of acuminate. Length uniformly about 11 centimeters in a large number of specimens. Maximum width, at or slightly below the middle, ranges from 3.6 to 6 centimeters. Margins entire. Texture subcoriaceous. Petiole relatively long, stout; length about 3 centimeters. Midrib stout, prominent on the lower surface of the leaf. Secondaries numerous, thin but prominent; about 12 alternate pairs diverge from the midrib at angles of 40° to 45°, pass upward in gentle, regular, subparallel curves, and are camptodrome close to the margins. Tertiaries thin, close-spaced, percurrent, well shown in Lesquereux's figured types and clearly shown in the specimen from Louisiana, which is preserved in a coarse calcareous sandstone.

This species is represented by a single characteristic specimen from Mississippi, by a single nearly complete specimen from Louisiana, and by material from Grenada, Miss., which agree in all respects with the material from Colorado and Wyoming. The material referred by Hollick to *Rhamnus cleburni* is not that species but differs in the characters enumerated under the discussion of *Rhamnus coushatta*, the name I have assigned to Hollick's species.

Rhamnus marginatus Lesquereux and *Rhamnus eolignitícus* Berry, two of the other species of Rhamnus known in the Wilcox, are readily distinguishable from the present species. *Rhamnus eolignitícus* is common in the flora of the Denver formation at Golden, Colo., and is rare in the Eocene at Black Buttes, Wyo. (according to Lesquereux). It has been recorded from Cherry Creek, Oreg., by Knowlton [1] and from Utah. It is apparently rare in the Wilcox.

Occurrence.—Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected

[1] Knowlton, F. H., U. S. Geol. Survey Bull. 204, p. 80, 1902.

by L. C. Johnson, No. 2581). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collections.—U. S. National Museum.

RHAMNUS PURYEARENSIS Berry, n. sp.

Plate LXIV, figure 7.

Description.—Leaves relatively small, broadly lanceolate in general outline. Length about 6 centimeters. Maximum width, at or above the middle, about 2.5 centimeters. From the widest portion the lamina narrows abruptly in both directions, the apex and base being about equally acuminate. Margins entire in the lower half of the leaf, above which they are full and more or less undulate and have somewhat variable, small dentate to serrate teeth, which are as numerous as the secondaries in this portion of the leaf. Leaf substance thin but apparently of considerable consistency. Petiole short and stout, about 3.5 millimeters in length. Midrib broad but not prominent, generally straight. Secondaries thin, numerous, regularly spaced, subparallel; about eight pairs diverge from the midrib at angles of 25° to 40°, curve regularly upward, and are camptodrome close to the margins. Tertiaries very thin and close, percurrent, typically rhamnaceous, joined by numerous very thin nervilles, forming a very fine areolation.

This species is readily distinguishable from the larger, entire-margined species of Rhamnus, which characterize the Wilcox flora. The only similar form is *Rhamnites bumeliaformis* Berry, which occurs in the Wilcox of Texas. That species is about the same size as the present species, but has less numerous forked secondaries and the margin is merely undulate or feebly crenate and not dentate or serrate.

Several existing species are very similar to the present form.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

RHAMNUS EOLIGNITICUS Berry, n. sp.

Plates LXIX, figure 4, and LXXI, figure 2.

Description.—Leaves medium in size, ovate-lanceolate in outline. Length about 10 centimeters. Maximum width, in the middle part of the leaf, about 3.75 centimeters. A small leaf from the vicinity of Naborton, La., is 7 centimeters long and has a maximum width of 1.8 centimeters. Apex narrowed and bluntly pointed. Base about equally pointed. Margins full and evenly rounded, entire but more or less irregularly undulate. Texture subcoriaceous. Petiole very stout, curved, about 1.75 centimeters in length. Midrib stout, rather straight, prominent on the lower surface of the leaf. Secondaries stout and prominent, about eight irregularly spaced pairs; they diverge from the midrib at angles of about 50° and curve regularly upward, become parallel with the margins in their upper courses, and are camptodrome. Tertiaries of two kinds—relatively stout branches from the midrib, one between each adjacent pair of secondaries, with which they are approximately parallel, becoming thin distad and obsolete about halfway to the margins, and thin, numerous, mostly percurrent nervilles.

This species approaches *Rhamnus marginatus* Lesquereux in appearance, but is somewhat smaller and more pointed, has thinner petiole and venation and fewer secondaries, which arch at a greater distance from the margins, and is further distinguished by the stout tertiary branches from the midrib and by the direction of the percurrent nervilles. It is practically identical with the form from Point of Rocks, Wyo., which Lesquereux [1] identifies as *Cornus rhamnifolia* Weber, but which is probably not that species. The Wilcox species is very similar in size and outline but has stouter and fewer secondaries, whose angle of divergence is slightly smaller.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and Hatchie River near Shandy, Tenn. (collected by L. C. Johnson in clay ironstone in 1889). Wilcox group, sec. 28, T. 13 N., R. 12 W., and sec. 13, T. 12 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

RHAMNUS COUSHATTA Berry, n. sp.

Plate LXVIII, figure 1.

Rhamnus cleburni Lesquereux. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 286, pl. 47, fig. 1, 1899.

Andromeda eolignitica. Veatch, U. S. Geol. Survey Prof. Paper 46, pl. 17, fig. 2, 1906.

Description.—Leaves oblong-ovate in general outline, the tip pointed and the base rounded

[1] Lesquereux, Leo, The Tertiary flora, p. 244, pl. 42, fig. 6, 1878.

or very broadly cuneate. Length about 13 centimeters. Maximum width, in the lower half of the leaf, about 6 centimeters. Margins entire, slightly undulate. Texture subcoriaceous. Petiole not preserved. Midrib stout, prominent on the lower surface of the leaf. Secondaries numerous, stout, prominent, and subparallel; about 12 subopposite to alternate pairs diverge from the midrib at angles between 35° and 40°; they are somewhat irregularly spaced, pursue a rather straight course, become more curved and camptodrome in the marginal region, and extend rather close to the margins. Tertiaries thin, percurrent, almost entirely obsolete.

This species is based on the forms from Louisiana which were referred by Hollick to *Rhamnus cleburni* Lesquereux,[1] which is an abundant and variable form in the flora of the Denver formation of Colorado. The present form is long-petioled, more slender, lanceolate as a rule, and has a narrower base, much thinner and more curved secondaries, and very close set, percurrent tertiaries. The last feature is invariably characteristic of the hundreds of specimens collected.

Rhamnus coushatta is more pointed distad and more rounded proximad than *Rhamnus marginatus* Lesquereux and has a thinner midrib and obsolete tertiaries. It differs from *Rhamnus eolignitícus* Berry in its larger size, ovate form, broader base, and more numerous and straighter secondaries.

Occurrence.—Grenada formation, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); 1 mile northeast of Rockdale Church, 3½ miles southeast and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum (No. 2581); New York Botanical Garden.

Genus RHAMNITES Forbes.

RHAMNITES BERCHEMIAFORMIS Berry, n. sp.

Plate LXXI, figure 3.

Description.—Leaves medium sized or relatively small, inequilateral in outline, widest in the middle and pointed at both ends, the tip slightly narrower than the base. Length about 6.5 centimeters. Maximum width about 2.8 centimeters. Margins feebly undulate; the undulations at times passing into remote obscure crenations, particularly in the upper half of the leaf. Leaf substance thin. Petiole not preserved. Midrib thin, flexuous. Secondaries thin, camptodrome; about six subopposite to alternate pairs diverge from the midrib at angles of 45° or less; they sweep upward in long, flat, subparallel curves, becoming more curved distad parallel with the marginal undulations and close to them. As a rule, an outer branch in their upper course diverges at a small angle, connecting with the secondary next below. Tertiary venation obsolete.

This species is based on scanty material, only a single nearly complete specimen (the one figured) being contained in the collections. It is, however, entirely distinct from the other members of Wilcox flora and is clearly referable to the Rhamnaceæ, suggesting among several genera an affinity with the genus *Berchemia* Necker, which is commemorated in the specific name. Because of the little material available for study it is referred to the form genus Rhamnites without any effort being made to allocate it among the more or less convergent genera of the Rhamnaceæ.

Occurrence.—Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

Order MALVALES.

Family TILIACEÆ.

Genus GREWIOPSIS Saporta.

GREWIOPSIS TENNESSEENSIS Berry, n. sp.

Plate LXIV, figures 4 and 5.

Description.—Leaves small or medium sized, broadly elliptical in outline, the base truncate or slightly cordate and the tip narrowly pointed, palmately five to seven veined from the top of the petiole. Length 4 to 8 centimeters. Maximum width 3.5 to 8 centimeters in the basal part of the leaf. Margin entire for a greater or less distance on either side of the petiole, gradually passing into a region of more or less prominent crenate teeth, which tend to become obsolete in the apex of the leaf. Petiole long and relatively stout, 2 to 3.5 centimeters in length. Primaries five to seven

[1] Lesquereux, Leo, The Tertiary flora, p. 280, pl. 53, figs. 1-3, 1878.

from the top of the petiole, diverging at acute angles, the midrib and a lateral on either side of the same caliber, outer laterals thinner and more or less obsolete. The lateral primaries curve outward and then upward in a rather full curve and are camptodrome. Secondaries curved and camptodrome; two or three subopposite pairs arise from the upper part of the midrib, and numerous outwardly directed, camptodrome secondaries arise from the lateral primaries, and from these latter secondaries tertiary branches run to the marginal teeth.

These leaves, which are thus far confined to the three localities enumerated below, where they are not common, suggest a relationship with many genera, such as Cissus, Ficus, Grewia, Zizyphus, and Populus. At first sight their obvious affinities are with the numerous forms from Greenland, Europe, and western North America that are commonly referred to the genus Populus, as *Populus arctica* Heer, *Populus zaddachi* Heer, *Populus cuneata* Newberry (a variable and common form of the Fort Union Eocene), *Populus genetrix* Newberry, *Populus paleomelas* Saporta, or *Populus glandulifora* Heer. I have discussed them with Dr. F. H. Knowlton, who is inclined to identify them with *Populus daphnogenoides*. Though this is hardly the place for an extended discussion of these forms of Populus, in a large measure known only from the publications of other students, it is singular that the Arctic and early American forms are palmately and not pinnately veined, like the modern species, and present in a varying degree other distinctive features. The specimens under discussion, which have relatively short and stout petioles and palmate venation, are believed to represent the modern genus *Grewia* Linné of the Tiliaceæ, which comprises between 75 and 100 species that range from China and Japan across Malaysia to Queensland in Australia and westward in southern Asia to Arabia, and also extend to tropical and southern Africa. Although it is an Old World type in the modern flora, four or five fossil species of Grewia have been described from the early Eocene of the Rocky Mountain region and from the Arctic regions, as well as from the Eocene, Oligocene, and Miocene of Europe. Eight or ten fossil species are known, and in the allied genus Grewiopsis the fossil species, which number more than a score, are especially characteristic of the early Eocene, both in this country and abroad. The present species is distinct from all the previously described species, although it resembles some of the forms that have been referred to the widespread *Grewia crenata* Heer.[1] Its similarity to some of the forms described by Lesquereux [2] from Carbon, Wyo., as *Zizyphus meeki* may also be pointed out. Lesquereux compared those forms with *Grewia crenata*, and though what appears to be the normal form of this variable species is not especially suggestive of the plant from Tennessee, some of the variants, such as the specimen shown in Lesquereux's figure 11, are decidedly similar but have thinner and more acrodrome laterals and lack the distal secondaries.

Grewiopsis tennesseensis resembles the Tuscaloosa (Cretaceous) species *Grewiopsis tuscaloosensis* Berry and may be genetically related to it.

Occurrence.—Wilcox group, between 3 and 4 miles below Hamilton, on Sabine River, Sabine County, Tex. (collected by A. C. Veatch). Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), 1 mile south of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

Family STERCULIACEÆ.

Genus STERCULIA Linné.

STERCULIA PURYEARENSIS Berry, n. sp.

Plates LXXII, figures 2 and 3, LXXIII, figure 1, and LXXIV, figure 4.

Description.—Leaves medium sized to large, for this genus, palmately 3 to 5 lobed from a point at or below the middle. Maximum length 18 centimeters. Maximum width, from tip to tip of the upper lateral lobes, 16 centimeters. Margins entire. Texture subcoriaceous. Lobes vary from narrow, lanceolate, and conically pointed to broad and ovate, the terminal lobe slightly larger than the principal lateral lobes. The maximum length of the lobes is 10 centimeters and the maximum width, at the base, ranges from 3.5 to 6 centimeters. The upper lateral lobes each form an angle of about 40° with the terminal lobe, from

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 42, pl. 109, figs. 12-21; pl. 110, figs. 1-11, 1859.

[2] Lesquereux, Leo, The Tertiary flora, p. 275, pl. 51, figs. 10-14, 1878.

which they are separated by narrow, ultimately rounded sinuses, which extend slightly more than halfway to the base; these lobes are about 8 centimeters long and range from 3.2 to 5.25 centimeters in maximum width at the base. Lower lateral lobes, when developed, diverge from the upper at angles of 45° to 50°, thus standing at right angles to the main axis of the leaf (midrib and petiole); they are about half the size of the upper lateral lobes, the intervening sinuses being more angular than the corresponding upper sinuses. The base of the leaf is cuneate in the three-lobed leaves, truncate or somewhat cordate in the less robust five-lobed forms, and markedly cordate in the large full forms. Petiole extremely stout, probably elongated but not preserved for its full length. Primaries three to five, diverging digitately from the base at angles of 40° to 50°, those running to the tips of the lower lateral lobes slightly less stout than those of the three main lobes, which are approximately equal in caliber. All are stout, prominent, and relatively straight. The secondaries are thin, numerous, and subparallel, more or less immersed in the leaf substance. They diverge from the primaries at angles of about 55° to 65° at evenly spaced intervals of about 7 millimeters and are regularly curved and camptodrome close to the margins.

A small trilobate leaf, conforming to the same general character as the larger specimen on which the foregoing description is based, measures 8 centimeters in length by 9 centimeters in maximum width.

This species is not abundantly represented in the Wilcox collections except at Puryear, Tenn. It is probable that, like most of the lobed species of Sterculia, both recent and fossil, the outline was somewhat variable and the lobes ranged in number from two or three to five or six. To mention only a few of the fossil forms, this is true of *Sterculia snowii* Lesquereux and *Sterculia mucronata* Lesquereux of the Dakota sandstone, *Sterculia minima* Berry of the Magothy formation, *Sterculia limbata* Velenovsky of the Bohemian Upper Cretaceous, and the widespread *Sterculia labrusca* Unger of the European Tertiary. The range of variation of the present species is well shown in the illustrations.

Sterculia puryearensis is remarkably similar and undoubtedly genetically related to the common Dakota sandstone form, *Sterculia snowii* Lesquereux.[1] It shows considerable resemblance to *Sterculia majoliana* Massalongo[2] of the Italian late Miocene and to *Sterculia labrusca* Unger, first described[3] from the Styrian lignites (Oligocene) and subsequently recorded from a large number of late Eocene, Oligocene, and early Miocene outcrops throughout Europe. Among the forms now grouped together as *Sterculia labrusca* the Wilcox species is very close to one from Sotzka, Styria, described originally by Unger as *Platanus sirii*.[4]

Between 40 and 50 fossil species of Sterculia have been described, ranging in age from the middle Cretaceous to the Pliocene. There are more than 100 existing forms, segregated in the sections Digitatæ, Lobatæ, and Integrifoliæ. *Sterculia puryearensis* is referable to the group Lobatæ, which comprises numerous existing tropical species in Asia, Africa, and especially in America, although the genus Sterculia as a whole is most strongly represented in the Malay archipelago and the East Indies.

It is gratifying to find the characteristic leaves of a species of Sterculia in the Wilcox deposits, which also contain the remarkable capsules of species of Sterculiaceæ described as Sterculiocarpus. A smaller, very characteristic Sterculia leaf form occurs in the overlying deposits of the Claiborne group.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, sec. 7, T. 12 N., R. 11 W., 3½ miles and 5 miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

Genus STERCULIOCARPUS Berry, n. gen.

This genus is established for fruits referable to the family Sterculiaceæ, but without exact living representatives. Its characters are those of the species here desribed.

[1] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 183, pl. 30, fig. 5, pl. 31, figs. 2, 3; pl. 32; pl. 33, figs. 1-4, 1892.

[2] Massalongo, Abramo, Studii sulla flora fossile e geologia stratigrafica del Senigalliese, p. 319, pl. 20, fig. 3, 1859.

[3] Unger, Franz, Die fossile Flora von Sotzka, p. 45, pl. 28, figs. 1-11, 1850.

[4] Idem, p. 36, pl. 15, fig. 1.

STERCULIOCARPUS EOCENICUS Berry, n. sp.

Plate LXXIV, figures 1–3.

Description.—Large capsular fruit, apparently dehiscent from the apex, consisting of a stout central peduncle surrounded by five elliptical, broadly keeled capsules which are united for nearly their whole length. Total length of fruit 6 centimeters. Diameter 6 centimeters. Diameter of peduncle 1.25 centimeters. Surface smooth. Texture apparently coriaceous or ligneous.

This magnificent fruit is perfectly symmetric and must have been of considerable consistency. A considerable portion of the matrix is cemented to the apex, as shown in the side view of the specimen, which has prevented the determination whether or not dehiscence had commenced, or whether the individual capsules were pointed distad or broadly rounded as they are proximad. In dorsal view each capsule forms an elongated ellipse, broadly and evenly rounded below and apparently equally rounded above, with a broad and not especially prominent dorsal keel. Photographs of the specimen have been submitted to a number of specialists familiar with the existing flora of the Tropics without arriving at any definite decision regarding their generic affinity, although there was a rather general agreement that the fruit was probably referable to the Sterculiaceæ. I have compared it with all the material representing this and allied families at the New York Botanical Garden without being able to match it with living forms, although a number of modern genera show similarities, for example, Reevesia Lindley, a small Asiatic genus (cf. *Reevsia thyrsoidea* Lindley, which has a whorl of 1-seeded tardily dehiscent capsules), Abroma Linné fils, a small East Indian and Australian genus, and Helicteres Linné, a cosmopolitan tropical genus, which comprises about two score existing species. There is also a resemblance to some of the Dilleniaceæ, Euphorbiaceæ, Zygophyllaceæ, and the like.

The only known fossil form at all similar enough to *Sterculiocarpus eocenicus* to be considered as related is *Sezanella major* Viguier,[1] described from the wonderful casts of fossils from the travertine of Sézanne made by the late Munier-Chalmas and in the collections of the Sorbonne. Sezanella, which is as well known as if it was a recent species, is based on complete flowers and fruits, showing the arrangement of the seeds in the capsules. It is only about two-thirds the size of Sterculiocarpus, the individual capsules are shorter, less full, and lack the keel of Sterculiocarpus. The form is referred by Viguier to the tribe Lasiopetalæ of the family Sterculiaceæ. The travertine of Sézanne is a fluvial deposit usually correlated with the Thanetian or lower Eocene marine sands of the Paris Basin.

Occurrence.—Wilcox group, Frierson Mill, and $3\frac{1}{2}$ miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson).

Collection.—U. S. National Museum.

STERCULIOCARPUS SEZANNELLOIDES Berry, n. sp.

Plate LXXII, figures 4–6.

Description.—Fruit consisting of a whorl of five coalescent capsules, forming a spherical 5-valved capsule, the units slightly free distad. Length about 2.5 centimeters. Lateral diameter slightly less than the length. Texture coriaceous. Valves equilateral, elliptical, widest in the middle and tapering about equally proximad and distad, with distinct keels. Dehiscence septicidal from the apex, the valves apparently becoming widely separate and possibly reflexed. Placentæ axile. Seeds numerous, elliptical in outline.

This species is based on the single, somewhat compressed specimen figured from a photograph. Although somewhat distorted, the five septicidal valves can be readily made out, as well as the impressions of some of the seeds on the capsular walls. A drawing has been made of the capsule before and after dehiscence, not only to further characterize the species but to elucidate the photographic illustration of the type. There seems to be little doubt that the present specimen represents a more or less buoyant capsule of some Wilcox species of Sterculiaceæ. It is not exactly like the fruit of any modern member of the family known to me, but it resembles several of the existing genera in certain particulars. It is much smaller than *Sterculiocarpus eocenicus* Berry, the valves are less strongly keeled, and the dehiscence is much more pronounced, although this may be partly due to compression during fossilization. Among previously described fossil

[1] Viguier, René, Revue générale de botanique, vol. 20, pp. 6–13, text figure 1, pl. 5, figs. 1–7, 10, 1908.

forms, the present species is so similar to the capsules in the genus Sezanella, already mentioned in the discussion of *Sterculiocarpus eocenicus*, that I have commemorated this resemblance in the specific name. The present species is apparently a rare form in the Wilcox deposits, which may possibly indicate that it was the fruit of an inland species of Sterculiaceæ. The abundance of different sized leaves of *Sterculia puryearensis* Berry in the same beds rather indicates that the foliage and fruit are not those of the same botanic species, for they would hardly have come to rest in the same beds, or if the nature of the fruits was such that they would sink as quickly as the foliage there should be an abundance of fruits instead of a single specimen.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family BOMBACACEÆ.

Genus BOMBACITES Berry, n. gen.

BOMBACITES FORMOSUS Berry, n. sp.

Plate LXXV, figure 1.

Description.—Leaves palmately compound. Leaflets relatively large, broadly lanceolate in outline, somewhat inequilateral and falcate, sessile or slightly petiolulate. Apex and base about equally acute, the base if anything a trifle more extended and slightly decurrent to the broad base of the petiolule just above its attachment to the leaf stalk. Length about 8 centimeters. Maximum width, at a point midway between the apex and the base, about 2.5 centimeters. Texture thick and coriaceous. Margins entire in the lower half; the upper half contains small dentate or serrate teeth, somewhat irregularly spaced and separated by shallow, equilaterally rounded sinuses. Midrib stout, more or less curved. Secondaries thin, subparallel, not prominent, nine or ten opposite to subopposite pairs, branching from the midrib at angles that average about 65°, curving upward near the margin in broad camptodrome arches. Tertiary venation immersed in the leaf substance.

In the existing flora the subfamily Adansonieæ of the family Bombacaceæ is made up of the following genera: Adansonia Linné, which includes the baobab of Africa and two or three additional species of Madagascar and North Australia; Bombax Linné, which comprises 50 species, mostly of tropical America, though one lives in Africa, six in Asia, and one in North Australia; Chorisia Humboldt, Bonpland, and Kunth, which contains three tropical species of South America; and Ceiba Gärtner, which embraces about 10 species of Central and South America, including the widely cultivated silk cotton tree of tropical countries.

All the forms have digitately compound leaves, the leaflets of which are rather large and entire or toothed. The present species is clearly referable to this subfamily and is very close to several existing species of tropical America of the genera Bombax and Chorisia. Because of the uncertainty as to which of these modern genera it is most like, and the probability that the generic limits were different in the early Eocene, the generic term Bombacites is proposed for the reception of this and other fossil species which are clearly referable to this subfamily but which can not be positively referred to one of the existing genera.

Foliage of the type of Bombacites occurs in abundance in the upper Eocene of Europe, and a few species continue in that area throughout the Tertiary period. Species referred to Bombax have been recorded from the Cretaceous of America by Fontaine[1] and from that of Europe by Velenovsky.[2] Fontaine's form has absolutely no claim to the name Bombax and Valenovsky's form is extremely doubtful.

A number of the European species are very similar to the present form, including *Bombax neptuni* Ettingshausen,[3] recorded from the Sannoisian Mayencian, and Sarmatian, which is probably closest to the American Eocene species and has the same general form, margin, and venation but is slightly wider; next in degree of affinity is *Bombax chorisiæfolium* Ettingshausen,[4] which comes from the base of the Miocene in Bohemia and which differs in its more prominent and close-set teeth and more extended petiolule; *Bombax chorisioides* Friedrich,[5] recorded from the Sannoisian of Saxony, has more prominent serrate teeth;

[1] Fontaine, W. M., U. S. Geol. Survey Mon. 15, p. 310, pl. 151, fig. 1, 1889 (*Bombax virginiensis*).

[2] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, Theil 1, p. 20, pl. 2, figs. 17–19; pl. 4, figs. 6–9, 1883 (*Bombax argillaceum*).

[3] Ettingshausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Radoboj, p. 886, pl. 3, fig. 17, 1870.

[4] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 3, p. 11, pl. 42, figs. 2, 4, 5, 1869.

[5] Friedrich, Paul, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen, p. 144, pl. 19, fig. 5, 1883.

Bombax sepultiflorum Saporta,[1] based in the first instance on the remarkably preserved remains of flowers at Aix in France (Sannoisian) but afterward correlated with the foliage which had been originally described by the same author as Knightites.[2] The leaves of *Bombax sepultiflorum* are more prominently and serrately toothed and are very close to those of *Ceiba pentandra* (Linné) Gärtner of the American Tropics. The flowers, beautifully preserved in the gypsiferous shales, were compared with those of the existing species *Bombax heptaphyllum*.

Among antecedent forms that may be mentioned are certain of the specimens from the Cenomanian of Bohemia, referred by Velenovsky to *Aralia coriacea*[3] and subsequently transferred to the genus Dewalquea.[4] The broader forms of this type (for example, Pl. I, figs. 1, 2, 4, of Velenovsky, 1884) are very much like Bombacites, but the narrower forms suggest a relationship with *Oreopanax oxfordensis*. *Aralia coriacea* has been identified by Hollick[5] from the Upper Cretaceous of the Atlantic Coastal Plain, but his material is not especially convincing.

The accompanying drawing (fig. 15) is an attempted restoration of a branch of *Bom-*

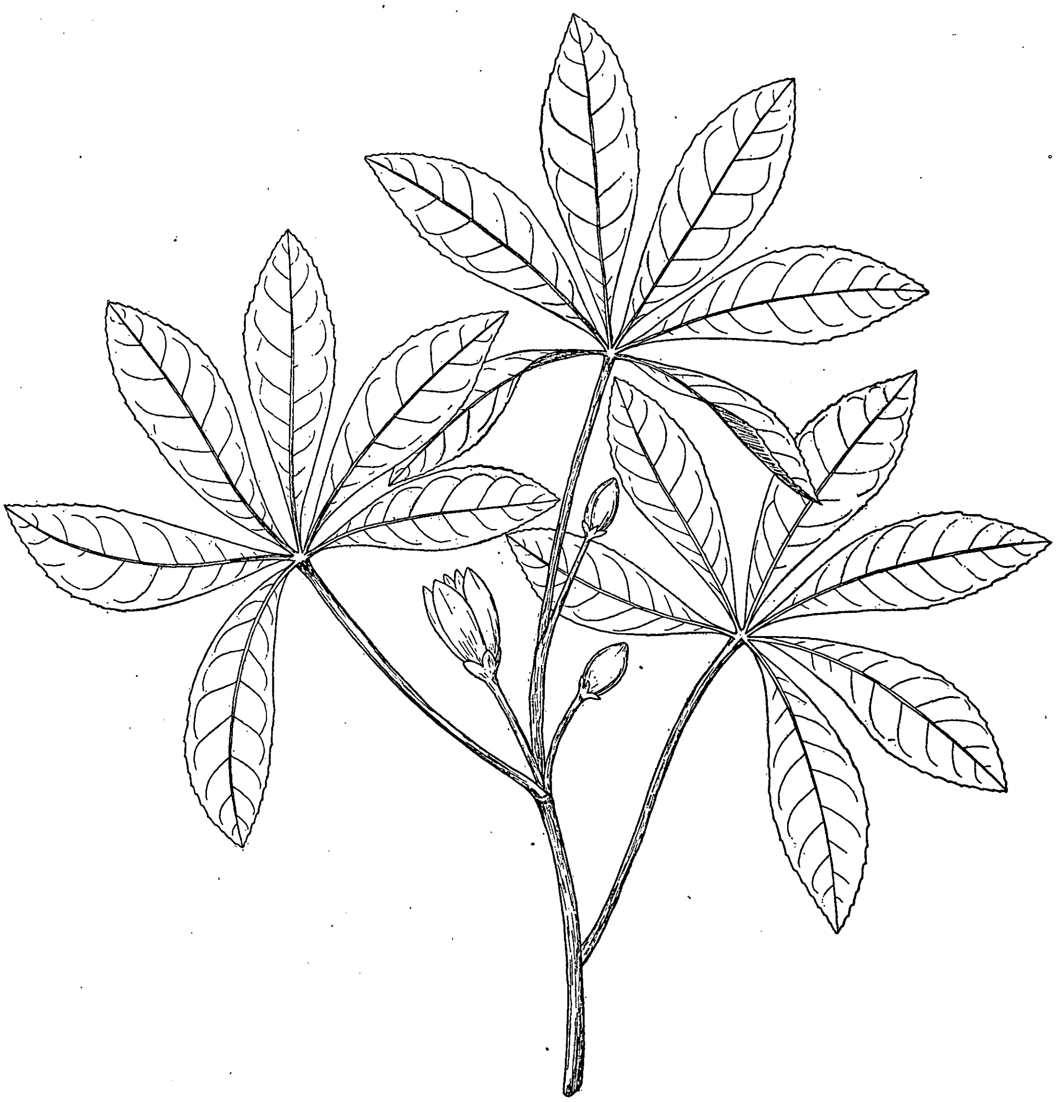

FIGURE 15.—Restoration of *Bombacites formosus* Berry. (One-half natural size.)

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 119, pl. 12, fig. 3, 1863.

[2] Idem, vol. 1, p. 101, pl. 9, fig. 1, 1863; vol. 3, suppl. 1, p. 86, pl. 14, 1867 (*Knightites salyorum* and *Knightites gaudini*).

[3] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, Theil 3, p. 11, pl. 1, figs. 1–9; pl. 2, fig. 2, 1884.

[4] Velenovsky, Josef, Květena českého cenomanu, p. 23, pl. 4, figs. 1–6, 1889.

[5] Hollick, Arthur, U. S. Geol. Survey Mon. 50, p. 99, pl. 38, figs. 5, 6, 1907.

bacites formosus. Except for its relatively smaller size, slightly different margin, and less numerous secondaries it would answer equally well for *Bombacites wilcoxianus*. The details and floral characters are of course conjectural but are sufficiently generalized to escape criticism. The foliar characters are believed to be correct and are based on numerous specimens of the fossil as well as on a consideration of the uniformly digitate, long-petioled leaves of the modern members of the subfamily Adansonieæ. Suggestions have been obtained from a study of the leaves of numerous Brazilian species of Bombax and Chorisia.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Bombacites wilcoxianus Berry, n. sp.

Plate LXXV, figure 2.

Description.—Leaflets as a rule relatively large, ovate-lanceolate in outline and slightly inequilateral, petiolulate. Length ranges from 8.5 to 11 centimeters. Maximum width, which is in the middle part of the leaf, ranges from 2.25 to 3 centimeters. Apex narrowed and extended, acuminate. Base narrowly cuneate and slightly decurrent. Petiolule stout, curved, tumid proximad, about 1 centimeter in length. Margins distinctly undulate, the chords of the undulations becoming progressively shorter distad until toward the tip the margin is weakly dentate. Texture coriaceous. Midrib very stout below, becoming thin in the apex, curved. Secondaries thin, subparallel, about 12 opposite to alternate pairs; they diverge from the midrib at wide angles that become somewhat more acute distad, curve upward in very flat arches, and ultimately curve in a camptodrome manner parallel with the marginal undulations and close to them, where they join the adjoining superior secondaries. Tertiary venation obsolete.

This species is clearly distinct from previously described forms and is obviously referable to the subfamily Adansonieæ of the Bombacaceæ. It resembles *Bombacites formosus* considerably but differs in its larger size, undulate margins, extended acumen, more numerous secondaries, which approach closer to the margins, and in the development of a stout petiolule.

Comparable recent and fossil forms are discussed at length under the *Bombacites formosus* and need not be repeated since their discussion applies almost equally well to both species.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

Order PARIETALES.

Family DILLENIACEÆ.

Genus DILLENITES Berry, n. gen.

The genus Dillenites is proposed for the reception of fossil plants that show characters of the Dilleniaceæ but not sufficient to ally them with certainty to a particular existing genus.

The genus may be considered as having the generic characters included in the descriptions of the following species:

Leaves more than 10 centimeters long, apex and base equally pointed, margin entire below, carries wide-spaced serrate teeth above...... *Dillenites microdentatus.*
Leaves less than 10 centimeters long:
  Ovate, base broadly rounded....... *Dillenites ovatus.*
  Base narrowed:
    Leaves relatively broad, teeth close-set, acuminate-serrate................. *Dillenites serratus.*
    Relatively narrow, teeth close-set, incumbent-serrate................. *Dillenites tetracerafolia.*
    Teeth remote, straight-serrate.. *Dillenites texensis.*

Dillenites microdentatus (Hollick) Berry.

Plates LXXV, figure 3; LXXVII, figure 1; CXIV, figure 5.

Quercus microdentata. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 34, 1899.

Description.—Leaves medium sized to large, elliptical in general outline, apex and base acuminate and equally pointed. Length ranges from 11.75 to 22 centimeters. Maximum width, midway between the apex and the base, ranges from 6.5 to 9 centimeters, the lateral margins forming regularly curved arcs from base to tip. Margins entire and undulate proximad for about one-third to one-half their length, crenate-serrate for the upper one-third to two-thirds of their length, the teeth remote and more or less evenly spaced, not enlarged, becoming closer distad. Texture coriaceous. Petiole missing. Midrib stout and prominent. Secondaries relatively thin, numerous, about

22 pairs, indifferently opposite to alternate; they diverge from the midrib at angles that average about 50°, widest basally and rather straight in their courses; a few basal ones camptodrome, the great majority as a rule craspedodrome, curving upward in the marginal region and each terminating in a marginal tooth. Tertiaries mostly obsolete, percurrent where seen.

Smaller specimens collected by me at the type locality are slightly inequilateral; the midrib is curved, and the marginal teeth are confined to the upper part of the leaf.

The present form was described by Hollick as a new species of Quercus, and it shows more or less resemblance to certain living and fossil species of chestnut oaks. It has, however, more obvious similarities with the leaves of various families whose recent distribution make them far more probable elements in the Wilcox flora—such families as the Dilleniaceæ, Ochnaceæ, Verbenaceæ, and Ternstrœmiaceæ. It resembles some modern forms of Clerodendron, such as *Clerodendron serratum* Sprengel, a type described by Friedrich[1] from the Oligocene of Saxony. It appears to be most closely allied with several genera of the tropical family Dilleniaceæ, more particularly the genera Tetracera Linné and Dillenia Linné. Tetracera comprises about 35 existing species, 2 confined to tropical South America, 2 confined to the Indo-Malayan region, and the remainder cosmopolitan tropical forms. The genus Dillenia is not a native of America in the recent flora, its 25 existing species being confined to tropical Asia, Malaysia, and Australia. The present species is very similar to *Dillenia indica* Linné (*Dillenia speciosa* Thunberg). Only one fossil species has been referred to Dillenia, namely, *Dillenia palæocenica* Saporta and Marion,[2] a narrower and more prominently toothed form, unfortunately based on very incomplete material from the lower Eocene of Belgium but apparently congeneric with *Dillenites microdentatus*. This Wilcox species is not unlike a form from the Thanetian of the Paris Basin described by Watelet[3] as *Castanea sezannensis*. Two species of Tetracera have been described by Engelhardt from the Tertiary of Chile.

It seems very probable that when we shall have learned to recognize the botanic affinities of leaves of this type with greater precision, as well as to accurately postulate the physical conditions under which the fossil floras lived, that a number of Eocene forms now masquerading as species of Quercus will be referred to Dillenites.

I am indebted to Dr. Arthur Hollick for the loan of his drawing of the type of this species.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris and E. W. Berry); 1½ miles northeast of Mansfield, 3½ miles southeast and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—New York Botanical Garden; U. S. National Museum.

DILLENITES OVATUS Berry, n. sp.

Plate LXVIII, figure 2.

Ulmus tenuinervis Lesquereux. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 280, pl. 32, fig. 6, 1899.

Description.—Leaves relatively small, short, and broad, ovate and equilateral in general outline. Apex acuminate, not extended. Base broadly rounded. Length about 4.75 centimeters. Maximum width below the middle about 2.5 centimeters. Margins entire near the base and apex; elsewhere they carry serrate teeth, which show a tendency to become crenate. Texture subcoriaceous. Petiole missing. Midrib stout, prominent, and slightly curved. Secondaries thin; about eight opposite to alternate pairs diverge from the midrib at different angles, open below and more ascending in the upper part of the leaf; all are much curved throughout their course and finally craspedodrome, sending off an outwardly directed branch distad, which also terminates in a marginal tooth. Tertiaries obsolete.

This species is based on a specimen from the Wilcox of Louisiana, which was referred by Hollick to *Ulmus tenuinervis* Lesquereux,[4] a much younger species of the Rocky Mountain province. The two forms are decidedly unlike not only in specific but in generic and ordinal characters. *Ulmus tenuinervis* is a typical Ulmus and is much more gradually narrowed

[1] Friedrich, Paul, K. preuss. geol. Landesanstalt Abh., vol. 4, p. 339, pl. 23, figs. 1-3, 1883.

[2] Saporta, G. de, and Marion, A. F., Revision de la flore heersienne de Gelinden, p. 82, pl. 12, fig. 7, 1878.

[3] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 142, pl. 36, figs. 1, 2, 1866.

[4] Lesquereux, Leo, The Tertiary flora, p. 188, pl. 26, figs. 1-3, 1878.

and elongated distad, markedly inequilateral especially proximad, with the typically double serrate margin of this genus. The secondaries are more numerous and much less curved and the tertiaries are percurrent or forked. The species now under discussion is clearly unallied to Ulmus, which, as a rule, is very inequilateral, or to Carpinus or to the species of Juglandaceæ, Celastraceæ, Rhamnaceæ, Sapindaceæ, and the like, with which it has been compared. It appears to be allied with the group of forms which I have constituted as the genus Dillenites of the Dilleniaceæ. Among these forms it is clearly distinct by reason of the broadly rounded base and much-curved ascending secondaries. In the known Wilcox flora the only species at all similar to it is *Juglans saffordiana* Lesquereux. In addition to the type material a single leaf of this species was discovered in splitting up some apparently worthless specimens of clay ironstone collected by Hilgard many years ago.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris). Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard, E. N. Lowe, and E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

DILLENITES SERRATUS Berry, n. sp.

Plate LXXV, figure 6.

Description.—Leaves small, ovate-lanceolate in general outline, the tip gradually narrowed and acuminate and the base acuminate and decurrent. Length about 6 or 7 centimeters. Maximum width at or below the middle of the leaf about 2.3 centimeters. Margins entire below for a distance of about 1 centimeter. Above the entire portion they show small close-set, upwardly directed, acuminate-serrate teeth. Texture coriaceous. Petiole medium sized, not preserved for its full length. Midrib of medium size. Secondaries thin but prominent, somewhat unequally spaced, subparallel; about 12 subopposite to alternate pairs diverge from the midrib at angles of about 45° and pursue a rather straight craspedodrome course. Tertiaries thin, comprising percurrent nervilles and one or two craspedodrome branches from the upper outer sides of the secondaries.

This species is much smaller than *Dillenites microdentatus* (Hollick) Berry, from which it also differs in its less regular secondaries and close-set marginal teeth. It is more robust than *Dillenites tetracerafolia* Berry, from which it differs also in the character of the marginal teeth, in general outline, and to a less degree in venation. Like that species, *Dillenites serratus* is very similar to certain existing species of Tetracera Linné, a cosmopolitan tropical genus. *Dillenites serratus* is not especially close to any described fossil forms, although certain leaves ascribed to the Celastraceæ and Ilicaceæ resemble it in outline but differ markedly in venation. For example, *Celastrus persei* Ettingshausen,[1] from Sagor in Carniola is identical in size, outline, and marginal character, but has a very different venation. There is also a superficial resemblance between these leaves and various fossil and living species of Ulmaceæ.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

DILLENITES TETRACERAFOLIA Berry, n. sp.

Plate LXXV, figures 4 and 5.

Description.—Leaves small, ovate-lanceolate and falcate in outline, the apex and base gradually narrowed and acuminate and the base decurrent. Length about 3.5 to 4 centimeters. Maximum width, in the middle part of the leaf, about 1.2 centimeters. Margins entire proximad. Along their distal two-thirds they carry apparently broad shallow crenate teeth, which are really incumbent serrate; the apex of each is small, sharply pointed, and distally directed. Texture coriaceous. Petiole short and stout, about 6 millimeters in length. Midrib stout, curved, broad but not prominent. Secondaries immersed in the leaf substance and only seen with magnification, thin, diverging from the midrib at wide angles, one running to each marginal tooth. Tertiaries obsolete.

These small, commonly more or less inequilateral, falcate leaves are characteristic, although superficially they suggest some of the Wilcox species of Ternstrœmites as well as certain described species of Celastrus from the European Tertiary. They are not especially close to the large Wilcox species *Dillenites microdentatus* (Hollick) and are smaller and more falcate than *Dillenites serratus* Berry and

[1] Ettingshausen, C. von, Die fossilen Flora von Sagor in Krain, Theil 2, p. 31, pl. 16, fig. 1, 1877.

have a different margin from that species. Among modern forms they are very similar to several species of the genus Tetracera Linné, which fact has suggested the specific name. Several species of Tetracera, for example *T. arborescens* Jack of Sumatra and *T. senegalensis* De Candolle of West Africa, are strand plants.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Dillenites texensis Berry, n. sp.

Plate LXVIII, figure 5.

Description.—Leaves medium sized, broadly oblong-lanceolate and slightly inequilateral in general outline. Length about 9.5 centimeters. Maximum width, in the middle part, about 3.3 centimeters. Apex sharply pointed. Base pointed, incurved, and decurrent. Margins feebly straight-serrate; teeth distinct, one to each secondary, or less in number than the secondaries. Texture subcoriaceous. Petiole not preserved. Midrib rather stout, prominent on the lower surface of the leaf. Secondaries relatively stout and prominent; at least 15 pairs diverge from the midrib at close but somewhat irregular intervals at angles of about 50°; their course is relatively straight except in the marginal region, where they curve upward somewhat and are craspedodrome. Tertiaries thin and largely immersed in the leaf substance; a few percurrent and lateral veins are visible, apparently forming open obsolete meshes.

This species, which is founded on very imperfect material collected from the sandy laminated clays of the Wilcox group along Colorado River in Texas and from a single specimen from the Grenada formation of Grenada, Miss., appears to be closely allied to the contemporaneous forms which are referred to the new genus Dillenites. It lacks the ovate outline and more numerous teeth of *Dillenites ovatus* Berry and the close-set teeth of the two small-leafed species *Dillenites tetracerafolia* Berry and *Dillenites serratus* Berry. Though less robust and much smaller it resembles *Dillenites microdentatus* (Hollick) Berry in the characters of the margin and in venation but differs somewhat in general outline.

Like the associated smaller-leafed species of *Dillenites*, it shows great similarity to existing tropical American forms of the genus Tetracera Linné (Rhinium Schreber, Euryandra Förster, Wahlbomia Thunberg). The slightly inequilateral outline suggests comparisons with the leaflets of compound leaves, for example those of Fraxinus or Rhus, and such comparisons have been made without success. Similar leaves, generally from younger horizons, have often been referred to the genus Planera, but many of these references are not conclusive.

Occurrence.—Wilcox group, 1,000 yards below Pope Bend on Colorado River, Bastrop County, Tex. (collected by Alexander Deussen). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collections.—U. S. National Museum.

Family TERNSTRŒMIACEÆ (THEACEÆ).

Genus TERNSTRŒMITES Berry, n. gen.

This genus is proposed for leaves resembling those of Gordonia, Hæmocharis, Pyrenaria, Freziera, Eurya, and the like, of the family Ternstrœmiaceæ, probably representing an ancestral Eocene form of more than one existing genus. For the present its characters are those of the following species:

Leaves with acuminate apex and base, margin finely dentate-serrate .... *Ternstrœmites eolignitícus.*
Base broadly rounded, slightly decurrent, margin rather coarsely crenate .... *Ternstrœmites preclaibornensis.*
Apex bluntly pointed, base much decurrent, margin finely crenate .... *Ternstrœmites ovatus.*
Leaves linear-lanceolate, falcate, margin shows distant shallow crenations .... *Ternstrœmites lanceolatus.*

Ternstrœmites eolignitícus Berry, n. sp.

Plates LXXVI, figures 1 and 2, and LXXVIII, figure 5.

Description.—Leaves as a rule relatively large, oblong-lanceolate in general outline, the tip narrowed and extended acuminate and the base sharply cuneate. Length ranges from 11 to 18 centimeters. Maximum width, at a point about midway between the apex and the base, ranges from 1.5 to 3.25 centimeters. Margins entire at the base, above which close-set dentate teeth gradate upward into serrate teeth, the margins in their entirety being irregularly more or less undulate. Texture coriaceous. Petiole not preserved. Midrib very stout, prominent on the lower surface of the leaf. Secondaries thin, numerous; about 25 unequally spaced and indifferently opposite to alternate pairs diverge from the midrib at angles of 60° to 80°, pursue a course that as a rule is but slightly curved, and are abruptly camptodrome some distance from the margins. Tertiaries very thin but distinct, forming irregularly sized and shaped four, five, and six sided meshes.

The form, toothed margin, thick midrib, and thin flat secondaries, abruptly camptodrome well within the margin, are abundant evidence of the relation of this Eocene species to certain existing and geographically scattered Ternstrœmiaceæ. I have compared it with all the existing genera, among which I will mention without undertaking detailed comparisons the following: *Gordonia excelsa* of the East Indies, *Hæmocharis semiserrata* (Cambessedes) of Bolivia, *Pyrenaria serrata* Blume of Java, *Eurya serrata* Blume of Java, and several American tropical species of Freziera Swartz, especially *Freziera undulata* Swartz of the West Indies, which, however, is smaller.

Numerous species of this family have been described from the European Tertiary and referred to the genera Stuartia, Freziera, Ternstrœmia, Saurauja, and the like. The present species is also much like a leaf described by Ettingshausen from the Bohemian Aquitanian as *Ardisia myricoides*.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

TERNSTRŒMITES PRECLAIBORNENSIS Berry, n. sp.

Plate LXXVIII, figures 1–4.

Description.—Leaves differ greatly in size, oblong-ovate in general outline. Length ranges from 6.5 to 13 centimeters. Maximum width, slightly below the middle of the leaf, ranges from 1.5 to 3.5 centimeters. Apex variable, either narrowed and bluntly pointed or elongated as a narrow or bluntly pointed acumen. Base rounded, or the rounded basal lateral margins may be more or less decurrent on the petiole. Petiole stout, its full length not preserved. Midrib stout, slightly curved, becoming attenuated in the acumen when one is developed, prominent on the lower surface of the leaf. Secondaries relatively thin, not prominent; about 15 opposite to alternate pairs diverge from the midrib at angles of about 80° and pursue a nearly straight course outward until they turn abruptly upward to form camptodrome arches a considerable distance within the margins. Tertiaries mostly obsolete; a few fine, nearly straight, percurrent ones were seen. Margins more or less prominently crenate, the teeth becoming flattened to undulations toward the apex and nearly straight in the acumen when one is developed; they also become obsolete in the basal part of the leaf. Texture subcoriaceous.

This species is clearly distinct from the larger and serrate-toothed *Ternstrœmites eolignitícus* Berry of the Wilcox flora. It is, however, similar and probably ancestral to *Ternstrœmites claibornensis* Berry, found in the Yegua ("Cockfield") formation of the Claiborne group, although it attains a larger size and is relatively somewhat wider, has fewer and more prominent secondaries, and is without the minute areolation of the Yegua species. Many specimens are slightly inequilateral. It is common in the clays at Puryear, Tenn.

Both this and the associated species of Ternstrœmites show many points of similarity to some of the Upper Cretaceous leaves commonly referred to the form genus Celastrophyllum. For example, *Celastrophyllum grandifolium* Newberry [1] of the Raritan formation in New Jersey is almost certainly referable to the Ternstrœmiaceæ and very probably ancestral to *Ternstrœmites preclaibornensis* Berry.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collection.—U. S. National Museum.

TERNSTRŒMITES OVATUS Berry, n. sp.

Plate LXXVII, figures 2–4.

Description.—Leaves medium sized, ovate in general outline, apex bluntly pointed and the base gradually narrowed and much decurrent. Length ranges from 13 to 17 centimeters. Maximum width, in the middle part of the leaf, ranges from 3 to 4 centimeters. Margins entire at the extreme base, above which they

[1] Newberry, J. S., The flora of the Amboy clays, p. 104, pl. 19, fig. 8; pl. 21, figs. 1–4, 1896.

carry minute close-set crenate teeth. Texture coriaceous. Petiole missing. Midrib stout, nearly straight, prominent on the lower surface of the leaf. Secondaries medium sized, not prominent, numerous, diverging from the midrib at angles of about 50°, somewhat irregularly spaced, straight at first, curving abruptly upward about two-thirds of the distance to the margin to form camptodrome arches.

This species is shorter and wider than *Ternstrœmites eolignitícus* Berry and the teeth are smaller, more close-set, and different. It is much like the larger leaves of *Ternstrœmites preclaibornensis* Berry but is more abruptly pointed, more narrowly decurrent, and the teeth are much smaller and more numerous.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry); Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

TERNSTRŒMITES LANCEOLATUS Berry, n. sp.

Plate LXXVII, figure 5.

Description.—Leaves linear-lanceolate and many of them falcate in outline, the apex acuminate and the base narrowed and markedly decurrent. Length ranges from 6 to 14 centimeters. Maximum width, below the middle, ranges from 6.5 millimeters to 2 centimeters. Margins entire for a short distance proximad, above which they bear more or less distant, very broad and shallow, crenate teeth. Texture coriaceous. Petiole stout, about 2.5 centimeters in length in the larger leaves. Midrib very stout and curved. Secondaries numerous, subparallel, thin, largely immersed, diverge from the midrib at angles of about 45°, slightly curved until the marginal region is reached, where they are regularly camptodrome. Tertiaries thin, mostly obsolete by immersion in the leaf substance, forming relatively large four or five sided meshes.

This species is smaller and relatively narrower than *Ternstrœmites eolignitícus* Berry or *Ternstrœmites ovatus* Berry. It is somewhat similar to the narrower forms of *Ternstrœmites preclaibornensis* Berry, but it may be distinguished at once by its less prominent teeth, longer petiole, more numerous, more ascending, and thinner secondaries.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry); Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Order THYMELEALES.

Family LAURACEÆ.

Genus CINNAMOMUM Blume.

Leaves with rounded tips........*Cinnamomum obovatus.*
Leaves with pointed tips:
  Primaries strictly acrodrome.....*Cinnamomum vera.*
  Primaries subacrodrome:
    Leaves small, linear or oblong-lanceolate. *Cinnamomum oblongatum.*
    Leaves large, oblong-lanceolate, equally acuminate at both ends..*Cinnamomum postnewberryi.*
    Leaves large, broad, tips more acuminate than bases:
      Ovate, tips not apiculate. *Cinnamomum mississippiensis.*
      Ovate, tips apiculate..*Cinnamomum buchii.*

CINNAMOMUM OBOVATUS Berry, n. sp.

Plate XXIX, figure 3.

Description.—Leaves medium sized, obovate in general outline, the tip broadly rounded, perhaps abnormal, and the base gradually narrowed, cuneate, and decurrent. Length about 5 centimeters. Maximum width, above the middle of the leaf, about 2.1 centimeters. Margins entire. Texture coriaceous. Petiole short, very stout, curved, enlarged proximad, about 7 millimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Lateral primaries, one on each side, subopposite, thin, suprabasilar, diverging from the midrib at angles of about 20°, rather straightly ascending parallel with the lateral margins, camptodrome in the upper part of the leaf. Secondaries thin, two or three alternate camptodrome pairs in the upper part of the leaf. Tertiaries thin but well marked, forming small straight-sided arches along the primaries, internally forming rather straight, anastomosing, mainly transverse veinlets. Nervilles forming small quadrangular or polygonal meshes.

This species is represented by the single specimen figured, which may be an abnormal variant of some other lauraceous member of the Wilcox flora. If it is assumed that the rounded apex is abnormal the base is surely normal, and this as well as the character of the venation differs from the known members of this flora, so that I am constrained to describe it as a new species.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CINNAMOMUM VERA Berry, n. sp.

Plates LXXIX, figures 3–8, and LXXXVII, figure 4.

Description.—Leaves elliptical to ovate-lanceolate in outline, somewhat variable in proportions and size, ranging from 4 to 8 centimeters in length and from 1.5 to 2.8 centimeters in maximum width about midway between the apex and the base. In the typical forms the apex and base are identical in size and shape and are broadly pointed by the coming together of the full rounded lateral margins, the leaves being strictly equilateral. There is a tendency in some specimens, like those figured from Oxford, Miss., and Puryear, Tenn., for the leaves to assume a narrower form, the apex being narrowed as compared with the broad base, somewhat elongated and acuminate, and these leaves are slightly falcate. The leaves were evergreen and coriaceous, and the margins were entire. Petiole short and stout, 3 to 5 millimeters in length, the average being about 4 millimeters, curved, and in some specimens 1.5 millimeters in diameter. There is a slight decurrence of the extreme basal margins on the petiole. The midrib is rather stout, considerably thinner than the petiole, generally straight. The lateral primaries are thinner than the midrib, from which they branch at or near the extreme base at angles of about 30°, regularly bowed and acrodrome, reuniting with the midrib at its extreme tip at the same or slightly more acute angles than their divergence angles. Outside the main primaries there is a single accessory primary on each side of the leaf. These accessory primaries diverge from the top of the petiole at slightly wider angles than the main primaries and run parallel with them and also with the leaf margin, pursuing a course close to the margin; in some specimens they constitute a marginal hem and in others are distant from the margin as much as 1.5 millimeters. Tertiaries fine, numerous, and obliquely transverse, both between midrib and main primaries and the main and accessory primaries. In no specimens are secondaries developed of the type found in the distal part of most species of Cinnamomum, nor are there any marginal upwardly directed and camptodrome tertiaries as in most species of Cinnamomum.

This is an unusually well marked species and unlike any previously described fossil species, although identical with several existing species. Species of Cinnamomum are abundant from the middle Cretaceous to the present. The leaves are always rather variable, as the reader can see by consulting the figures of the widespread Tertiary species *Cinnamomum buchii* Heer, *C. scheuchzeri* Heer, *C. rossmässleri* Heer, *C. polymorphum* Heer, and *C. lanceolatum* Heer. Leaves of the types of these species are recorded from numerous American, European, and some Asiatic localities at horizons ranging from the base of the Eocene through the Pliocene. They are figured by Heer [1] and by numerous other authors. It is possible to find single variants among Heer's species, as well as among the fifty or more additional fossil species, that closely resemble *Cinnamomum vera*, but none are consistently similar, the most similar being *Cinnamomum rossmässleri* Heer.[2]

Cinnamomum vera appears to have been common all along the eastern shore of the embayment during middle and later Wilcox time.

Occurrence.—Holly Springs sand, Oxford, Lafayette County, Miss., and Holly Springs, Marshall County, Miss. Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (All collected by E. W. Berry.)

Collections.—U. S. National Museum.

CINNAMOMUM OBLONGATUM Berry, n. sp.

Plates LXXIX, figures 1 and 2, and LXXXIII, figure 6.

Description.—Leaves small but different in size, oblong-lanceolate in general outline, the apex gradually narrowed and acuminate and the base cuneate and slightly decurrent. Length ranges from 7 to 10 centimeters. Maximum width, in the middle part of the leaf, ranges from 1.25 to 1.8 centimeters. Margins entire. Texture coriaceous. Petiole very stout,

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, pls. 91–95, 1856.
[2] Idem, p. 84, pl. 93, figs. 2–4, 15–17.

generally curved, about 6 millimeters in length. Midrib stout and prominent. Lateral primaries thin, diverging from the midrib at acute angles very near its base, acrodrome, running close to and parallel with the margins. Tertiaries thin, numerous, nearly straight, and transverse.

This species, though it greatly resembles some of the forms referred to *Cinnamomum lanceolatum* (Unger) Heer,[1] is clearly distinct and may be distinguished from this and allied species of lanceolate Cinnamomums by the lack of widening in the basal lamina. It is represented in the succeeding Claiborne flora by a closely allied, undescribed species, which probably represents a direct descendant and is consistently narrower and more linear, with suprabasilar lateral primaries and a somewhat different and well-marked tertiary venation.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson).

Collection.—U. S. National Museum.

CINNAMOMUM POSTNEWBERRYI Berry, n. sp.

Plate LXXIX, figure 9.

Cinnamomum scheuchzeri Heer. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 41, fig. 4, 1899.

Daphnogene Kanii Heer. Hollick, idem, p. 284, pl. 41, fig. 3.

Description.—Leaves differing in size, lanceolate in general outline, equally pointed at the apex and the base. Length ranges from 8 to 13 centimeters. Maximum width, midway between the apex and the base, ranges from 2.25 to 3.5 centimeters. Margins entire, uniformly and regularly rounded. Texture coriaceous. Petiole not preserved. Midrib stout and prominent. Lateral primaries nearly as stout as the midrib, prominent, diverging from its extreme base at angles of about 10°, acrodrome about halfway between the midrib and the margins, and parallel with the margins. One or two camptodrome secondaries may be developed in the extreme tip of the leaf. Outer branches from the primaries diverge at a wide angle and are rather straight and camptodrome. Midrib and primaries connected by nearly straight, thin transverse veins.

This species is represented by fragmentary specimens from the western embayment area, some of which were confused with Arctic or European forms by Hollick. They resemble *Cinnamomum scheuchzeri* Heer and *Daphnogene kanii* Heer in a general way but are perfectly distinct, differing in general form and in the details of their venation.

The present species is named from its obvious filiation with the widespread Upper Cretaceous species *Cinnamomum newberryi*,[2] of which abundant figures may be consulted under the preoccupied name *Cinnamomum intermedium* Newberry.[3]

Occurrence.—Wilcox group, Slaughter Pen and Vineyard bluffs on Cross Bayou, Caddo Parish, La. (collected by A. C. Veatch), and Hardys Mill, Greene County, Ark. (collected by R. E. Call).

Collections.—U. S. National Museum; New York Botanical Garden.

CINNAMOMUM MISSISSIPPIENSIS Lesquereux.

Plate XXXVII, figure 2.

Cinnamomum mississippiensis. Lesquereux, in Dana, J. D., Manual of geology, 1st ed., p. 513, fig. 794, 1866.

Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 418, pl. 19, fig. 2, 1869.

Knowlton, Am. Geologist, vol. 16, p. 308, 1895.

Description.—Lesquereux's description, written in 1869, is as follows:

C. foliis subcoraceis, ovatis, lanceolatis, acuminatis, basi in petiolo brevi, semipollicari longo, subdecurrentibus, integerrimis, triplinerviis, nervis lateralibus ultra ⅔ evanidis.

Lesquereux described *Cinnamomum affine* in the American Journal of Science for 1868 without figures and in 1869 he described and figured *Cinnamomum mississippiensis* in the Transactions of the American Philosophical Society. Knowlton in 1898 united these two species, but after detailed comparisons I believe that they are distinct. Lesquereux had furnished a figure of the southern form to Dana, who published it in the first edition of his Manual in 1866, so that the name *mississippiensis* must obviously stand for the combination in case it should be discovered that *mississippiensis* is simply a variant of *affine.* The species is not common in the embayment region and is

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 86, pl. 93, figs. 6–11, 1856.

[2] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 423, 1911.

[3] Newberry, J. S., The flora of the Amboy clays, p. 89, pl. 29, figs. 1–8 10, 1896.

only represented in the available collections by fragments, the type collected by Hilgard having been subsequently lost.

The species is represented in the lower Eocene of the Rocky Mountain region, where it occurs as far south as New Mexico.

Occurrence.—Ackerman formation, Raglands Branch, Lafayette County, Miss. (collected by E. W. Hilgard). Dana gives a locality in Winston County, Miss., at Colemans Mill near New Prospect, now in Choctaw County. At this locality a collection, probably otherwise unrecorded, was made by Hilgard.

Collection.—U. S. National Museum.

CINNAMOMUM AFFINE Lesquereux.

Cinnamomum affine. Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, p. 206, 1868.
Lesquereux, The Tertiary flora, p. 219, pl. 37, figs. 1–4, 7, 1878 (not fig. 5).
Knowlton, U. S. Geol. Survey Bull. 152, p. 68, 1898.

Description.—This species has already been described from the Midway (?) of Texas. (See p. 13.) It is common in the Wilcox of the western Gulf area but has not been observed in the eastern Gulf area. The material is identical with that described by Lesquereux from the Denver formation of the Rocky Mountain province.

Occurrence.—Old Port Caddo Landing, on Little Cypress Bayou, Cross Lake, Harrison County, Tex. (collected by T. W. Vaughan); sec. 28, T. 13 N., R. 12 W., 1½ miles northeast of Mansfield and 2¾ miles southeast of Naborton, De Soto Parish, La. (collected by G. C. Matson).

Collections.—U. S. National Museum.

CINNAMOMUM BUCHII Heer.

Plate LXXIX, figure 10.

Cinnamomum Buchii. Heer, Flora tertiaria Helvetiæ, vol. 2, p. 90, pl. 95, figs. 1–8, 1856.
Gaudin and Strozzi, Contributions à la flore fossile italienne, pt. 2, p. 49, pl. 8, fig. 3, 1859.
Saporta, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 279, 1866.
Saporta, idem, vol. 3, p. 177, pl. 1, fig. 6; pl. 5, figs. 5, 6, 1867.
Sismonda, Matériaux pour servir à la paléontologie du terrain tertiaire du Piémont, p. 52, pl. 25, fig. 6, 1865.
Unger, Die fossile Flora von Kumi, p. 30, pl. 7, fig. 39, 1867.
Pilar, Flora fossilis susedana, p. 60, 1883.
Boulay, Notice sur la flore tertiaire des environs de Privas, Ardèche, p. 23, 1887.
Peola, Flora fossile Braidese, p. 54, 1895.
Peola, Flora dell' Elveziano torinese, p. 36, 1899.
Peola, Rivista italiana di paleontologia, vol. 5, p. 104, 1899.
Peola, idem, vol. 6, p. 84, 1900.
Peola, Soc. geol. ital. Boll., vol. 19, pl. 16, fig. 115, 1896.
Paolucci, Nuovi materiali e ricerche critiche sulle piante fossili terziarie dei gessi di Ancona, p. 94, pl. 16, fig. 115, 1896.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 43, fig. 1, 1899.

Description.—Leaves oblong-elliptical or obovate in outline, the tip abruptly narrowed and apiculate and the base gradually narrowed and cuneate. Length of Wilcox forms about 13 centimeters. Maximum width, midway between the apex and the base, about 4.25 centimeters. Margins entire, full and rounded, recurved to form the slender extended acuminate tip. Texture subcoriaceous. Primaries three, suprabasilar, the midrib stoutest; the laterals diverge suboppositely at acute angles, pursuing a course that is but slightly curved, joining outward branches from the lowermost secondary on each side in the upper half of the leaf. Secondaries, two or three alternate curved camptodrome pairs in the upper half of the leaf, diverging from the midrib at wide angles.

This species is a type that approaches close to three supposedly different European Tertiary species—*Cinnamomum buchii* Heer, *Cinnamomum polymorphum* Heer, and *Cinnamomum spectabile* Heer—especially to the first and last of these three. It is also similar to certain European forms referred to Daphnogene, for example *Daphnogene amplior* Saporta[1] from the Sannoisian of Aix. On the whole the form from Louisiana can not be separated from *Cinnamomum buchii*, although it is somewhat larger and its coarser venation suggests *Cinnamomum spectabile*. Both are mainly Aquitanian species, although *Cinnamomum buchii* is found as low as the Bartonian in Italy and *Cinnamomum spectabile* has been identified by Knowlton from the Fort Union beds in Yellowstone Park. In the absence of the upper half of the leaf *Cinnamomum buchii* can not be distinguished from a large variety of triple-veined lauraceous forms. It does not appear to have been common in the Wilcox flora; at least if it was it has not been preserved in large numbers.

[1] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, p. 38, pl. 4, fig. 5, 1889.

It is difficult to appreciate the differences that have led European students to separate *Cinnamomum buchii* and *Cinnamomum spectabile*. Certainly some of the specimens appear to intergrade. I have identified *Cinnamomum spectabile* from the Claiborne group in Arkansas and would be inclined to consider the form from Coushatta as referable to this species on the grounds of size, texture, and variability of the tip. As it has been identified as *Cinnamomum buchii* there is hardly sufficient warrant for changing the name, especially in view of the probability that the two species may not really be distinct.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

Genus PERSEA Gärtner fils.

Persea wilcoxiana Berry, n. sp.

Plate LXXXVI, figure 3.

Description.—Leaves elliptical in general outline. Length about 12 to 13 centimeters. Maximum width, which is about midway between the apex and the base, about 6 centimeters. Apex and base short and broad, about equally pointed. Margins full, regularly rounded and entire, the upper and lower halves of the leaves being counterparts as regards their outline. Texture subcoriaceous. Midrib stout and straight. Secondaries thin but distinct; about eight chiefly subopposite, regularly spaced, and approximately parallel pairs diverge from the midrib at angles of 45° or more and curve upward, the curve increasing distad as they bend approximately parallel with the margins to form camptodrome arches. Tertiaries thin but distinct, largely percurrent, the cross veinlets forming large quadrangular or polygonal meshes.

This species is not liable to be confused with any other member of the Wilcox flora, although it is not unlike a species of Persea from the overlying Claiborne group in Mississippi. Among recent forms it resembles a number of species of the American tropics and subtropics. The genus has been segregated in different ways since its characterization by Gärtner in 1805. Engler and Prantl, in the Natürlichen Pflanzenfamilien, refer 10 species of the southeastern Asiatic region to Persea, but Sargent states that with the exception of the single form endemic in the Canary Islands all its 50 species are American, ranging from the southern United States, where 2 species extend northward as far as Virginia in the coastal region, to Brazil and Chile, the great majority of the forms being tropical.

Occurrence.—Wilcox group, Frierson Mill, De Soto Parish, La.

Collection.—U. S. National Museum (No. 145).

Persea longipetiolatum (Hollick) Berry.

Plate LXXXVI, figures 1 and 2.

Persea speciosa Heer. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 284, pl. 41, fig. 5, 1899.

Toxylon longipetiolatum. Hollick, idem, p. 282, pl. 48, 1899.

Description.—Leaves rather large, apparently somewhat inequilateral and falcate, ovate-lanceolate in general outline. Apex sharply pointed but not extended. Base sharply pointed and slightly decurrent or else bluntly pointed. Length from 11 to 15 centimeters. Maximum width, in the middle part of the leaf, ranges from 4.3 to 6.2 centimeters. Margins entire. Texture coriaceous. Petioles long and very stout, curved, tumid proximad, ranging in length from 4.5 to 6.5 centimeters. Midrib stout, curved, and prominent. Secondaries stout, nine or ten subopposite to alternate pairs, diverging from the midrib at angles of about 45° or slightly more but slightly curved upward until they reach the marginal region, camptodrome. Tertiaries obsolete.

This fine large species exhibits some variation, as shown by the forms identified by Hollick as Persea and Toxylon. This difference is mainly one of size and consequent petiolar length. Neither is at all close to the normal forms of *Persea speciosa* Heer but is somewhat similar to a deformed leaf of that species figured by Heer[1] from the upper Miocene of Oeningen, Baden (Tortonian), a geologic horizon as widely removed as the localities are geographically. I fail to see any basis for the reference of this species to the monotypic existing genus Toxylon, which has relatively wider, more equilateral and elliptical leaves whose truncate base is commonly so full that the basal margin is fluted or even cordate. The apex of Toxylon is more or less produced as a slender

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, pl. 100, fig. 18, 1856.

acumen; the petiole is much shorter, and the secondaries are fewer in number, forking and arching some distance from the margins. On the other hand, *Persea longipetiolatum* is distinctly lauraceous in all its characters and very similar to the leaves usually referred to Persea, although it may also be compared with some species of Nectandra. It resembles closely *Laurus præstans* described by Lesquereux [1] from the early Eocene at Point of Rocks, Wyo., but lacks the prominent tertiaries and acuminate tip of the western form. It is also much like *Persea coriacea,* from the Tertiary of Colombia, described by Engelhardt [2] and compared with the existing Brazilian species *Persea rigida* Nees. No material other than the type, except a small specimen from Puryear, has been discovered. I am indebted to Dr. Hollick for the drawing of the specimen that constituted his type of Toxylon.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); sec. 7, T. 12 N., R. 11 W., De Soto Parish, La. (collected by G. C. Matson); and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—New York Botanical Garden.

Genus OREODAPHNE Nees.

Leaves with well-marked lateral primaries in the lower half of the leaf:
- Primaries extending above the middle, apex usually obtuse. .... *Oreodaphne obtusifolia.*
- Primaries not extending above the middle, apex and base equally pointed .... *Oreodaphne salinensis.*

Leaves without well-marked lateral primaries:
- Linear-lanceolate, falcate, with remote secondaries. *Oreodaphne pseudoguianensis.*
- Relatively broad leaves with less remote secondaries:
  - Elongated with undulate margins. *Oreodaphne mississippiensis.*
  - Short and broad with regularly rounded margins:
    - Equally pointed at both ends, petiole short, secondaries five or more pairs, venation thin .... *Oreodaphne coushatta.*
    - Apex slightly extended, secondaries five or fewer pairs, venation very coarse. *Oreodaphne wilcoxensis.*
    - Apex extended, petiole elongated, secondaries eight or more pairs. *Oreodaphne puryearensis.*

[1] Lesquereux, Leo, The Tertiary flora, p. 215, pl. 63, fig. 7, 1878.

[2] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 26, pl. 6, figs. 3, 4, 1895.

OREODAPHNE PURYEARENSIS Berry, n. sp.

Plate LXXXIII, figure 1.

Description.—Leaves medium sized, ovate-lanceolate in general outline, with full rounded lateral margins. Length about 9 centimeters. Maximum width about 3 centimeters, in the middle part of the leaf. Apex narrowed, somewhat elongated and acuminate. Basal half much fuller than the apical half, finally slightly decurrent on the stout petiole. Margins entire. Texture coriaceous. Petiole long and stout, 1.5 centimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries stout, not prominent, however, but immersed in the leaf substance, about 8 pairs, irregularly spaced and diverging from the midrib at different angles, the lower secondaries at acute angles, more or less parallel in their course with the lower lateral margins. Angles increase distad; the median secondaries are regularly curved and camptodrome at a considerable distance from the margins; the distal secondaries are short and nearly straight to the point, where they bend abruptly upward in flat arches approximately parallel with the margins to join the secondary next above.

This species is not unlike *Oreodaphne fœteus* Nees, as well as other existing species in this genus. It is also somewhat like *Mespilodaphne coushatta* Berry, from the Wilcox deposits of Louisiana.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

OREODAPHNE OBTUSIFOLIA Berry, n. sp.

Plates LXXX, figure 1; LXXXIII, figures 2-5, and LXXXIV, figures 1 and 2.

Cinnamomum sezannense Watelet. Hollick (not Watelet), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 42, fig. 2, 1899.

Description.—Leaves variable in size and form, elongate-elliptical to ovate-lanceolate in outline. Length 12 to 25 centimeters, averaging about 16 centimeters. Maximum width, about midway between the apex and the base, 3.4 to 7.5 centimeters, averaging about 4 centimeters. Apex variable, pointed in some specimens, as a rule broadly rounded, retuse in one specimen. Base more acute than the apex, ranging from narrowly cuneate in the more slender leaves to broadly cuneate and ultimately somewhat decurrent in the broader leaves. Margins entire, full throughout most of their course; some of them show an undulation, as in Plate LXXXIII, figure 2. Texture coriaceous. Petiole short and stout, 1.5 to 2 centimeters in length, curved. Midrib stout and prominent, as a rule more or less curved. Lateral primaries much less stout, but prominent, suprabasilar, subopposite, diverging from the midrib at angles of about 30°, curving slightly upward and then nearly straight to the middle of the leaf or above that region, where they unite with the outer tertiary branches from the lowest secondaries. Secondaries, four to seven pairs, opposite to alternate, thin but prominent, branching from the midrib at an angle of about 50°, sweeping upward in a broad curve, ultimately camptodrome. Internal tertiaries thin, numerous and percurrent. Marginal tertiaries from the outside of the primaries, for the most part camptodrome. Epidermal cells very small, but with thin walls, differing on the upper and lower surfaces of the leaf, the substance of which in some specimens is preserved, indicating that in life the leaves were glossy above. Preparations fail to show stomata, but the lower epidermis is poorly preserved, which may explain this feature; yellowish globules in the preparations would seem to indicate that the leaves of this species were aromatic and punctate as in the majority of existing Lauraceæ, since they have the exact appearance of the secretory cells of that family.

This species is represented by doubtfully determined material from the St. Maurice formation of the Claiborne group of Arkansas and from a higher horizon in the Claiborne group on Colorado River in Texas.

Oreodaphne obtusifolia constitutes a very distinct type easily distinguishable from the numerous other lauraceous forms of the Wilcox flora, although the triveined basal fragments might readily be confused with Cinnamomum or Malapœnna. Perfect specimens are very abundant in the clays at Puryear, Tenn., and in most of these the leaf substance is preserved, although it exfoliates as a rule on drying. The full form of the leaves with their blunt apex renders the identification of complete specimens a simple matter. This broadly rounded apex, though not a constant character, is unusual in this family, the great majority of existing species being lanceolate and more or less falcate. Two specimens were collected by the writer from the locality near Grand Junction, Tenn., and the incomplete leaf from Louisiana identified by Hollick as *Cinnamomum sezannense* Watelet [1] is undoubtedly the basal half of a leaf of this species and may be compared with some of the narrower forms figured in this work. It may be remarked that the present species is much like *Cinnamomum sezannense* of the European Eocene, especially in the details of venation.

The genus Oreodaphne in the existing flora contains numerous exclusively American tropical species. Pax, in Engler and Prantl, makes it a subgenus of the genus Ocotea of Aublet, an arrangement which is undesirable from every viewpoint.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, Vineyard Bluff, Cross Bayou, Caddo Parish, La. (collected by A. C. Veatch); 1½ miles northeast of Mansfield, 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins); and Old Port Caddo Landing on Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (very abundant), and 1 mile south of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

OREODAPHNE COUSHATTA Berry, n. sp.

Plate LXXXI, figures 1 and 2.

Tetranthera præcursoria Lesquereux. Hollick (not Lesquereux), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 284, pl. 44, figs. 3, 4, 1899.

Veatch, U. S. Geol. Survey Prof. Paper 46, pl. 17, figs. 3, 3a, 1906.

Description.—Leaves ovate-lanceolate in outline. Apex and base about equally and ab-

[1] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 175, pl. 50, fig. 2, 1866.

ruptly pointed. Length about 15 centimeters. Maximum width in the middle part of the leaf about 5 centimeters. Margins entire. Texture subcoriaceous. Petiole short and nearly straight, about 0.75 centimeter in length. Midrib medium sized, nearly straight. Secondaries, six subopposite to alternate pairs, no lateral primaries differentiated. Secondaries branch from the midrib at acute angles, 45° or less, curve slightly, and become parallel with the margins; they become shorter and more curved in the upper part of the leaf and are unequally spaced. Tertiaries mostly percurrent. Areolation quadrangular or polygonal, mostly obsolete.

This form was recorded by Hollick in 1899 from Louisiana and identified with the Fort Union species *Tetranthera præcursoria*, which it somewhat resembles, although it may be readily distinguished by its larger size and broader, less lanceolate form, its less distant secondaries, and shorter petiole. It is not especially close to the other species of Oreodaphne in the Wilcox flora, but approaches nearest to *Oreodaphne puryearensis* Berry, from which it differs in its larger size, very much shorter and more slender petiole, more slender midrib, longer and less curved secondaries, which approach much nearer the margins, and in lacking the extended tip of that species. It seems to be a rare or possibly an inland element in the Wilcox flora, since only the type material has been collected.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris), and 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—New York Botanical Garden.

Oreodaphne salinensis Berry, n. sp.

Plate LXXXII, figures 1 and 2.

Description.—Leaves medium sized, lanceolate in general outline. Length about 10 to 12 centimeters. Maximum width 2.2 to 2.75 centimeters, about midway between the apex and the base. The margins are entire, full, and rather evenly rounded, the blade narrowing almost equally distad and proximad, slightly fuller proximad. The apex is not extended and is obtusely pointed. The base is somewhat more pointed and slightly decurrent on the short curved petiole. Midrib stout and nearly straight, slightly flexuous in some specimens, prominent on the lower surface of the leaf. Secondaries stout and more or less prominent; one or two lower pairs subopposite, diverging at acute angles and ascending parallel with the lower lateral margins nearly halfway to the apex, where they form a series of arches from the ends of percurrent tertiary branches from the outer side of the respectively adjacent secondaries. From the middle of the leaf to the apex six or seven pairs of subopposite to alternate secondaries diverge from the midrib at angles of about 45° below but become more open with each successive pair; they curve regularly upward and are subparallel and camptodrome. Tertiaries not prominent, percurrent for the most part. Texture coriaceous.

This is the smallest and narrowest of the Wilcox species of Oreodaphne and appears to to be confined to the western shores of the Mississippi embayment. It is close to certain still existing species, and basal fragments are liable to be confused with Cinnamomum.

Occurrence.—Wilcox group, Benton, Saline County, and Malvern, Hot Spring County, Ark. (collected by R. E. Call).

Collection.—U. S. National Museum.

Oreodaphne mississippiensis Berry, n. sp.

Plate LXXXII, figures 3-5.

Laurus primigenia Unger. Hollick (in part), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 284, pl. 41, fig. 1 (not fig. 2), 1899.

Description.—Leaves large, ovate-lanceolate in outline, as a rule slightly inequilateral, the base narrowly cuneate and the apex abruptly acuminate and commonly falcate. Maximum length about 19 centimeters. Maximum width, which is below the middle, about 4 centimeters. Fragments of considerably larger specimens are associated with the type material, one having a width of 5.25 centimeters. The lateral margins are full and entire but slightly undulate; toward the apex they approach abruptly to the acuminate tip. Toward the base they are full and rounded, curving inward rather abruptly and then continuing downward to form the narrowly cuneate base. Texture coriaceous but the leaf substance not especially thick. Midrib very stout, especially proximad, flattened rather than prominent on lower surface of the leaf, more or less curved. Secondaries distant, about 10 or 12 subopposite to alternate pairs, rather stout; the basal pair, which are subopposite, form angles of 25° to 30° with the midrib about 2 centimeters above its base, ascending in broad regular curves, camptodrome. Secondaries above the basal pair more or less regularly spaced at intervals of about 2 centimeters, subtending angles of about 40°, the angle increasing somewhat in the upper part of the leaf, camptodrome, becoming fine and arching along the margin for considerable distances in all but the apical portion of the leaf. The interval between the basal and the next succeeding pair of secondaries may be much greater than between normal succeeding pairs, giving the leaves a triveined, Cinnamomum-like appearance; or all the secondaries may be normally spaced; or one of the basal secondaries may be ascending and subtend a longer interval, as in one of the specimens figured. Tertiary venation fine, typically lauraceous, and visible with great distinctness with magnification.

This large and striking species is distinct among the numerous lauraceous forms of the Wilcox flora and is readily recognized by its characteristic outline. The leaves were punctate and as preserved the texture is characteristic and suggests that the lower surface was tomentose. The most similar associated species is *Nectandra glenni* Berry, described from the clays of Wilcox age near Grand Junction, Tenn., which has a more gradually narrowed apex and base, giving the leaf a much more symmetrical appearance, and fewer and more ascending secondaries.

Among described species from western American Tertiary localities, there are none especially close to the present type. It is, however, much like *Litsæa expansa*, described by Saporta and Marion[1] from the Paleocene (marnes heersiennes) of Belgium, which has, however, a more extended tip and a more broadly cuneate base. It may also be compared with *Laurus attenuata*, described by Watelet[2] from the Ypresian of the Paris Basin.

Numerous existing species of the American Tropics and subtropics in this and allied genera approach closely to this type. In fact, though there may be differences among students of fossil floras, as there are among students of the existing flora regarding the proper generic limits of the genera of the Lauraceæ, no one can dispute the correctness of the family reference of these Wilcox species. The present species is very similar to the larger-leafed forms of the existing *Persea pubescens* (Pursh) Sargent[3] so common in our Southern States in low wet places in the Coastal Plain. I have also seen unnamed specimens of Ocotea (Oreodaphne) from New Grenada identical with it.

Among the collections of fossil plants accumulated by the Arkansas Geological Survey under Dr. J. C. Branner and turned over to the United States National Museum, there is a nearly complete leaf of *Oreodaphne mississippiensis*, which was obtained in digging a shallow well near Texarkana and bears the designation Persea sp. in Prof. Ward's handwriting. (U. S. Nat. Mus. Accession No. 8608.) The species is also represented by fragmentary specimens collected by A. C. Veatch for the Louisiana Geological Survey at Coushatta, in Red River Parish, and now in the collections of the New York Botanical Garden. The largest of the two forms figured by Hollick as *Laurus primigenia* represents one of these specimens. Among the lauraceous forms of the Upper Cretaceous in this area the present species is somewhat similar to *Oreodaphne alabamensis* Berry, which is abundant in the lower part of the Tuscaloosa formation of northwestern Alabama and also occurs in the Woodbine sand of Lamar County, Tex.

Occurrence.—Holly Springs sand, near Holly Springs, Marshall County, Miss. (collected by E. W. Berry), and 2 miles north of Lockhart, Lauderdale County, Miss. Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch); Shreveport, Caddo Parish, La. (collected by O. B. Hopkins); 4½ miles and 5 miles southeast and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins); and from a well near Texarkana, Miller County, Ark. (U. S. Nat. Mus. No. 8608).

Collections.—U. S. National Museum.

[1] Saporta, G. de, and Marion, A. F., Revision de la flore heersienne de Gelinden, p. 68, pl. 11, figs. 1, 2, 1878.

[2] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 187, pl. 52, figs. 3, 4, 1866.

[3] Sargent, C. S., Silva of North America, vol. 7, pl. 302, 1895.

Oreodaphne pseudoguianensis Berry, n. sp.

Plate LXXXI, figures 3 and 4.

Description.—Leaves narrowly elongate-lanceolate and falcate in general outline, the apex gradually attenuated and the base somewhat shorter, acuminate. Length ranges from 15 to 18 centimeters. Maximum width, in the lower half of the leaf, 1.7 to 2 centimeters. Margins entire, very faintly undulate. Leaf substance very thick. Texture decidedly coriaceous. Petiole long, stout, and curved, about 3 centimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries stout, prominent on the lower surface of the leaf; three or four commonly subopposite pairs of the same character above these; and numerous thin reduced pairs, diverging at wide angles, in the attenuated tip. The basal pair are opposite and subbasal, diverging from the midrib at angles of about 20°, rather straight in their course and close to and parallel with the lower lateral margins. The succeeding two or three pairs, generally subopposite, arise at intervals of 1.5 to 2.5 centimeters. They diverge at slightly wider angles, about 30°, and are regularly curved and ascending, becoming parallel with the lateral margins, along which they ascend for a considerable distance, and are eventually camptodrome. The secondaries diverge at wider and wider angles and are more curved in the upper half of the leaf until in the tip they become very thin and diverge at angles of about 70°, running straight about halfway to the margin, where they turn abruptly upward to form wide arches to the adjacent superior secondaries. Tertiary venation largely immersed, consisting of transverse, slightly curved nervilles, as shown in the figured specimen from Puryear. Areolation obsolete.

This striking species is very distinct from the associated forms of Lauraceæ and is readily distinguished from the other species of Oreodaphne as well as from those of related genera by its narrow elongated falcate form. With the exception of its long petiole and less distinct areolation it is practically identical with the existing *Oreodaphne guianensis* Aublet, a species of northern South America, the type locality being Guiana.

I am indebted to Dr. Arthur Hollick for permission to figure the fine specimen of *Oreodaphne pseudoguianensis* from Coushatta, La.

Occurrence.—Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

Oreodaphne wilcoxensis Berry, sp. nov.

Plate LXXXVII, figure 6.

Description.—Leaves medium sized, ovate in general outline, the base broadly cuneate and the tip slightly extended, acuminate. Length about 11 centimeters. Maximum width, in the middle part of the leaf, about 3.8 centimeters. Margins entire. Texture coriaceous. The marginal curvature is irregular and the leaf is not strictly equilateral. Petiole not preserved. Midrib stout, somewhat flexuous, very prominent on the lower surface of the leaf. Secondaries few in number, widely and irregularly spaced, very stout and prominent on the lower surface of the leaf; four or five alternate pairs diverge from the midrib at angles of about 50° to 55°; halfway to the margin they have swung around subparallel with it and they ascend for a long distance in this position in a series of flat arches. The tertiaries also are prominent, transverse in general direction, commonly percurrent but generally forked.

This fine species is unfortunately represented by a very meager amount of material. Among the numerous Wilcox species of Lauraceæ, especially those of the genus Oreodaphne, it is closest to *Oreodaphne coushatta* Berry, from which it differs in its more irregular form, coarser and more prominent venation, and in its fewer and less regularly spaced secondaries. It is very similar to a form from the Tertiary of Colombia described by Engelhardt[1] as *Laurophyllum rigidum* and compared with the existing *Ampelodaphne arunciflora* Meissner of Brazil.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus MESPILODAPHNE Nees.

Mespilodaphne puryearensis Berry, n. sp.

Plate LXXXVII, figure 1.

Description.—Leaves narrowly ovate-lanceolate in general outline, commonly falcate,

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 30, pl. 8, fig. 5, 1895.

the base pointed and the tip gradually narrowed, elongated, and acuminate. Length about 10 centimeters. Maximum width, in the basal half of the leaf, about 2.5 centimeters. Margins entire, slightly undulate in the upper part. Texture coriaceous. Petiole long and stout, slightly curved, longitudinally striated, about 2.5 centimeters in length. Midrib stout, becoming thin distad, prominent on the lower surface of the leaf. Secondaries thin, about 10 subopposite to alternate pairs, somewhat irregularly spaced, diverging from the midrib at angles of about 45° or less, curving regularly upward and camptodrome. Tertiaries relatively stout, forming a typically lauraceous areolation, which is, however, nearly obsolete by immersion in the substance of the lamina.

This species resembles a number of Wilcox species of Lauraceæ referred to the genera Oreodaphne, Mespilodaphne, and Nectandra but is entirely distinct. It is something like *Oreodaphne pseudoguianensis* Berry in outline but is more ovate, the secondaries are more numerous, and the venation is finer. It is also more ovate in form than *Oreodaphne salinensis* Berry and lacks the lateral pseudoprimaries of that species. It is very much narrower and more elongated than *Mespilodaphne pseudoglauca* Berry or *Mespilodaphne coushatta* Berry but is more ovate than *Mespilodaphne eolignitica* Berry and the venation is much finer. The species of Nectandra are not close enough to occasion any confusion.

In the modern flora of tropical and subtropical America a number of forms in all three genera are closely comparable with the present species.

It does not appear to have been common in the Wilcox flora.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MESPILODAPHNE PSEUDOGLAUCA Berry, n. sp.

Plate LXXX, figure 4.

Laurus socialis. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.

Laurus californica. Lesquereux (not Lesquereux, 1883), U. S. Nat. Mus. Proc., vol. 11, p. 12, pl. 4, fig. 1, 1888.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, 1888.

Description.—Leaves medium sized, broadly ovate-lanceolate in outline. Apex somewhat produced to form a narrow acuminate tip. Base narrowly cuneate. Length ranges from 9 to 11 centimeters. Maximum width, ranging from 3 to 5 centimeters, midway between the apex and the base. Margins entire. Texture coriaceous. Petiole short, stout, and curved, about 9 millimeters in length. Midrib stout, more or less curved, prominent on the lower surface of the leaf. Secondaries rather stout, six or seven pairs, irregularly spaced, diverging from the midrib at angles ranging from more than 55° in the upper part of the leaf to 35° in the lower part, the basal pairs tending to assume a course parallel with the lower lateral leaf margins, all curved and camptodrome. Tertiaries thin, forming open polygonal, typically lauraceous meshes.

This species resembles a number of existing as well as fossil Lauraceæ that are referred to several genera, being closest to certain existing species of Ocotea of the section Mespilodaphne Nees, often and properly segregated as a distinct genus. With the exception of 8 or 9 African species the remainder of the more than 200 existing species referred to Ocotea are natives of tropical and subtropical America. The most similar existing form is *Mespilodaphne glauca* of Brazil, which is very close to the fossil in size, outline, venation, areolation, texture, and the like, the only difference being the slightly blunter apical acumen of the modern leaf.

A specimen of this species, collected by R. H. Loughridge near Boaz, Ky., was identified by Lesquereux in 1888 with his species *Laurus californica* from the auriferous gravels of California,[1] which, though somewhat similar, is entirely distinct. For one thing its secondaries are much fewer, and there are numerous other differences. A small leaf of this species from Campbell's quarry, in Louisiana, was identified by Lesquereux as *Laurus socialis* Lesquereux, which it only remotely resembles. It is only 5 centimeters long and 1.7 centimeters in maximum width, and except for its fewer secondaries is exactly like the normal-sized leaves of this species in form and venation.

Occurrence.—Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson), and 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins). Holly Springs sand,

[1] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 252, pl. 57, fig. 3; pl. 58, figs. 6–8, 1883.

Vaughans, near Lamar, Benton County (formerly part of Tippah County), Miss. (collected by L. C. Johnson). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry); $1\frac{1}{4}$ miles east of Grand Junction, Hardeman County, Tenn. (collected by L. C. Glenn); Wickliffe, Ballard County, Ky. (collected by L. C. Glenn); and Boaz, Graves County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

MESPILODAPHNE EOLIGNITICA (Hollick).

Plate LXXX, figures 2 and 3.

Andromeda eolignitica. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 287, pl. 47, fig. 2, 1899.

Description.—Leaves elongate-lanceolate, somewhat inequilateral in outline, the apex more or less extended and acuminate and the base narrowly pointed. Length ranges from 10 to 16 centimeters. Maximum width, in the middle part of the leaf, ranges from 1.7 to 3.2 centimeters. Margins entire, faintly undulate and slightly revolute. Texture coriaceous. Petiole very stout, at least 2 centimeters in length. Midrib stout, prominent on the lower surface of the leaf, curved. Secondaries stout and prominent on the lower surface of the leaf; 10 to 15 irregularly spaced pairs, opposite to alternate, diverge from the midrib at wide angles, somewhat irregular in their courses, curve upward, and arch in the marginal region, the distal pairs, particularly when the apex is prolonged as an acumen, diverging at angles approaching 90°, nearly straight in their courses, their tips joined by flat arches subparallel with the margins. Tertiaries distinct, forming rather large quadrangular or polygonal meshes.

These leaves have a characteristic appearance, well shown in the accompanying figures, which are chosen to represent the extremes of observed variation—the one relatively shorter and wider, with an obtusely pointed tip, the other similar but with a produced acuminate tip. In specimens preserved in clay ironstone, like those from Louisiana, Hurleys, and Wolf River, the venation as a rule is entirely obsolete.

This species, though it suggests certain previously described Tertiary species of other areas, is clearly distinct from any of them. It is somewhat similar to *Oreodaphne mississippiensis* Berry, a Wilcox form common at several localities, but the specific differences are obvious and need not be enumerated. Among recent Lauraceæ it appears to be most like the Brazilian tropical species *Mespilodaphne sassafras* Meissner.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by Lowe and Berry). Ackerman formation, Hurleys, Benton County (formerly part of Tippah), Miss. (collected by E. W. Hilgard but not named by Lesquereux). Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); $1\frac{1}{2}$ miles southeast and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Beds of Wilcox age on Calaveras Creek, 300 yards east of San Antonio & Aransas Pass Railway bridge, Wilson County, Tex. (collected by Alexander Deussen). Lagrange formation (in beds of Wilcox age), Hatchie River near Shandy, Hardeman County, Tenn. (collected by L. C. Johnson); Baughs Bridge, Wolf River, Fayette County, Tenn. (collected by L. C. Johnson in 1889), and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

MESPILODAPHNE COUSHATTA Berry, n. sp.

Plates LXXX, figure 6, and LXXXVII, figure 3.

Andromeda delicatula Lesquereux. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 287, pl. 45, fig. 1, 1899.

Description.—Leaves medium sized, elliptical in general outline, the apex narrowed and bluntly pointed, and the base equally narrowed, but finally much decurrent. Length about 8.5 centimeters. Maximum width, midway between the apex and the base, about 3.5 centimeters. Margins entire, slightly irregularly rounded. Texture subcoriaceous. Petiole long and stout, about 2.5 centimeters in length. Midrib stout, more or less curved. Secondaries rather stout, mostly subopposite; about eight unequally spaced pairs diverge from the midrib at wide angles, especially in the basal part of the leaf, where they are also more closely spaced; they curve gently and regularly upward and are subparallel and camptodrome close to the margins, with which they eventually become subparallel. Tertiaries at right angles to secondaries, thin, percurrent or forking to form large pentagonal meshes.

This species was identified by Hollick with *Andromeda delicatula* Lesquereux,[1] a small species of the Green River formation in Wyoming. The two are perfectly distinct and have no characters in common except for their general similarity of outline and long petioles. The western form is not only much younger than the Wilcox species, but it is only about half its size, the petiole, leaf substance, and venation are more delicate, and the secondaries are less numerous and more ascending, especially in the basal part of the leaf, which is also less decurrent.

This species is not unlike the other Wilcox species of Mespilodaphne, but is perfectly distinct from any of them. It is about the same size as *Mespilodaphne pseudoglauca* Berry, which has, however, more ascending basal secondaries and a more acuminate tip. It also differs in the same particulars and in its long petiole from the existing *Mespilodaphne glauca* of northern South America. It is much like *Oreodaphne puryearensis* Berry in size and length of petiole but is a broader, less acuminate leaf and has a different venation. There is a fine specimen in the National Museum that was collected many years ago in northeastern Arkansas. Among foreign fossil species it is closely comparable with a form from the Ypresian of the Paris Basin which was described by Watelet[2] as *Persea regularis*.

Occurrence.—Wilcox group, Hardys Mill, near Gainesville, Greene County, Ark. (collected by J. C. Branner); 1½ miles northeast of Mansfield, De Soto Parish, La., and Shreveport, Caddo Parish, La. (collected by G. C. Matson and O. B. Hopkins); and one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—New York Botanical Garden.

Genus NECTANDRA Roland.

Leaves large and relatively very broad:
- Over 20 centimeters long .... Nectandra sp.
- Under 20 centimeters long:
  - Secondaries remote .... *Nectandra glenni.*
  - Secondaries closer, subparallel, leaf relatively wider .... *Nectandra lancifolia.*

Leaves narrow and elongated:
- Over 17 centimeters long, apex bluntly pointed. *Nectandra puryearensis.*
- Under 17 centimeters long, acuminate:
  - Strongly acuminate at both ends, commonly falcate, secondaries numerous. *Nectandra pseudocoriacea.*
  - Relatively wider, less acuminate, fewer secondaries .... *Nectandra lowii.*

[1] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 175, pl. 34, figs. 10, 11, 1883.

[2] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 182, pl. 51, fig. 4, 1866.

NECTANDRA LANCIFOLIA (Lesquereux) Berry.

Plate LXXXV, figure 2.

Persea lancifolia. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 419, pl. 19, figs. 3, 4, 1869.

Quercus Lyellii Heer. Lesquereux (in part), Am. Philos. Soc. Trans., vol. 13, p. 415, pl. 17, figs. 1, 2 (not fig. 3), 1869.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 198, fig. 10, 1888.

?*Laurus carolinensis* Michaux. Lesquereux, in Safford, J. M., Geology of Tennessee, p. 426, pl. K, fig. 10, 1869.

Rhamnus Eridani. Lesquereux (not Unger), U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Description.—Leaves medium sized to large, ovate-lanceolate in outline. Apex narrowed into a bluntly pointed acumen. Base equally narrowed, pointed. Length about 12 centimeters. Maximum width, midway between the apex and the base, about 4 centimeters. Margins entire and full, slightly undulate. Petiole short and stout, tumid, 1 centimeter or less in length. Midrib stout, more or less curved, prominent on the lower surface of the leaf. Secondaries stout, prominent on the lower surface of the leaf; 7 to 10 subopposite to alternate pairs, somewhat irregularly spaced, diverge from the midrib at angles of about 40°, curve slightly upward at first but more abruptly toward the margin, and arch in a camptodrome manner close to the margin. Tertiaries thin, distinct but not prominent, immersed in the leaf substance, percurrent or reticulating to form large quadrangular or polygonal meshes. Texture coriaceous.

Poorly preserved specimens of this well-marked species collected by Hilgard were described by Lesquereux as *Persea lancifolia.* It resembles somewhat the associated Wilcox species, *Nectandra glenni* Berry, but is broader, and the secondaries are more numerous, stouter, and less ascending. It is practically identical with the existing *Nectandra antillana*

Meissner, a common form of the woods and river banks throughout the West Indies. Other West Indian species of Nectandra are also very similar.

The forms from Hurleys, Miss., that Lesquereux referred to the Arctic Tertiary species *Quercus lyellii* Heer, are not that species, but two of Lesquereux's figured specimens are probably referable to this species, although the type material is lost. His Plate XVII, figure 1, shows a specimen somewhat smaller and slightly narrower and the secondaries are less ascending, but the general form, character of the base, and the arching of the secondaries close to the slightly undulating margin serve to identify it with *Nectandra lancifolia*. The single form described by Lesquereux from Somerville, Tenn., as *Laurus carolinensis* Michaux, which was thought to be of Pleistocene age and afterward referred to *Quercus lyellii,* is also not that species. It is only a fragment and the specimen is lost, but it is probably a fragment of *Nectandra lancifolia*, although the base is less sharply pointed.

A specimen of this species in the National Museum (No. 2578) from Campbell's quarry, Caddo Parish, La., was identified by Lesquereux as *Rhamnus eridani* Unger, from which it is perfectly distinct.

Nectandra lancifolia is represented by a closely related form in the lower Claiborne of Arkansas, which will be described as *Nectandra arkansana*. It differs from this Wilcox species in its slightly smaller size, fewer secondaries, and longer petiole.

Nectandra lancifolia is present, according to Knowlton, in the lower Eocene flora of the Raton coal field in New Mexico.

Among homotaxial foreign forms it is closely comparable to *Laurus excellens* described by Watelet[1] from the Ypresian of the Paris Basin.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Colemans Mill, Choctaw County, Miss. (collected by E. W. Hilgard). Grenada formation, Grenada County, Miss. (collected by E. W. Hilgard). Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson); sec. 28, T. 13 N., R. 12 W., 2¾ miles southwest and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins); Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry); Somerville, Fayette County, Tenn. (collected by J. M. Safford); and Baughs Bridge, Wolf River, near La Grange, Fayette County, Tenn. (collected by L. C. Johnson).

Collections.—U. S. National Museum.

Nectandra glenni Berry, n. sp.

Plate LXXXV, figure 1.

Description.—Rather large and symmetric leaves, lanceolate in general outline, the tips and bases about equally pointed. Length about 16 centimeters. Maximum width, which is near the middle of the leaf, about 3.9 centimeters. Margins entire but slightly undulate. Petiole stout and curved, slightly more than 2 centimeters in length. Midrib curved, less stout than in *Oreodaphne mississippiensis* Berry; the vascular bundles of which it is composed show as longitudinal striæ on the impressions of the fossil. Secondaries remote, somewhat irregularly spaced, opposite to alternate, camptodrome. The lowest pair are of smaller caliber than the others and spring from the top of the petiole, forming a marginal hem along the lower lateral leaf margins. The next pair diverge from the midrib at angles of about 30° 2 centimeters above the base, pursue at first a straight course, and ultimately curve upward parallel with the margin, along which they arch. They are stronger than the basal pair but less stout than the third subopposite pair, which leave the midrib 3.5 centimeters above the base at angles of about 30° and sweep upward in broad, gentle curves, becoming parallel with the margins, along which they arch for a long distance. This is the stoutest pair of secondaries; the difference in caliber is, however, slight, and were it not for the interval which they subtend would scarcely be noticed. The interval to the next secondaries is 3.5 to 4 centimeters, and the remaining four or five pairs of alternate secondaries branch from the midrib at angles of 40° to 45°, passing upward in regular subparallel curves. The tertiaries are fine and mostly percurrent, though a few slight variations are shown near the right-hand margin of the specimens figured. The areolation, only

[1] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 185, pl. 52, fig. 2, 1866.

distinct with magnification, is well marked and typically lauraceous.

This species is not especially close to previously described species of either the North American or the European Tertiary. It resembles *Oreodaphne mississippiensis* Berry in its general appearance, undulate margins, and areolation, as was noted in the discussion of that species, but it is a slightly smaller, more symmetric leaf, and its specific differences have already been enumerated. It is also similar and of the same general type as *Nectandra lancifolia* (Lesquereux) Berry, but it is relatively narrower, and the secondaries are more distant and less regularly spaced.

It resembles somewhat *Persea palæomorpha*, described from Gelinden by Saporta and Marion,[1] but is a more lanceolate form, and its secondaries are thinner, less regularly spaced, and more ascending. It may be compared with numerous Miocene and still existing species, without, however, throwing any light on its relations. Among some of the recent forms with similar leaves are *Goeppertia hirsuta* Nees of the mountains of Bolivia, *Goeppertia anomala* Nees of Brazil, and *Oreodaphne blancheti*, also of Brazil. The most similar recent forms are *Nectandra patens* Grisebach and *Nectandra krugii* Mez of the West Indies.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1¼ miles east of Grand Junction, Hardeman County, Tenn. (collected in 1904 by Prof. L. C. Glenn, for whom the species is named).

Collection.—U. S. National Museum.

NECTANDRA PURYEARENSIS Berry, n. sp.

Plate CV, figure 2.

Description.—Leaves of relatively great length, oblong-lanceolate and somewhat falcate in general outline, gradually narrowed distad to the bluntly pointed and slightly emarginate tip and somewhat more abruptly narrowed to the narrowly cuneate base. Length about 18.5 centimeters. Maximum width, midway between the apex and the base, about 3.3 centimeters. Margins entire, very slightly undulate. Texture coriaceous. Petiole not preserved. Midrib rather stout, becoming thin distad, very prominent on the lower surface of the leaf. Secondaries relatively thin but prominent; about 15 mostly alternate pairs diverge from the midrib at angles of about 45°, curving regularly upward, camptodrome. Tertiaries form a typically lauraceous areolation, not well shown in the specimen figured, which shows the upper surface of a leaf on which the areolation is very faint.

This fine species is well differentiated from the other Wilcox Lauraceæ, among which it shows resemblances to *Oreodaphne mississippiensis* Berry, a form, however, that is relatively wider and less elongated, somewhat narrowed distad and that has a wider midrib and fewer more ascending secondaries. *Nectandra puryearensis* has somewhat the proportions of *Mespilodaphne eolignitica* (Hollick) Berry, but that form is somewhat smaller and more coarsely veined and the secondaries are wider spaced and more curved. Compared with the other Wilcox species of Nectandra, it is much larger and more oblong than either *Nectandra pseudocoriacea* Berry or *Nectandra lowii* Berry. It is narrower and much more elongated than the broad-leafed acuminate *Nectandra glenni* Berry or *Nectandra lancifolia* (Lesquereux) Berry, which have thinner, more numerous, and less ascending secondaries. It shows some similarity to *Laurus ocoteoides* Lesquereux,[2] a rare species of the Denver formation of Colorado, and greatly resembles several European Tertiary forms referred to Laurus. It may be matched by material of the existing South American forms of Oreodaphne, Mespilodaphne, and Nectandra.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 2¾ miles southeast and 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

NECTANDRA LOWII Berry, n. sp.

Plate LXXXVIII, figures 4 and 5.

Description.—Leaves medium sized, lanceolate in general outline. Length about 10 centimeters. Maximum width, about halfway between the apex and the base, about 2 centimeters. Apex narrowed, acuminate. Base almost equally narrowed and acuminate, the basal margins being slightly fuller than the

[1] Saporta, G. de, and Marion, A. F., Revision de la flore heersienne de Gelinden, p. 64, pl. 10, fig. 1, 1878.

[2] Lesquereux, Leo, The Tertiary flora, p. 215, pl. 36, fig. 10, 1878.

apical margins. Petiole stout, not preserved for its entire length. Midrib stout. Secondaries thin, numerous, alternate, subparallel, unequally spaced, diverging from the midrib at angles of 45° to 50°, curving regularly upward, camptodrome in the marginal region. Tertiaries obsolete. Margins entire. Texture coriaceous.

This species may be compared with a large number of existing species of Nectandra and Ocotea and with a number of Tertiary species of Laurus, so called. Among Wilcox forms it is similar to the common *Nectandra pseudocoriacea* Berry but is relatively wider and has a less acuminate apex and base and fewer secondaries. It is named for Dr. E. N. Lowe, State geologist of Mississippi, who in company with the writer collected it at the fine plant locality in the town of Oxford.

Occurrence.—Holly Springs sand, ravine at Oxford, Lafayette County, Miss. (collected by E. W. Berry). Wilcox group, 4 miles southwest of Boydsville, Clay County, Ark. (collected by E. W. Berry); and 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by O. B. Hopkins). Lagrange formation (in beds of Wilcox age), Baughs Bridge, Wolf River, near La Grange, Fayette County, Tenn. (a doubtfully determined specimen collected by L. C. Johnson in 1889).

Collections.—U. S. National Museum.

NECTANDRA PSEUDOCORIACEA Berry, n. sp.

Plates LXXXVII, figure 2, and LXXXVIII, figures 1-3.

Laurus primigenia Unger. Hollick (in part), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 284, pl. 41, fig. 2 (not fig. 1), 1899.

Description.—Leaves narrowly lanceolate, generally falcate in outline, some of them slightly inequilateral at the base. Length 7.5 to 10 centimeters. Maximum width, midway between the apex and the base, 1 to 2 centimeters, averaging about 1.6 centimeters. Apex narrowed and extended as a slender, sharply pointed acumen. Base narrowed and descending to match the apex. Margins entire. Texture very coriaceous. Petiole relatively very stout, generally curved, averaging about 1 centimeter or slightly more in length. Midrib stout, as a rule more or less curved, and in a few specimens somewhat flexuous. Secondaries numerous, thin, subparallel, immersed, diverging from the midrib at wide angles, in some specimens irregularly spaced, camptodrome close to the margin. Tertiaries usually obsolete, typically lauraceous in one transparent specimen that I was able to wash out of the clays near Grand Junction, Tenn.

This narrowly lanceolate and commonly falcate form is common at many of the Wilcox localities both east and west of Mississippi River. It is a characteristic form, readily recognized by its coriaceous texture, its numerous fine secondaries, slender apex and base, the apex commonly produced as a typical "dripping point." It is clearly distinct from previously described species but is very close to some of the Tertiary leaves of both America and Europe that have been referred to the protean species *Laurus primigenia* Unger.

Among Recent lauraceous trees it is very similar to the narrow leaves of the closely allied or mutually identical forms from the American Tropics and subtropics variously described as *Persea catesbyana* Chapman, *Nectandra coriacea* (Swartz) Grisebach, and *Ocotea catesbyana* Sargent. These are found in abundance on the shores and islands of peninsular Florida south of Capes Romano and Canaveral, in the Bahamas, and on some of the West Indian islands.

The slender falcate specimen from Oxford, Miss., shown in Plate LXXXVIII, figure 1, is marred by a large circular group of gypsum crystals.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Holly Springs sand, ravine near Oxford, Lafayette County, Miss. (collected by E. W. Berry); also near Holly Springs, Marshall County, Miss. (collected by E. W. Berry); Vaughans, near Lamar, Benton County, Miss. (collected by L. C. Johnson). Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch); sec. 28, T. 13 N., R. 12 W.; sec. 11, T. 12 N., R. 12 W.; 3 miles east, 1½ and 5 miles southeast, and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson, L. C. Chapman, and O. B. Hopkins); 4 miles southwest of Boydsville, Clay County, Ark. (collected by E. W. Berry); and Benton, Saline County, Ark.

(collected by R. E. Call). Also in the Lagrange formation (in beds of Wilcox age): Puryear, Henry County, Tenn. (collected by E. W. Berry); 1¼ miles east of Grand Junction, Hardeman County, Tenn. (collected by L. C. Glenn); and Baughs Bridge, Wolf River, near La Grange, Fayette County, Tenn. (collected by L. C. Johnson).

Collections.—U. S. National Museum; New York Botanical Garden.

NECTANDRA sp.

Plate CX, figure 3.

Description.—Leaves very large, ovate-lanceolate in outline, the acumen gradually narrowed and greatly extended. Margins entire. Texture subcoriaceous. Estimated length about 25 centimeters. Maximum width about 7 centimeters. Midrib stout and prominent on the lower surface of the leaf. Secondaries stout, prominent, numerous, distant, opposite to alternate, ascending, camptodrome. They diverge from the midrib at different angles, acute below, more open above, and curve upward, regularly below, more abruptly above, until they become subparallel with the lateral margins. Tertiaries obsolete.

This extremely large and handsome form is unfortunately represented by fragments, the most complete of which is figured. Since no complete specimens have been found, I have not proposed a specific name for this form, although it appears to be entirely distinct from previously described forms. It is not abundant but appears to have had a considerable distribution.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson); Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan).

Collections.—U. S. National Museum.

Genus **CRYPTOCARYA** R. Brown.

CRYPTOCARYA EOLIGNITICA Hollick.

Plate LXXXVIII, figure 6.

Cryptocarya eolignitica. Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 42, fig. 1, 1899.

Description.—Leaves oblong-ovate and slightly inequilateral in general outline, tapering rather abruptly to the shortly pointed apex, broadly rounded and slightly decurrent at the base. Length about 13 centimeters. Maximum width at or below the middle about 4.6 centimeters. Margins full, entire, slightly undulate. Texture coriaceous. Petiole stout, about 1.5 centimeters in length, slightly curved. Midrib stout, somewhat flexuous. A single lateral primary diverges from the midrib on each side about 1 centimeter above the base at a wide angle, curves abruptly upward and then slightly outward, somewhat flexuous, arching from the ends of straight lateral branches of the lowermost secondaries close to the margins at or slightly above the median region of the leaf. The laterals are thinner than the midrib and subopposite. Secondaries, three or four distinct subopposite or alternate pairs, in the upper half of the leaf, diverging at a wide angle and strongly curved, camptodrome. Tertiaries thin, mostly percurrent except for a series of straight-sided flat-arched loops from the outer sides of the lateral primaries, from which they diverge at a wide angle of almost 90°, the arches approximately parallel with the leaf margins.

This clearly distinct species is represented by the fine and nearly complete leaf figured by Hollick, and unfortunately no additional material has been found. It is clearly a member of the Lauraceæ and very likely of the subfamily Lauroideæ (tribe Cryptocaryeæ), although it resembles in a general way some species of Cinnamomum, Oreodaphne, Nectandra, and the like, of the subfamily Persoideæ.

In a note appended to his paper on the plants from Louisiana Hollick calls attention to certain Chilean species described by Engelhardt from the South American Tertiary as Goeppertia,[1] particularly *Goeppertia spectabilis*, with which he is disposed to identify the leaf from Coushatta. I have compared the two forms carefully and also compared them with the material representing Goeppertia in the herbarium of the New York Botanical Garden. I do not think the form from Louisiana is identical with that from Chile. Cryptocarya R. Brown comprises only 10 South American species, the 30 additional forms being widely distributed in southeastern Asia, Africa, Oceanica, and Australia. The genus Aydendron,

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., Bd. 16, p. 652, pl. 3, figs. 4, 8, 9b; pl. 4, fig. 9; pl. 5, fig. 4, 1891.

on the other hand, to which Engler and Prantl refer the genus Goeppertia Nees as a subgenus, contains more than 50 exclusively American species. This is the only basis for changing the generic reference from Cryptocarya to Goeppertia, and in the absence of more definite similarities to one rather than to the other I prefer to leave the species in the genus Cryptocarya, where it was placed by its original describer.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris).

Collection.—New York Botanical Garden.

Genus LAUROPHYLLUM Göppert.

LAUROPHYLLUM JUVENALIS Berry, n. sp.

Plate LXXXVI, figure 4.

Description.—Small leaf, oblong-lanceolate in outline, 3 cubic centimeters in length and 7.5 millimeters in maximum width, the apex bluntly pointed and the base gradually narrowed, decurring to the point of attachment. Margins entire, irregularly curved. Texture subcoriaceous. Midrib stout and curved. Lateral primaries diverge at a very acute angle. Upper secondaries, one or two pairs, camptodrome.

A single specimen of this form is found in the wonderfully rich collections from Puryear, and it is almost certainly a juvenile leaf of one of the other Wilcox species of Lauraceæ described from mature leaves. As it is impossible to determine which one it is given the distinctive name of *juvenalis*, which also indicates its juvenile character. The small size, unformed character of the venation, decurrent base, and undeveloped petiole are all characters of young leaves, and the diagnosis is further emphasized by the rarity of the form, since young leaves are much less likely to become detached and preserved than mature leaves. It is almost identical with the young leaves of all the existing species of Lauraceæ with which it has been compared, especially *Cinnamomum camphora* Nees and Ebermaier, and *Cinnamomum burmanni* Blume. None of the described Wilcox species of Cinnamomum, however, afford any close comparisons with the present fossil, and there is the further possibility that it may represent a juvenile leaf of *Oreodaphne obtusifolia* Berry, which is so common in the deposits of Wilcox age at Puryear. It is therefore referred to the form genus Laurophyllum.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

LAUROPHYLLUM FLORUM Berry, n. sp.

Plate LXXXVI, figure 6.

Description.—Species based on an apetalous pedunculate flower of small size with a calyx of four, five, or six ovate, bluntly pointed sepals. Peduncle stout and curved, about 5.5 millimeters in length. Sepals about 3 millimeters in length and 2 millimeters in maximum width. Calyx 3.5 millimeters high and 5 millimeters in diameter. Essential organs present but not well enough preserved to be characterized.

This form is based on a single specimen and its counterpart, too poorly preserved to permit generic determination but obviously the flower of some genus of the Lauraceæ and very similar to the flowers of the existing species of Cinnamomum.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

LAUROPHYLLUM PREFLORUM Berry, n. sp.

Plate LXXXVI, figure 5.

Description.—Species based on a small flower bud which is almost certainly referable to the Lauraceæ and very similar to remains often referred to the genus Cinnamomum. The specimen, well shown in Plate LXXXVI, figure 5, has a slender curved peduncle about 3 millimeters in length, thickening distad, surmounted by an unopened perianth, which is spherical in form and 2.5 millimeters in diameter. It is certainly very similar to the unopened buds of the existing species of Cinnamomum, but as so many Lauraceæ have flower buds that are practically indistinguishable it is referred to the form genus Laurophyllum. Unless it is abortive it represents a different species from the flower described as *Laurophyllum florum* Berry.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus LAURINOXYLON Felix.

LAURINOXYLON BRANNERI Knowlton.

Plate XVI, figures 6–10.

Laurinoxylon branneri. Knowlton, Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 256, pl. 9, figs. 8, 9; pl. 10, figs. 1, 2; pl. 11, fig. 4, 1891.
Penhallow, Roy. Soc. Canada Trans., 3d ser., vol. 1, p. 98, figs. 6–8, 1908.

Description.—Knowlton's description, published in 1891, is as follows:

The annual ring can not be clearly distinguished, although there are slight evidences of its having been present. The wood cells are thick walled and ordinarily arranged in radial rows. The vessels are placed singly or arranged in radial rows of from 1 to 3 or rarely 4. They are usually separated by the medullary rays, although in one exceptional instance a row of three vessels was in immediate contact with another row of four. When single they are oval in shape; when more than one, each is modified by pressure. The medullary rays as seen in this section are numerous; two cells broad and usually but little curved in their course.

On account of the poor state of preservation it is difficult to make out the exact shape of the wood cells as seen in this section. Some of them have been rather short with square ends, but probably the larger number have had pointed ends. The medullary rays are in vertical plates of six to thirty or more rather long cells, and so far as can be determined were not provided with pits or markings. The large vessels are, of course, very prominent in this section. They are long, rather thick walled, and provided with numerous elliptical or nearly circular bordered pits.

This section, from another portion of the same specimen, shows the wood cells clearly. Some have square and others pointed extremities. The medullary rays are always arranged in two vertical series of from 6 to 30 or more cells. They are very numerous. * * *

The large vessels are provided with net-form thickening over the entire surface. It seems hardly probable that the vessels have been provided with circular-bordered pits on one wall and with net-form thickenings on the other, since there can be no satisfactory explanation of transition from one to the other in the same vessel, but the fact remains that in all the instances in which it has been possible to make out the nature of the thickening on the walls, the circular pits are always confined to the radial walls and the net-form thickenings to the tangential walls.[1]

This species was based on silicified specimens from two different horizons and probably represented by poorly preserved lignitized material from which sections were cut. The exact age of these horizons can only be approximately determined. The beds in Poinsett County may lie near the top of the Wilcox, since recent collections from this or a near-by locality on Bolivar Creek contain five Wilcox species of leaves, which were, however, in place, whereas the wood was reworked in the top of the section and may be of Claiborne age. It is included in the Wilcox flora with a great deal of doubt.

The second locality is in St. Francis County and is at the top of the Yegua ("Cockfield") formation or probably at the base of the Jackson formation. It has been reported by Penhallow from the Claiborne of Texas. The species is unique in having been the first anatomical dicotyledonous species described from the United States. It was compared by Knowlton with *Laurus biseriata*, described by Caspary [2] from the Tertiary of Russia.

Occurrence.—Wilcox(?) group, Bolivar Creek, near Harrisburg, Poinsett County, Ark. (collected by R. E. Call).

Collection.—U. S. National Museum.

Order MYRTALES.

Family MYRTACEÆ.

Genus MYRCIA De Candolle.

Leaves elongated, linear-lanceolate:
With obtusely pointed tip........ *Myrcia bentonensis.*
Small, falcate, and acuminate .... *Myrcia grenadensis.*
Leaves small, obovate.................. *Myrcia parvifolia.*
Leaves ovate, acuminate............. *Myrcia puryearensis.*
Leaves lanceolate:
Falcate, acuminate, marginal vein an appreciable distance from the margin .... *Myrcia vera.*
Broader, equally pointed at both ends, marginal vein close to the margin .... *Myrcia wortheni.*

MYRCIA VERA Berry, n. sp.

Plate XC, figure 3.

Description.—Small, narrow falcate leaves, lanceolate in outline, the base pointed and the tip elongated and gradually narrowed, acuminate. Length 5 to 7 centimeters. Maximum width, in basal half of the leaf, 1 centimeter to 1.6 centimeters. Margins entire, full and regularly curved. Petiole short. Midrib curved, stout proximad, slender distad. Secondaries nearly regularly spaced, at intervals of 2 to 4 millimeters, diverging from the midrib at wide angles but slightly curved upward in their outward course, joining a strong marginal vein that forms a hem along the margin and 1 millimeter from it in the proximal part of the leaf, becoming closer in the tip; the marginal veins diverge from the midrib at acute angles

[1] See footnote 3, p. 174.

[2] Caspary, R., Geol. Specialkarte von Preussen und den Thüringischen Staaten Abh., Bd. 9, Heft 2, pp. 54–60, pl. 10, figs. 10–17, pl. 11, figs. 1–5, 1889.

at its extreme base and run parallel with the respective margins to the extreme tip of the leaf, one in each limb. The leaves are stiff and coriaceous.

This species is of a type usually referred by paleobotanists to the allied genus Eucalyptus or Myrtus, to which so many fossil species from the Upper Cretaceous to the present have been placed, and it is not very different from the widespread *Eucalyptus oceanica* Unger of the European Tertiary. I have compared it with all the existing genera of Myrtaceæ and have come to the conclusion that it is indubitably a species of Myrcia. Among the existing species it is close to *Myrcia rostrata* De Candolle and *Myrcia acutata* Berg, both species of tropical Brazil. Among fossil species, of which only one or two have been referred to this genus, it is almost identical with *Myrcia lancifolia* Friedrich,[1] described from the Oligocene of Saxony (Eisleben), which has the same form and venation but is slightly smaller and has somewhat more numerous secondaries. The genus Myrcia is considered to comprise more than 400 existing species, and though this number is probably too large it remains one of the most important genera of the American Myrtaceæ. It ranges from the West Indies and Mexico to Uruguay and Chile, and most of the species are found in tropical South America.

Occurrence.—Holly Springs sand, gully at Oxford, Lafayette County, Miss. (collected by E. W. Berry). Lagrange formation (in the beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MYRCIA WORTHENII (Lesquereux).

Plate XC, figures 2 and 10.

Salix Worthenii. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 414, pl. 15, fig. 7, 1869.

Description.—Small leaves, lanceolate in general outline. Length about 5 or 6 centimeters. Maximum width, in the middle part of the leaf, about 1.25 centimeters. Apex and base regularly, sharply, and about equally pointed. Margins entire. Texture subcoriaceous. Petiole short and rather stout, about 3 millimeters in length. Midrib stout, somewhat flexuous. Secondaries thin, very numerous, subparallel. They diverge from the midrib at approximately regular intervals of 1.5 to 2 millimeters, at angles of about 50° to 55°, curving but slightly to the marginal region, where their tips are joined by an acrodrome vein on either side, close to and parallel with the margin. This acrodrome vein may be somewhat arched, giving the secondaries a pseudocamptodrome appearance.

This species was described as a Salix by Lesquereux from material collected in southern Illinois and western Tennessee. Although the type material is lost, there is little doubt that the specimens from Tennessee referred to this species are identical with the material now under consideration. They show no characters that serve to suggest the genus Salix, which would be a most anomalous element if found in the Wilcox flora. The secondaries are numerous, relatively straight, and united by marginal veins as in the Myrtaceæ and suggest a close relationship with the other species of Myrcia found in this flora.

The specific name is given in honor of the late Prof. A. H. Worthen, the eminent State geologist of Illinois at the time Lesquereux wrote.

Occurrence.—Lagrange formation (in beds of Wilcox age): Mound City, Pulaski County, Ill. (collected by A. H. Worthen); La Grange, Fayette County, Tenn. (collected by J. M. Safford); and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MYRCIA PARVIFOLIA Berry, n. sp.

Plate XC, figure 1.

Description.—Leaves small, obovate in outline, the apex rounded or bluntly pointed and the base narrowed and pointed. Length about 3 centimeters. Maximum width, at or above the middle, about 1 centimeter. Margins very entire. Texture coriaceous. Petiole short and stout, tumid proximad, about 2.5 millimeters in length. Midrib stout, slightly curved. Secondaries relatively stout, numerous, parallel; about 15 subopposite to alternate pairs diverge from the midrib at approximately uniform intervals of about 2 millimeters; they pursue a nearly straight course to the margins, where their tips are joined by an acrodrome marginal vein on each side, parallel with and very close to the margin, from which it can only with difficulty

[1] Friedrich, Paul, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen, p. 205, pl. 25, fig. 16, 1883.

be distinguished; easily seen with magnification; angles of divergence of the secondaries open, about 50° to 55°. Tertiaries immersed in the thick leaf substance.

This coriaceous little leaf by its size, texture, and especially its venation is referable to the genus Myrcia. It is markedly different from the larger lanceolate-acuminate *Myrcia vera* Berry from the deposits of Wilcox age at Puryear or from the linear-lanceolate *Myrcia bentonensis* Berry from the Wilcox of Arkansas. It somewhat resembles a form from the Tertiary of Ecuador described by Engelhardt[1] as *Pterogyne oblongifolia*. European Tertiary forms of this type are often referred to the oriental myrtaceous genus Metrosideros R. Brown.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MYRCIA GRENADENSIS Berry, n. sp.

Plate XCI, figure 3.

Description.—Leaves small, narrowly elongate-lanceolate, somewhat inequilateral and falcate in general outline, widest near the middle and gradually narrowing to the equally extended and acuminate apex and base, both of which are somewhat inequilateral. Length about 4 centimeters. Maximum width about 4.5 millimeters. Margins strict and entire. Texture coriaceous. No petiole is differentiated, as the gradually narrowing margins extend to the point of attachment of the leaf as petiolar wings. Midrib very stout throughout its length, curved, relatively prominent on the lower surface of the leaf, longitudinally striated. Secondaries thin, largely immersed in the substance of the leaf; numerous thin pairs diverge from the midrib at angles of about 65° at intervals of 1 to 2 millimeters; they pursue a nearly straight course to the acrodrome vein which closely parallels each margin.

This species is readily separable from the other Wilcox species that have been referred to this genus by its narrow and elongate-lanceolate form and its acuminate apex and base. Among these species it is most similar to *Myrcia vera* Berry but differs in its relatively narrower, more elongate form and its narrower more extended base. Its secondaries are less numerous than those of the smaller leaves of *Myrcia bentonensis* Berry and in addition it differs in having an acuminate tip instead of an obtuse tip. Among previously described species in other genera the species under discussion is almost identical in size and outline with *Eugenia densinervia* (Lesquereux) Berry, which comes from the upper part of the beds of Wilcox age at Somerville, Tenn. In well-preserved material there is no danger of confusing the two, as the venation is very different, *Eugenia densinervia* having anastomosing veins and lacking the marginal veins. A number of existing species of Myrcia have leaves very similar to those of this fossil species.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

MYRCIA PURYEARENSIS Berry, n. sp.

Plate XCI, figures 1 and 2.

Description.—Leaves relatively short, ovate in outline, the tip narrowed and acuminate and the base abruptly pointed. Length about 4.5 centimeters. Maximum width, at or below the middle, about 1.7 centimeters. Margins entire. Texture subcoriaceous. Petiole stout, tumid proximad, about 4.5 millimeters in length. Midrib stout, prominent, curved. Secondaries thin, numerous, subparallel, more or less immersed in the leaf substance; they diverge from the midrib at angles of about 65° at intervals of about 1.5 millimeters, running with but slight or no curvature, some of them forked, ending in a marginal vein which runs along the extreme margin of the leaf. Tertiaries mostly immersed, straight, joining the secondaries at very acute angles.

This characteristic species is sparingly represented in the collections. As far as known the leaves are invariably inequilateral, one side of the lamina being distinctly wider and fuller than the opposite side. Among the other Wilcox species of Myrcia it is somewhat larger and much wider than *Myrcia parvifolia* Berry or *Myrcia worthenii* (Lesquereux) Berry. It is much shorter and wider than the lanceolate-leafed *Myrcia vera* Berry or the elongated

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol 19, p. 2, pl. 2, figs. 21, 22, 1895.

linear-leafed *Myrcia bentonensis* Berry. It is very close to a number of existing species of Myrcia and may be compared with the leaves of *Myrcia rostrata* De Candolle. With the exception of the produced acumen of the modern species the fossil is closely comparable with the tropical American *Myrcia terebinthacea* Pöpp, figures of the leaves of which are given by Ettingshausen.[1] It also greatly resembles a form described by Engelhardt[2] as *Myrcia antediluviana* from the Tertiary of Ecuador.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MYRCIA BENTONENSIS Berry.

Plate XC, figures 7–9.

Quercus retracta. Lesquereux (in part), Am. Philos. Soc. Trans., vol. 13, p. 416, pl. 16, fig. 4 (not fig. 5), 1869.
Knowlton, in Harris, G. D., Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 56, 1894.

Description.—Leaves linear-lanceolate in outline, the apex bluntly pointed or rounded, and the base narrowly pointed. Length ranges from 7 to 12 centimeters. Maximum width, in the middle part of the leaf, ranges from 0.7 centimeter to 1.5 centimeters. Margins entire. Texture coriaceous. Petiole short or wanting. Midrib stout. Secondaries thin, numerous, regularly spaced at intervals of about 1.5 millimeters, diverging from the midrib at angles of 60° to 70°, straight in their course, their tips joined by a thin acrodrome vein close to and parallel with the margin.

This species was based, in the first instance, on a single specimen, collected many years ago at Benton, Ark., by R. E. Call for the Arkansas Geological Survey. It was subsequently discovered at several localities along the eastern shore of the Mississippi embayment in Mississippi and Tennessee and survives the Wilcox, being present in the St. Maurice formation (lower formation of Claiborne group) of Cleveland County, Ark.

It suggests fossil forms that have been referred to the genera Eucalyptus, Nerium, Ficus, and Apocynophyllum, but appears to be most like the genus Myrcia, which has so many existing species in the American Tropics. It may be compared with certain existing species of Myrcia. Among fossil forms it is similar to *Nerium parisiense* Saporta,[3] from the middle Eocene (Lutetian) of the Paris Basin. It is also much like the Myrcia from the Green River formation, which Newberry[4] identified as *Salix angusta* and which may be a descendant of this southern Eocene form.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard). Holly Springs sand, Oxford ravine, Lafayette County (common), Miss. (collected by E. W. Berry). Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call). Lagrange formation (in beds of Wilcox age), Puryear, Henry County (collected by E. W. Berry), and $1\frac{1}{2}$ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Johnson).

Collections.—U. S. National Museum.

Genus EUGENIA Linné.

EUGENIA DENSINERVIA (Lesquereux).

Salix (?) densinervis. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859.
Lesquereux, in Safford, J. M., Geology of Tennessee, p. 427, pl. K, fig. 9, 1869.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 197, fig. 9, 1888.

Description.—Leaves narrowly lanceolate in general outline, slightly falcate, gradually narrowed from the middle to the acuminate apex and the equally pointed base. Length about 5.5 centimeters. Maximum width, midway between the apex and base, about 4.5 millimeters. Margins entire. Texture subcoriaceous. Petiole missing. Midrib stout, curved, and prominent. Secondaries very thin, numerous, closely spaced, diverging from the midrib at angles of about 35°, connected by oblique nervilles of the same caliber as the secondaries, giving them the appearance of inosculating.

This species is based on the form described by Lesquereux as a Salix, although he queried this generic determination and says that when

[1] Ettingshausen, C. von, Die Blattskelete der Dicotyledonen, p. 195, figs. 206, 210, 1861.
[2] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 17, pl. 15, fig. 15, 1895.
[3] Saporta, G. de, Le monde des plantes avant l'apparition de l'homme, p. 227, fig. 46, 1879.
[4] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 54, pl. 65, fig. 2, 1898, Hollick in a footnote on p. 55 calls attention to the Eucalyptus-like venation of this form.

better material is found the plant will probably be referred to another genus. Although no new material has been obtained in subsequent collections, I have ventured to transfer this form to the genus Eugenia, with which in my judgment it shows the greatest affinity. It is much narrower and more elongated than the associated *Eugenia hilgardiana* Berry. Other Wilcox plants which resemble the present species are *Sapindus linearifolius* Berry and *Myrcia bentonensis* Berry. Both are somewhat larger and differ decidedly in their venation characters.

Occurrence.—Lagrange formation (in beds of Wilcox age), Somerville, Fayette County, Tenn. (collected by J. M. Safford).

Collection.—Location of type unknown.

EUGENIA HILGARDIANA Berry, n. sp.

Plate XC, figure 6.

Sapindus undulatus Alexander Braun. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 420, pl. 22, fig. 6, 1869.

Description.—Leaves small, ovate-lanceolate in outline, the apex narrowed and bluntly pointed and the base rather narrow and cuneate. Length about 4 centimeters. Maximum width, in the lower half of the leaf, about 1.5 centimeters. Margins entire, slightly wavy and markedly revolute. Texture very thick and coriaceous. Petiole if present very stout, not preserved. Midrib extremely stout, curved, prominent on the lower surface. Secondaries rather stout, thin compared with the midrib, more or less immersed in the thick leaf substance; five or six subopposite pairs diverge from the midrib at acute angles of about 30°, pursuing a nearly straight ascending course, subparallel, the lower pairs parallel with the lower margins of the leaf, all curving approximately parallel with the lateral margins toward their camptodrome tips.

This species is based on the single specimen collected by Prof. Hilgard half a century ago and identified by Lesquereux with *Sapindus undulatus* Alexander Braun, with which it has practically nothing in common. The illustration of the type specimen given in Plate XC, figure 6, brings out its true character and shows its thick form and revolute margins. It is named in honor of E. W. Hilgard, the veteran southern geologist who did such a large amount of most excellent and lasting pioneer work on the geology of our Southern States. The genus was named by Linné in commemoration of Prince Eugene of Savoy, an early patron of botany, and by an unintentional combination serves also to commemorate the Christian name of the geologist to whom the present species is dedicated.

Eugenia hilgardiana can scarcely be distinguished from some of the leaves of three of the existing species that reach southern Florida—*Eugenia axillaris* Willdenow, *Eugenia rhombea* Krug and Urban, and *Eugenia confusa* De Candolle, all coastal tropical forms.

The genus comprises several hundred existing species (about 500 according to Sargent) and is common in the Tropics of both the Eastern and Western hemispheres, with littoral species in both regions.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard).

Collection.—U. S. National Museum.

EUGENIA PURYEARENSIS Berry, n. sp.

Plate XC, figures 11 and 12.

Description.—Leaves small, elliptical-ovate and somewhat inequilateral in general outline, sessile, widest near the middle and tapering about equally distad and proximad. Tip bluntly pointed. Base broadly cuneate. Length about 2 centimeters. Maximum width about 11.5 millimeters; the lamina on one side of the midrib at least 2 millimeters wider than that on the opposite side. Midrib extremely stout and prominent at the base, longitudinally striated, 1.5 to 2 millimeters in diameter, tapering rapidly upward until it is not at all prominent and scarcely discernible in the tip. Margins entire and full, especially on the broader side of the lamina. Texture very coriaceous. Secondaries and tertiaries entirely immersed in the thick substance of the leaf.

This small-leafed species is well characterized and is apparently referable to the genus Eugenia. Among the other Wilcox species of Eugenia it shows considerable resemblance to *Eugenia hilgardiana* Berry but differs in its less elongate form and smaller size and in lacking the prominent ascending secondaries of that species. It comes from a higher horizon in the Wilcox than *Eugenia hilgardiana*, and like it seems to be of rare occurrence.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

EUGENIA GRENADENSIS Berry, n. sp.

Plate XCI, figures 4 and 5.

Description.—Leaves medium sized for this genus, lanceolate in general outline, widest at or slightly below the middle, from which point they taper almost equally in both directions in the smaller leaves, although in the larger leaves the base is wider than the tip. Apex abruptly pointed. Base cuneate. Length ranges from 5.5 to 7 centimeters. Maximum width, at or slightly below the middle, ranges from 1.5 to 2 centimeters. Margins entire, invariably somewhat irregularly undulate in the material collected. Texture coriaceous. Petiole short, very stout, and much curved, about 3 millimeters in length. Midrib stout throughout its length, prominent. Secondaries numerous, thin, brochidodrome; they diverge from the midrib at acute angles of about 35° and curve but slightly in their ascending course, being scarcely distinguishable from the tertiaries and not at all differentiated in the upper part of the leaf. Tertiaries thin, forming a close-set ascending transverse areolation.

This species is well distinguished among the Wilcox species of Eugenia, being longer and narrower than *Eugenia hilgardiana* Berry, which also differs in its thicker midrib, fewer, stouter secondaries, and tertiary areolation. The other Wilcox species, *Eugenia densinervia* (Lesquereux) Berry, is a small linear-lanceolate falcate form quite unlike *Eugenia grenadensis*. The leaves of a number of existing species of Eugenia closely resemble those of the fossil species. Those that reach our southern coast are as a rule relatively wider, but *Eugenia confusa* De Candolle is not very dissimilar from the fossil form.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus CALYPTRANTHES Swartz.

CALYPTRANTHES EOCENICA Berry, n. sp.

Plate XC, figure 5.

Description.—Rigid coriaceous leaves, elliptical or ovate in outline, the base broadly cuneate or rounded, and the tip acute and not extended. Length about 7 centimeters. Maximum width, in the middle part of the leaf, about 3.5 centimeters. Midrib rather stout. Secondaries thin, numerous, close set, subparallel, in places forked and anastomosing; they diverge from the midrib at wide angles and pursue a nearly straight course almost to the margin, where their ends are joined by a marginal vein parallel with the entire margin.

This characteristic new species resembles a number of existing American genera of the Myrtaceæ as well as several West Indian species of Sapotaceæ, especially of the genus Chrysophyllum. It also resembles several species of the myrtaceous genus Aulomyrcia Berg (Myrcia De Candolle) from tropical South America, but is especially close to certain species of Calyptranthes, particularly *Calyptranthes syzygium* (Linné) Swartz, which is a shrub or small tree 20 or 30 feet in height ranging from sea level to the mountains in rich woods on the West Indian islands, and mostly an upland form. Some modern students refer it to the allied genus Chytraculia R. Brown. The fossil is near the maximum in size of the leaves of this species and except for its more sharply pointed tip is identical with the leaves of this recent species in all its characters.

Among previously described fossil forms it is perhaps most like the somewhat smaller *Myrtus rectinervis*, which is described by Saporta[1] from the Oligocene (Tongrian) of St. Zacharie in southeastern France.

The genus Calyptranthes appears to be an early branch of the Eugenia-Myrcia plexus, supposed to have been largely developed in the American tropics during the Cretaceous. As treated by Niedenzu[2] it comprises about 70 species, ranging from Mexico and the West Indies to southern Brazil. Several insular forms have been referred to this genus on evidence which I believe is insufficient. These are 3 forms from the Fiji Islands, 1 from Africa and Mauritius, and 1 from Java. With these exceptions the genus is entirely American in the existing flora. An undescribed fossil species is present in the Oligocene of the Isthmus of Panama.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

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[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 251, pl. 11, fig. 5, 1863.

[2] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, 1893.

Family COMBRETACEÆ.

Genus LAGUNCULARIA Gärtner.

LAGUNCULARIA PRERACEMOSA Berry, n. sp.

Plate XCV, figures 4–8.

Description.—Leaves somewhat variable in size and outline, elliptical or oblong-elliptical. Length 4 to 6 centimeters, averaging about 5 centimeters. Maximum width, midway between the apex and the base, 2 to 2.5 centimeters. Apex more or less broadly rounded in specimens slightly emarginate. Base a counterpart of the apex in outline. The lateral margins may be approximately parallel with the broadly rounded apex and base or they may be gently and equally curved in both directions from the region of maximum width, and in these specimens the apex and base are more narrowly rounded. Petiole short, stout, and curved, about 4 millimeters in length. Midrib stout and straight. Secondaries thin, numerous, and camptodrome, diverging from the midrib at wide angles and immersed in the leaf substance. Margins entire. Texture coriaceous, slightly rugose. Fruit turbinate, several ribbed, ligneous, the corona composed of several rather long, somewhat recurved coriaceous acute teeth, presumably a one-seeded coriaceous drupe as in the modern species.

This species is one of those rare fossil forms represented by both foliage and fruit, for though the leaves and fruit were not found in organic union they are associated in the same deposits, and I have no doubt were borne by the same tree, since both are characteristic.

Both the leaves and fruit are so much like those of the existing *Laguncularia racemosa* Gärtner that it seems reasonably certain that they represent its Eocene progenitor. The leaves are almost identical with the existing species in outline and venation and have the same thick rugose texture, the only difference being in the somewhat shorter petioles of the fossils and their lack of tuberculation on the surface in the marginal region. The fruits are also nearly identical with those of the existing species. They are shorter and relatively broader and the coronal teeth are longer and fewer in number, thus resembling more nearly the unripe fruits of the existing species. The number of ribs is probably the same as in the existing form, but this feature can not be made out positively.

The genus Laguncularia is monotypic in the existing flora, and its single species, *Laguncularia racemosa* Gärtner, the buttonwood or white mangrove, inhabits muddy tidal shores of estuaries and lagoons. It is common in southern Florida southward from Cape Canaveral and Cedar Keys, in Bermuda, and throughout tropical America—the Bahamas, Antilles, Mexico, Central America, and northern South America. It is also found along the west coast of Africa in the equatorial belt. Although I know of no experimental evidence, this distribution would indicate that the small ligneous fruits withstand submergence for long periods and that the species is distributed by ocean currents.

Laguncularia preracemosa is one of those fortunate finds which enable the student to piece together the scraps of evidence and to build up a reasonable picture of the physiography, climate, and ecologic grouping of the Wilcox flora. This is, so far as I know, the first recorded occurrence of a fossil species of Laguncularia, and though Tertiary species with leaves of similar outline have been described, for example, *Mimosites adenanthera* Unger [1] from Radoboj in Croatia, there is little difficulty in distinguishing them.

There are also similar leaves of unrelated species in the Wilcox flora that might in the absence of the rare fruits be confused with the present species. These are the following forms: *Mimusops sieberifolia* Berry, which is found in the same deposits as *Laguncularia preracemosa* but is distinguishable by its more elongate form, slightly revolute margin, and much more prominent and different venation; *Sophora wilcoxiana* Berry, also found at Puryear, Tenn., whose leaflets are thinner and slightly inequilateral, and have a different venation and an almost obsolete petiolule; *Cassia wilcoxiana* Berry, in which the outline of the leaves is much like the most tapering forms of Laguncularia, but the venation is somewhat different and the leaflets are sessile.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

[1] Unger, Franz, Die fossile Flora von Radoboj, p. 155, pl. 3. fig. 2, 1869.

Genus COMBRETUM Linné.

COMBRETUM OVALIS (Lesquereux) Berry.

Plates XCIII, figure 1, and XCIV, figure 1.

Magnolia ovalis. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 422, pl. 21, figs. 3, 4, 1869.
Knowlton, Am. Geologist, vol. 16, p. 308, 1895.
Magnolia cordifolia. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 422, pl. 22, figs. 1, 2, 1869.

Description.—Leaves relatively large, elliptical or orbicular in general outline, the apex broadly rounded or bluntly pointed, the base very broadly rounded or truncate. Length ranges from 12 to 15 centimeters. Maximum width, in the middle part of the leaf, ranges from 5.5 to 12 centimeters, averaging about 9 centimeters. Margins entire, full, and rather evenly rounded. Leaf substance thin but apparently subcoriaceous. Petiole very stout and curved, not preserved for its full length in any of the material. Midrib very stout, curved; if prominent in life it has been flattened during fossilization, but the fact that it is longitudinally channeled favors the supposition that it was more or less prominent, the lines being due to collapse caused by pressure. Secondaries relatively thin, not prominent, their spacing variable, in general rather remote; they branch from the midrib at angles of 45° or more, pursue a regularly curved subparallel course, and are camptodrome in the marginal region. There are usually about eight subopposite to alternate pairs. Tertiary venation entirely obsolete.

These leaves exhibit considerable variation in outline and most of them are conspicuously inequilateral; the lamina of one of the larger specimens has an extreme width of 8.5 centimeters on one side and only 4 centimeters on the other side. The apex may be broadly rounded or slightly extended; I doubt if it was ever pointed. The large specimen illustrated by Lesquereux as *Magnolia cordifolia* in his figure 1 apparently terminated in a point, but by chipping away more of the matrix in the type specimen it was found that the distal margin was abruptly rounded off.

The material on which the present species is established formed the basis for two species that were referred by Lesquereux to the genus Magnolia, although he states that they are unlike any true Magnolias known to him. In this he is entirely correct. There is considerable variation in the material but no basis for specific segregation, and the variable apex, inequilateral form, obsolete tertiaries, and thin texture, are all characters unlike Magnolia. On the other hand they are paralleled in the modern genus Combretum. This fact, coupled with the presence of leaves of Terminalia in this flora, characteristic fruits of Terminalia in this and in European Eocene floras, leaves, and fruits of Laguncularia in this flora, a combretaceous flower in this flora, and combretaceous wood (Combretacinium Felix) in the European Eocene flora, all indicate the abundance of the Combretaceæ in the Eocene and the prevalence of physical conditions unsuited for Magnolia. Leaves of Combretum have been described by Massalongo, O. Weber, and Heer from the European Tertiary, three species occur in the Wilcox flora, and another in the Claiborne flora. Engelhardt has described two species from the Tertiary of Chile, and Menzel described a species of Combretiphyllum from the Oligocene of Bohemia.

The present species occurs in the Raton formation of the Rocky Mountain province and is referred by Knowlton to Magnolia.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly a part of Tippah County), Miss. (collected by E. W. Hilgard). Wilcox group, Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), 1 mile south of Grand Junction, in Fayette County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

COMBRETUM WILCOXENSIS Berry, n. sp.

Plate LXXXIX, figures 1 and 2.

Description.—Leaves medium sized, elliptical in general outline, the tip bluntly pointed and the base cuneate and decurrent. Length ranges from 12 to 15 centimeters. Maximum width, in the middle or lower part of the leaf, 6 to 10 centimeters. Petiole curved, extremely stout and channeled, between 4 and 5 centimeters in length. Margins entire, conspicuously undulate and somewhat revolute. Leaf substance thick and coriaceous. Midrib stout, prominent on the lower surface of the leaf and narrow on the upper surface. Secondaries relatively narrow on the upper surface. Secondaries relatively (not actually) thin; eight or nine subopposite pairs diverge from the midrib at angles of 45° to 50°, subparallel, unequally spaced, rather straightly ascending to the marginal region, where they curve upward in a camptodrome manner close to and parallel with the marginal undulations. Tertiaries immersed and obsolete.

The distinctive characters of this striking form are well shown by the photograph of the basal and distal portions of the leaves lying close together in the clays, the basal portions showing the under surface and the distal portions the upper surface. The species, though fragmentary, is not rare and the fragments are assembled in the drawing of a complete leaf which shows the minimum of size and width rather than the maximum, the long stout petiole also giving it a more slender appearance than it really possesses. These leaves are well marked, only slightly variable, and more or less inequilateral but not nearly to the extent of *Combretum ovalis*.

They are readily distinguishable from the orbicular-like leaves of *Combretum ovalis*, and their long stout channeled petiole is unlike that of any other known member of the Wilcox flora. They are not dissimilar from the leaves of several existing American species of Combretum and constitute another striking element of the Wilcox flora. They are not especially close to any described fossil species of Combretum.

The existing species of Combretum number about 130, of which about half are trees. They are widely distributed in the tropical and subtropical regions of both the old and new world but do not reach the southern border of the United States. They are absent in Australia, New Zealand, and Oceanica. About 35 species are endemic in South America. Several species, scandent in habit, extend through the West Indies from South America to Cuba.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Combretum obovalis Berry, n. sp.

Plate XCI, figures 6 and 7.

Description.—Large coarse, somewhat inequilateral leaves, elliptical-obovate in general outline, widest above the middle, the apex broadly rounded, slightly retuse and finally prominently mucronate and the base abruptly rounded and finally cuneate. Length about 13 centimeters. Maximum width about 7.75 centimeters. Margins entire. Texture thick and coriaceous. Petiole very stout, not preserved. Midrib extraordinarily stout throughout, 3 millimeters in diameter at the base, very prominent on the lower surface of the leaf. Secondaries stout; about eight pairs diverge from the midrib at angles of about 55° to 60°, curving but slightly in their courses, camptodrome in the marginal region. Tertiaries immersed in the leaf substance.

This is a very characteristic form, with its broad retuse and then apiculate tip, its roundedly constricted and then cuneate base, and its very thick texture and coarse venation. In its coarse texture and elliptical form it resembles *Combretum ovalis* (Lesquereux) Berry, which, however, is relatively shorter and wider and has a pointed tip, fewer secondaries, and a broad, evenly rounded base. The other Wilcox species of Combretum, *Combretum wilcoxensis* Berry, is not quite so coarsely veined and is relatively longer and narrower, being gradually narrowed from about the middle upward to the obtusely pointed tip.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, near Mansfield, De Soto Parish, La. (collected by Mr. Fox).

Collection.—U. S. National Museum.

Genus COMBRETANTHITES Berry.

Combretanthites. Berry, U. S. Nat. Mus. Proc., vol. 45, p. 261, 1913.

This genus was proposed for the following species, which is based on a fossil flower referable to the Combretaceæ and very similar to the flowers of some of the species of Combretum. To avoid any seeming inaccuracies the species is described in detail from the specimen, even though such a method repeats some of the floral characters that run through the family.

Combretanthites eocenica Berry.

Plate XCVI, figures 1–5.

Combretanthites eocenica. Berry, U. S. Nat. Mus. Proc., vol. 45, p. 262, pl. 21, 1913.

Description.—This species is based on the exceptionally preserved flower shown in natural size in Plate XCVI, figure 1, lying across a leaf of *Cassia emarginata* Berry, the other markings on the leaf being those of a well-marked leaf-spot fungus. Before describing the flower in detail it should be pointed out that figures 1, 2, and 4 of Plate XCVI are from photographs that have not been retouched in any particular.

As I interpret it, the flower shows the following characters: Peduncle stout, curved, about 4 millimeters long. Calyx rather deeply four or five lobed, the lobes ovate in outline and the tips bluntly pointed. Corolla polypetalous composed of four or five petals alternating with the calyx lobes, long and narrow, seemingly pointed, about twice the length of the calyx lobes. Ovary inferior, style long and slender, probably bearing a single terminal stigma. Stamens 12 in number, exserted, the filaments long and slender. Anthers elongate-elliptical in form, two celled, dehiscing by longitudinal slits. The stamens may vary in length or their apparent variation may be simply a feature of preservation. I am not sure that the appearances that I have interpreted as petals are correctly identified, but it is hard to imagine what else they can possibly represent. The single slender style is also a feature that may be simulated by a filament. As shown in the accompanying restoration, the flower is polypetalous, regular, and perfect. It is represented as having a four-lobed calyx and four petals, although only three calyx lobes and two petals are distinctly seen in the specimen. If four is the correct number then the stamens are three times as numerous as the petals. The reason for the belief that these flowers were capitate or grew in crowded spikes is their small size, narrow petals, and exserted style and stamens—all characters shared by the flowers of the Mimosaceæ and Combretaceæ, the two families whose flowers are most like the fossil. In the Mimosaceæ the filaments are as a rule more slender and more elongated, as well as more or less united, but in the fossil they are free. The anthers are also much smaller and less elongated in the Mimosaceæ. The flowers of most of the Combretaceæ are very similar to the fossil, although the stamens are generally reduced in number to twice the number of the petals or of the calyx lobes in the apetalous forms. However, some of the modern forms have three times as many stamens as petals or calyx lobes. The most similar modern flowers in appearance that I have been able to find are those of *Combretum guianaense* Rusby from Bolivia, and in this species the stamens are only eight in number and more exserted. I have submitted the specimen to botanists who are familiar with the flora of tropical America and have also compared it with a vast amount of recent material, and I am satisfied that it represents an Eocene member of the Combretaceæ, a family that was apparently well represented in the early Eocene, since I have described from contemporaneous deposits the leaves of three species of Combretum, three species of Terminalia, one species of Conocarpus, and both leaves and fruit of a species of Laguncularia. These all serve in a measure to substantiate one another, and a certain amount of confirmatory evidence is furnished by the petrified wood described by Felix from the European Eocene as Combretacinium[1] and compared with the woods of modern forms of Terminalia, Bucida, and the like. Leaves of Terminalia and Combretum have also been described by several authors from the European Tertiary.

Occurrence.—Lagrange formation (in beds of Wilcox age), 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn).

Collection.—U. S. National Museum.

Genus TERMINALIA Linné.

TERMINALIA LESLEYANA (Lesquereux) Berry.

Plate LXXXIX, figure 4.

Terminalia radobojensis Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, suppl., p. 15, 1872.

Magnolia lesleyana. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 21, figs. 1, 2, 1869.

Lesquereux, The Tertiary flora, p. 248, pl. 44, figs. 1–3, 1878.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, suppl., p. 14, 1872.

Description.—Lesquereux's description, published in 1869, is as follows:

M. foliis obovatis, breviter obtuse acuminatis, in petiolum longe attenuatis; nervo medio valido, transversim eroso striato; nervis secundariis distantibus, irregularibus, secundum marginem valde curvatis.

The type material came from Hurleys, in Benton County (formerly the western part of

[1] Felix, Johannes, Deutsche geol. Gesell. Zeitschr., vol. 46, p. 90, pl. 10, figs. 1a–c, 1894.

Tippah County), Miss., and was collected by Hilgard, who has given a section at this locality and a list of Lesquereux's preliminary identifications.[1] It is interesting to note that in this list the present species is referred to the genus Terminalia, as were also certain specimens afterward collected from Fischers Peak in New Mexico (Raton formation), but all were subsequently transferred to the genus Magnolia by their original describer and compared with the modern species *Magnolia tripetala* Linné, which they resemble in a general way. The type material was not especially well preserved in clay ironstone and seems to have consisted only of the two specimens figured by Lesquereux. These were preserved on a single slab, and the original is not contained in the Hilgard collection at the State University, Oxford, Miss. The counterpart of this specimen, however, is still in the collection, and, though less complete than the figures of the type, serves to show the essential correctness of Lesquereux's drawings.

In their general outline, texture, venation, and the marginal and peduncular characters they are closely allied to the leaves of the existing and fossil species which have been referred to the genus Terminalia, and this resemblance is so striking and so in harmony with the ecologic grouping of the Wilcox flora that I feel justified in transferring the species to this genus.

Among recent forms the present species may be compared with *Terminalia phæocarpa* Eichler or *Terminalia hylobates* Eichler, inhabitants of tropical South America. Among fossil species it may be compared with *Terminalia radobojensis* Unger,[2] which has been identified at a large number of European horizons ranging from the Tongrian to the middle Pliocene (Astian). It is also strictly congeneric with *Terminalia phæocarpoides* Berry, recently described,[3] with other members of a typical subtropical strand flora, from the Claiborne or middle Eocene of Georgia.

The modern species of Terminalia are all tropical and number more than 100 forms, about equally distributed between Asia, Africa, Australia, and America. But one indigenous species, *Terminalia buceras* (often referred to the genus Bucida Linné), reaches the United States. It is found generally on coral soil and has extended from the Caribbean region northward through the West Indies to Elliotts Key, Fla. While some of the species are distributed by birds the seeds of *Terminalia catappa* and *T. littoralis* float in sea water for months without injury, according to Schimper, Guppy, and others.

Besides the species next described, *Terminalia hilgardiana* and *Terminalia wilcoxiana*, only one other species, *Terminalia phæocarpoides*, has been recognized among the fossil floras of North America, although Britton[4] has recognized characteristic fruits in a collection of Tertiary age from Bolivia in South America. From Europe, on the other hand, a dozen or more species have been described. They occur for the most part along the extended Tertiary coast of southern Europe from Eocene to Pliocene times and are represented by characteristic fruits as well as leaves. Two species are described by Watelet from the Ypresian of the Paris Basin, and a form from this horizon somewhat similar to *Terminalia lesleyana* is described from the Sparnacian and Ypresian as *Ficus deshayesi*.[5]

The writer has not seen the material on which Lesquereux based the occurrence of *Terminalia lesleyana* in the Eocene at Evanston, Wyo., and it is included in the foregoing synonymy with considerable hesitation, since it is a somewhat older Eocene horizon than the Wilcox. Remains indistinguishable from the present species have been collected from the Raton formation of northeastern New Mexico.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly a part of Tippah County), Miss. (collected by E. W. Hilgard). Lagrange formation (in beds of Wilcox age) 1 mile south of Grand Junction, in Fayette County, Tenn. (material not positively determined) (collected by E. W. Berry). Wilcox group, sec. 28, T. 13 N., R. 12 W., and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins). Beds of Wilcox age on Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum; State University of Mississippi.

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

[2] Unger, Franz, Chloris protogæa, p. 142, pl. 48, fig. 2, 1847. See also Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, pl. 108, figs. 10-12, 1859.

[3] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 146, pl. 29, fig. 3, 1914.

[4] Britton, N. L., Am. Inst. Min. Eng. Trans., vol. 21, p. 254, figs. 16, 28, 68-70, 1893.

[5] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 151, pls. 39, 40, 41, fig. 1, 1866.

Terminalia hilgardiana (Lesquereux) Berry.

Plate XCII, figure 2.

Magnolia Hilgardiana. Lesquereux, in Owen, D. D., Second report of a geological reconnaissance of the middle and southern counties of Arkansas, p. 319, pl. 6, fig. 1, 1860.
Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 20, fig. 1, 1869.
Lesquereux, The Tertiary flora, p. 249, pl. 44, fig. 4, 1878.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 282, pl. 39, 1899.
Knowlton, in Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 73, pp. 60, 61, 1911.
Magnolia laurifolia. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 421, pl. 20, figs. 2, 3, 1869; Proc. U. S. Nat. Mus., vol. 11, p. 25, 1888.
Quercus Lyellii. Lesquereux (in part, not Heer), Am. Philos. Soc. Trans., vol. 13, p. 415, pl. 17, fig. 3 (not figs. 1, 2).

Description.—Leaves medium sized to large, oblong-ovate in general outline. Apex not preserved in any of the material. Base narrowly or broadly cuneate. Length ranges from 15 to 25 centimeters. Maximum width at or above the middle ranges from 4 to 10 centimeters. Margins entire, more or less irregularly undulate. Leaf substance thin but coriaceous. Only fragments of the petiole preserved; it was evidently short and very stout. Midrib stout, more or less curved, prominent on the lower surface of the leaf. Secondaries relatively thin, numerous, subparallel; about 20 rather regularly spaced, opposite to alternate pairs diverge from the midrib at angles of 40° to 70°, averaging about 50°, curving slightly and regularly, camptodrome close to the margins.

The type material of this species was collected by Hilgard from the Ackerman formation at Hurleys, Benton County, Miss., and first figured by Lesquereux in Owen's second report of a geologic reconnaissance of part of Arkansas. It is not to be found in the remains of the Hilgard collection at the University of Mississippi. When Lesquereux described and illustrated this material he differentiated two species, although there is obviously only one form represented. The species is abundant in the Midway (?) formation at Earle, Tex., is rather widespread in the Wilcox, and occurs in the lower Eocene of Fishers Peak, N. Mex. (Raton formation). It has also been recorded from the Fort Union formation of Montana and the Eocene of Lassen County, Cal.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly a part of Tippah County), Miss. (collected by E. W. Hilgard). Wilcox group, Campbell's quarry, Cross Bayou, Caddo Parish, La. (collected by L. C. Johnson); McLees, 2 miles north of Mansfield, De Soto Parish, La. (collected by L. C. Johnson); one-fourth mile above Coushatta, Red River Parish, La. (collected by G. D. Harris); 1½ miles northeast of Mansfield and sec. 28, T. 13 N., R. 12 W., De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins), and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry) (rare).

Collections.—U. S. National Museum; New York Botanical Garden.

Terminalia wilcoxiana Berry, n. sp.

Plate LXXXIX, figure 3.

Description.—Fruit crustaceous, large, narrowly elliptic in outline, compressed, about 3.5 centimeters in length by about 1.4 centimeters in maximum width midway between the apex and the base, ventricose medianly, with two grooves on each side toward the margins. Margins keeled. Pericarp thin and dry.

This fruit is almost identical with the fruits of the Indian almond, *Terminalia catappa* Linné, as well as with those of other existing species of Terminalia whose fruits are dry and have reduced wings.

Only two specimens of this characteristic fruit have been collected, but the leaves of two species of Terminalia are common throughout the Wilcox, and the genus is represented in the later Tertiary formations of the Mississippi embayment region.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus CONOCARPUS Linné.

Conocarpus eoligniticus Berry, n. sp.

Plate XCV, figures 1 and 2.

Description.—Leaves of different sizes, ovate-lanceolate and generally falcate in outline, the tip acute or obtuse and the base acute and decurrent. Length ranges from 6 to 8 centimeters. Maximum width, in the middle part of the leaf, ranges from 1.8 to 3 centimeters. Margins entire but somewhat irregular. Leaf substance very thick and surface roughened. Petiole stout and curved, merging insensibly with the basal part of the lamina of the leaf, about 1 centimeter to 1.5 centimeters in length, thus a trifle longer than in the modern *Conocarpus erectus* Linné. Midrib stout and curved, mostly immersed in the thick substance of the leaf. Secondaries nearly obsolete in the leaf substance, about five or six curved camptodrome pairs. Tertiaries obsolete.

This characteristic species in its limits of size, somewhat irregular and generally falcate form, its very coriaceous texture, and its obsolete venation is almost exactly like the leaves of the modern *Conocarpus erectus* Linné, which inhabits both sandy and muddy tidal shores, lagoons, and bays, from the Antilles and the Florida Keys to Central America and tropical South America, as well as tropical western Africa. It is a characteristic element of the tropical strand flora, which is replaced in the Orient by different species of Eugenia and mangroves. The genus Conocarpus is monotypic in the existing flora. A single fossil species has been recently described by me from the Claiborne group of Georgia,[1] and Menzel [2] has described fruits from the Aquitanian of Rhenish Prussia. The two extremes of size have been figured; the ornate radial groups of marking on the larger leaf are casts of gypsum crystals, probably indicating the lagoon-like character of the basin of deposition.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 2 miles south of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collection.—U. S. National Museum.

Family HYDROCARYACEÆ (TRAPACEÆ).

Genus TRAPA Linné.

TRAPA WILCOXENSIS Berry, n. sp.

Plate CI, figures 7–9.

Description.—Fruit relatively small, kite-shaped, one-celled, indehiscent, somewhat coriaceous, armed with two more or less extended, laterally directed or ascending, not recurved spines. Width 1.3 to 1.8 centimeters. Height 7 to 9 millimeters. Expanded medianly, broad and extended below, more or less extended above. Spines stout and conical. Surface more or less tuberculate medianly.

This small-fruited species is common at Puryear. It shows considerable variation in outline and the extent to which the spines are developed. Though smaller than most fossil species that have been described and much smaller than the fruits of the three existing species, it is clearly referable to the genus Trapa. The genus, formerly referred to the family Onagraceæ, is made the type and only genus of the family Hydrocaryaceæ (Trapaceæ) by Raimann.[3] In the existing flora there are three species, all of which are confined to the Old World, though *Trapa natans* is naturalized in New England and New York. *Trapa natans* Linné, which has normally four horns, inhabits central and southern Europe but formerly possessed a much greater range; *Trapa bicornis* Linné grows in China and Japan, and *Trapa bispinosa* Roxburg in southern Asia and Africa. The last two species each have two horns, as their names indicate. The genus has an extended geologic history. Rosettes supposed to represent the floating leaves (*Trapa* (?) *microphylla* Lesquereux, *Trapa* (?) *cuneata* Knowlton) are widespread in the Rocky Mountain province in beds of late Upper Cretaceous to early Eocene age. The oldest fruits are those described above from beds of Wilcox age, and a large-fruited bicornute species from the Eocene of Canada and Alaska. In the Oligocene there is a species in Saxony (*Trapa credneri* Schenk).

No less than seven species have been described from the Miocene; two of them occur in Idaho (Payette formation), one in Japan, and the remainder in Europe, where two forms extend into the Pliocene.

The existing European *Trapa natans* has been recorded from the preglacial deposits of England and Saxony, from numerous interglacial and postglacial localities in Portugal, Italy, Netherlands, Germany, Sweden, Russia, and Denmark (Andersson mentions 18 localities in West Prussia, 6 in Denmark, 17 in Sweden, and 29 in Finland). The present species is not especially close to any previously described.

[1] Berry, E. W., U. S. Geol. Survey Prof. Paper 84, p. 147, pl. 29, figs. 4–7, 1914.

[2] Menzel, P., K. preuss. geol. Landesanstalt Jahrb., Bd. 34, Theil 1, Heft 1, p. 53, pl. 5, figs. 17–21, 1913.

[3] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, 1893.

The finding of nuts of a species of Trapa is interesting, since it shows that an inhabitant of ponds and slow streams grew near enough to the deposit at Puryear for its nuts to be brought in and fossilized.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family MELASTOMATACEÆ.

Genus MELASTOMITES Unger.

MELASTOMITES AMERICANUS Berry, n. sp.

Plate XCVII, figures 1–3.

Description.—Leaves of different sizes, elliptical-lanceolate and more or less falcate in general outline. Apex narrowed and bluntly pointed, in some specimens slightly inequilateral. Base narrowed and extended, decurrent for a more or less considerable distance. Length ranges from 2.5 to 8 centimeters, averaging about 7 centimeters. Maximum width, in the middle part of the leaf, ranges from 1 to 2.6 centimeters, averaging about 2 centimeters. Petiole stout and curved, its length not determinable. Midrib stout and curved. Secondary venation peculiar, the lowest suprabasilar pair subopposite, long, and ascending; they diverge from the midrib at angles of about 25°, and though thinner than the midrib they are, because of their greater length, stouter than the regular secondaries; they curve upward, parallel to the lower lateral margins, and continue with successive flat arches close to the margin, joining the midrib in the tip in an acrodrome. After a basal interval above these laterals there are about six pairs of thin, more or less equally spaced, alternate to opposite secondaries; they diverge from the midrib at wide angles, ranging from 50° to 70° and becoming wider distad; they curve upward, becoming subparallel with the margin and also with the marginal vein, with which they merge, causing it to arch slightly. Tertiaries thin, more or less immersed, forming small arches in the marginal region and quadrangular or pentagonal meshes internally. Leaf margins entire. Texture subcoriaceous.

This well-marked species suggests comparisons with a variety of unrelated forms, as, for example, certain species of Lauraceæ, Myrtaceæ, Thymelæaceæ, Celastraceæ, Rhamnaceæ, and the like. It seems to me, however, to be more properly referable to the Melastomataceæ, a family mostly tropical and so largely developed in America. The fossil may be compared with a number of modern genera, but the name Melastomites is preferable, as indicative of the family without being unduly specific as to the modern genus that is closest to this Eocene form. According to Krasser, who monographed the family for Engler and Prantl's Natürlichen Pflanzenfamilien, at least 2,000 of the 2,800 existing species are American and largely South American. Several fossil forms ranging in age from the Upper Cretaceous through the Tertiary, and nearly all European, have been referred to Melastomites, but none of these are especially close to *Melastomites americanus*. A single small leaf from Puryear is referred to this species, which is present in considerable abundance at the outcrop in Fayette County, occurring also along the western shore of the embayment.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry), and 1½ miles west of Grand Junction, in Fayette County, Tenn. (collected by L. C. Glenn). Wilcox group, 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson).

Collections.—U. S. National Museum.

Order UMBELLALES.

Family ARALIACEÆ.

Genus ARALIA of authors.

ARALIA NOTATA Lesquereux.

Plate XCVII, figure 4.

Platanus dubia.[1] Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 406, 1874.

Aralia notata. Lesquereux, The Tertiary flora, p. 237, pl. 39, figs. 2–4, 1878.

Ward, U. S. Geol. Survey Bull. 37, p. 60, pl. 27, fig. 1, 1887.

Ward, U. S. Nat. Mus. Proc., vol. 11, p. 40, pl. 17, fig. 1, 1888.

(?) Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 20, 1888.

Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 745, pl. 100, fig. 1, 1899.

Knowlton, Torrey Bot. Club Bull., vol. 29, p. 706, 1902.

(?) Penhallow, Roy. Soc. Canada Trans., ser. 2, vol. 8, sec. 4, p. 70, 1902.

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[1] The name *dubia* in combination with Aralia is preoccupied by a European Tertiary species so named by Schimper in 1874 (Paléontologie végétale, vol. 3, p. 35).

Magnolia laurifolia. Lesquereux (in part), U. S. Nat. Mus. Proc., vol. 11, p. 25, 1888.

Aralia, fragment. Lesquereux, idem, p. 25, 1888.

(?) Aralia sp. Knowlton, U. S. Geol. Survey Bull. 204, p. 81, 1902.

Description.—The materials on which the original description of this species was based came from strata since referred to the Denver formation in Colorado and the Fort Union formation in Montana. From the first they were more or less confused with similar large lobate leaves showing more or less toothed margins and more or less craspedodrome venation, of a type usually regarded as platanoid. There can be but little question that this species is not the same as *Platanus nobilis*. Whether or not the forms are related to the Araliaceæ can not be settled at present. They may represent genera of Platanales, which order seems really to be closely related to the Urticales rather than to the Rosales, or they may be referable to the order Malvales. I have described a form rather similar to *Aralia notata* from the Midway (?) formation of Earle, Tex., which I have referred to the genus Pourouma.

Aralia notata is at present known from only a few localities in the Wilcox, where it is but sparingly represented. The materials represent a leaf about 22 centimeters in length by about the same width from tip to tip of the lateral lobes. The leaves are palmately triveined and trilobate, subcoriaceous in texture, the margins strictly entire; stout primaries are prominent on the lower surface of the leaf; the numerous rather close set, well-defined subparallel secondaries are characteristically camptodrome close to the margins.

This is an abundant Denver and Fort Union species, and the Wilcox material is identical with that from the Rocky Mountain region, except that the lobes are slightly more slender but not more so than in some of the western specimens. Two specimens were collected from a locality near Mansfield, La., by L. C. Johnson and submitted to Lesquereux. One of these (U. S. Nat. Mus. No. 2431, Lesquereux's No. 806) was identified as "Aralia, fragment." The other (U. S. Nat. Mus. No. 2516, Lesquereux's No. 804) was mistakenly referred to *Magnolia laurifolia*.

Occurrence.—Wilcox group, Hardys Mill, near Gainesville, Greene County, Ark. (collected by John C. Branner), and McLees, 2 miles north of Mansfield, De Soto Parish, La. (collected by L. C. Johnson).

Collections.—U. S. National Museum.

ARALIA ACERIFOLIA Lesquereux.

Aralia acerifolia. Lesquereux, The Cretaceous and Tertiary floras, pp. 232, 265, pl. 49, fig. 5; pl. 45B, fig. 1, 1883.

Description.—Lesquereux's description, published in 1883, is as follows:

> Leaves small, palmately three-lobed, broadly rounded at base; lobes oblong, enlarged in the middle, gradually narrowed to the obtuse sinuses, contracted above and lanceolate to a blunt point, entire; primary nerves comparatively strong; lower secondary nerves at right angles, the upper very open and curved in passing toward the borders, camptodrome.

A single fragmentary specimen of what is almost certainly this species was collected at Grenada. It is identical in size, caliber, and character of the venation and has the same broadly rounded base, basilar primaries, and a marginal secondary on each side from the base of the lateral primaries.

This species was described by Lesquereux from the Fort Union formation of Dakota, and in a supplementary part of the same volume he records it from the Chalk Bluffs of California, which are of Miocene age according to Knowlton. There are, however, certain differences between the forms from California and Dakota, and they may not be identical. The name does not appear in Knowlton's recently published revision [1] of the flora of the auriferous gravels of California, so that it is not considered a member of that flora at the present time. The specimen from Mississippi, however, is identical with the type of the species from Dakota.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

ARALIA JORGENSENI Heer (?).

Aralia Jorgenseni. Heer, Flora fossilis arctica, vol. 7, p. 116, pl. 101, fig. 1, 1883.

Description.—Leaves palmately trilobate, divided almost to the base by deep narrow sinuses. Tips acute. Base cuneate, decurrent. Margins entire. Lobes elongate-lanceo-

[1] Knowlton, F. H., in Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 73, pp. 57-64, 1911.

late, the two lateral lobes inequilateral, the median lobes narrowed at the base. Petiole stout. Primaries three, suprabasilar, diverging at angles of about 30° to 35°. Secondaries thin, mostly immersed, their tips united by flat camptodrome arches. Tertiaries obsolete.

This species was described by Heer from the Tertiary of Unartok, western Greenland, and among other forms compared with *Aralia primigenia* De la Harpe, which occurs at Monte Bolca, Italy, and Alum Bay, England. Heer considered the Arctic plant-bearing beds to be of Miocene age, but, as shown by Gardiner and Saporta and now generally admitted, they are of middle or upper Eocene age. The occurrence of this species in Mississippi is queried, since it is unfortunately based on a single incomplete specimen, which, however, agrees closely with the form from Greenland and is almost certainly that species.

Of much interest in the present connection is the resemblance of this species to forms occurring in the Dakota sandstone of the West and the Woodbine sand of Texas and described as *Sterculia lugubris* Lesquereux. It would seem that *Aralia jorgenseni* Heer is a descendant of *Sterculia lugubris*, and the difference in age between the Wilcox and the Tertiary of western Greenland would measure the interval of time that was occupied by this species in its northward migration during Eocene time.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus **OREOPANAX** Decaisne and Planchon.

OREOPANAX OXFORDENSIS Berry, n. sp.

Plate XCVIII, figures 1–5.

Description.—Leaves large, digitately compound. Leaflets three to seven, radiating in a more or less peltate manner from the apex of a long stout petiole about 15 centimeters in length and about 4 millimeters in diameter, enlarged at the base and apex. Leaflets ovate-lanceolate in outline, many of them falcate, differing in number, size, and relative width. They range from 7 to 11 centimeters in length and from 1 to 3 centimeters in maximum width in the basal half of the leaflet. Apex gradually narrowed and more or less obtusely pointed. Base rounded to narrowly cuneate, more or less full and as a rule somewhat inequilateral. Margins variable, in some specimens entire and slightly undulate, but serrate-toothed in most of the specimens collected. The margins of the serrate-toothed specimens are entire below upward to or beyond the point of greatest width of the leaflet, and then irregularly spaced and more or less distant serrate teeth appear, separated by rounded open inequilateral sinuses for the rest of the distance to the apex. In other specimens the margins are entire more than halfway to the apex and bear scattered teeth distad, and in still other specimens the teeth are relatively numerous nearly down to the base. Leaflets petiolulate. Petiolules stout, channeled, turgid at the point of attachment, 1 to 2 centimeters in length. Midrib stout, more or less curved. Secondaries thin; about seven subopposite to alternate pairs branching from the midrib at angles of about 45° and sweeping upward in broad even curves, eventually camptodrome, sending short branches into the marginal teeth. Tertiaries obsolete. Texture coriaceous.

This remarkably handsome species is clearly distinct from any hitherto known outside of the existing flora. Its general proportions are well shown in the accompanying drawing (fig. 16), which is a greatly reduced restoration of a complete leaf of this form. No part of this restoration is conjectural, however, for though the actual fossil material is fragmentary it is very abundant and all parts of the large compound leaves are represented by actual specimens, some of the more complete of which are reproduced from photographs in Plate XCVIII. A fragment from Benton, Ark., is somewhat doubtfully identified as this species.

This species belongs to the section Digitatæ of Harms, which embraces several existing species of the uplands of Mexico and Central America, and is especially close to *Oreopanax xalapensis* (Humboldt, Bonpland, and Kunth) Decaisne of Mexico and also to *Oreopanax taubertianus* Donnell Smith of the mountains of Guatemala, which is almost identical with the fossil form and has leaves composed of different-sized leaflets that may be entire margined or toothed. The leaves range somewhat larger than the Wilcox species and the leaflets are relatively wider. With the exception of these slight variations the similarity between the Eocene and the modern species is most remarkable. The digitate species of Oreopanax grade imperceptibly into the lobate forms which are commoner than the former in Central America and are also abundant in tropical South America. The genus Macropanax Miquel embraces three or four species of the Malayan region which also somewhat resembles *Oreopanax oxfordensis*.

are very much like those of Oreopanax. Subsequent to its original description Velenovsky transferred *Aralia coriacea* to the genus Dewalquea,[2] although his attempted restorations are not particularly happy. The Bohemian species has been recognized by Engelhardt[3] in the Upper Cretaceous of Saxony and by Hollick[4] in that of eastern North America, but the American material is not very convincing, so that there is considerable doubt in the suggestion that *Aralia coriacea* may be ancestral to *Oreopanax oxfordensis*.

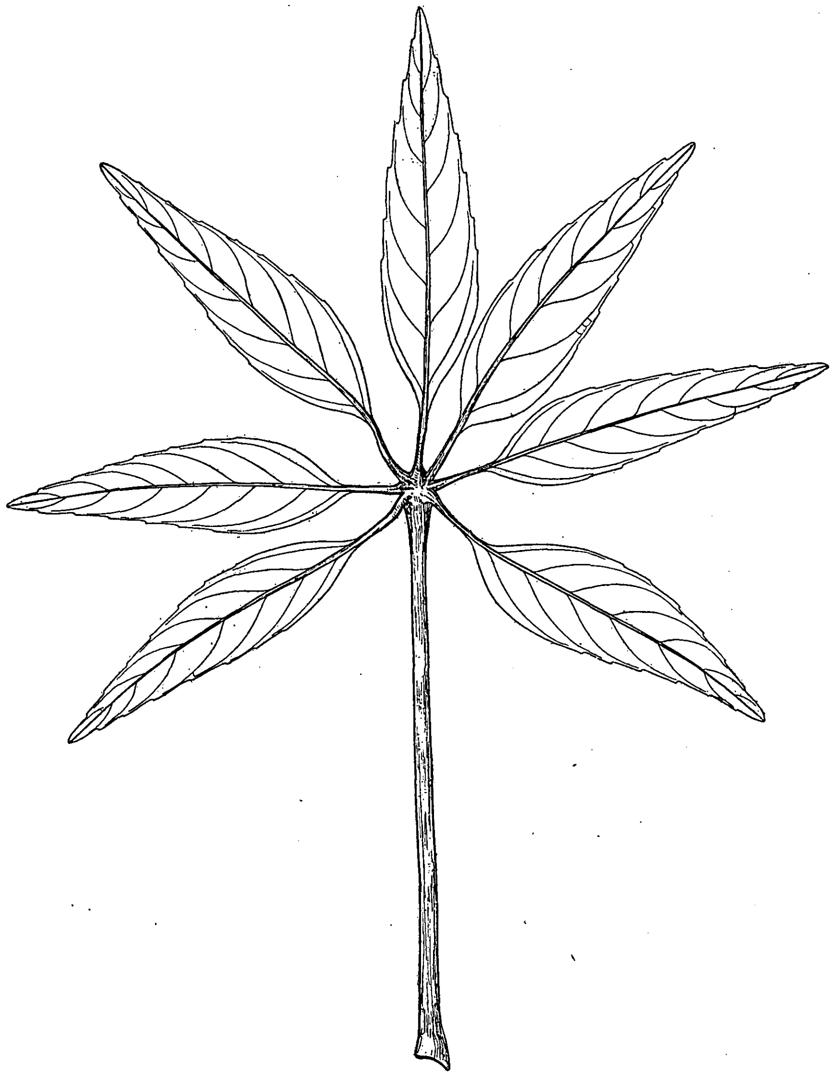

FIGURE 16.—Restoration of a leaf of *Oreopanax oxfordensis* Berry. (One-half natural size.)

The only antecedent form worth mentioning in the present connection is *Aralia coriacea*, described by Velenovsky [1] from the Cenomanian of Bohemia. In the discussion of *Bombacites formosus* Berry I have already mentioned the resemblance of the wider leaves of *Aralia coriacea* to Bombacites. The narrower leaves

Occurrence.—Holly Springs sand, railroad cut (common), ravine (rare) Oxford, Lafayette

[1] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, pt. 3, p. 11, pl. 1, figs. 1-9; pl. 2, fig. 2, 1884.

[2] Velenovsky, Josef, Květena českého cenomanu, p. 23, pl. 4, figs. 1-6, 1889.

[3] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1891, Abh. 7, p. 99.

[4] Hollick, Arthur, U. S. Geol. Survey Mon. 50, p. 99, pl. 38, figs. 5, 6, 1907.

County, Miss. (collected by E. W. Berry). Wilcox group, Benton (Henderson pit), Saline County, Ark. (collected by J. C. Branner).

Collections.—U. S. National Museum.

Oreopanax minor Berry, n. sp.

Plate XCIX, figure 1.

Description.—Leaves relatively small, digitately compound. Petiole long and stout, slightly tumid at the apex and base, about 6 centimeters in length. Leaflets at least four, and probably from five to seven in number, lanceolate, with entire margins and narrowly pointed tips and bases, very slightly petiolulate. Midribs stout. Secondaries thin, diverging from the midrib at wide angles, curved, camptodrome. Texture coriaceous.

This species is unfortunately based on very fragmentary material, the most complete specimen being the one figured, which, though poor, shows clearly the petiole and leaf habit. The rarity of this form would indicate an inland or upland habitat, specimens now and then being brought down to the basin of sedimentation by streams.

It is too incomplete to merit a detailed comparison with Recent forms that resemble it in a general way. It is readily distinguishable from the robust *Oreopanax oxfordensis* Berry as well as from the previously described fossil species, which are mostly European.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family CORNACEÆ.

Genus CORNUS Linné.

Cornus studeri Heer (?).

Plate LXVIII, figure 3.

Cornus studeri. Heer,[1] Flora tertiaria Helvetiæ, vol. 3, p. 27, pl. 105, figs. 18–21, 1859.
Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 293, 1872.
Lesquereux, The Tertiary flora, p. 244, pl. 42, figs. 4, 5, 1878.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 286, pl. 45, fig. 2, 1899.
Knowlton, U. S. Geol. Survey Bull. 163, p. 68, pl. 15, fig. 3, 1900.

Description.—Leaves large, broadly ovate in general outline, many of them slightly inequilateral, the tip somewhat narrowed and acuminate and the base rounded or very broadly pointed. Margins entire, in some specimens faintly undulate. Texture subcoriaceous. Midrib stout and prominent. Secondaries stout; six to nine pairs, diverge from the midrib at irregular intervals at angles of about 45°, camptodrome. Tertiaries distinct, percurrent. The single Louisiana specimen has a length of 16 centimeters and a maximum width midway between the apex and the base of 8.75 centimeters.

This species is represented in the Wilcox flora by numerous fragments, the single specimen figured being the most complete. It is certainly identical with the material described by Lesquereux from the Denver formation and with that described by Knowlton from the Raton formation. I have queried the determination, for its identity with the type material of Heer from the Aquitanian of Switzerland is extremely doubtful. Heer's specimen is not only much younger, but the leaves are smaller and there are minor differences of venation. I imagine that it is really a species of Ficus instead of a Cornus, and Schenk[2] makes the same suggestion in regard to the European form. Rather than obscure its value in correlation by transferring it to another genus, especially as my material is so poor, I have allowed it to remain in Cornus. It may be more properly compared with the European Paleocene species *Cornus platyphylla* Saporta[3] and *Artocarpoides conocephaloides* Saporta.[4]

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris and E. W. Berry), and sec. 28, T. 13 N., R. 12 W., and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum; New York Botanical Garden.

Genus NYSSA Linné.

Nyssa wilcoxiana Berry, n. sp.

Plate XCIX, figures 5–7.

Description.—Stones medium sized to large, terete or slightly compressed, ovate in general outline, widest in the middle, rounded at the

[1] I have omitted all other European citations.

[2] Schenk, August, Die fossilen Pflanzenreste, p. 236, 1888.

[3] Saporta, G. de, Prodrome d'une flore fossile des travertins anciens de Sézanne, p. 103, pl. 11, figs. 8, 9, 1868.

[4] Idem, p. 356, pl. 6, fig. 6.

base, acuminate distad. Texture ligneous. Surface ornamented with close-set, narrow, longitudinal ridges. Length ranges from 1.6 to 2.25 centimeters, and width from 4.5 to 10.5 millimeters.

Nineteen so-called species based on Nyssa stones have been described from the small pocket of lignite at Brandon, Vt. Among these the present species may be compared with *Nyssa multicostata* Perkins.[1]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 4½ miles southeast of Naborton, De Soto Parish, La. (collected by O. B. Hopkins).

Collections.—U. S. National Museum.

NYSSA EOLIGNITICA Berry, n. sp.

Plate XCIX, figure 8.

Description.—Stones rather large, elliptical in outline, rounded at both ends, slightly compressed, with numerous narrow, close-set, longitudinal ridges. Length about 2.6 centimeters. Maximum width about 11 millimeters.

This species is much larger and more elliptical in outline than *Nyssa wilcoxiana* Berry. It resembles the larger forms from Brandon which Perkins[2] identified as *Nyssa lescurii* Hitchcock, although it is not identical with Hitchcock's original form. It is also much like an undescribed form that is abundant in the clays of the Yegua formation and in the Catahoula sandstone of eastern Texas.

The genus Nyssa is represented in fossil floras from the late Upper Cretaceous onward, the water-side habit of many of the species and the resistant nature of the fruit stones being very favorable to fossilization. The genus comprises five or six species in the existing flora, all of which are confined to southeastern North America except one Asiatic form, which ranges from the eastern Himalayas to the island of Java.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Perkins, G. H., Vermont State Geologist Rept. 1903–4, p. 197, pl. 79, fig. 103, 1904.

[2] Perkins, G. H., Vermont State Geologist Rept. 1905–6, pl. 52, fig. 9, 1906.

Superorder GAMOPETALÆ.

Order PRIMULALES.

Family MYRSINACEÆ.

Genus ICACOREA Aublet.

ICACOREA PREPANICULATA Berry, n. sp.

Plate CVII, figure 5.

Description.—Leaves lanceolate and many slightly inequilateral in general outline, widest at or above the middle and tapering to both ends; the base more narrowly extended than the tip, which is commonly blunt. Length between 8 and 9 centimeters. Maximum width about 2.75 centimeters. Margins entire, slightly undulate by reason of a tendency to be unevenly revolute. Texture coriaceous. Petiole short, stout, and curved, much expanded proximad, about 1 centimeter in length. Midrib stout, curved, prominent, subparallel, eight to ten opposite to alternate pairs; they diverge from the midrib at angles of 50° to 65°; as a rule the more open angles are in the tip or base of the leaf and the more ascending and less open angled secondaries in the median part of the leaf; all become subparallel with the lateral margins, along which they continue for a considerable distance, forming a series of regularly diminishing arches until they finally merge with the Tertiary areolation. Tertiaries percurrent, partly obsolete by immersion in the leaf substance.

The species here discussed is exceedingly like the leaves of the existing *Icacorea paniculata* Sudworth, a shore shrub or small tree of the Florida Keys, southern Mexico, the Bahamas, and Antilles.

The genus Icacorea is sometimes extended to include the 200 existing species of the Tropics and subtropics of both hemispheres which by other authors are referred to the genus Ardisia Swartz. Pax, one of the most experienced students of the Myrsinaceæ, makes Icacorea a subgenus of Ardisia and restricts it to the American species. Icacorea is unquestionably entitled to generic rank and should be separated from Ardisia. Whether the other subgenera of Ardisia are entitled to rank as genera I am not prepared to say, although all have received such rank at one time or another. About a dozen fossil species have been referred to Ardisia, and several of these should probably be referred to Icacorea, namely, *Icacorea lanceolata* Ettingshausen from the Aquitanian of Bohemia, compared with the existing *Icacorea dentata* De Candolle of Cuba, *Icacorea primæva* Ettingshausen of the Burdigalian of Bohemia, compared with *Icacorea semicrenata* De Candolle of Brazil, and possibly also *Icacorea daphnoides* Massalongo from the Pliocene of Italy.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order EBENALES.

Family EBENACEÆ.

Genus DIOSPYROS Linné.

DIOSPYROS BRACHYSEPALA Alexander Braun.

Plates CI, figures 3 and 4, and CVII, figure 6.

Diospyros brachysepala. Alexander Braun, Die Tertiär Flora von Oeningen, Neues Jahrb., 1845, p. 170.
Unger, Blätterabdrücke aus dem Schwefelflötze von Swoszowice in Galicien, p. 125, pl. 14, fig. 15, 1850.
Unger, Genera et species plantarum fossilium, p. 435, 1850.
Heer, Flora tertiaria Helvetiæ, vol. 3, pp. 11, 191, pl. 102, figs. 1–14, 1859.
Heer, Die Urwelt der Schweiz, pp. 354, 355, fig. 215, 1865.
Sismonda, Matériaux pour servir à la paléontologie du terrain tertiaire du Piémont, p. 443, pl. 11, fig. 6; pl. 16, fig. 5; pl. 19, fig. 3, 1865.
Ettingshausen, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 2, p. 232, pl. 38, fig. 28; pl. 39, fig. 1, 1868.
Ettingshausen, Die fossile Flora der älteren Braunkohlenformation der Wetterau, p. 865, pl. 3, fig. 7, 1868.
Heer, Miocene baltische Flora, p. 84, pl. 27, figs. 1–6; pl. 28, fig. 1, 1869.
Heer, Ueber Braunkohlenpflanzen von Bornstädt, p. 16, pl. 3, figs. 7, 8, 1869.
Engelhardt, Flora der Braunkohlenformation in Königreich Sachsen, p. 21, pl. 5, figs. 8–10, 1870.
Heer, Flora fossilis arctica, vol. 1, p. 117, pl. 15, figs. 10–12, pl. 17, figs. 5h, 5i, 1871; vol. 2, pt. 4, p. 475, pl. 55, fig. 8, 1871; vol. 5, pt. 2, p. 41, pl. 11, figs. 3–6a, 1878; vol. 6, Obth. 1, pt. 2, p. 13, pl. 3, figs. 15, 16, 1882; vol. 7, p. 109, pl. 79, figs. 1–8, pl. 92, fig. 10, pl. 94, fig. 6, 1883.
Schimper, Paléontologie végétale, vol. 2, p. 949, 1872.
Engelhardt, Die Tertiärflora von Göhren, p. 28, pl. (v)xii, fig. 7, 1873.
Engelhardt, Tertiärpflanzen aus dem Leitmeritzer Mittelgebirge, p. 362, pl. 18, figs. 1, 2, 1876.
Geyler, Ueber fossile Pflanzen aus den obertertiären Ablagerungen Sicilien's, p. 326, pl. 68, figs. 12, 13, 1876.
Lesquereux, The Tertiary flora, p. 232, pl. 40, figs. 7–10; pl. 63, fig. 6, 1878.
Zwanziger, Beiträge zur Miocänflora von Liescha, p. 66, pl. 25, figs. 1, 2, 1878.
Lesquereux, The Cretaceous and Tertiary floras, p. 174, pl. 34, figs. 1, 2, 1883.
Pilar, Flora fossilis Susedana, p. 82, pl. 14, fig. 1, 1883.
Friedrich, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen, pp. 63, 119, 126, 253, 255, pl. 6, fig. 1, 1883.
Ward, Synopsis of the flora of the Laramie group, p. 556, pl. 60, figs. 4, 5, 1886.
Lesquereux, U. S. Nat. Mus. Proc., vol. 10, p. 41, 1887.
Ward, Types of the Laramie flora, U. S. Geol. Survey Bull. 37, p. 104, pl. 49, figs. 1, 2, 1887.
Cavara, Istituto di Bologna Reale Accad. Sci. Mem., vol. 7, p. 723 (table), 1887.
Peola, Flora fossile Braidese, p. 96, 1895.
Paolucci, Nuovi materiali e ricerche critiche sulle piante fossili terziarie dei gessi di Ancona, p. 104, pl. 18, figs. 127, 128, 1896.
Peola, Rivista ital. di paleontologia, vol. 2, pp. 156, 272, 1896.
Almera, Com. mapa geol. España Bol., 2d ser., vol. 2, p. 157, 1897.
Peola, Rivista ital. di paleontologia, vol. 4, p. 82, 1898; vol. 5, p. 108, 1899.
Peola, Soc. geol. ital. Boll., vol. 18, p. 253, 1899.
Peola, Flore dell' Elveziano torinese, p. 38, 1899.
Almera, Soc. géol. France Bull., vol. 26, p. 686, 1899.
Marty, Végétaux fossiles des cinérites pliocènes de Las Clausades (Cantal), p. 17, pl. 5, fig. 8; pl. 6, figs. 1–3, 1905.

Andromeda dubia. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 364, 1859.
Lesquereux, in Safford, J. M., Geology of Tennessee, p. 428, pl. K, fig. 5, 1869.
Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 196, fig. 5, 1888.

Description.—This polymorphous species has been recorded from a very large number of localities and horizons, as the partial synonymy given above clearly emphasizes. The type material came from both the earliest and latest Swiss Miocene, but subsequently this species has been identified from all stages of the Tertiary of Europe. In America it has been recorded from beds of late Upper Cretaceous age and at different Tertiary horizons. It seems incredible that all these records should represent a single species and probably several species are included, but their segregation on other than stratigraphic grounds is impossible at the present time. The Wilcox leaves are much smaller and are otherwise readily distinguished from *Diospyros wilcoxiana* Berry. They occur also in the Claiborne deposits of the western Gulf region.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County (collected by E. W. Berry), and Somerville, Fayette County, Tenn. (collected by J. M. Safford). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum.

DIOSPYROS WILCOXIANA Berry, n. sp.

Plate CI, figures 1 and 2.

Description.—Leaves medium sized to large, ovate-lanceolate in outline, the lateral margins regularly curved and the apex and base about equally pointed. Length ranges from 7.5 to 15 centimeters. Maximum width, about midway between the apex and the base, ranges from 3.5 to 5.5 centimeters. Margins entire, in places slightly undulate. Texture subcoriaceous. Petiole short and stout, enlarged proximad; in minimum-sized leaves, in which only it seems to be preserved, it is 5 or 6 millimeters long. Midrib stout, as a rule more or less curved. Secondaries rather stout, numerous, subparallel, camptodrome; from 10 to 15 subopposite to alternate pairs branch from the midrib at angles of 50° to 70° and pursue a rather straight course until near the margin, where they curve upward and form abruptly decreasing arches more or less parallel with it. Tertiary venation relatively prominent. Main nervilles largely percurrent, the interspaces made up of relatively large four, five, or six sided meshes.

The two extremes in size of this species have been figured. The secondaries of the smaller are less numerous and more ascending, but the differences observable are not of specific value.

Diospyros is an abundant type in fossil floras and ranges back to the middle Cretaceous, from which a variety of leaf species have been described. I recently described an unmistakable fruit calyx from this horizon under the name *Diospyros vera*,[1] so that the affinity of the leaves is abundantly confirmed. About 50 Tertiary species have been described from a large number of localities and horizons and abundantly fortified by fruiting material.[2] The genus is especially abundant from the upper Eocene through the Oligocene of Europe and in the lower Eocene of Western America (Fort Union formation). The forms from the Rocky Mountain region which were contemporaneous with the present species are all smaller, readily distinguishable species.

The existing species of Diospyros number more than 150 and are widely distributed in the Tropics and warmer temperate regions of both hemispheres. Several species, for example *D. maritina* Linné and *D. teysmanni* Miquel of the East Indies, are typical strand plants. The species now under consideration, which is common at Puryear, is very similar to numerous existing forms, including the larger leaves of *Diospyros virginiana* Linné of our Southern States.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family SAPOTACEÆ.

Genus SIDEROXYLON Linné.

SIDEROXYLON ELLIPTICUS Berry, n. sp.

Plate C, figure 8.

Description.—Leaves relatively large, elliptical in general outline. Apex rounded. Base ronded or broadly pointed. Margins entire, appearing to be repand because of their somewhat revolute condition, as is also clearly indicated by the appearance of the venation in that part of the leaf. Petiole short and stout. Midrib stout and curved, prominent on the lower surface of the leaf, impressed on the upper surface. Secondaries prominent; about 12 subopposite to alternate pairs diverge from the midrib at angles of about 60°, pursue a rather straight course at first, and eventually curve upward; camptodrome. Tertiaries thin, forming large five or six sided meshes. Texture coriaceous.

This fine large-leafed species is entirely distinct from previously described forms and rather larger than most of the existing members of the Sapotaceæ. It is, however, practically identical in size, texture, petiole, margin, and venation—primary, secondary, and tertiary—with the existing *Sideroxylon surinamense* Miki from northern South America (Surinam).

The genus Sideroxylon comprises about 60 modern species found in the warmer parts of both hemispheres, a single Antillean species reaching southern peninsular Florida. Several fossil leaves from the Oligocene and Miocene

[1] Berry, E. W., Torrey Bot. Club Bull., vol. 38, p. 418, pl. 19, fig. 5, 1911.

[2] For an account of the geologic history of the genus see Berry, E. W., Plant World, vol. 15, pp. 15-21, figs. 1-7, 1912.

of Europe have been referred directly to the genus Sideroxylon. Of these the Wilcox species is much like *Sideroxylon putterliki* Unger [1] in everything except size, Unger's species being about one-half the size of the Wilcox form.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

SIDEROXYLON PREMASTICHODENDRON Berry, n. sp.

Plate XCIX, figure 4.

Description.—Leaves medium sized, elongate-elliptical in general outline. Apex variable, in most specimens broadly rounded. Base rounded or broadly cuneate. Length about 9 to 10 centimeters. Maximum width, which is generally just below the middle, about 3.3 centimeters. Margins entire, slightly undulate. Leaf substance thick and coriaceous in texture. Petiole short and stout, enlarging proximad, about 1 centimeter in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries rather stout, seven or eight alternate or subopposite irregularly spaced pairs; they diverge from the midrib at angles ranging from 30° to 50° and are but slightly curved for three-fourths of the distance to the margin, where they curve abruptly upward to form broad camptodrome arches. Tertiaries consist of a few rather stouter branches from the midrib, subparallel with two successive secondaries where these are widely spaced, of camptodrome marginal arches, and of more or less percurrent internal nervilles. Areolation fine, composed of transversely elongated meshes of small size.

This species is smaller and much less robust than the associated *Sideroxylon ellipticus* Berry, which it resembles closely in a general way. The secondaries are less numerous and more ascending and curved, and the areolation is finer. It is much like numerous existing species of Sideroxylon and except for its shorter petiole is practically identical with the leaves of *Sideroxylon mastichodendron* Jacquin, a tree of the Florida Keys, the Bahamas, and many of the Antilles.

[1] Unger, Franz, Die fossile Flora von Kumi, p. 41, pl. 11, figs. 1–4, 1867.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CHRYSOPHYLLUM Linné.

CHRYSOPHYLLUM FICIFOLIA Berry, n. sp.

Plate C, figure 7.

Description.—Leaves relatively large, oblong or ovate-lanceolate in outline, the apex and base pointed. Length about 15 centimeters. Maximum width, near the middle of the leaf, about 5.5 centimeters. Margins entire in some specimens, slightly repand distad. Texture very coriaceous. Petiole short and stout. Midrib very stout, curved, prominent on the lower surface of the leaf. Secondaries very thin and close set, diverging from the midrib at angles of more than 45°, curving upward, subparallel, camptodrome.

Several modern genera have been compared with this fossil species. Among those that show more or less resemblance may be mentioned Brosimum Swartz of the American tropical Moraceæ, Ardisia and Icacorea of the Bombacaceæ, and especially Ficus. This species may be a Ficus, since it resembles more or less closely several existing and fossil species which have been referred to that extensive genus. The venation, however, seems to me to indicate a relationship with the genus Chrysophyllum, which among its 50 or 60 existing species contains several West Indian forms practically identical with the fossil in all its features.

The genus Chrysophyllum is tropical or subtropical, most of the forms being American, although it is found in tropical Africa, southern Asia, Australia, and the Hawaiian Islands, and is represented in all tropical countries by the cultivated star apple, *Chrysophyllum cainito* Linné, a native of the West Indies. The only species of the genus that reaches the United States is *Chrysophyllum oliviforme* Lamarck of the Bahamas and Antilles, which is rare along the Florida coast northward to Mosquito Inlet on the east coast and to the vicinity of Pine Island on the west coast. This species has leaves much like the fossil but only about half their size. Seven or eight fossil forms have been referred to this genus, all of which come from the European Tertiary except one not very convincing form described by Engelhardt[1] from the Cenomanian of Saxony.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Pinson, Madison County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus BUMELIA Swartz.

Leaves short and broad, retuse or emarginate:
- Small, under 2 centimeters, slightly retuse. *Bumelia pseudohorrida.*
- Over 2 centimeters, deeply emarginate:
  - Obcordate, that is, with a narrowed base. *Bumelia wilcoxiana.*
  - Orbicular or elliptical, that is, with a broad base. *Bumelia americana.*
- Large with coarse venation, that is, conspicuously retuse.......................... *Bumelia hurleyensis.*

Leaves narrower, length more than twice the width, apex rounded or slightly emarginate:
- Midrib slender, secondaries few and ascending. *Bumelia pseudotenax.*
- Midrib very stout, secondaries numerous and directed laterally.............................. *Bumelia grenadensis.*

BUMELIA WILCOXIANA Berry, n. sp.

Plates C, figures 4 and 5, and CVII, figure 3.

Description.—Leaves obcordate in outline, the apex deeply emarginate and the base broadly pointed and cuneate. Size somewhat variable, the length ranging from 3 to 4 centimeters and the maximum width, widest above the middle, from 2 to 3 centimeters. Margins entire, full, and evenly rounded. Apical ears broadly rounded, directed upward. Petiole short and stout, 2 or 3 millimeters in length. Midrib stout and straight, prominent on the lower surface of the leaves. Secondaries relatively thin, prominent on the lower surface of the leaf, five to seven pairs, tending to be subopposite, branching from the midrib at angles of about 55° or somewhat less, curving upward, camptodrome. Texture coriaceous.

This species is not uncommon in the Wilcox. It resembles in a general way some of the European forms referred to the papilionaceous genus Colutea, as, for example, *Colutea macrophylla* Heer.[2] It is close to certain existing and fossil species of Bumelia and probably congeneric with them. Among these it is very similar to some of the forms referred to the widespread European Tertiary species *Bumelia oreadum* Unger, as, for example, the forms from the Sannoisian of Aix in southeastern France described by Saporta.[3] It may also be compared with *Bumelia subspathulata* Saporta[4] from the same locality and horizon. It is very similar to and probably descended from *Sapotacites shirleyensis* Berry,[5] a common form of the Upper Cretaceous Tuscaloosa formation in western Alabama. The genus is abundantly represented in the Tertiary of Europe, but in the existing flora it is confined to America and comprises about 20 species scattered from the southern United States through the West Indies and Central America to Brazil. It is the only genus of this strictly tropical and subtropical family which extends into the temperate region of North America.

Several recent species resemble this Eocene form, and it may be matched almost completely by some of the leaves of the variable *Bumelia retusa* Swartz of the West Indies.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

BUMELIA PSEUDOHORRIDA Berry, n. sp.

Plate C, figure 1.

Description.—Leaves small and nearly orbicular in outline, many somewhat inequilateral, the apex broadly rounded and slightly retuse, and the base rounded or broadly cuneate. Length about 1.25 centimeters. Maximum width about 1 centimeter or slightly less. Margins entire. Texture coriaceous. Petiole short and stout, curved, about 2 millimeters in length. Midrib stout. Secondaries immersed in the leaf substance, about four pairs, diverging from the midrib at acute angles, ascending approximately parallel with the lateral margins, eventually camptodrome.

[1] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1891, Abh. 7, p. 98, pl. 2, fig. 15.

[2] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 3, p. 102, pl. 132, figs. 43-46, 1859.

[3] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, pl. 9, fig. 14, 1889.

[4] Idem, pl. 13, figs. 3, 4.

[5] Berry, E. W., unpublished MS.

This small form is absolutely indistinguishable from many of the leaves of the existing West Indian species, *Bumelia horrida* Grisebach, which is very much like the fossil in size, texture, petiole, and in all the observable details of venation. That the modern form is a lineal descendant of this early Eocene species seems indisputable.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Bumelia pseudotenax Berry, n. sp.

Plate C, figure 2.

Banksia helvetica Heer. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 418, pl. 16, fig. 6, 1869.

Description.—Leaves small, obovate in general outline, practically sessile, the tip rounded and the base narrowed, cuneate, or slightly decurrent. Length about 4 centimeters. Maximum width, at or above the middle, about 1.3 centimeters. Margins entire. Texture coriaceous. Midrib rather stout but not prominent, immersed in the leaf substance and generally curved. Secondaries thin, immersed, four to six alternate pairs, diverge at angles of about 45°, curving more or less upward, camptodrome. Tertiaries obsolete.

This characteristic small leaf is very similar to the leaves of some of the West Indian species of Bumelia. It is perhaps most like *Bumelia tenax* Willdenow, a tree of sandy soils near the coast, which ranges northward from the Florida Keys as far as North Carolina. Another very similar extratropical species is *Bumelia lanuginosa* Persoon, also a small tree, not common but ranging from southern Georgia to Texas, said to reach its maximum size and greatest abundance in the river bottoms of eastern Texas. In the Texas region the smaller obovate leaves are more like the fossil than are the larger variants. The narrower leaves of *Bumelia angustifolia* Nuttall, a small tree of the Bahamas, Florida Keys, and lower Rio Grande Valley, are also close to the fossil, and *Bumelia cuneata* Swartz (*parvifolia* De Candolle) of the West Indies is also practically identical with it.

Among previously described fossil forms it is much like several species usually referred to the genus Persoonia of the Proteaceæ. The small leaf collected many years ago by Hilgard and since lost was referred by Lesquereux to *Banksia helvetica* Heer. It is undoubtedly a leaf of *Bumelia pseudotenax* Berry. The type material of *Banksia helvetica*[1] came from the European Aquitanian and is very different from the leaf from the American lower Eocene, some of Heer's specimens distinctly showing a serrated margin.

A poorly preserved leaf from Calaveras Creek, Wilson County, Tex., is very similar in form and venation to the species now under discussion but is larger, measuring 5.5 centimeters in length and 2 centimeters in maximum width.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard). Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collections.—U. S. National Museum.

Bumelia americana (Lesquereux) Berry.

Plate C, figure 6.

Sapotacites americanus. Lesquereux (not Hollick, 1900), in Safford, Geology of Tennessee, p. 428, pl. K, fig. 8, 1869.

Loughridge, Report on the geological and economic features of the Jackson's purchase region, p. 197, 1888.

Description.—Leaflets broadly elliptical, almost orbicular in outline, the apex deeply emarginate and the base broadly pointed. Margins entire, full, and evenly rounded. Length 3 to 4 centimeters. Maximum width 2.5 to 3 centimeters in the middle part of the leaf. Texture very coriaceous. Midrib very stout and straight, prominent on the lower surface of the leaf. Secondaries stout, prominent on the lower surface of the leaf; four or five alternate pairs branch from the midrib at angles of 55° to 75°, curving upward and each arching to join its superadjacent secondary some distance from the margin.

The type of this species, which is somewhat more orbicular than the material subsequently collected, was described by Lesquereux from the deposits of Grenada age south of Somerville, Tenn., at that time thought to be of Pleistocene age. It was subsequently recorded by Hollick[2] from Coushatta on Red River in

[1] Heer, Oswald, Flora tertiaria Helvetiæ, vol. 2, p. 98, pl. 97, figs. 44–48; pl. 98, fig. 16, 1856.

[2] Hollick, Arthur, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 287, pl. 42, fig. 3, 1899.

Louisiana, but the single specimen from this locality appears not to belong to this species.

It closely resembles *Bumelia wilcoxiana* Berry, which is, however, a somewhat smaller form that has an obcordate instead of an orbicular outline and a cuneate base that is almost straight sided instead of broadly rounded. The secondaries of *wilcoxiana* are more numerous, less prominent, and more ascending.

What was said under *Bumelia wilcoxiana* in regard to similar fossils and existing forms applies with almost equal force to this species. Attention should be called, however, to its resemblance to a leaf from the Ypresian of the Paris Basin which Watelet[1] referred to the genus Piscidia Linné, a leguminous genus of tropical America, and which he described as *Piscidia protogea*.

Occurrence.—Lagrange formation (in beds of Wilcox age), Somerville, Fayette County, Tenn. (collected by J. M. Safford), and Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Bumelia hurleyensis Berry, n. sp.

Plate CVIII, figure 2.

Description.—Leaves relatively coarse and large, orbicular to elliptical and somewhat inequilateral in general outline, widest above the middle. Base broadly rounded on one side, truncated on the other. Apex broadly rounded and then deeply retuse. Length about 4.6 centimeters. Maximum width about 4 centimeters or slightly more. Margins entire. Texture coriaceous. Petiole not preserved. Midrib stout and prominent, somewhat flexuously curved. Secondaries few, very stout and prominent; three opposite to alternate unequally spaced pairs diverge from the midrib at angles ranging from 35° to 55°; they sweep upward in broad curves parallel with the lateral margins of the leaf and all except the basal pair are camptodrome in the apex of the leaf. Tertiaries relatively stout and well marked, nearly straight and subparallel, percurrent. Areolation of fine nervilles, nearly obsolete, in general consisting of relatively large quadrangular areolæ.

This species has the general form of all the Wilcox species of Bumelia except *Bumelia pseudotenax* Berry and *Bumelia grenadensis* Berry. It is, however, much larger and more coarsely veined than any of these, being nearly twice the size of *Bumelia americana* (Lesquereux) Berry, which approaches closest to it in size. It also differs from the other Wilcox species in being broadly retuse and not emarginate in its fewer, much coarser, and more ascending secondaries, and in its percurrent tertiaries. It was apparently not common along the Wilcox coast, since it is only represented by scanty material from a single locality.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Bumelia grenadensis Berry, n. sp.

Plate CVIII, figure 3.

Description.—Leaves medium sized for this genus, obovate and markedly inequilateral in general outline, the apex broadly rounded or slightly emarginate and the base narrowly cuneate. Length about 4 centimeters. Maximum width at or above the middle about 1.75 centimeters. Margins entire. Leaf substance thin but of a stiff coriaceous texture. Petiole wanting. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries rather stout, rather regularly and closely spaced; about 15 pairs diverge from the midrib at wide angles, which vary from about 90° in the basal part to 70° in the middle and distal portions of the leaf; they pursue a relatively straight course and narrow rapidly in the marginal region, where they are camptodrome. Tertiaries thin, forming a close-meshed anastomosing areolation, which in the marginal region is fully as prominent as are the secondaries. Not common in the collections.

Of the four other Wilcox species of Bumelia three are relatively much shorter and wider; the only one whose form is similar to the present species is *Bumelia pseudotenax* Berry, which is a smaller, less inequilateral leaf, relatively narrower, and its secondaries are fewer, thinner, and more ascending.

Among previously described fossil species *Bumelia grenadensis* Berry resembles the European *Bumelia oreadum* Unger,[2] which is common and widespread from the extreme base of

[1] Watelet, A., Descriptions des plantes fossiles du bassin de Paris, p. 240, pl. 59, fig. 3, 1866.

[2] Unger, Franz, Die fossile Flora von Sotzka, p. 42, pl. 22, figs. 7-14, 1850.

the Oligocene into the Miocene and which has been compared with the living West Indian forms *Bumelia nervosa* and *Bumelia retusa*. These West Indian species also offer numerous points of comparison with the species under discussion.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus MIMUSOPS Linné.

MIMUSOPS SIEBERIFOLIA Berry, n. sp.

Plate XCIX, figure 2, and C, figure 3.

Description.—Leaves elongate-elliptical in outline, the apex broadly rounded, more or less retuse in some specimens, and the base only slightly narrowed, rounded, or wide and bluntly pointed. Margins entire and full, somewhat revolute, as indicated by the impression they make on the clay and their slightly undulating appearance in specimens that show the upper surface of the leaf, like the one figured. Texture very coriaceous. The lamina is generally broken near the base so that the petiole, which must have been long and stout, is missing. Somewhat variable in size, averaging about 9 centimeters in length by 2½ centimeters in maximum width, about halfway between the apex and the base of the symmetrical leaves. An extra large specimen is 12 centimeters long and 3.5 centimeters in maximum width. Midrib stout and straight, channeled above and more or less prominent on the lower surface of the leaf. Secondaries about 10 subopposite to alternate pairs; they branch from the midrib at angles ranging from 40° to 65° and curve upward, ultimately camptodrome. The tertiaries form rather large isodiametric, five or six sided meshes.

This fine species is not uncommon at Puryear and is scarcely to be distinguished from several of the existing species of Mimusops, the specific name being given in allusion to its resemblance to *Mimusops sieberi* A. De Candolle, of the Florida Keys and Bahama Islands, a small tree of the strand flora, like so many of the existing species of Sapotaceæ. The species now under consideration may also be compared with *Mimusops spectabilis* Pittier of the littoral forest of Costa Rica or with the Brazilian *Mimusops longifolia*. It may be also compared with certain species of the closely allied genus Sideroxylon Linné. *Capparis jamaicensis* Jacquin is also very similar in outline and texture.

The genus Mimusops contains 30 or 40 existing species widely distributed in the Tropics of both hemispheres. Several fossil species have been described, and comparisons may be made with the Oligocene species *Mimusops tertiaria* Ettingshausen[1] from southern Europe (Carniola) and *Sapotacites mimusops* Ettingshausen[2] from the Tyrol. Both are less elongated, and though similar in their general facies are less typical of Mimusops than the present species. In the Wilcox flora *Laguncularia preracemosa* Berry has somewhat similar leaves; they are, however, relatively shorter and have a different, more or less obsolete venation and a different texture. They are no more readily confused than the leaves of the existing *Laguncularia racemosa* Gaertner and *Mimusops sieberi* A. De Candolle.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

MIMUSOPS EOLIGNITICA Berry, n. sp.

Plate XCIX, figure 3.

Quercus chlorophylla Unger. Lesquereux (part), Am. Philos. Soc. Trans., vol. 13, p. 416, pl. 17, fig. 6 (not figs. 5, 7), 1869.

(?) *Phyllites truncatus*. Lesquereux, idem, p. 423, pl. 17, fig. 9.

Description.—Leaves relatively large, elongate-elliptical in outline, the apex prominently emarginate and the base broadly cuneate or rounded. Length about 9 centimeters. Maximum width, in the middle part of the leaf, about 3.5 centimeters. Margins entire, slightly undulate distad. Texture coriaceous. Petiole missing. Midrib stout and curved, prominent on the lower surface of the leaf. Secondaries stout, numerous; about 10 opposite to alternate pairs diverge from the midrib at angles of about 50°, are in many specimens unequally spaced, curve upward in a subparallel manner, and are camptodrome close to the margins. Tertiaries thin, some subparallel with and between some

[1] Ettingshausen, C. von, Die fossile Flora von Sagor, pt. 3, p. 17, pl. 30, figs. 14, 14a, 1885.

[2] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 62, pl. 21, fig. 22, 1853.

of the secondaries, others percurrent, joined by nervilles in different directions to form small, isodiametric, four or five sided meshes.

This species is readily distinguishable from the associated Wilcox species *Mimusops sieberifolia* Berry by its relatively shorter and wider outline, more numerous secondaries, and conspicuously emarginate apex. It is very close and unquestionably ancestral to *Mimusops claibornensis* Berry, a relatively shorter and more robust form of the middle Eocene.

Among the leaves from Mississippi referred by Lesquereux to *Quercus chlorophylla* Unger is one that is clearly a leaf of the species now under discussion, and this also seems to be the affinity of the single associated leaf which Lesquereux described as *Phyllites truncatus* and which lacks the tip, the chief diagnostic feature of the present species; hence the name is queried and is not taken up for the species as now described from complete material.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly a part of Tippah County), Miss. (collected by E. W. Hilgard). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

MIMUSOPS MISSISSIPPIENSIS Berry, n. sp.

Plate CVIII, figure 1.

Description.—Leaves medium sized, elongate-elliptical in general outline, the tip somewhat narrowed and rounded and the base cuneate, decurrent on the petiole. Length ranges from 8 to 8.5 centimeters. Maximum width, at or below the middle, about 2.6 centimeters. Margins entire, evenly rounded. Texture coriaceous. Petiole short and stout, alate. Midrib stout, curved, prominent. Secondaries of medium caliber, partly immersed; about nine opposite to alternate pairs diverge from the midrib at angles that average about 50°, rather straight in their courses two-thirds of the distance to the margin, where they bend upward and are camptodrome. Tertiaries thin but well marked, forming an open quadrangular or pentagonal isodiametric areolation.

This species is somewhat smaller than the other Wilcox species of Mimusops and is more tapering in both directions, approaching the the form of *Sideroxylon premastichodendron* Berry in outline. The secondaries are less prominent than in *Mimusops sieberifolia* Berry and *Mimusops eolignitions* Berry, but the areolation is practically identical for the three species.

Mimusops mississippiensis was confined to the Grenada formation south of the Mississippi-Tennessee boundary and apparently was not common.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Order GENTIANALES.

Family OLEACEÆ.

Genus FRAXINUS Linné.

FRAXINUS WILCOXIANA Berry, n. sp.

Plate CI, figure 5.

Description.—Samara oblanceolate in outline, slender, contracted gradually proximad to the peduncle, which is relatively stout and about 3 millimeters long. Total length about 3 centimeters. Maximum width 6.5 millimeters at a point about halfway between the apex and the base. Body large, flattened, oblanceolate in outline, about 1.75 centimeters long, or more than half the total length of the samara, longitudinally lined, maximum width 4 millimeters, toward the distal end. Wing coriaceous, the tip narrowly rounded, the margins entire, decurrent on the body from which the veins radiate. Calyx not persistent.

This well-marked samara of an early Eocene species of Fraxinus is well marked and distinct from known Tertiary forms. Except for its relative median width it might almost pass for the fruit of the common American red ash, *Fraxinus pennsylvanica* Marsh, which, however, has a persistent calyx. It resembles a number of other existing species of ash, but this resemblance can not be held to indicate a close filiation with these forms. It is not uncommon in the clays at Puryear but has not as yet been correlated with the foliage of the tree which bore it. It is quite possible that this foliage is represented by the Wilcox species, based on leaves from Tennessee and Louisiana, which is identified as *Fraxinus johnstrupi* Heer.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Fraxinus johnstrupi Heer (?).

Plate CI, figure 6.

Fraxinus Johnstrupi. Heer, Flora fossilis arctica, vol. 7, p. 113, pl. 80, figs. 1, 2, 1883.
Hollick, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 287, pl. 44, fig. 1, 1899.

Description.—Heer's description, published in 1883, is as follows:

Fr. foliolis ovato-ellipticis, basi valde inæqualibus, margine dentatis, nervis secundariis angulo peracute egredientibus, valde camptodromis.

This species was described by Heer from the locality in western Greenland at Atane Kerdluk, which he regarded as part of his Arctic Miocene but which is almost certainly of Eocene age. In 1890 Hollick identified it with a query from Louisiana. His material is scanty but more complete than that from Greenland. It shows a petiolulate inequilateral leaflet about 11 centimeters in length by about 4 centimeters in maximum width, the midrib curved, and a petiolule about 9 millimeters in length. A fragmentary specimen is also contained in the collections from Tennessee, and it is not rare at several other localities.

I retain the query after this species, since no complete new material has been collected, although in so far as comparisons are possible that from Louisiana is practically identical with the Greenland types and may represent the foliage of the tree represented by samaras in the clays of Wilcox age in Tennessee. The flora from Greenland is almost certainly somewhat younger than the Wilcox, and the two have very few characters in common, differing markedly in this respect from the conditions shown in comparisons between the Upper Cretaceous floras of western Greenland and the Atlantic Coastal Plain. For these reasons the occurrence of *Fraxinus johnstrupi* is of especial interest.

Occurrence.—Wilcox group, one-fourth of a mile above Coushatta, Red River Parish, La. (collected by G. D. Harris). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

Genus OSMANTHUS Loureiro.

Osmanthus pedatus (Lesquereux) Berry.

Plate CIV, figure 1.

Olea americana. Hilgard, Report on the geology and agriculture of Mississippi, pp. 108, 113, 1860.
Laurus pedatus. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 418, pl. 19, fig. 1, 1869.

Description.—Lesquereux's description, published in 1869, is as follows:

L. foliis coriaceis, oblanceolatis, in petiolum longe attenuatis integerrimis; nervo primario latiore, plano, nervis secundariis tenuibus, sub angulo acuto 30° egredientibus, camptodromis, areolatione ultima punctiformi.

Lesquereux states that his description and figure of this species were made from a single broken specimen, which I have been unable to find in the remains of the Hilgard collection at the State University of Mississippi. I have, however, collected typical specimens from the clays of Henry County, Tenn., and Lesquereux's description quoted above may be amplified as follows: Leaves oblanceolate in outline, the tip bluntly pointed and the base long and gradually narrowed, decurrent. Length about 13 centimeters. Maximum width, in the upper half of the leaf, about 2.75 centimeters. Margins entire. Texture coriaceous. Petiole short and stout, somewhat tumid. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin and immersed in the leaf substance, subopposite to alternate, diverging from the midrib at angles of about 50°, curving upward, camptodrome. Tertiaries thin, approximately straight, transverse.

Except that the tertiaries are almost obsolete in the modern form, *Osmanthus pedatus* is indistinguishable from *Osmanthus americanus* Bentham and Hooker, which is found in wet situations in the coastal region of our Southern States from southern North Carolina to eastern Louisiana. Both forms show the same oblanceolate outline, bluntly pointed apex, long tapering base, prominent midrib, and immersed secondaries. A second species, *Osmanthus floridana* Chapman, found in the hammocks of peninsular Florida, bears leaves that are practically identical with the preceding. I have figured a nature print of a leaf of *Osmanthus americanus* for comparison with the Wilcox species.

The genus Osmanthus embraces about 10 existing species of eastern and southern Asia, Polynesia, and southeastern North America.

The fossil record is not extensive, and such forms as have been found are usually referred to the allied genus Olea. In Hilgard's section of the type locality for this species he mentions the occurrence of what he calls *Olea americana* in these deposits, which undoubtedly represents the species now under discussion and was the preliminary determination of Lesquereux,[1] and was subsequently altered when he came to publish his account of the Mississippi plants.

The present species occurs in the Raton formation of the Rocky Mountain province.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. W. Hilgard). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Family APOCYNACEÆ.

Genus APOCYNOPHYLLUM Unger.

APOCYNOPHYLLUM WILCOXENSE Berry, n. sp.

Plates CIII, figures 2 and 3, and CVIII, figure 4.

Description.—Leaves oblong-lanceolate and more or less falcate in outline, the apex sharply pointed and the base gradually narrowed. Length about 17 to 18 centimeters. Maximum width about 2.4 centimeters. Margins entire, slightly revolute. Petiole not preserved. Midrib stout, especially proximad, curved, prominent on the lower surface of the leaf, relatively thin on the upper surface. Secondaries thin, very numerous, approximately 1 millimeter apart, subparallel, immersed in the leaf substance. They diverge from the midrib at wide angles, fully 90° in the lower part of the leaf, and pursue a nearly straight course, branching somewhat and becoming nearly obsolete at the margin. There may be marginal veins, but if present they constitute the margin and are not distinguishable. Texture very coriaceous.

This fine large species is very unlike any previously known fossil forms from the American continent. Among the Tertiary floras of Europe it is most similar to the leaves referred to the genus Nerium of the Apocynaceæ, for example *Nerium bilinicum* Ettingshausen[2] from the Burdigalian of Bohemia or *Nerium sarthacense* Saporta[3] from the middle Eocene of France (Sarthe). It is also much like the existing *Nerium oleander* Linné of Europe, commonly cultivated as an ornamental shrub, especially in our Southern States. Together with an allied but still larger species it is not uncommon in the Raton formation of the southern Rocky Mountain province.

The genus Apocynophyllum seems preferable since it is less definite than Nerium or similar-leafed existing tropical genera. Its use indicates a relationship with the family Apocynaceæ rather than with the genus Apocynum Linné, as might possibly be inferred.

Fossil species of Apocynophyllum have rarely been recognized in American Tertiary floras. The form from the Eocene of the Raton Mountains of New Mexico, identified by Lesquereux[4] as *Quercus neriifolia* Alexander Braun, is not that species and it has been properly redefined by Ettingshausen[5] and renamed *Apocynophyllum lesquereuxii*. Another species, *Apocynophyllum heerii* Ettingshausen occurs in the Eocene of Greenland.

Occurrence.—Holly Springs sand, gully at Oxford, Lafayette County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry). Wilcox group, 1½ miles northeast of Mansfield and 2 miles south of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins).

Collections.—U. S. National Museum.

APOCYNOPHYLLU MMISSISSIPPIENSIS Berry, n. sp.

Plate CVIII, figure 6.

Description.—Leaves relatively large, lanceolate in general outline, widest midway between the apex and the base, the margins incurving uniformly to the acutely pointed apex and the greatly decurrent base. Length about 13 centimeters. Maximum width about 3.5 centimeters. Margins entire, full, and evenly rounded. At the base the lamina on each side narrows like it does in the apex to less than 2 millimeters from the petiole, where it recurves and follows a course parallel with the petiole

[1] Hilgard, E. W., Report on the geology and agriculture of Mississippi, p. 109, 1860.

[2] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 2, p. 30, pl. 36, fig. 20; pl. 37, fig. 2, 1868.

[3] Crié, L., Recherches sur le végétation de l'ouest de la France à l'époque tertiaire, p. 45, pl. L, figs. 70-73, 1877.

[4] Lesquereux, Leo, The Tertiary flora, p. 150, pl. 19, fig. 5, 1878.

[5] Ettingshausen, C. von, K. Akad. Wiss. Wien Denkschr., vol. 47, p. 32, 1883.

to its extreme base, forming petiolar wings, each from 1 to 2 millimeters wide. Leaf texture subcoriaceous. Petiole stout, grooved, about 2 centimeters in length. Midrib stout below, becoming thin in the upper part of the leaf, longitudinally striated, somewhat prominent on the lower surface in the proximal half of the leaf. Secondaries thin, largely immersed in the leaf substance; 15 to 20 irregularly spaced and mostly alternate pairs diverge from the midrib at angles of about 45°, curving slightly outward and then upward, camptodrome in the marginal region. Tertiaries not well marked; some are parallel and between secondaries and others percurrent; they are fine and largely immersed.

This species is readily separable from the other Wilcox species of Apocynophyllum, its peculiar decurrent base alone rendering it easily recognizable. It is intermediate in its resemblances between *Apocynophyllum sapindifolium* Hollick and *Apocynophyllum tabellarum* (Lesquereux) Berry. It is less oblong in outline than either species; the secondaries are more numerous than those of *sapindifolium* and much fewer than those of *tabellarum*. It is not common in the collections.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, 1½ miles northeast of Mansfield, De Soto Parish, La. (collected by G. C. Matson).

Collections.—U. S. National Museum.

APOCYNOPHYLLUM TABELLARUM (Lesquereux).

Plates CII, figures 2–5, and CIII, figure 5.

Salix tabellaris. Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 414, pl. 17, fig. 4, 1869.

Description.—Lesquereux's description, published in 1869, is as follows:

Foliis elongatis, ultra pollicaribus latis, linearibus, margine parallelis, integerrimis, in petiolum attenuatis; nervo medio lato, nervis secundariis numerosis, irregularibus, angustis, camptodromis.

The type, from the "soft white clay of Lafayette County, Miss.," was collected by Hilgard and described by Lesquereux. It probably consisted of the single specimen figured, which I have not been able to find in the remains of the Hilgard collection at Oxford, Miss. Additional material has been found in abundance in the clays at Puryear, Tenn., and elsewhere, and the species may be somewhat more fully characterized as follows:

Leaves oblong-lanceolate in outline, the apex short but sharply pointed and the base more narrowly pointed and slightly decurrent. Length about 17 centimeters. Maximum width about 4 centimeters, the average being somewhat less than this figure. Margins entire but slightly undulate, deeply constricted in one specimen. Petiole short and stout, less than 1 centimeter in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, very numerous, somewhat irregularly spaced, subparallel; they diverge from the midrib at angles of about 60° at intervals of 1 to 3 millimeters and run outward with only a slight curvature to the marginal region, where they curve upward parallel with it to form a series of rapidly reduced camptodrome arches. Tertiaries mostly obsolete, indistinctly shown in one of the figured specimens. Texture coriaceous.

Lesquereux compared this species with the European Miocene *Salix longa* Alexander Braun, and thought that it might even be a variety of that widespread type. The species is obviously not related to *Salix longa* nor is it even a Salix in either size, outline, venation, or texture. It is, however, closely allied to a number of tropical American genera of the Apocynaceæ and very close to the numerous Tertiary species, of which at least two score, mostly European forms, have been described. American fossil species are uncommon. Lesquereux [1] described *Apocynophyllum scudderi* from the Green River formation of Wyoming. It is very distinct, however, from any Wilcox species. Hollick [2] referred a fragmentary specimen from this horizon in Louisiana to Apocynophyllum, and though I have since collected more complete material, the generic reference can not be said to be conclusively established. *Apocynophyllum sapindifolium* Hollick has the same general outline but is a smaller leaf and has a more obtuse apex, longer petiole, and less numerous, relatively distant secondaries.

Apocynophyllum tabellarum suggests to a certain extent some American species of the genus Chrysophyllum of the Sapotaceæ, and

[1] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 172, pl. 45A, figs. 1-5, 1883.

[2] Hollick, Arthur, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 288, pl. 46, fig. 3, 1899.

though relatively narrower and more elongated somewhat resembles *Chrysophyllum ficifolia* Berry, described from the basal beds of Wilcox age near Pinson, Tenn.

Occurrence.—Holly Springs sand, Oxford, Lafayette County (collected by E. W. Hilgard), and Vaughns, near Lamar, Benton County, Miss. (collected by L. C. Johnson). Wilcox group, near Boydville, Clay County, Ark. (collected by E. W. Berry); sec. 29, T. 13 N., R. 12 W.; 4½ miles southeast and 3 miles southwest of Naborton, De Soto Parish, La. (collected by G. C. Matson and O. B. Hopkins); and Old Port Caddo Landing, Little Cypress Bayou, Harrison County, Tex. (?) (collected by T. W. Vaughan). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

APOCYNOPHYLLUM SAPINDIFOLIUM Hollick.

Plates CII, figure 1, and CVIII, figure 5.

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.

Description.—Hollick's description, published in 1899, is as follows:

> Leaf lanceolate, entire, slightly inequilateral, narrowed and decurrent for a short distance at the base; midrib strong; secondaries thin and regular, leaving the midrib at an acute angle near the base, at a slightly more obtuse angle upward, running parallel to each other for a short distance, and approaching each other close to the margin, where they curve upward; tertiary nervation straight, subparallel, and essentially at right angles to the secondaries.

Complete material shows that the apex was not elongated but was rather abruptly and obtusely pointed, that the margin in some individuals was slightly undulate, and that the petiole was very stout and about 1.75 centimeters in length. The dimensions of the whole leaf are as follows: Length about 12 centimeters; maximum width about 3 centimeters.

This species was described from an incomplete specimen from Coushatta, La., and compared with *Ficus lanceolata* (Heer) Weber,[1] *Laurus princeps* Heer,[2] and *Laurus primigenia* Unger.[3] The first is a younger composite form, and my material shows that the present species represents a leaf altogether lacking the narrowed tip of Lesquereux's material. The third comparison loses force from the fact that such a variety of probably unrelated leaves have been referred to *Laurus primigenia* that the comparison is worth but very little. The second comparison is valid, and I am not sure that the southern material is not identical with that from the Eocene of California. A similar but somewhat larger leaf is figured by Knowlton[4] from the early basic breccias of Fort Union age in the Yellowstone Park, and this also is very close to the present form if not identical with it. *Laurus princeps* is another species that has been too freely identified from numerous localities and horizons, so that rather than make any ill-advised changes at this time, the species under discussion is allowed to stand as described by Hollick.

It is smaller than *Apocynophyllum tabellarum* (Lesquereux) Berry of the Wilcox flora, and has a longer petiole and much fewer secondaries.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry). Wilcox group, one-fourth mile above Coushatta, Red River Parish, La. (collected by A. C. Veatch), and Benton, Saline County, Ark. (collected by R. E. Call). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum; New York Botanical Garden.

APOCYNOPHYLLUM CONSTRICTUM Berry, n. sp.

Plate CIII, figure 4.

Description.—Leaves relatively short and broad, ovate-lanceolate in outline, constricted at the middle by a pair of deep, opposite, narrowly pointed sinuses into a lower elliptical segment and a distal ovate-lanceolate segment. Base rounded. Base of distal segment rounded, its apex narrowed and bluntly pointed, slightly inequilateral. Margins full, rounded, and entire, except for the sinuses just mentioned. Petiole short and stout, about 1 millimeter in length. Midrib stout below, becoming thin distad. Secondaries numerous, paral-

[1] Lesquereux, Leo, The Tertiary flora, pl. 28, figs. 1-5, 1878.

[2] Lesquereux, Leo, The Cretaceous and Tertiary floras, pl. 58, fig. 2, 1883.

[3] Velenovsky, Josef, Die Flora aus den ausgebrannten tertiären Letten von Vřsovic bei Laun, pl. 5, figs. 1-5, 1882.

[4] Knowlton, F. H., U. S. Geol. Survey Mon. 32, pt. 2, p. 725, pl. 95, fig. 3, 1899.

lel, straight, craspedodrome, diverging from the midrib at very wide angles in the proximal segment, more widely spaced and more ascending in the distal segment.

This species is based on the single specimen figured, which was collected many years ago by R. E. Call for the Arkansas Geological Survey. It came from the clays of the Henderson pit at Benton, Ark., long since worked out and abandoned, so that the chances are against finding additional material except from outcrops not yet discovered.

It may be an anomalous leaf, since marginal irregularities are commonly observed in the leaves of *Nerium oleander* Linné, some specimens suggesting by their outline the lobate forms of the Mesozoic cycadophyte genus Nilsonia. A constricted leaf of *Apocynophyllum tabellarum* is figured on the accompanying plates. If the constricted form be interpreted as a variant from a normally entire ovate-lanceolate leaf, it is still readily distinguishable from the Wilcox species *Apocynophyllum wilcoxense* Berry by its smaller size and relative shortness and breadth.

Occurrence.—Wilcox group, Benton, Saline County, Ark. (collected by R. E. Call).

Collection.—U. S. National Museum.

Genus ECHITONIUM Unger.

ECHITONIUM LANCEOLATUM Ettingshausen.

Plate CIII, figure 1.

Echitonium lanceolatum. Ettingshausen, Beiträge zur Kenntniss der Tertiärflora Australiens: K. Akad. Wiss. Wien Denkschr., vol. 47, p. 134, 1883.

Laurus reussii. Heer (not Ettingshausen), Flora fossilis arctica, vol. 6, pt. 2, p. 12, pl. 3, fig. 14, 1880; idem, vol. 7, p. 105, pl. 77, figs. 1–7, 1883.

Description.—The following description is drawn from the material from Tennessee, which has been referred to this species, which differs in minor particulars from the leaf from Greenland on which Ettingshausen based his diagnosis: Leaves oblong-lanceolate in outline, more or less falcate, the apex and base rather shortly pointed. Length about 11 centimeters. Maximum width about 2.1 centimeters. Margins entire, parallel for a considerable distance medially. Texture subcoriaceous. Petiole short and expanded, tumid proximad, about 4 millimeters in length. Midrib stout and curved, becoming thin distad. Secondaries numerous, thin, about 12 subopposite to alternate camptodrome pairs, diverging from the midrib at angles of 45° or more, curving upward in the marginal region. Tertiaries mostly obsolete.

In 1880 Heer identified a single small leaf from the Eocene of Greenland as *Laurus reussii* Ettingshausen, a European species. Ettingshausen three years later pointed out that the form from Greenland was not identical with his *Laurus reussii* and redescribed Heer's species as *Echitonium lanceolatum*. The same year Heer published several additional figures of forms from Greenland that he identified as *Laurus reussii*. These are similar to the form that he described in 1880 but range to a larger size, and these larger leaves with short tumid petioles are identical with the Wilcox leaves.[1] The smaller leaves from Greenland were used by Ettingshausen in framing his diagnosis of *Echitonium lanceolatum*. They have longer petioles and fewer secondaries than the larger leaves, but all are probably variants of a single species.

The genus Echitonium was described by Unger and contains from 8 to 10 species, mostly European, ranging from the Paleocene through the Miocene. It is based on forms comparable with the existing genus Echites Linné, which embraces about two score species of tropical America (West Indies and Antilles and northern South America).

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order POLEMONIALES.

Family BORAGINACEÆ.

Genus CORDIA Linné.

CORDIA EOCENICA Berry, n. sp.

Plate CVI, figures 11 and 12.

Description.—Leaves oblong-ovate in outline, the apex acute and the base broadly cuneate or rounded. Length ranges from 6.5 to 10 centimeters. Maximum width, in the lower half of the leaf, ranges from 2.8 to 4 centimeters. Petiole short and stout. Midrib stout. Secondaries thin, remote; six or seven alternate pairs diverge from the midrib

[1] Compare pl. 103, fig. 1, of this paper with Heer's pl. 77, fig. 6.

at angles of about 60°, curving upward, camptodrome. Margins entire, slightly undulate. Texture subcoriaceous.

This species is clearly distinct from the other known members of the Wilcox flora. Although it resembles some of the leaves of Ficus in its outline, it shows a different type of venation. It has a peculiar textural character, hard to describe but easily recognized and in a measure shown in the illustration, that serves for its recognition. This may be due to a more or less scabrous condition in life.

This species is very close to several existing American tropical species. The genus comprises more than 200 existing forms of the Tropics and the warmer extratropical regions of both hemispheres, most of them American, and several extend northward as far as the Bahamas, the Florida Keys, and the Rio Grande valley. The leaves are variable in outline and are commonly more or less toothed, even an entire-margined form showing toothed margins in some individuals. There is a strong generic likeness in the leaves of the different species and some of them are very similar to the leaves of some species of Populus.

Some of the species are distributed by frugivorous birds, but the fruits of *Cordia subcordata*, a widely distributed oriental beach plant, float uninjured for months, according to Guppy.[1]

The known history of Cordia is not very extensive. Ettingshausen has described a Tertiary species from Tasmania and another from Bohemia; Engelhardt has described a species from the early Tertiary of Chile; and I have described a rather common species from the Upper Cretaceous of southeastern North America, *Cordia apiculata* (Hollick).

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Cordia (?) lowii Berry, n. sp.

Plate CVII, figure 1.

Description.—Leaves relatively short and broad, elliptical-ovate and very slightly inequilateral in general outline, widest in the middle and tapering abruptly to the acuminate tip and somewhat less abruptly to the truncate, ultimately slightly decurrent base. Length about 11 centimeters. Maximum width about 7.5 centimeters. Margins rather full and evenly curved, beset with well marked but flattened crenulations, which disappear entirely in the basal region. Texture thick and coriaceous. Petiole short and stout. Midrib stout. Secondaries relatively thin, rather uniformly spaced, subparallel, and camptodrome; eight or nine pairs diverge from the midrib at angles of about 55° to 60°, curving but slightly to the marginal region, where they bow upward in sweeping arches. Tertiaries thin, not prominent, percurrent.

This species is rare, is not certainly referable to Cordia, and is confined to the lower part of the Wilcox. It is clearly separable from the other Wilcox species, although it resembles somewhat some of the forms of *Euonymus splendens* Berry. It resembles somewhat the entire margined *Juglans leconteana* Lesquereux and may also be compared with a variety of unrelated genera, for example, Grewiopsis, Hippomane, Camellia, Juglans, Omalanthus, Pavonia, Celastrus, and the like.

Named in honor of Dr. E. N. Lowe, State geologist of Mississippi, who was instrumental in the rediscovery of this classic locality and who helped make the collection containing the present type.

Occurrence.—Ackerman formation, Hurleys, Benton County (formerly part of Tippah County), Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Order PERSONALES.

Family VERBENACEÆ.

Genus CITHAREXYLON Linné.

Citharexylon eolignitіcum Berry, n. sp.

Plate CVI, figure 10.

Description.—Leaves ovate-lanceolate in outline, slightly falcate. Apex narrowed to an obtuse point. Base cuneate. Length about 8 centimeters. Maximum width, in the middle part of the leaf, about 2.75 centimeters. Margins entire, somewhat irregular. Petiole short and very stout. Midrib stout, curved, and prominent. Secondaries relatively stout, prominent, numerous, about 12 subopposite to alternate pairs, subparallel and camptodrome.

[1] Guppy, H. B., Plant dispersal, p. 530, 1906.

They diverge from the midrib at angles of about 50° and are relatively straight. Tertiaries obsolete.

This species, which is rare in my collections, is very close to *Citharexylon villosum* Jacquin, a small tree of the Florida Keys, Bahamas, and Antilles, differing merely in the more numerous, straighter, and less ascending secondaries of the fossil form. The genus Citharexylon includes more than a score of species confined to tropical America, where they are distributed through the West Indies to southern Mexico, Lower California, Bolivia, and Brazil. One or two species have been doubtfully recorded from the European Miocene.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

Genus AVICENNIA Linné.

AVICENNIA EOCENICA Berry, n. sp.

Plate CIV, figure 6.

Description.—Fruit capsular, ovate, and slightly oblique in outline, widest in the median portion and narrowing almost equally in both directions, truncate proximad, shortly apiculate distad, greatly compressed. Length 2.7 centimeters. Maximum width 1.35 centimeters. Pericarp thin, coriaceous, feebly ridged with two or three slight longitudinal elevations, longitudinally striated.

The identification of the present form with the capsule of Avicennia is not conclusively proved, although the resemblance between the fossil and a single valve of the tardily dehiscent capsule of such a modern form as *Avicennia nitida* Jacquin amounts as nearly to proof as is possible with detached parts of fossil vegetation, especially as Avicennia-like leaves are also present at this horizon. This form is slightly smaller and more nearly symmetric than a valve of a capsule of the black mangrove; otherwise the resemblance is complete. It is possible that the Wilcox species of Citharexylon based on foliage may be the foliage of *Avicennia eocenica,* although the form appears to be more closely allied with Citharexylon.

The genus Avicennia includes about 30 existing species widely distributed on the muddy tidal shores of the Tropics of both hemispheres.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

AVICENNIA NITIDAFORMIS Berry, n. sp.

Plate CVII, figure 4.

Description.—Leaves medium sized, lanceolate in general outline and as a rule somewhat falcate and consequently slightly inequilateral, widest in the middle and tapering to both ends. Apex narrowly rounded. Base cuneate. Length about 8 centimeters; maximum width at or slightly below the middle, about 2.1 centimeters. Margins entire, in many specimens irregularly curved. Texture coriaceous. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries stout, somewhat prominent; nine or ten pairs diverge from the midrib at angles between 35° and 40°, ascending with but slight curvature close to the margins, where they turn upward rather abruptly to join the secondary next above and thus collectively form a pseudoacrodrome marginal vein along each margin. Tertiaries immersed in the leaf substance.

This species is not common in the collections. It may be matched with some of the leaves of the existing *Avicennia nitida* and in connection with the fruits from Puryear, Tenn., described as *Avicennia eocenica,* renders the generic determination reasonably conclusive. What is almost certainly a second fossil occurrence of Avicennia may be seen in a form from the Tertiary of Colombia, which Engelhardt [1] erroneously referred to the myrtaceous genus Jambosa Rumphius and compared with the oriental *Jambosa vulgaris* De Candolle, extensively cultivated in tropical South America.

All the existing species are inhabitants of tidal muddy shores and are cosmopolitan in tropical regions. One species, *Avicennia nitida,* reaches the Florida coast. Its leaves exhibit considerable variation, both in size and outline, ranging from small obovate to lanceolate and lanceolate-elliptical forms, which may be rounded or acuminate distad. Among numer-

[1] Engelhardt, Hermann, Senckenbergische naturf. Gesell. Abh., vol. 19, p. 35, pl. 9, figs. 6, 7, 1895.

ous leaves of this species the fossil is nearer to the average form of the existing species than to any of its variants. It agrees rather closely in size, outline, and venation with this mean form, but is relatively slightly narrower.

A characteristic view showing the habit and habitat of the black mangrove and serving to suggest the appearance and environment of the Wilcox form is shown on Plate VII, *B* (p. 177).

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Family SOLANACEÆ.

Genus SOLANITES Saporta.

SOLANITES SAPORTANA Berry, n. sp.

Plate CVI, figures 4 and 5.

Description.—Flower gamopetalous. Calyx inferior, gamosepalous. Corolla rotate, depressed internally to form a short open throat, the limb five parted, the lobes narrow and cuneate pointed, separated by relatively deep angular sinuses. There are traces of stamens, which appear to have been five in number, inserted on the corolla, and alternate with the corolla lobes, their anthers not connate. Pistil not discernible. The flower is small, about 6 or 7 millimeters across the limb. The corolla lobes are about 2.5 millimeters in length and 1.75 millimeters in maximum width, at their base. The flowers, which must have been of considerable consistency, are preserved close together in the type and only specimen, which may be taken to indicate that the flowers were not solitary but grouped in a cymose inflorescence.

This unique specimen was collected from the fine-grained plastic clays at Holly Springs, and though exceptional as the imprint of a flower the essential organs are flattened and incomplete. A canvass of the floral structures of the natural orders leads at once to the Solanaceæ, and since it is impossible to allocate the flower with precision in any of the numerous genera of this family it is referred to the form genus Solanites. This genus was described by Saporta [1] for floral remains of small size and rare occurrence in the Sannoisian of Aix, in southeastern France, which he constituted as the single species *Solanites brongniarti.*[2] This he compared in a most painstaking way with the flowers of certain existing Solanaceæ and concluded that it was most similar to the flowers in the genus Saracha Ruiz and Pavon of Central America and northwestern South America. This also seems to be true of the Wilcox flower described above, which is very similar to *Solanites brongniarti*, although less completely preserved. I have reproduced some of the figures of the type of Solanites, as well as of Sarracha and Witheringia, and have named the American species in honor of the Count de Saporta, one of the most profound students of fossil floras who graces the annals of paleobotany.

The genus Sarracha comprises about a dozen species of existing plants distributed from Mexico to Bolivia. In this connection attention should be called to a form from the Tertiary of Bolivia described by Engelhardt [3] as *Antholithes quinquepartita*, which is very similar to the Wilcox form and should probably be considered as congeneric.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Order RUBIALES.

Family RUBIACEÆ.

Genus GUETTARDA Endlicher.

GUETTARDA ELLIPTICIFOLIA Berry, n. sp.

Plate CVI, figures 1 and 2.

Description.—Leaves medium sized or small, more or less broadly ovate and generally falcate in outline. The apex has a short wide point or is narrowly rounded. Base generally inequilateral, broadly cuneate, or slightly decurrent. Length ranges from 4 to 6 centimeters. Maximum width, in the middle part of the leaf, ranges from 2 to 2.5 centimeters. Margins entire, irregularly undulate in many specimens. Texture subcoriaceous. Petiole stout, curved, about 5 millimeters in length. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries stout; seven or eight opposite to alternate pairs diverge from the midrib at angles of 45° to 50°, pursu-

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 109, 1863.

[2] Idem, pl. 11, fig. 2.

[3] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh., 1894, p. 13, pl. 1, fig. 57.

ing a relatively straight course, camptodrome. Tertiaries obsolete.

This species is named from its great resemblance to *Guettarda elliptica* Swartz, a small tree of the coastal region that has a buttressed trunk; it inhabits the more southern Florida Keys, the Bahamas, and the West Indies. The genus Guettarda, which comprises about 50 existing species, is chiefly developed in tropical America. One species is widely distributed on maritime shores from tropical eastern Africa to Australia and Oceanica, its habitat forming a just comparison with that of the fossil species.

Occurrence.—Holly Springs sand, Holly Springs, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collections.—U. S. National Museum.

Genus EXOSTEMA Richard.

EXOSTEMA PSEUDOCARIBÆUM Berry, n. sp.

Plate CVI, figure 3.

Description.—Leaves small, lanceolate in general outline, the apex and base narrowed and acutely pointed. Length about 6 to 7 centimeters. Maximum width, midway between the apex and the base, about 1.75 centimeters. Margins entire, slightly irregularly curved. Leaf substance thin. Petiole stout, terete, swollen in its lower part, about 7.5 millimeters in length. Midrib stout below, becoming thin distad. Secondaries numerous, thin; about 10 pairs diverge from the midrib at different angles, averaging between 45° and 50°, and are as a rule but slightly curved until they reach the marginal region, where they become subparallel with the margins in the usual camptodrome manner. Tertiary venation distinct, consisting of marginal arches and of intermediate veins from the midrib, parallel with the secondaries, combined with cross nervilles in different directions, forming relatively large four, five, or six sided areolæ.

This species is contained in old collections from Wickliffe, Ky., labeled *Sapindus dubius*. It is almost identical in all its characters with the existing *Exostema caribæum* Roemer and Schultes, which ranges from the Florida Keys through the Antilles, the coast region of southern Mexico and Central America, and occurs also on the Pacific coast of Central America. The genus consists of about a score of species of shrubs and small trees, exclusively American and confined to the Tropics and subtropics. They are most abundant on the Antilles, and only *Exostema caribæum* reaches the Florida mainland. So far as I know the genus has not been previously recognized in the fossil state.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry). Lagrange formation (in beds of Wilcox age), Wickliffe, Ballard County, Ky. (collected by R. H. Loughridge).

Collections.—U. S. National Museum.

Genus PSYCHOTRIA Linné.

PSYCHOTRIA GRANDIFOLIA Engelhardt.

Plate CV, figure 1.

Psychotria grandifolia. Engelhardt, Senckenbergische naturf. Gesell. Abh., vol. 16, p. 656, pl. 11, fig. 4, 1891.

Description.—Leaves large, oblong lanceolate in general outline, greatly elongated, widest in the middle part, tapering upward to the abruptly narrowed and bluntly pointed tip, and abruptly to the broadly cuneate base. Length about 21 centimeters. Maximum width, midway between the apex and the base, about 6.5 centimeters. Margins entire, full, and somewhat undulate. Texture coriaceous. Petiole not preserved, obviously very stout. Midrib stout and prominent. Secondaries stout; about 15 or 16 pairs diverge from the midrib at angles of about 70°, curving regularly upward and camptodrome in the marginal region. Tertiaries form pseudosecondaries, alternating with the true secondaries. Areolation fine, largely immersed. An uncommonly small leaf measures but 11.3 centimeters in length by 33.5 millimeters in maximum width.

The present striking species may be compared with the Wilcox species *Anona wilcoxiana* Berry or *A. eolignitica* Berry, but it does not equal the largest leaves of *A. ampla* Berry. It differs from the latter species in its much narrower, slightly inequilateral, less pointed form and in the details of venation. It is much more elongated and straight-sided than the other two Wilcox species previously mentioned, with narrower tip and base and more numerous secondaries. Of the two it is perhaps closest to the larger leaves of *Anona* *eolignitica*. It is very similar to the leaves of several existing tropical species of Anona.

I am unable to separate this striking form from the species described by Engelhardt from the early Tertiary of Chile. The genus Psychotria, to which it is referred, includes many existing tropical shrubs and trees, of which two-thirds, or about 230 species, are peculiar to the West Indies, Central America, Brazil, and Peru. The fossil form may be compared with *Psychotria grandis* Swartz, a shrubby form ranging from the West Indies (Cuba, Jamaica, etc.) to Mexico and Central America.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

INCERTÆ SEDIS.

Genus ANTHOLITHUS Brongniart.

ANTHOLITHUS ARUNDITES Berry, n. sp.

Plate CXII, figure 6.

Description.—The inflorescence shown in Plate CXII, figure 6, has an extraordinarily stout axis that bears a compact cluster of small flowers, which are very imperfectly preserved, the only feature that can be made out with certainty being the lanceolate segments of the floral envelope, and these greatly resemble the empty and flowering scales of the grasses. Though a botanic affinity with that group is only a probability, it is commemorated in the specific name chosen for this form.

Ordinarily it would not be worth while to describe or figure such poorly preserved material, but though it furnishes little that is of botanic interest it serves to help round out our picture of the life along this early Eocene coast, and as definite remains of grasses are such rare fossils, even imperfectly preserved specimens are not without value.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

ANTHOLITHUS MARSHALLENSIS Berry, n. sp.

Plate CXII, figure 1.

Description.—Flower campanulate or tubular; it may be interpreted as having aborted or greatly reduced petals and a gamosepalous calyx, or more probably the calyx was inconspicuous and is not visible in the fossil, and the corolla was gamopetalous. Peduncle about 6.5 millimeters in length, slightly enlarged distad. The ovary appears to have been inferior; that is, the flower was epigynous. The corolla appears to have been tubular, the campanulate appearance on the left side of the figure being due to a broken part of the gamopetalous corolla and not to an individual petal. Stamens slender, exserted, five in number.

This species is based on the single specimen well shown in Plate CXII, figure 1. The preservation is unfortunately not of the best, the remains being flattened and the stamens having lost their anthers, which it would seem were versatile. With material as imperfectly preserved as this specimen any extended search among existing gamopetalous flowers for possible relationships is hardly worth while.

Occurrence.—Holly Springs sand, Early Grove, Marshall County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

Genus CALYCITES of authors.

CALYCITES DAVILLAFORMIS Berry, n. sp.

Plate CIV, figure 7.

Description.—This name is proposed for concavo-convex, coriaceous objects, broadly elliptical or orbicular in outline, about 2 centimeters long and 1.7 centimeters in maximum width, slightly deflected and flanged along the sides and top, the maximum width of this flange being about 2 millimeters. The tip is broadly and roundly pointed. The base is rounded at the sides and truncate across the middle.

This form, which appears to represent a sepal, is named from its resemblance to the modified inner pair of sepals in the genus Davilla Velloso of the family Dilleniaceæ, a family represented in the Wilcox flora by several species referred to the form genus Dillenites Berry and comparable for the most part with the existing species of Tetracera Linné.

The genus Davilla comprises about 25 species, confined to the American Tropics and ranging from Mexico southward, chiefly living in the Brazilian region. In this genus the inner pair of sepals becomes enlarged and forms a hard leathery or woody, more or less nearly closed, bivalve envelope, surrounding the essential organs and subsequently the fruit. The fossil form in all of its characters resembles such a sepal.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CALYCITES OSTRYAFORMIS Berry, n. sp.

Plate CIV, figures 4 and 5.

Description.—Small bract or other floral appendage, broadly elliptical in outline, rounded at both ends, the proximal somewhat more narrowed than the distal end. Length about 9 millimeters. Maximum width about 7.5 millimeters, midway between the apex and the base. Substance not thick but apparently coriaceous, since the single specimen is preserved in sandy deposits where most of the plant remains are much macerated. Venation shows about 16 subparallel longitudinal veins, which converge toward both ends and a few fork. Cross veinlets are apparently fine and not especially numerous.

This species, unfortunately based on the single specimen figured, may be compared with *Ostrya humilis* Saporta [1] from the lower Oligocene of southeastern France, being similar in size, outline, and venation, except that the forks of the veins in the American form are less numerous. It may also be compared with *Ostrya atlantidis* Unger as figured by Ettingshausen [2] from Carniola and with *Ostrya walkeri* described by Heer from West Greenland. There is no trace of a seed, but one of the central veins is thickened at the base, and the base is slightly frayed, which might indicate that the base with the seed has been broken away. Whatever the botanic affinity, this form seems certainly congeneric with Saporta's species.

The genus Ostrya includes about a dozen fossil species ranging from the middle Eocene to the present. In the modern flora the genus is widely distributed in the Northern Hemisphere, ranging northward to Nova Scotia and southward to the highlands of southern Mexico and Guatemala in North America, and through southern Europe and southwestern Asia and in northern Japan in the Old World. The saclike bracts of our two American species are larger than the fossil and have fewer longitudinal veins and more numerous and stouter transverse veinlets.

Occurrence.—Beds of Wilcox age, Calaveras Creek, Wilson County, Tex. (collected by Alexander Deussen).

Collection.—U. S. National Museum.

[1] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 83, pl. 6, fig. 5, 1863; vol. 3, suppl. 1, p. 33, pl. 5, fig. 8, 1867; Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, p. 12, pl. 1, fig. 11, 1889.

[2] Ettingshausen C. von, Die fossile Flora von Sagor in Krain, pt. 1, p. 177, pl. 4, figs. 13, 14, 1871.

Genus CARPOLITHUS Allioni.

CARPOLITHUS PURYEARENSIS Berry, n. sp.

Plate CIV, figure 8.

Description.—Ovate-lanceolate compressed bilocular capsule-like form, about 1.5 centimeters in length by 8 millimeters in maximum width, in the median region. A longitudinal median sinus marks the central peduncular column. Surface somewhat corrugated and texture apparently coriaceous.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS PRANGOSOIDES Berry, n. sp.

Plate CIV, figure 9.

Description.—Fruit laterally compressed, elliptical in outline. Carpels two, separated by a deep median commissure, oblong in outline, terete, bluntly pointed at both ends, each with a large dorsal wing. Length of fruit about 2.5 centimeters. Maximum width, about midway between the apex and the base, about 1.4 centimeters. The individual carpels are 2.1 centimeters in length and about 3.25 millimeters in diameter. Pericarp thickened, the surface being marked with fine longitudinal corrugations.

This species is described with the assumption that it represents the fruit of some Wilcox species of Umbelliferæ, although the fruits of that family as a rule have more than two ribs or wings developed by the pericarp.

I have not found any recent Umbelliferæ that resemble it closely, and it is named from its rather remote resemblance to the fruits of the oriental genus Prangos of Lindley.

I know of no closely comparable fossil forms, although I have not searched the literature exhaustively.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum

CARPOLITHUS HENRYENSIS Berry, n. sp.

Plate CXII, figure 16.

Description.—Small costate fruit, elliptical in outline and nearly cylindrical or slightly compressed in cross section, bearing five or six longitudinal costæ separated by narrow sulci. Length about 1.5 centimeters. Maximum width about 7.5 millimeters. Ends equally rounded. Texture ligneous.

A rare fruit of unknown affinity somewhat resembling several of the fruits from the Brandon lignites that have been referred to Aristolochites, as for example *Aristolochites sulcatus* Perkins [1] and *Aristolochites conoideus* Perkins.[2]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS GRENADENSIS Berry, n. sp.

Plate CXII, figure 15.

Description.—Small fruit, circular in outline, much compressed, 3 millimeters in diameter, borne on a straight, stout, inequilaterally placed peduncle about 3.75 millimeters long.

This small form, represented by a single specimen, is of unknown botanic affinity.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS TENNESSEENSIS Berry, n. sp.

Plate CXII, figure 17.

Description.—Species apparently representing a berry-like or drupaceous fruit with a wrinkled coriaceous pericarp. Outline nearly circular, apparently somewhat compressed in cross section. Length 12.5 millimeters. Maximum width 11 millimeters in the equatorial region. Fruit is decurrent to a stout peduncle about 7.5 millimeters in length.

This form is represented by the single specimen figured and is of unknown botanic affinity.

[1] Perkins, G. H., Vermont State Geologist Rept. for 1903–4, p. 204, pl. 81, figs. 156, 157, 1904.

[2] Idem, fig. 154.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS SOPHORITES Berry, n. sp.

Plate CXII, figure 7.

Description.—Large seed, unsymmetrically ovate, compressed, distinctly keeled or margined. Length about 14.5 millimeters. Width in the median region about 8.25 millimeters. More obtuse distad. Margin slightly angular near the hilum and also forms an inner posterior angle, elsewhere curved, fuller on the outside and bears a sharp sinus partly due to compression on the inside above the hilum. Seed much compressed and original thickness can not be determined. Surface smooth.

This large form evidently belongs to one of the Wilcox species of Papilionaceæ and suggests the genus Sophora, which is so well represented by leaves in the Wilcox deposits.

Bowerbank [3] described many species of a genus which he named Faboidea from the Isle of Sheppey (Ypresian), all of which, however, present certain morphologic features, such as their thick testa, punctate surface, and funiculus umbilicalis, which are absent in the form here discussed, which is therefore referred to the indefinite genus Carpolithus.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS PILOCARPOIDES Berry, n. sp.

Plate CXII, figure 11.

Description.—Large ligneous asymmetric compressed seeds or fruits, about 1 centimeter in length, 5.5 millimeters in width, and 2 to 3 millimeters in thickness. Proximal margin straight or incurved. Distal margin full and rounded, as are both ends. Margins show a well-marked keel.

This is a well-marked form of possible stratigraphic importance, since it is readily recognizable. It comes from the top of the Wilcox and is represented in the collections by several specimens. Its botanic affinity is uncertain, although it suggests the fruits of the genus

[3] Bowerbank, J. S., History of the fossil fruits and seeds of the London clay, pp. 98–123, pl. 14–16, 1840.

Protium (Burseraceæ) and those of Pilocarpus of the Rutaceæ, the similarity to Pilocarpus being commemorated in the specific name.

Occurrence.—Grenada formation, Grenada, Grenada County, Miss. (collected by E. N. Lowe and E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS PROTEOIDES Berry, n. sp.

Plate CXII, figure 2.

Description.—A slightly asymmetric winged seed, narrowly ovate in outline, about 8.5 millimeters in length and 2.5 millimeters in maximum width near the base, tapering upward to a falcate acuminate tip, rounded and slightly asymmetric at the base. Nucellus small, compressed. Wing longitudinally veined.

This characteristic winged seed is in my judgment positively referable to the Proteaceæ and might well represent the fruit of *Banksia tenuifolia* Berry, which is so common at this locality. It may be almost exactly matched by seeds of different existing species of Banksia, Hakea, and similar genera of the Australian region, commonly represented in the Oligocene floras of Europe.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS HYOSERITIFORMIS Berry, n. sp.

Plate CXII, figure 4.

Description.—A small, slightly asymmetric fusiform seed or achene-like fruit, about 8 millimeters in length and 1.75 millimeters in maximum diameter about midway between the apex and the base, acuminate proximad, contracting above the middle and expanding distad in a crown of short, diverging simple awns or bristles about ten in number and about 2 millimeters in length. Surface costate.

This characteristic form, represented by two specimens, is almost certainly an achene of some Wilcox species of Compositæ, but rather than give it a generic name implying a knowledge of its botanic affinity beyond what the facts warrant I prefer to retain it in the indefinite genus Carpolithus, commemorating in its specific name its great resemblance to the genus Hyoserites of Ettingshausen, a genus of Compositæ not uncommon in the European Tertiary.[1]

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

CARPOLITHUS DICTYOLOMOIDES Berry, n. sp.

Plate CXI, figures 2 and 3.

Description.—A small winged seed or fruit, which has an elliptical, laterally compressed nucellus about 2.5 millimeters long by 1.5 millimeters wide, truncate on its proximal side, and a scarious, minutely reticulate veined, marginal keel or wing 1 to 2 millimeters wide. This wing was of considerable consistency as shown by its vascular skeleton; it is full and rounded, except at the upper end, where it is somewhat extended and acuminate. Length of the whole fruit, including the wing, about 7 millimeters. The hilum is centrally located on the truncated portion of the unwinged proximal margin.

This characteristic winged fruit is comparable with those of a number of existing genera, especially in the families Malpighiaceæ, Rutaceæ, and Bignoniaceæ. Among the forms with which comparisons are especially suggestive are the species of Stigmatophyllon Jussieu, a genus of Malpighiaceæ that comprises about 45 existing species, ranging from the Bahamas to Uruguay, in which, however, the venation of the wings is not markedly reticulate, and the genus Dictyoloma De Candolle, consisting of two species of trees of Brazil and Peru. It is the resemblance of the fossil to Dictyoloma that has suggested the specific name.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

PHYLLITES sp.

Plate CIV, figure 2.

Description.—A characteristic fragment of a large leaf of unknown botanic affinity.

Occurrence.—Lagrange formation (in beds of Wilcox age), Puryear, Henry County, Tenn. (collected by E. W. Berry).

Collection.—U. S. National Museum.

[1] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 2, p. 18, 1868.

PLATES IX–CXVII.

PLATE IX.

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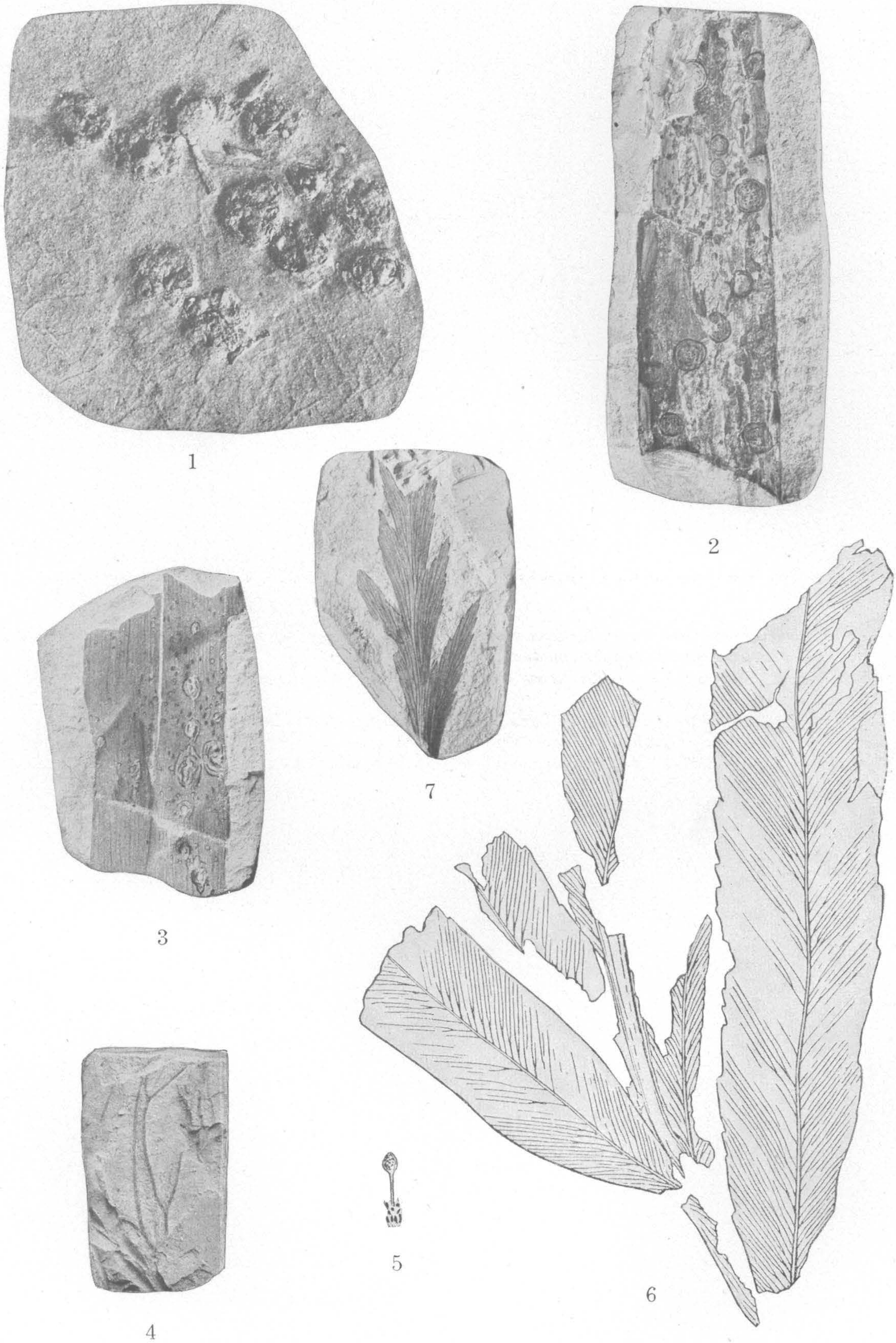
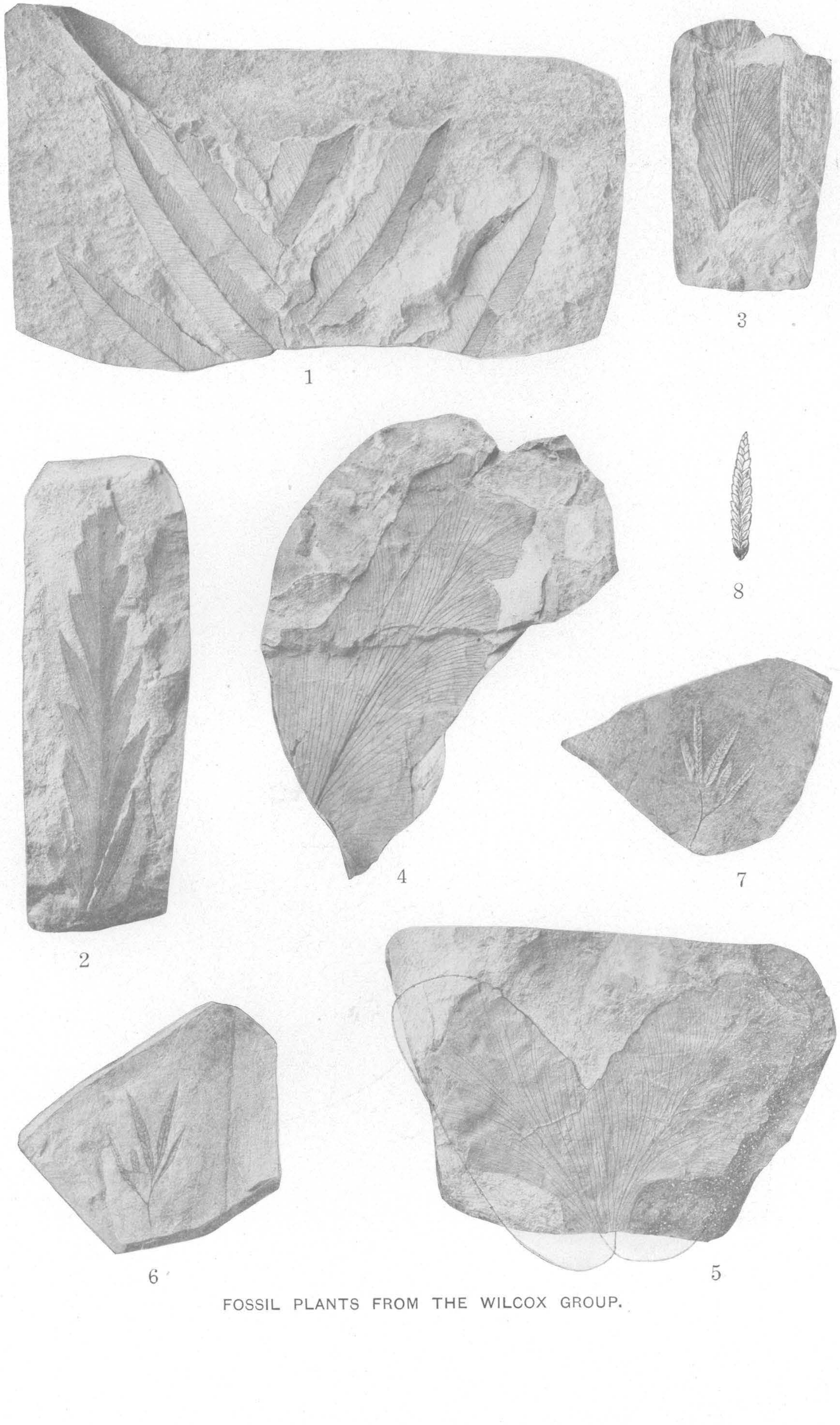


FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

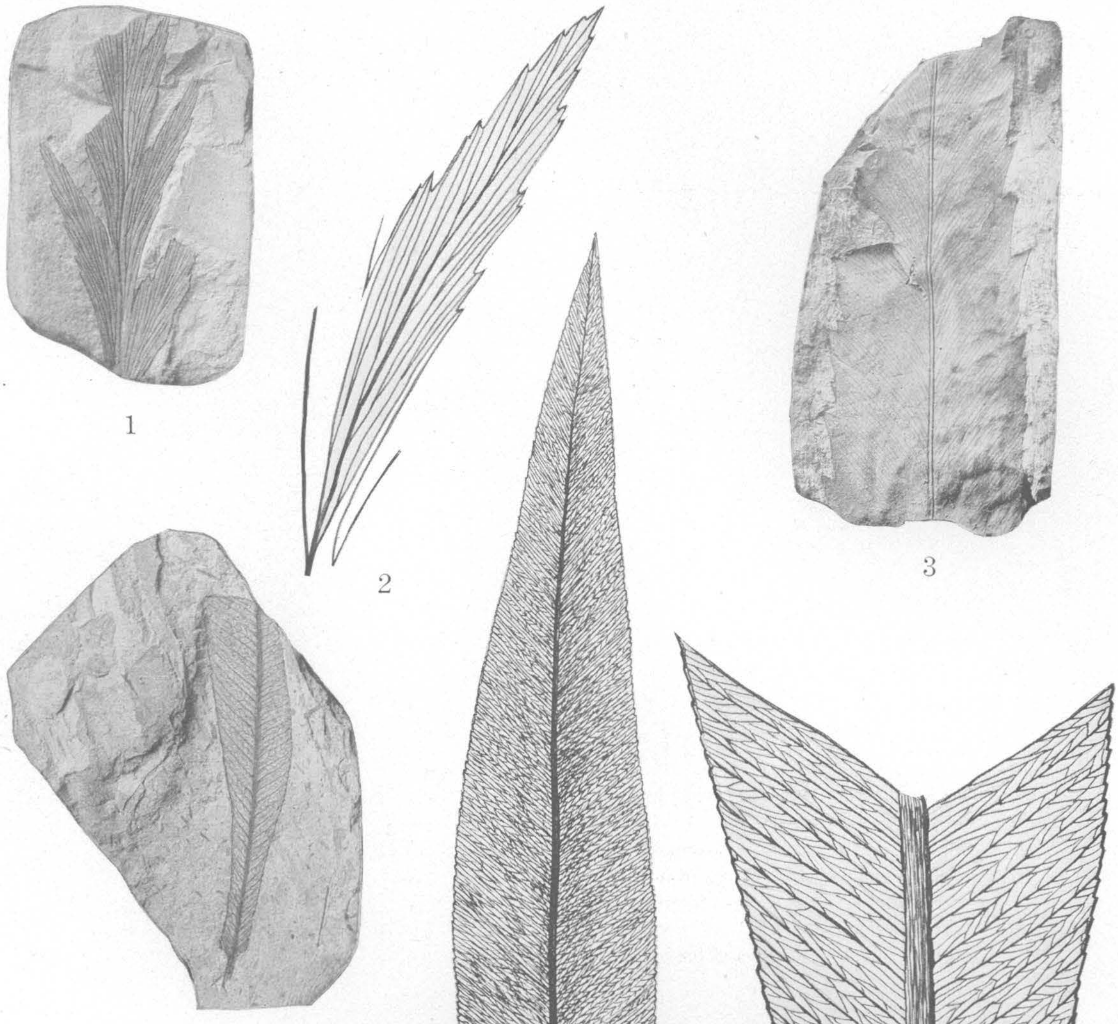
PLATE X.

3-5. Fragments of sterile pinnules.

6, 7. Fertile pinnules.

8. Single spike, × 2.

PLATE XI.



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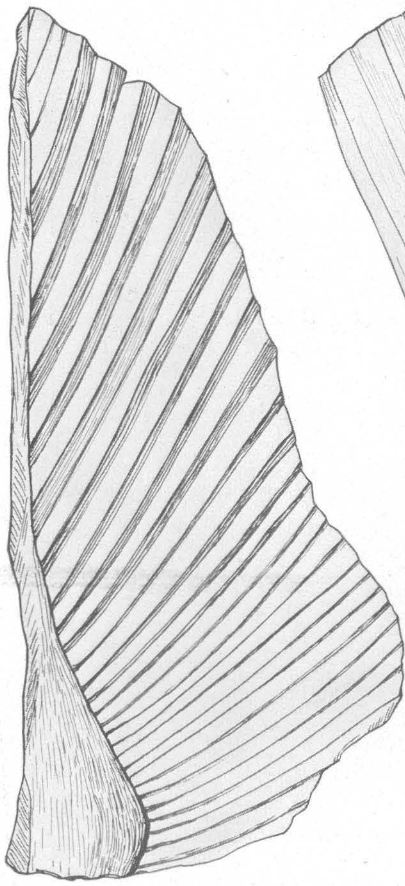

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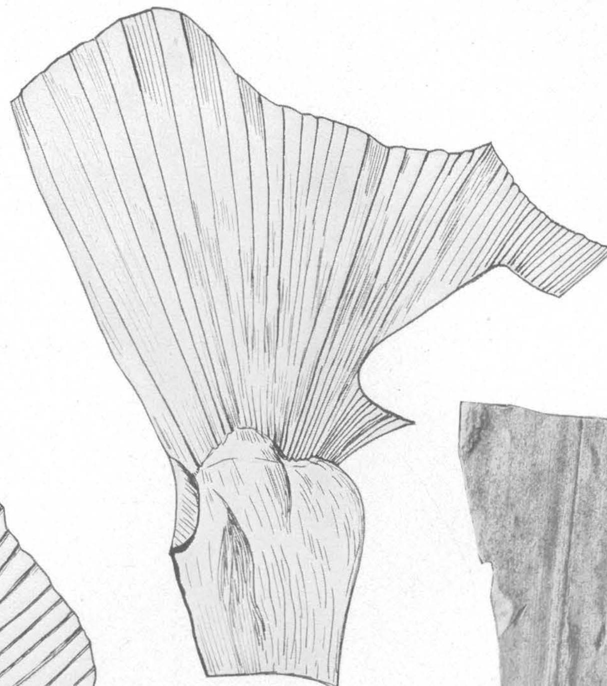

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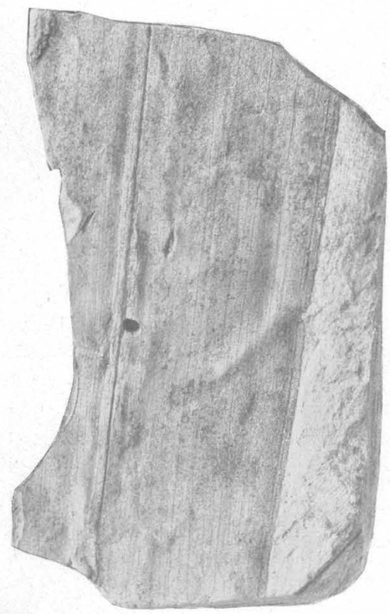

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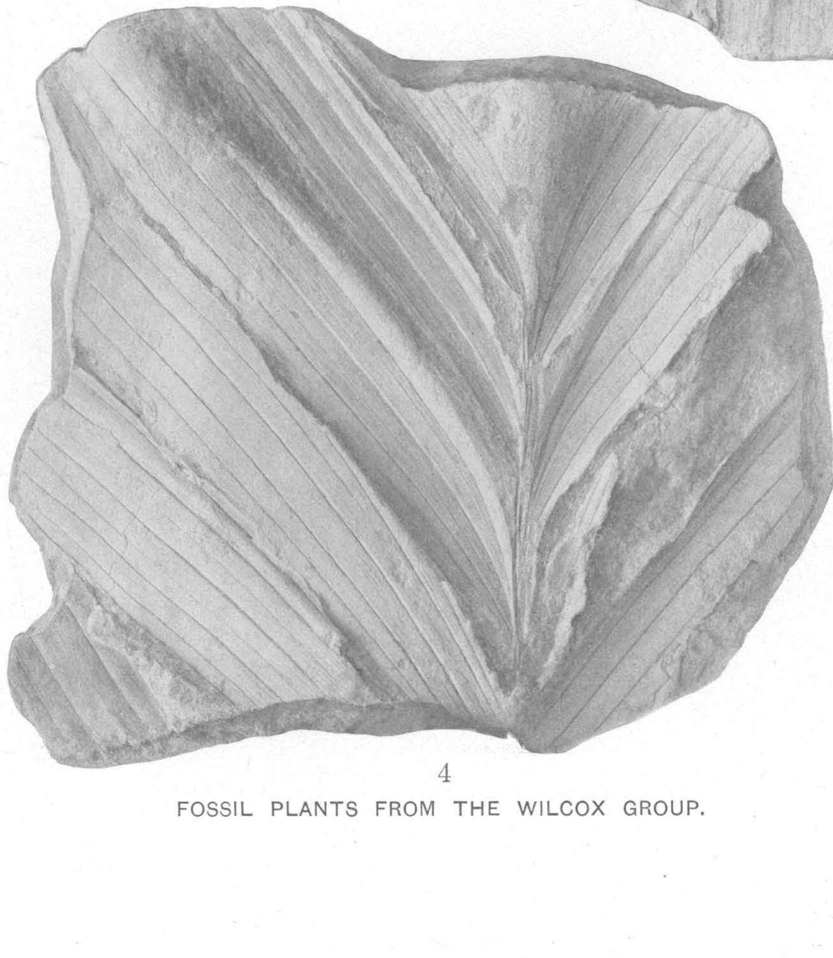

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FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XII.

PLATE XIII.

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FIGURES 1–3. *Chamædorea danai* (Lesquereux) Berry from Ackerman formation at Colemans Mill, Choctaw County, Miss 179

3. Venation of a ray with a single secondary on each side of the midrib, × 4.

1

2

3

FOSSIL PLANTS FROM THE WILCOX GROUP.

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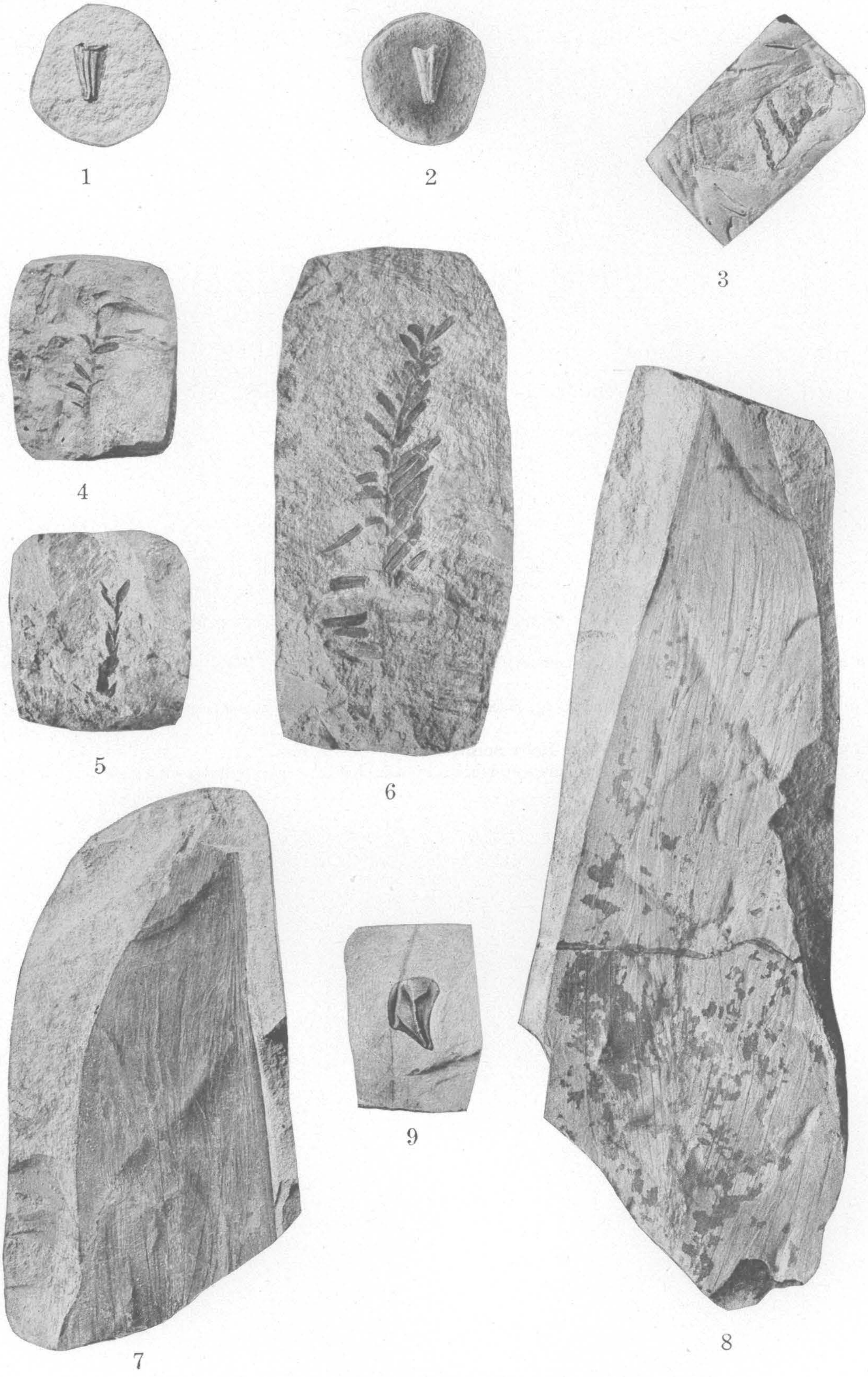
FIGURE 9. Taxodium sp., seed from Lagrange formation (in beds of Wilcox age) $1\frac{1}{2}$ miles west of Grand Junction, Tenn 173



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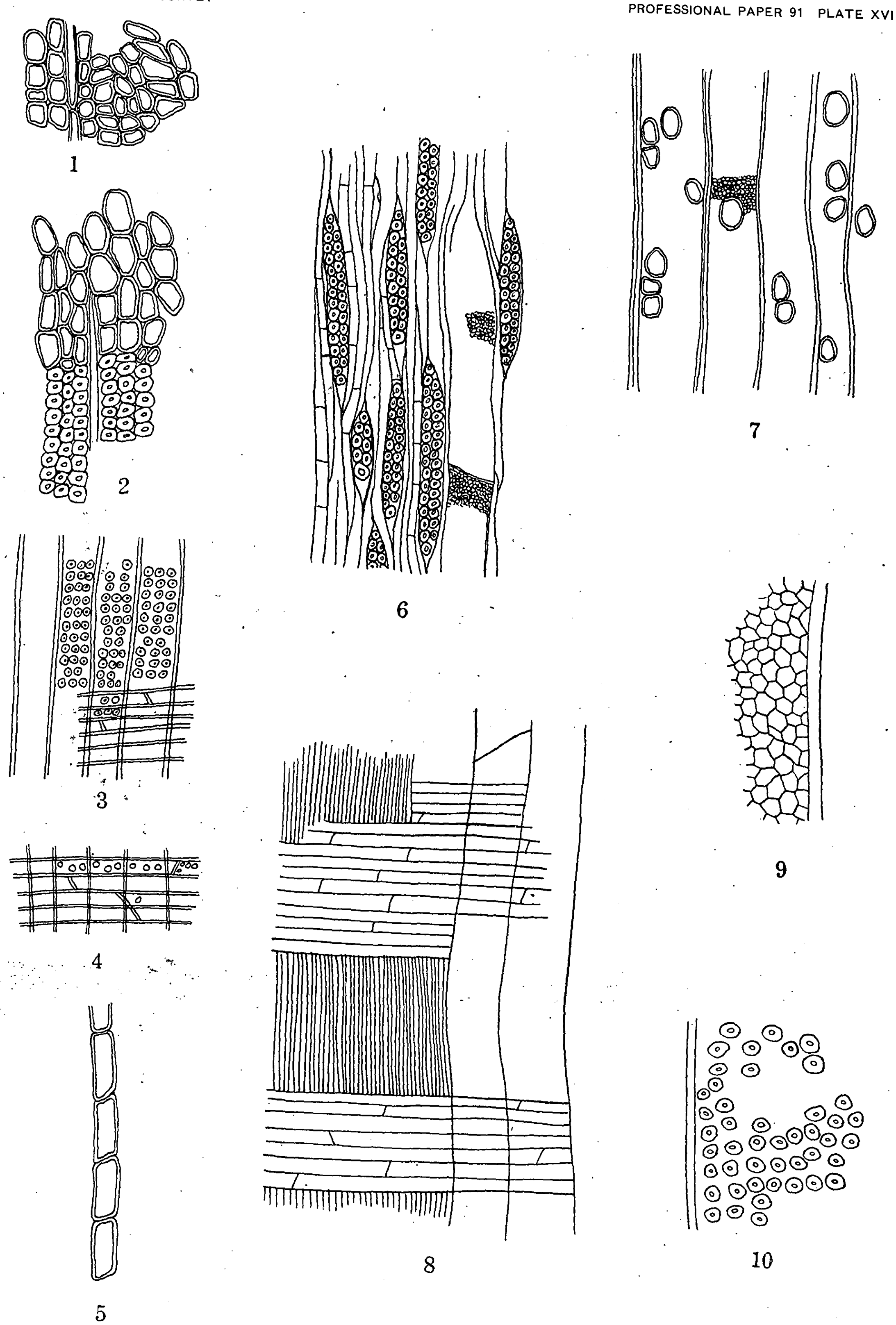

FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XVI.

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1. Transverse section showing a medullary ray.
2. Same, passing through a growth ring.
3. Radial section showing bordered pits.
4. Same, showing pits on medullary rays.
5. Radial section showing chain of resin cells.

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7. Transverse section showing arrangement of ducts and rays.
8. Radial section showing ducts and large medullary rays, wood cells not well preserved.
9. Tangential section showing reticulate thickening of tangential walls of ducts.
10. Radial section showing pitting on radial walls of ducts.

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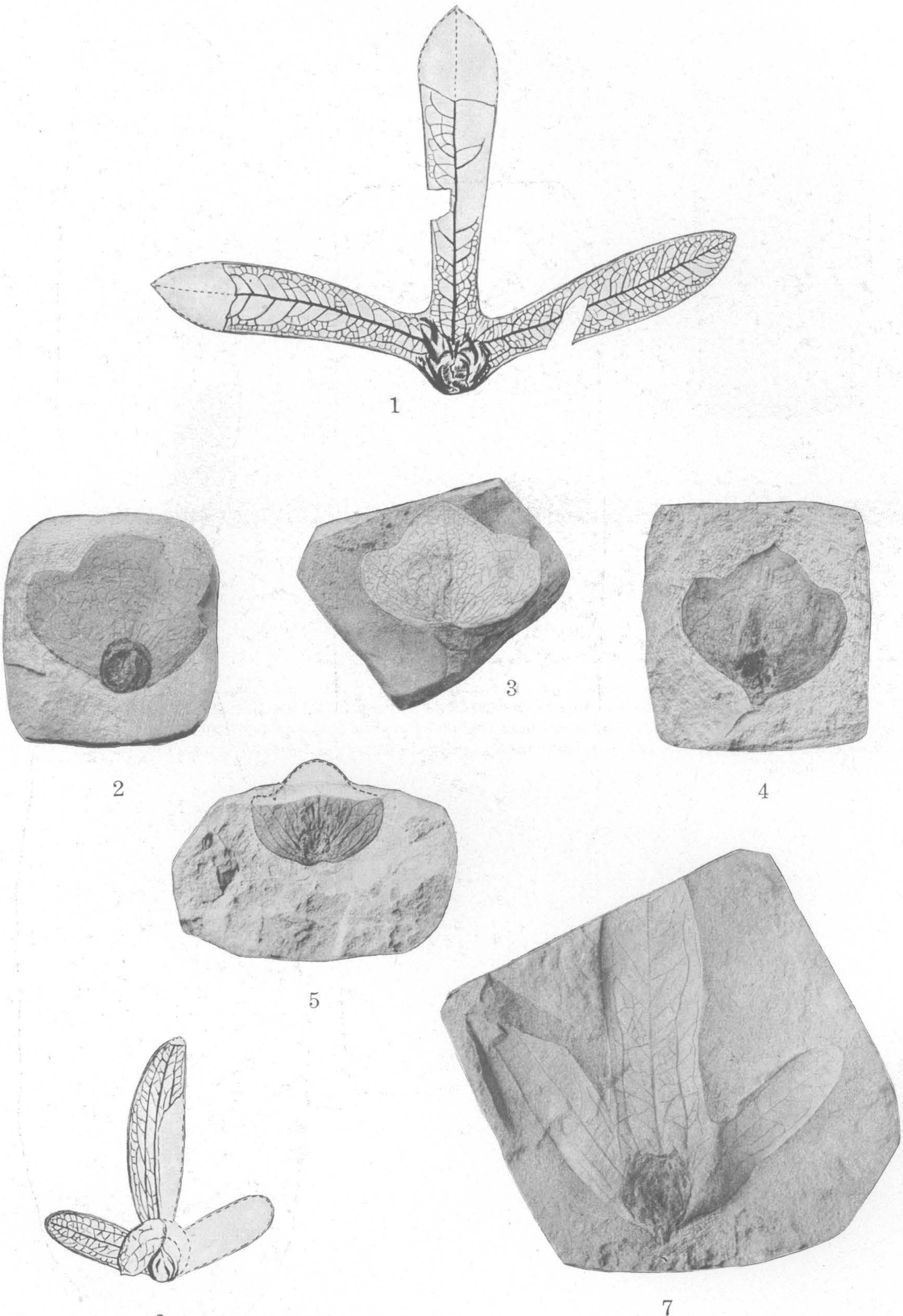
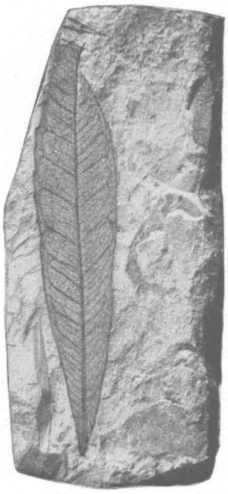


FOSSIL PLANTS FROM THE WILCOX GROUP.



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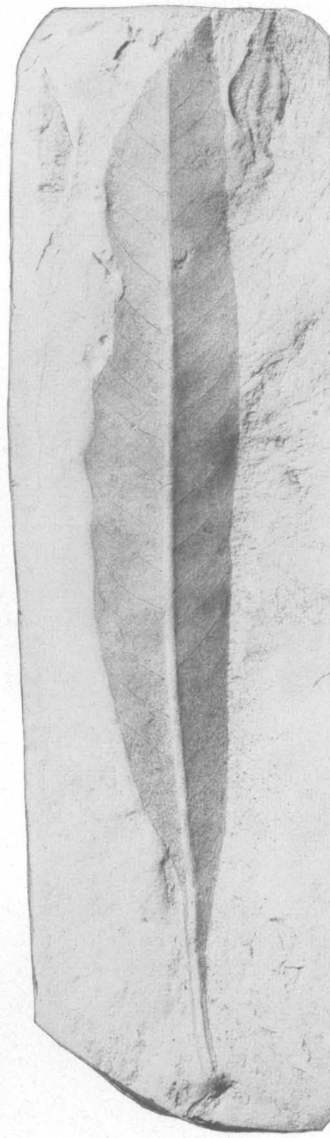

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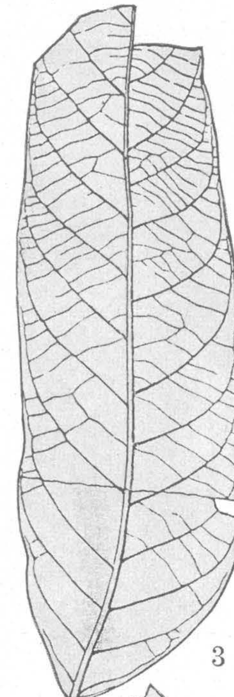

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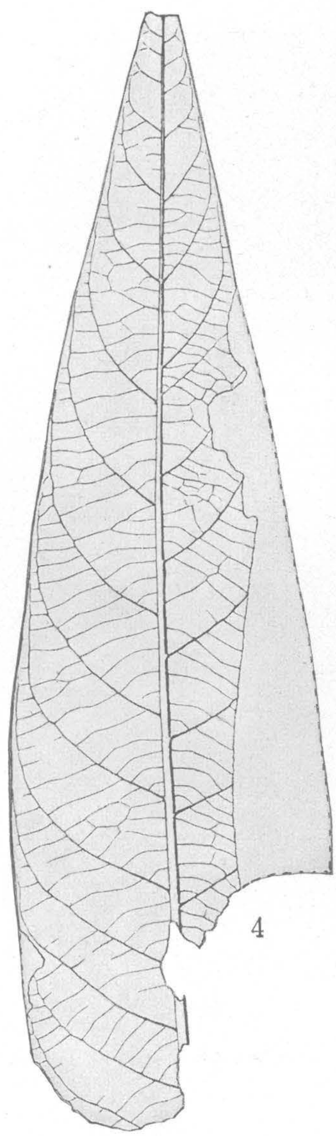

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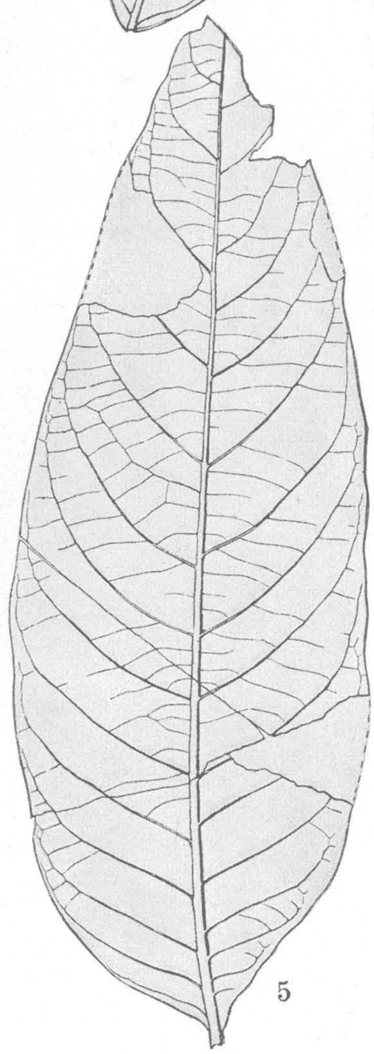

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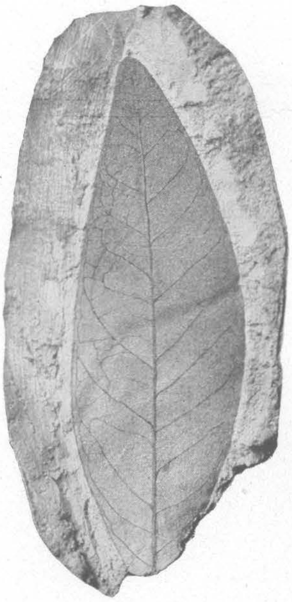
FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XVIII.

PLATE XIX.



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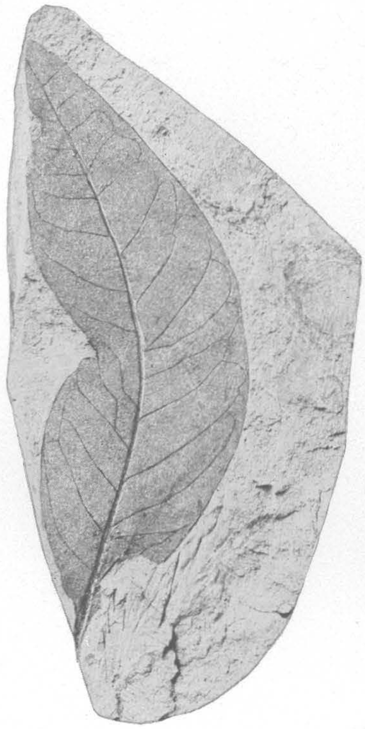

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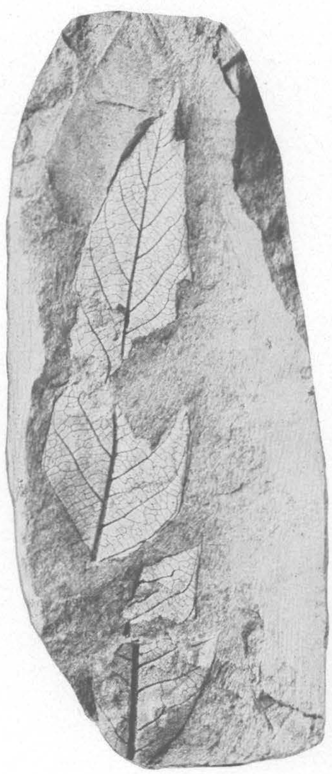

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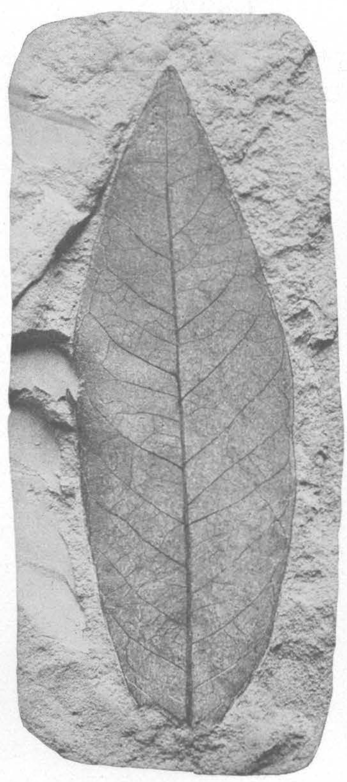

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FOSSIL PLANTS FROM THE WILCOX GROUP.

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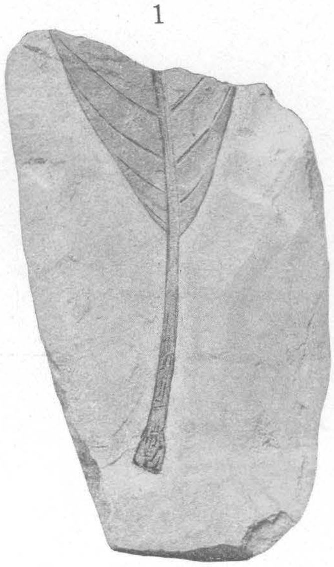

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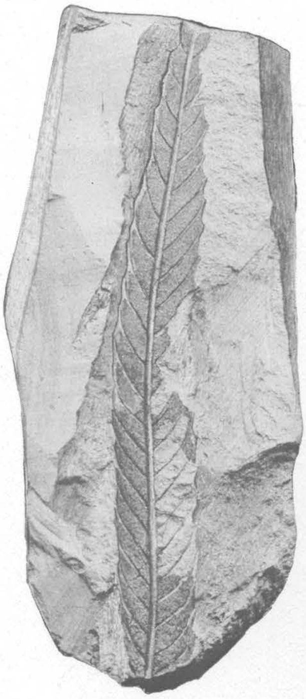
FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XX.

PLATE XXI.

All the specimens are from the Lagrange formation (in beds of Wilcox age) at Puryear, Tenn.



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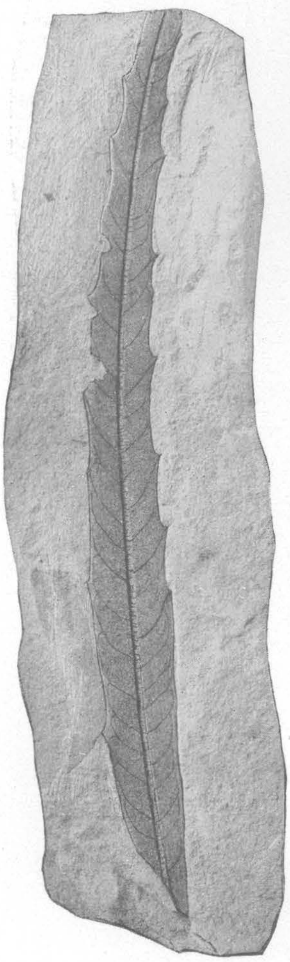

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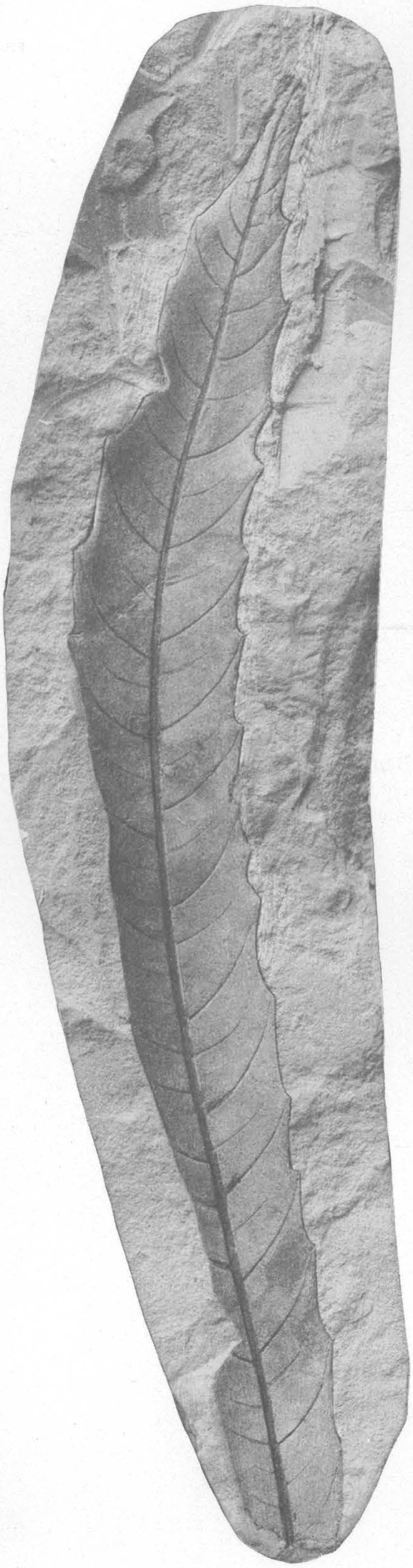

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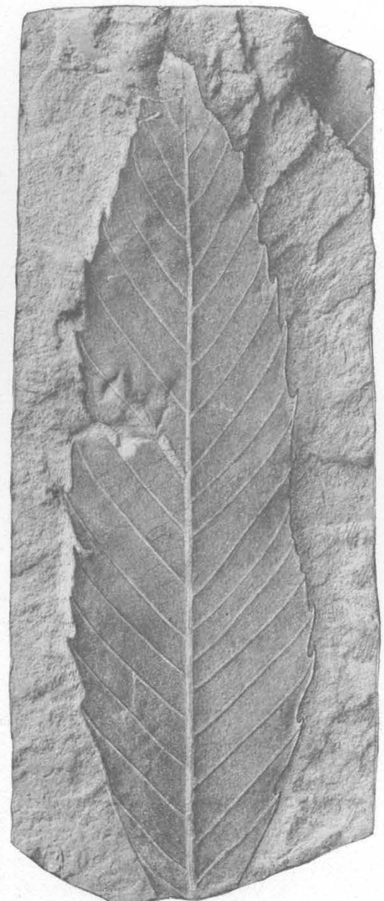

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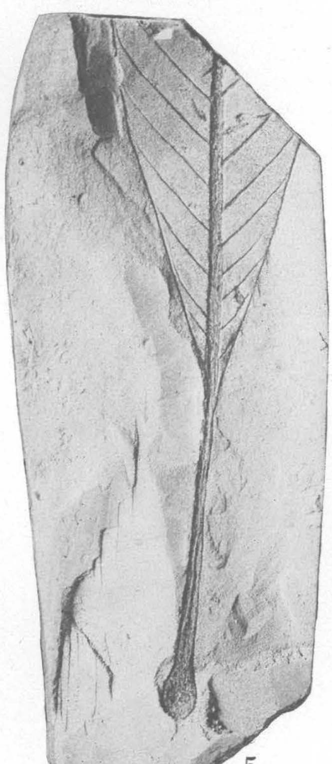

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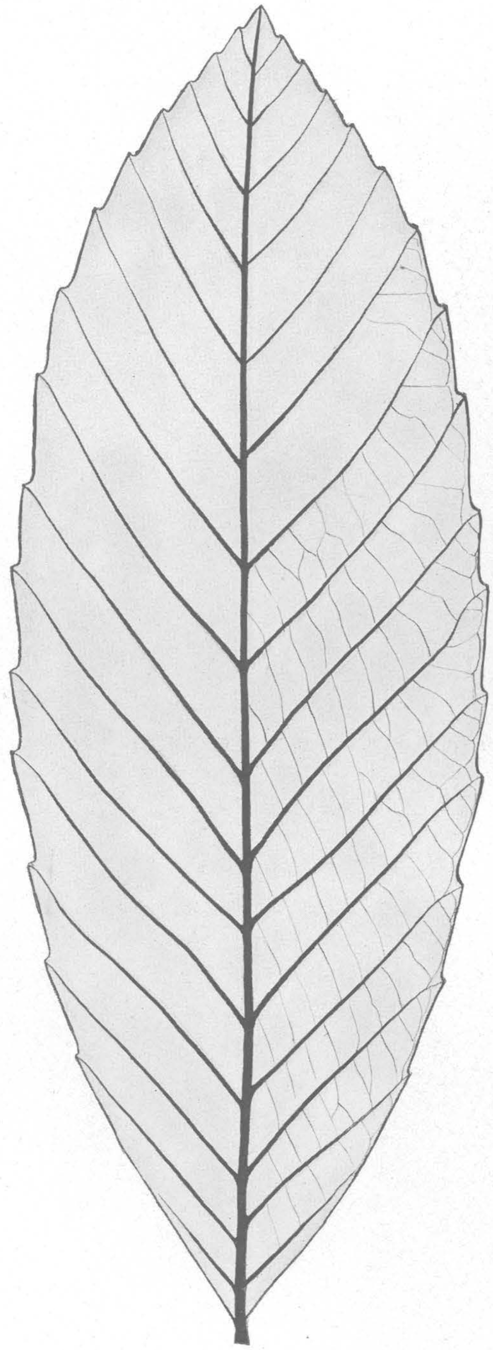

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FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XXII.

PLATE XXIII.

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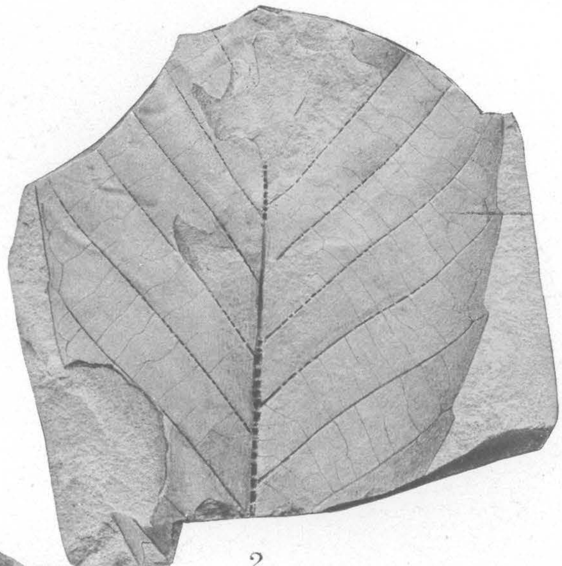

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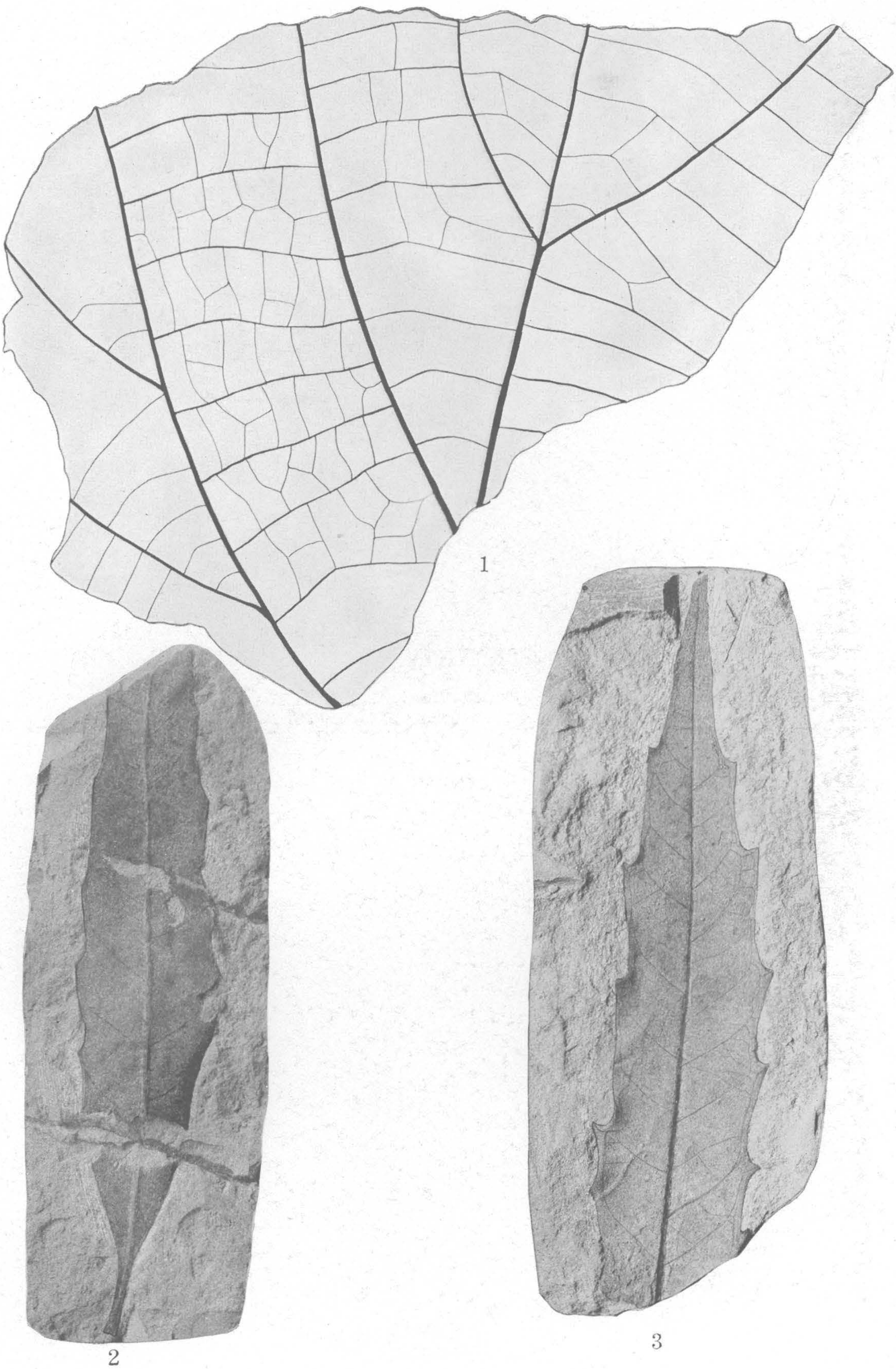
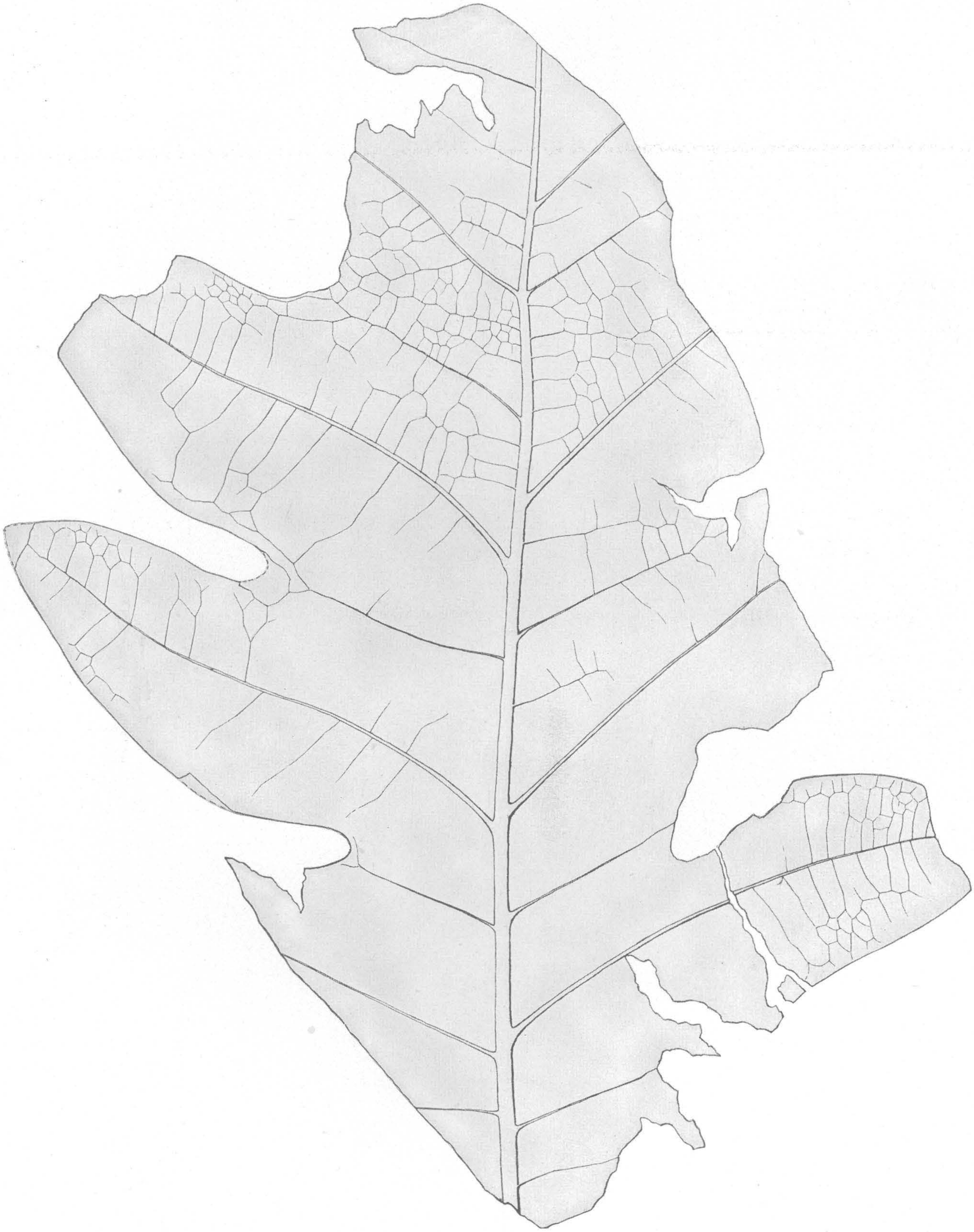


FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE XXIV.

PLATE XXV.

FOSSIL PLANT FROM THE WILCOX GROUP.



FOSSIL PLANT FROM THE WILCOX GROUP.

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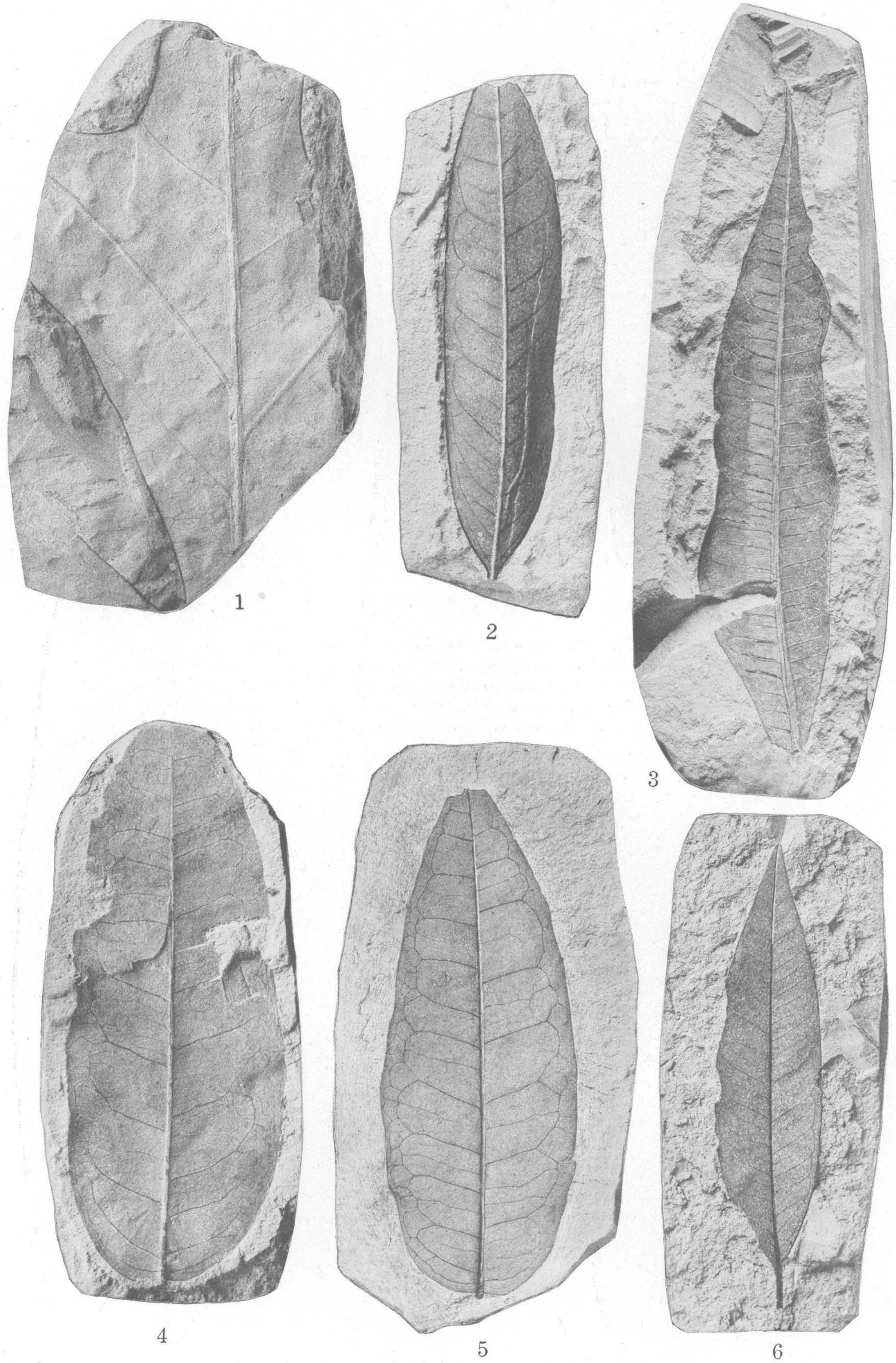
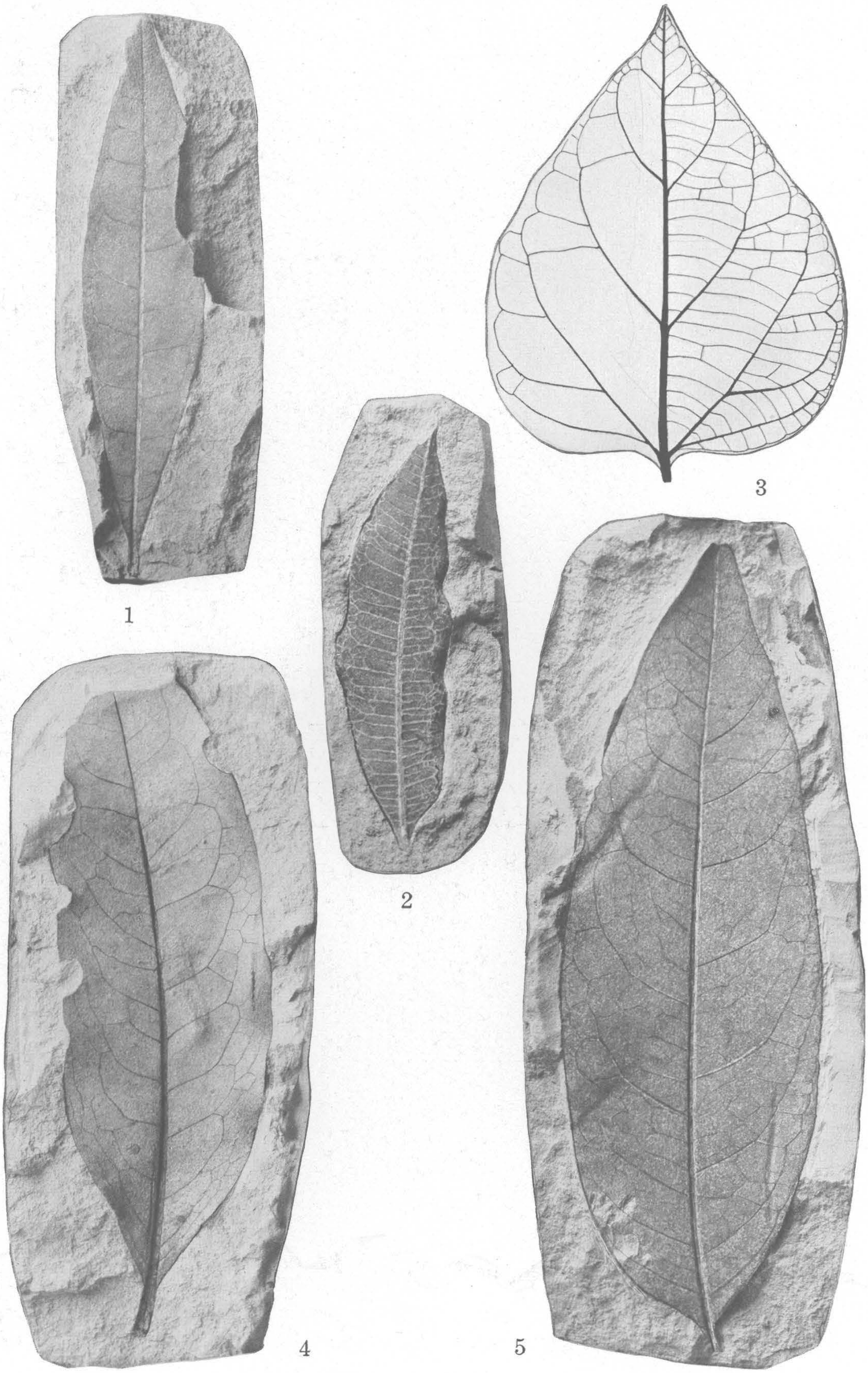


FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

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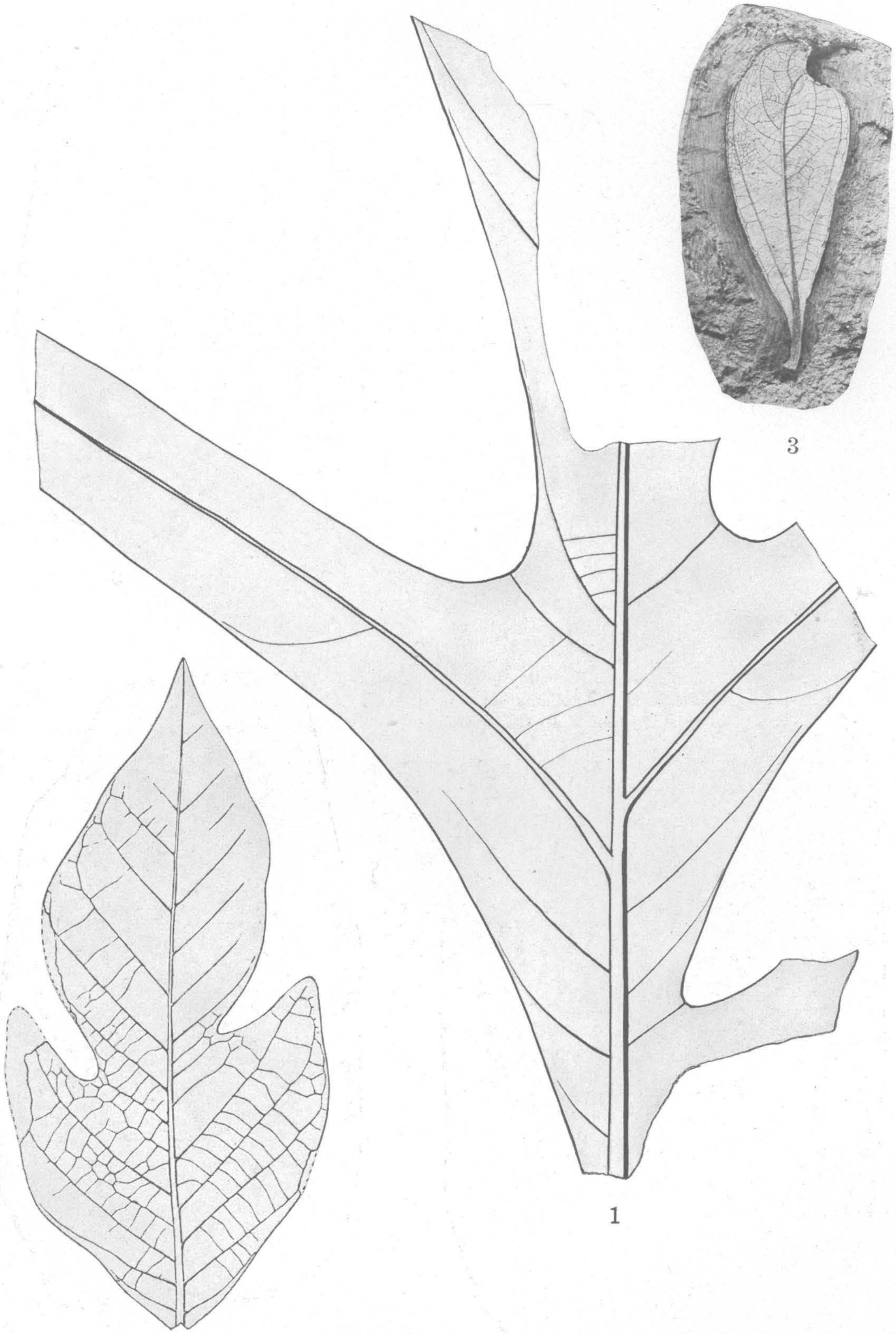

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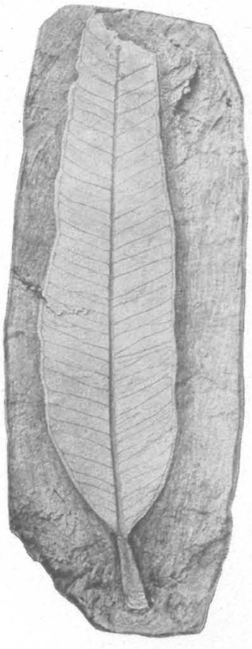
FOSSIL PLANTS FROM THE WILCOX GROUP.



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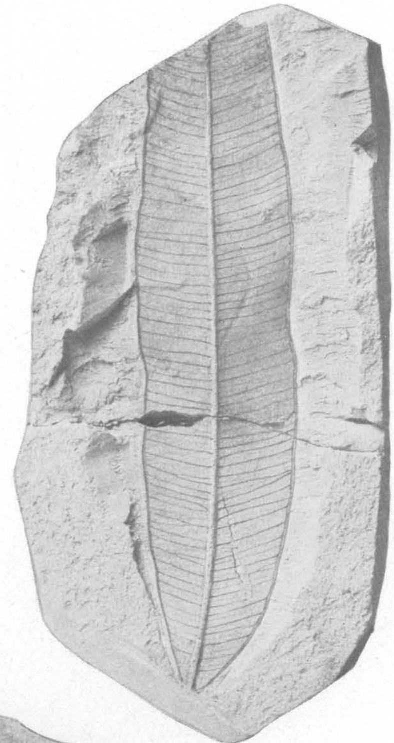

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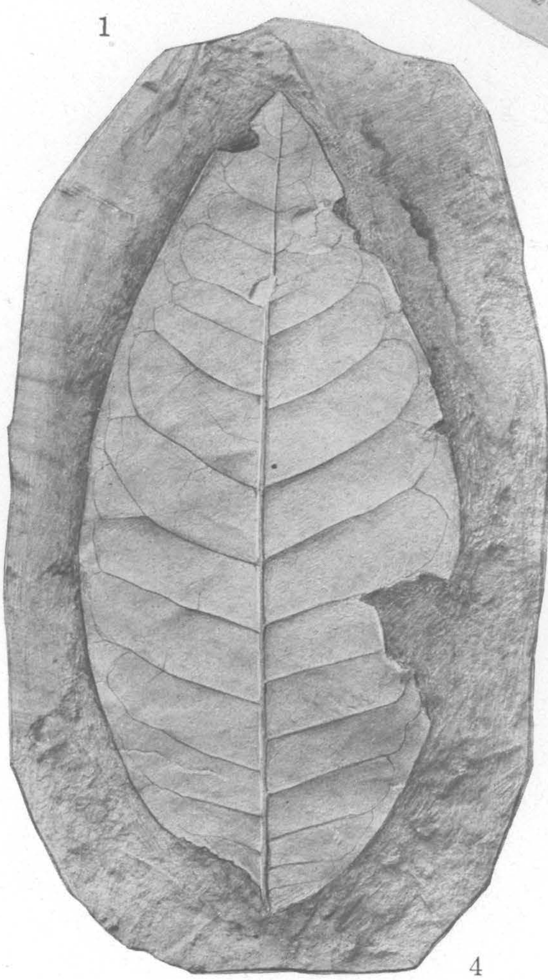

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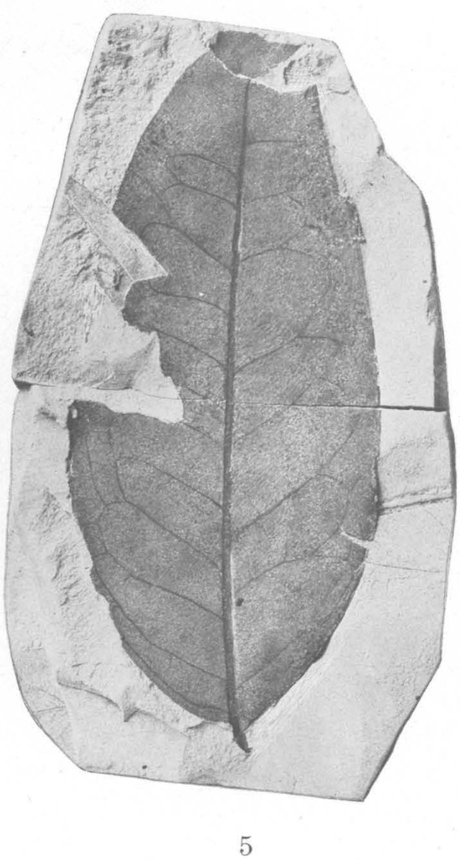

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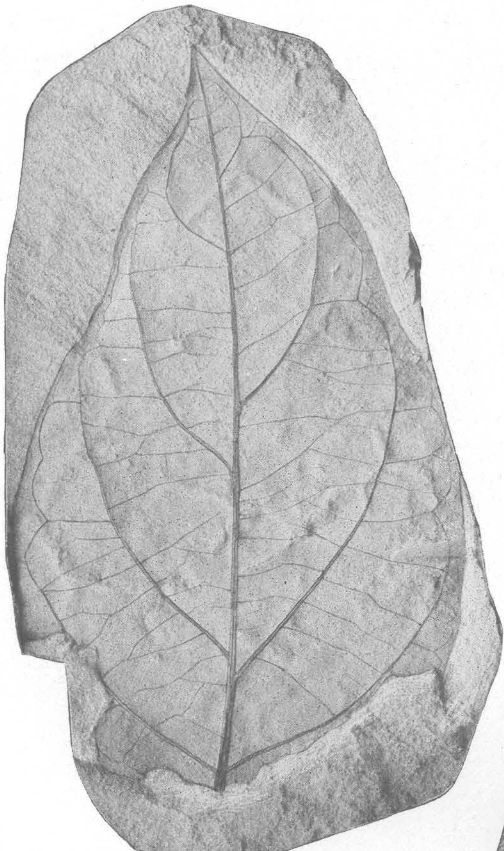

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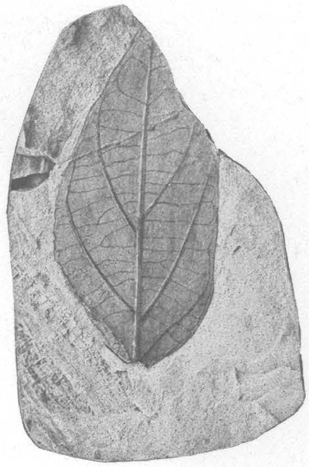

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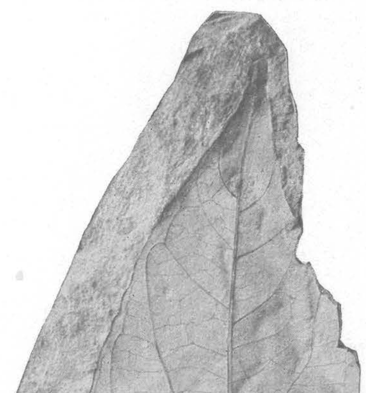

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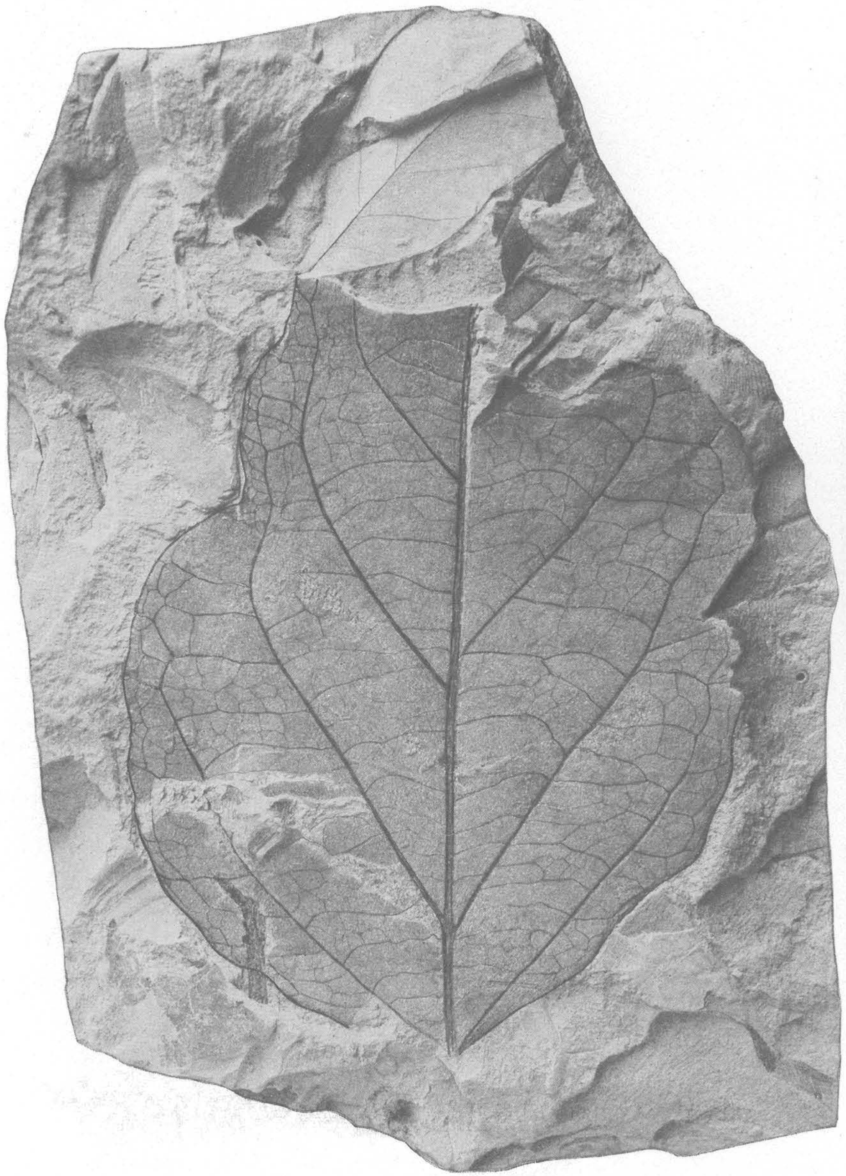
FOSSIL PLANTS FROM THE WILCOX GROUP.



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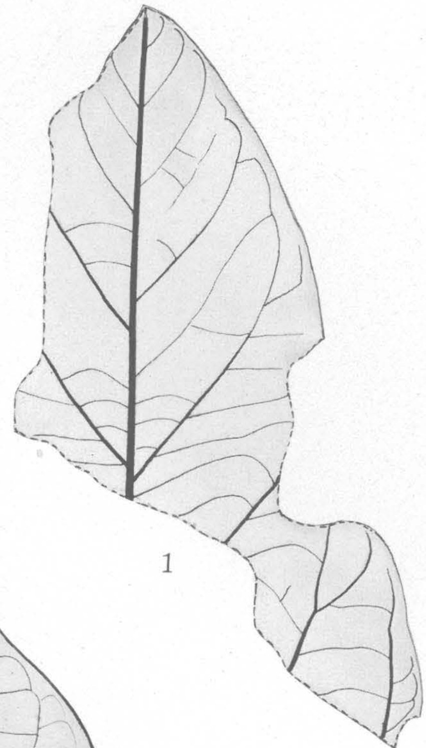

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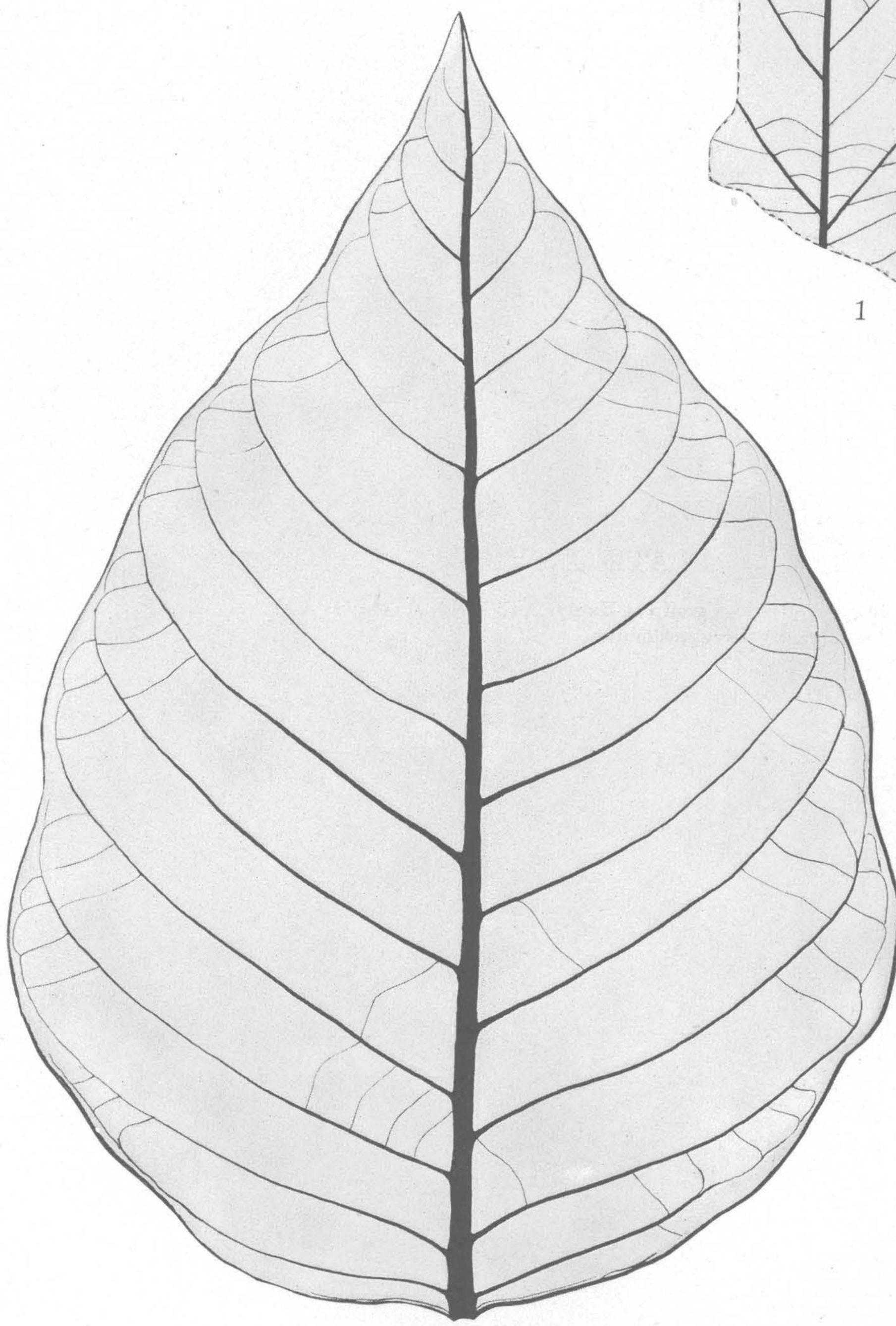

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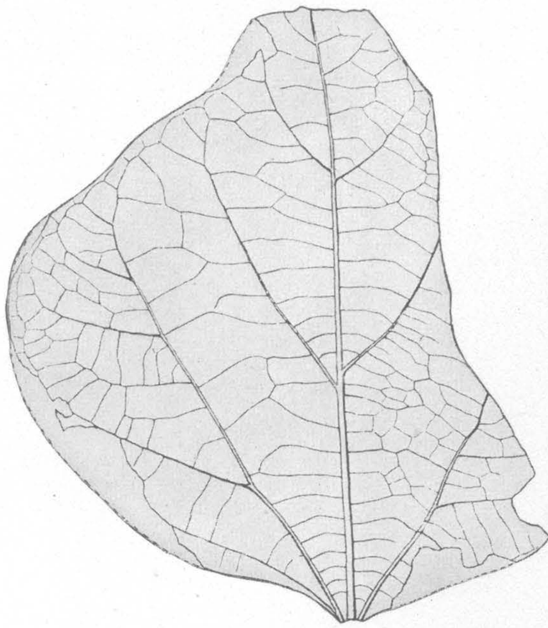

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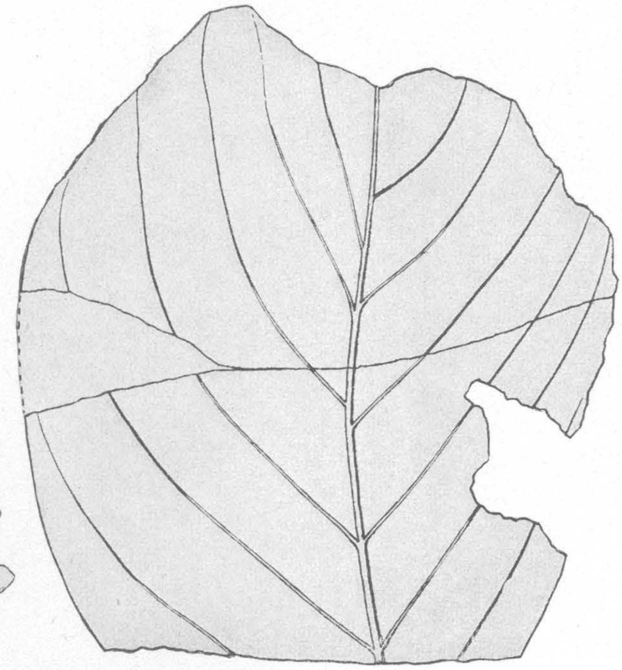

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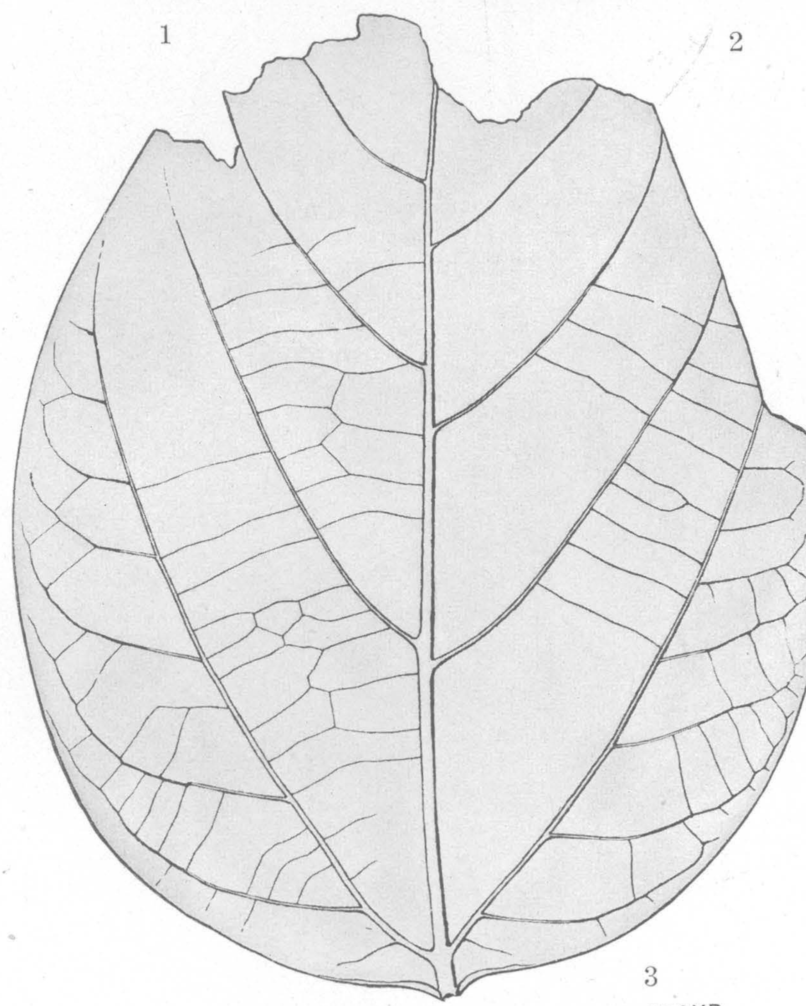

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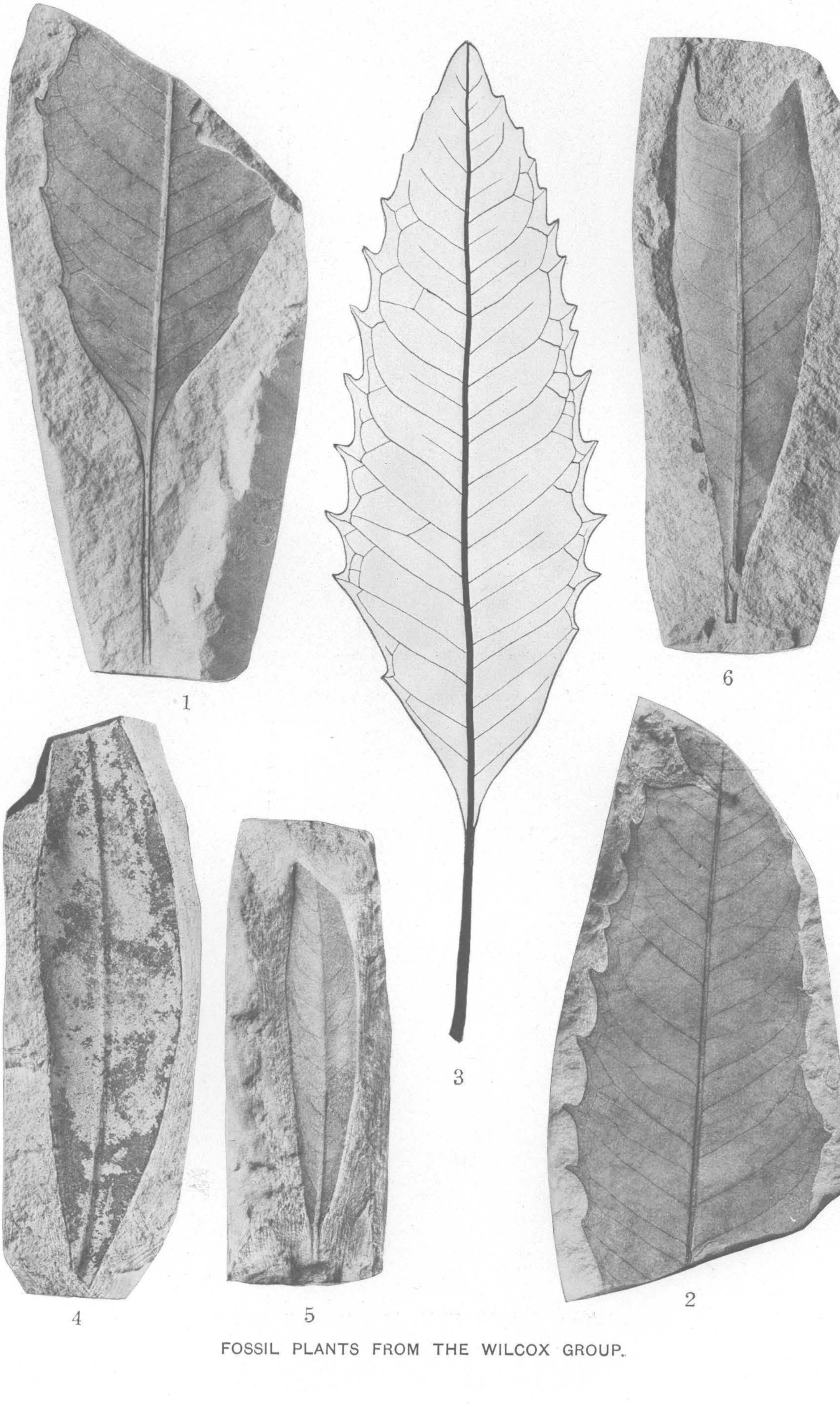
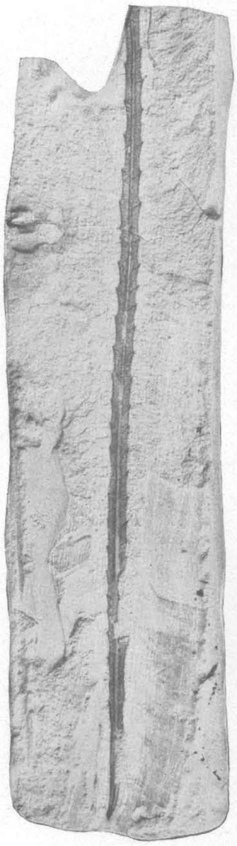


FOSSIL PLANTS FROM THE WILCOX GROUP.



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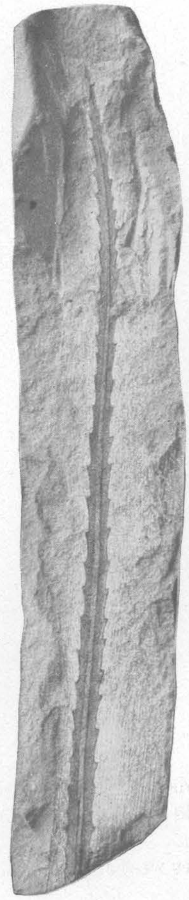

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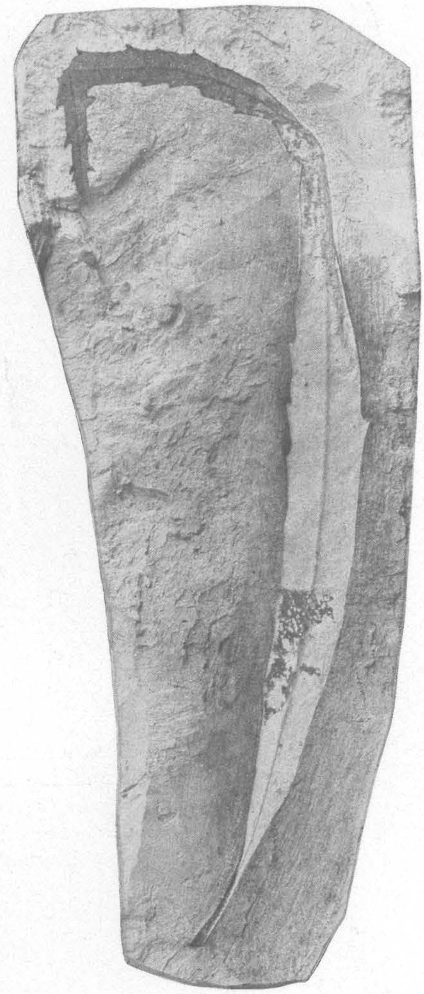

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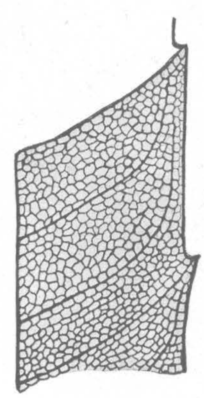

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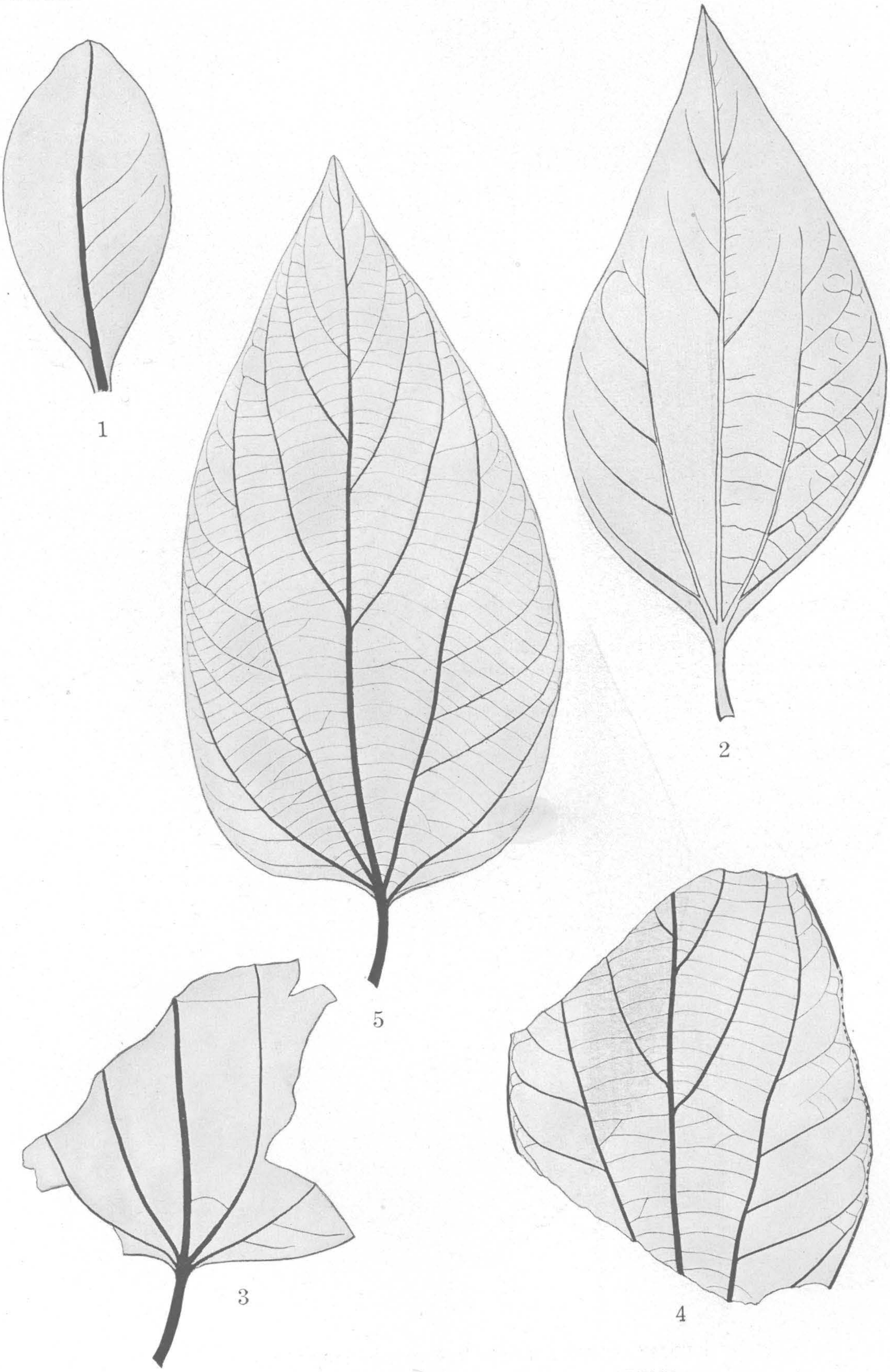
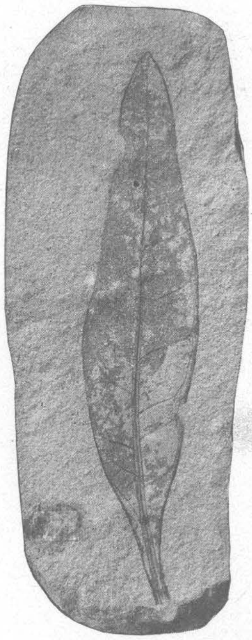


FOSSIL PLANTS FROM THE WILCOX GROUP.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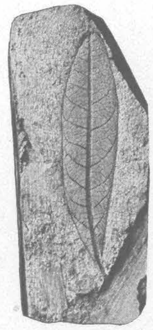
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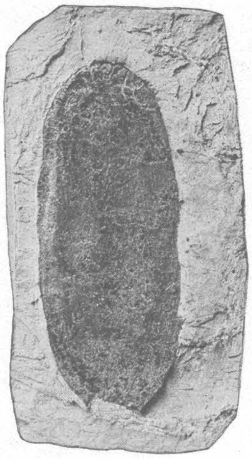
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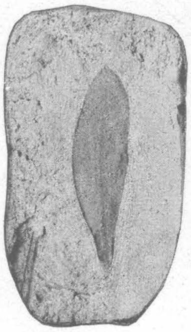
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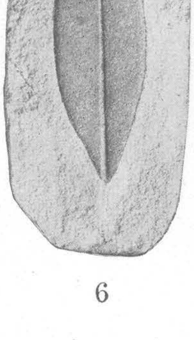
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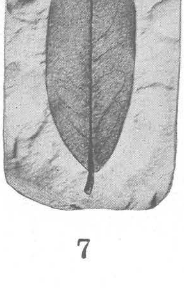
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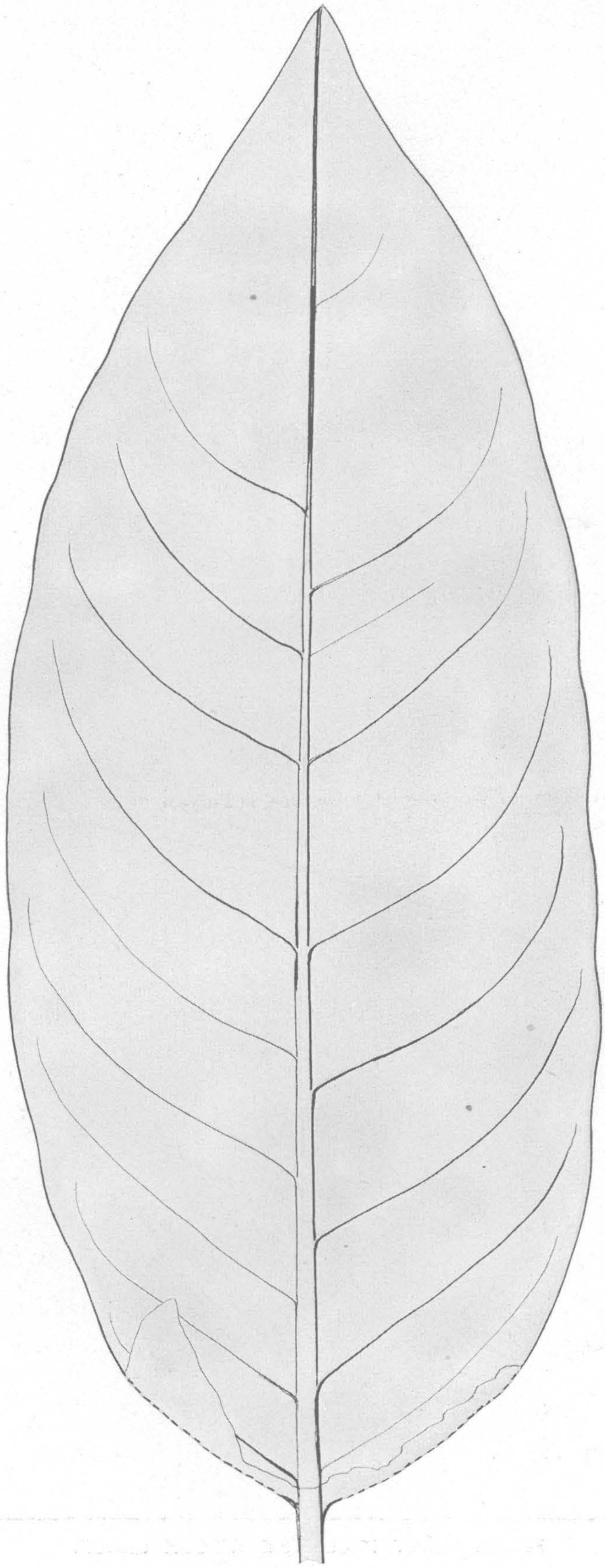

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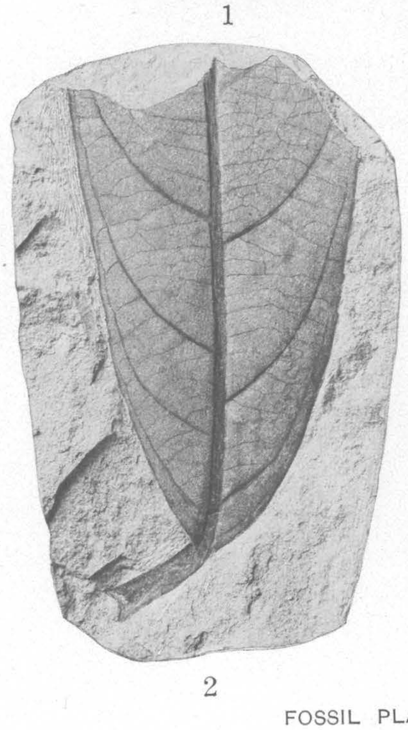

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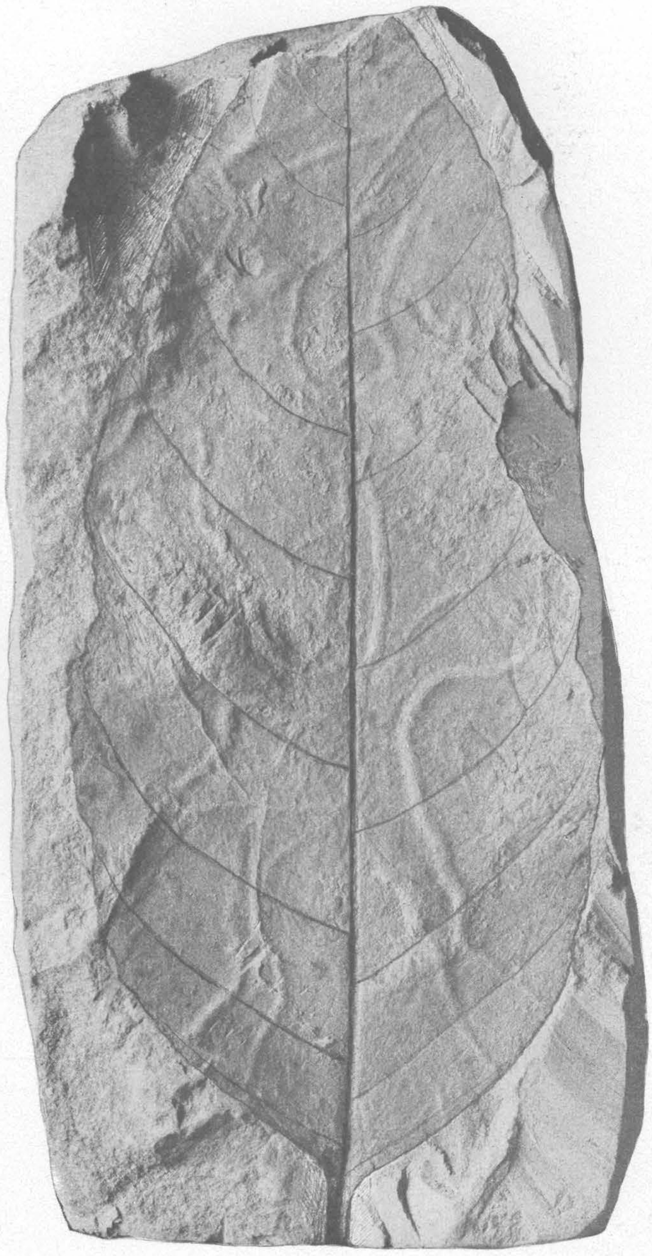

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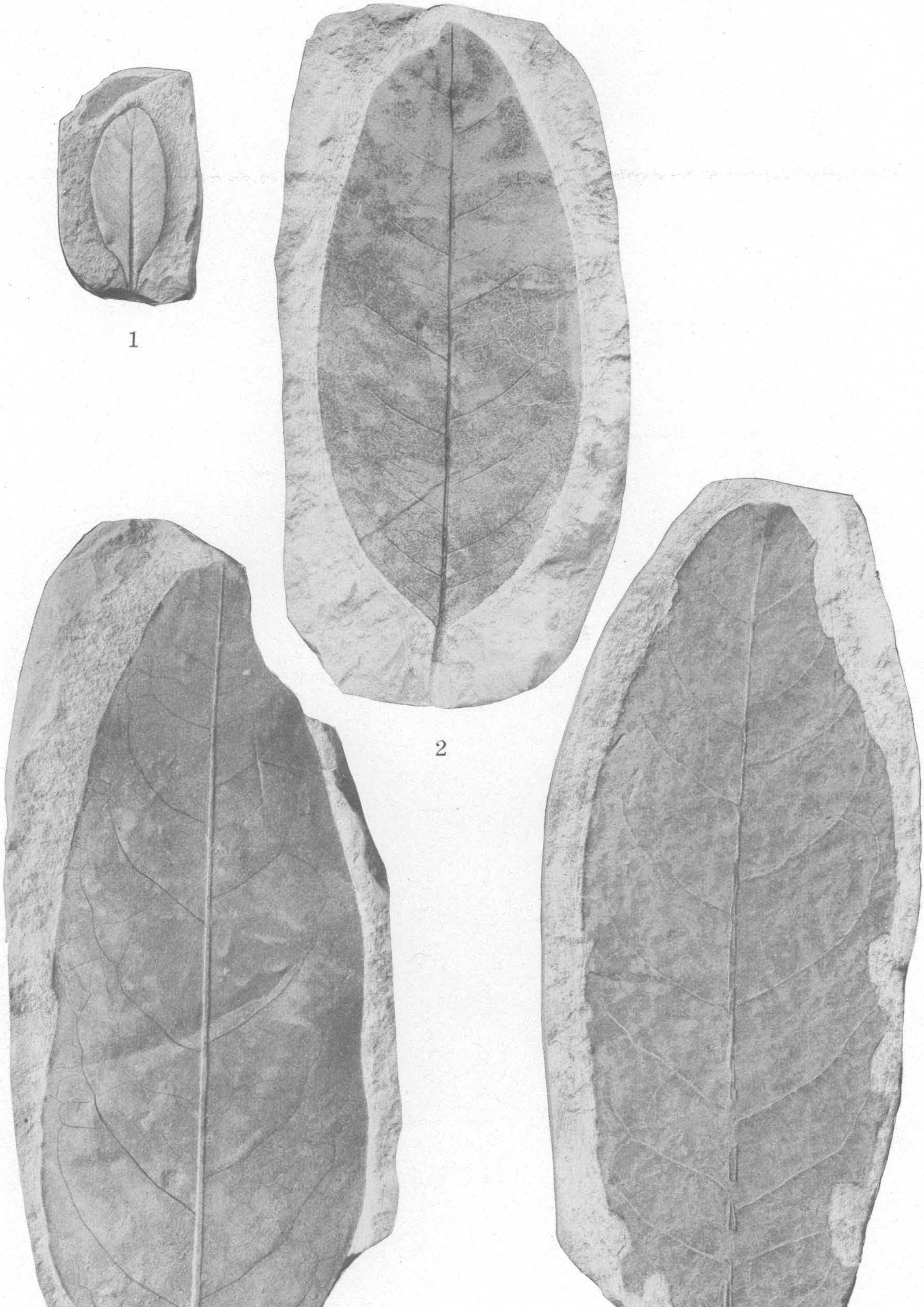
FOSSIL PLANTS FROM THE WILCOX GROUP.



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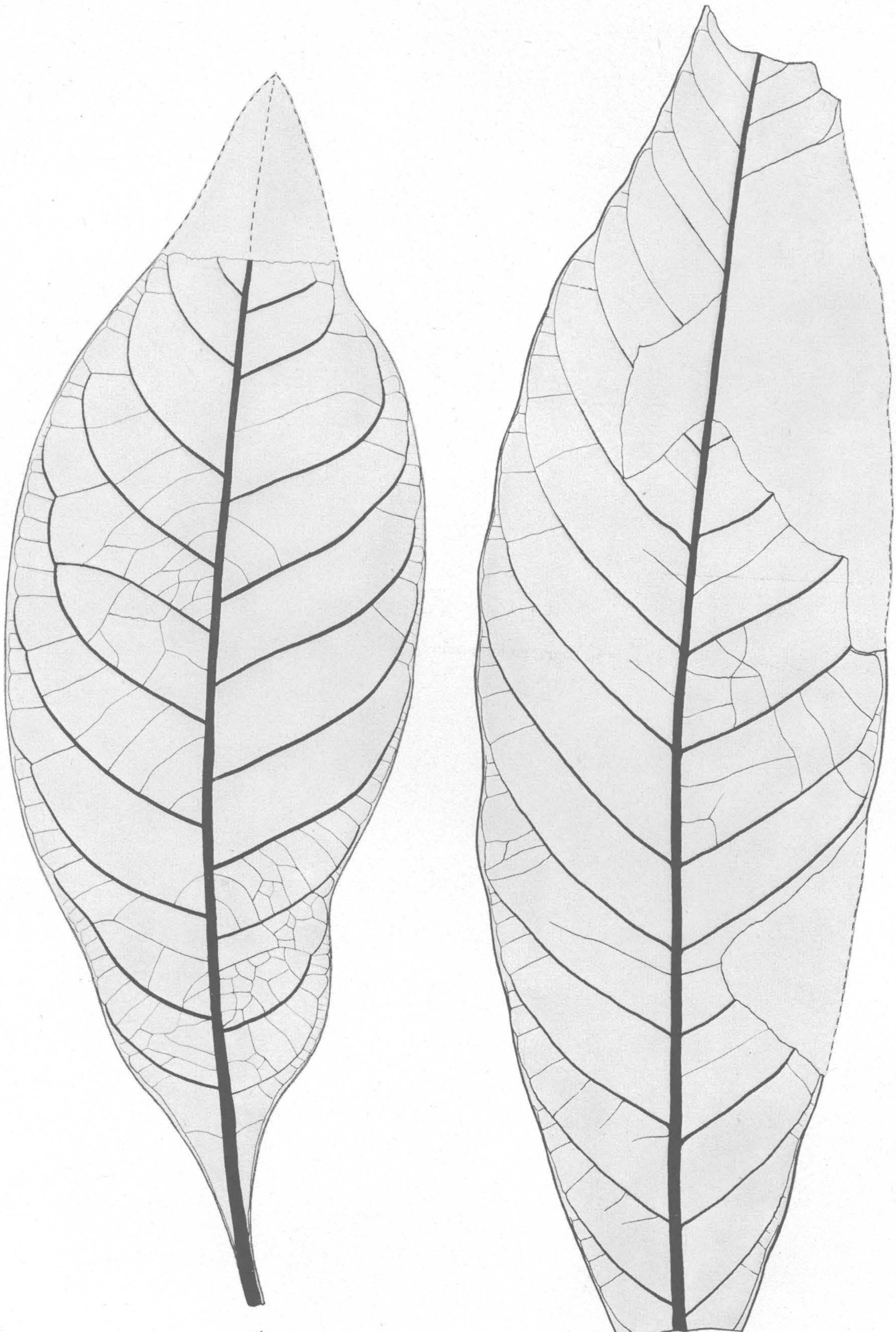

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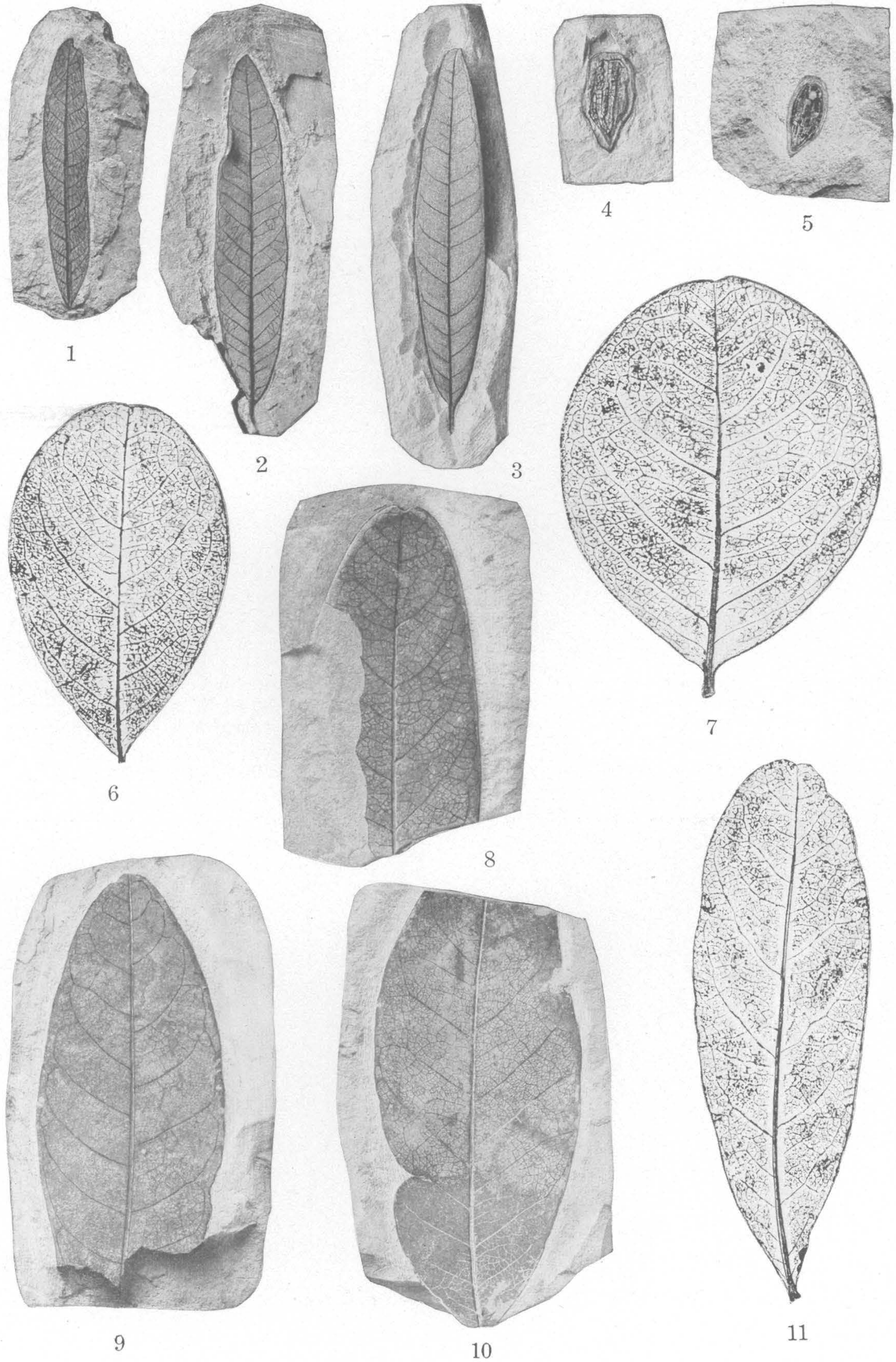

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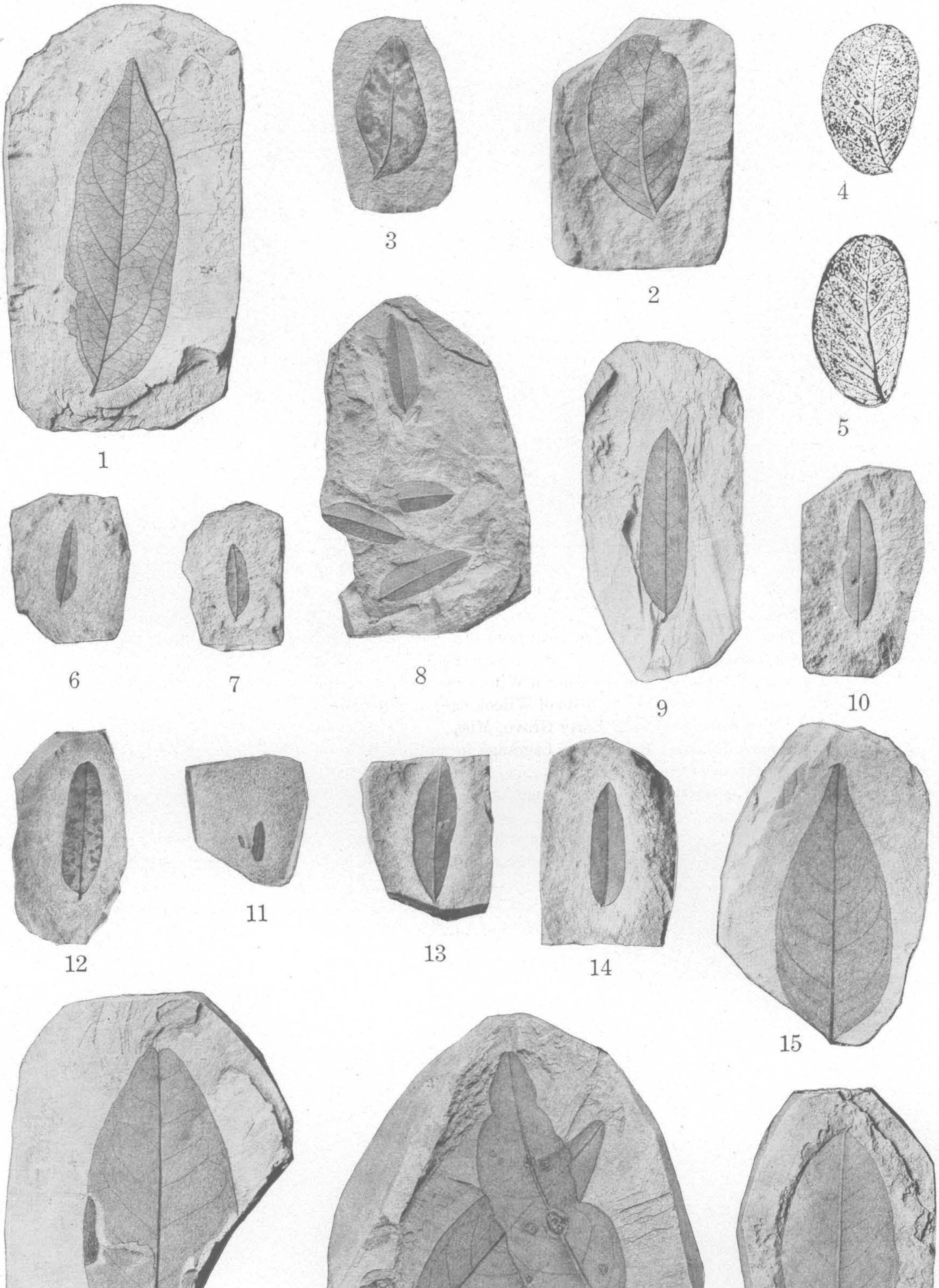
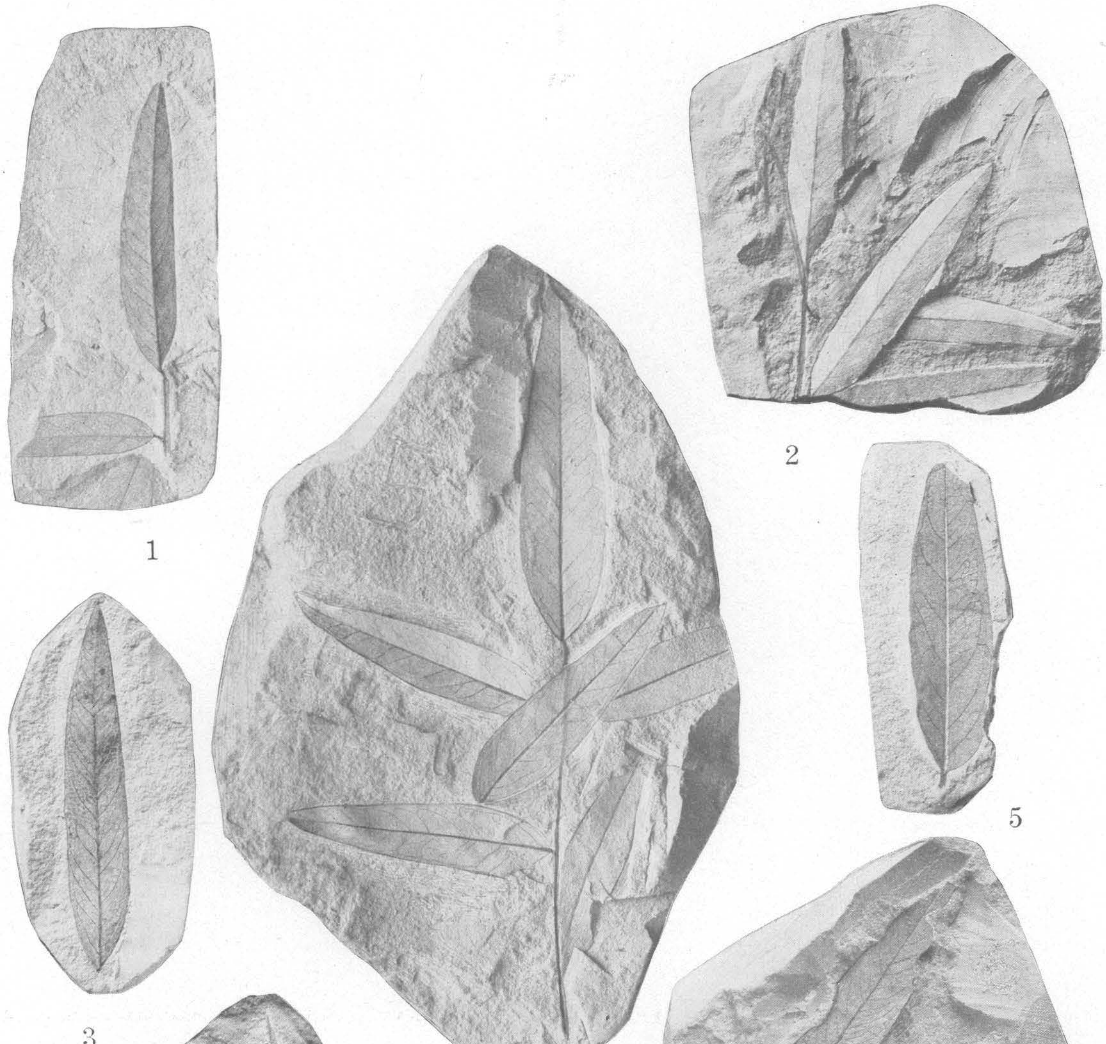


FOSSIL PLANTS FROM THE WILCOX GROUP.



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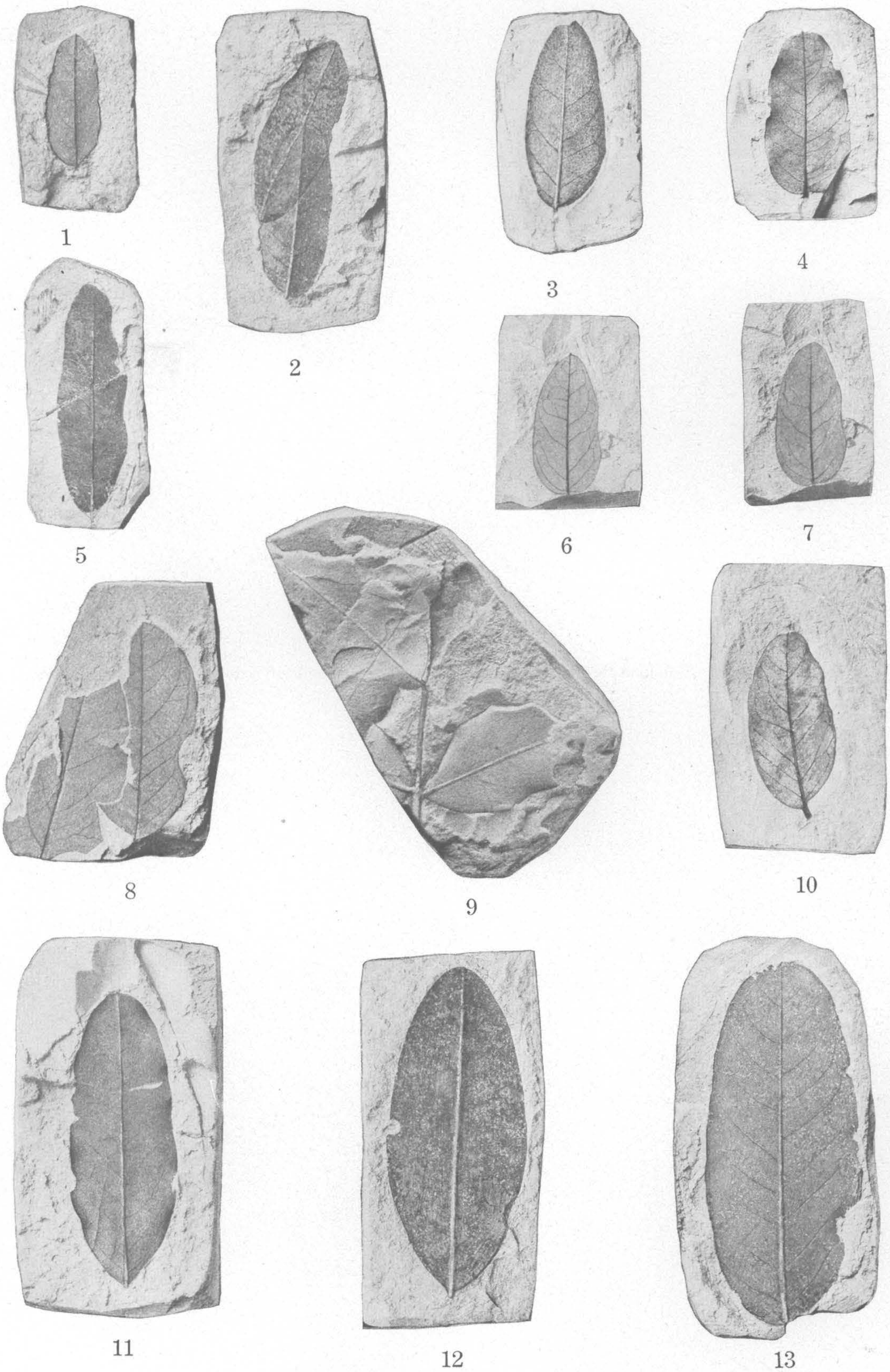
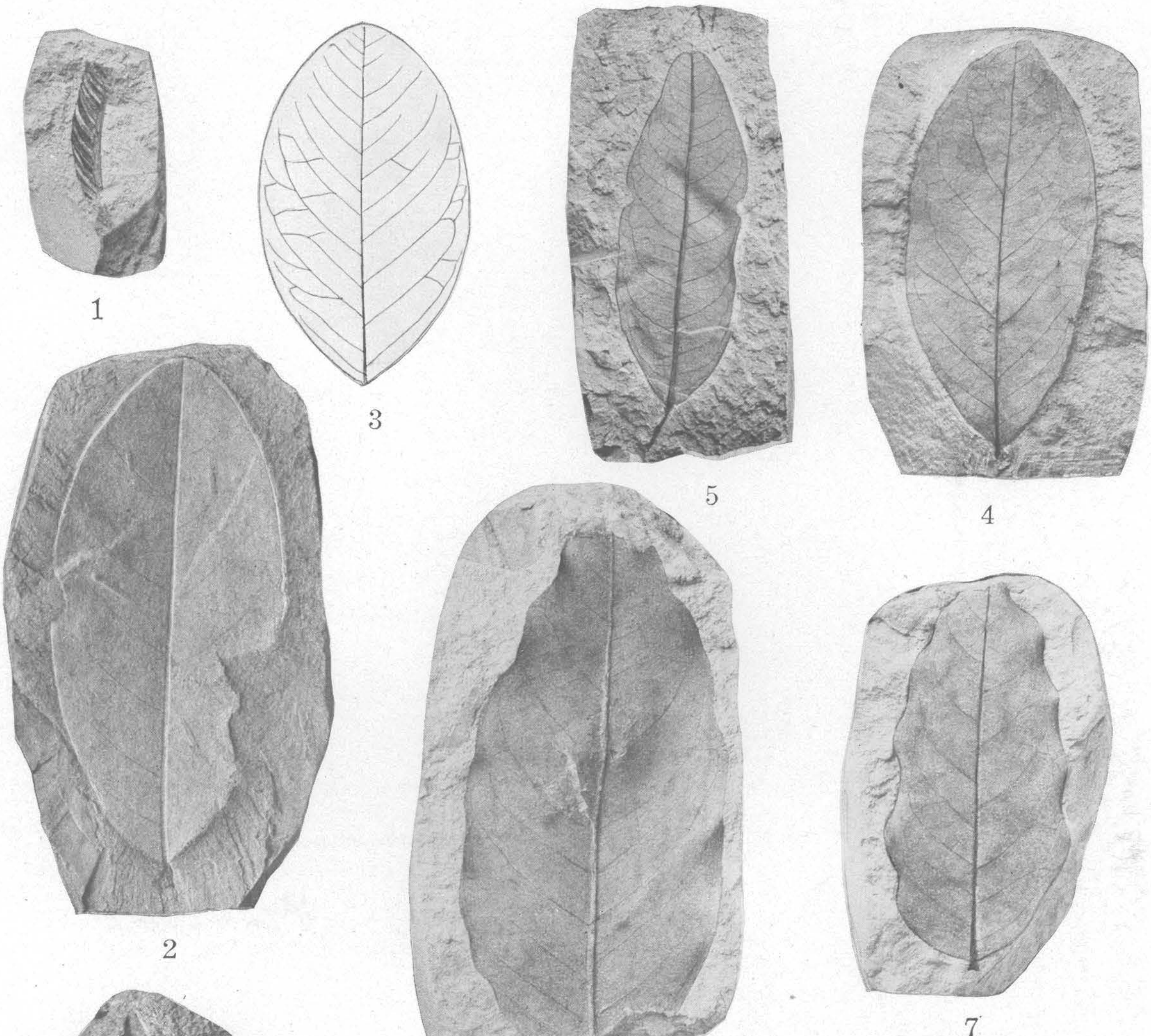


FOSSIL PLANTS FROM THE WILCOX GROUP.



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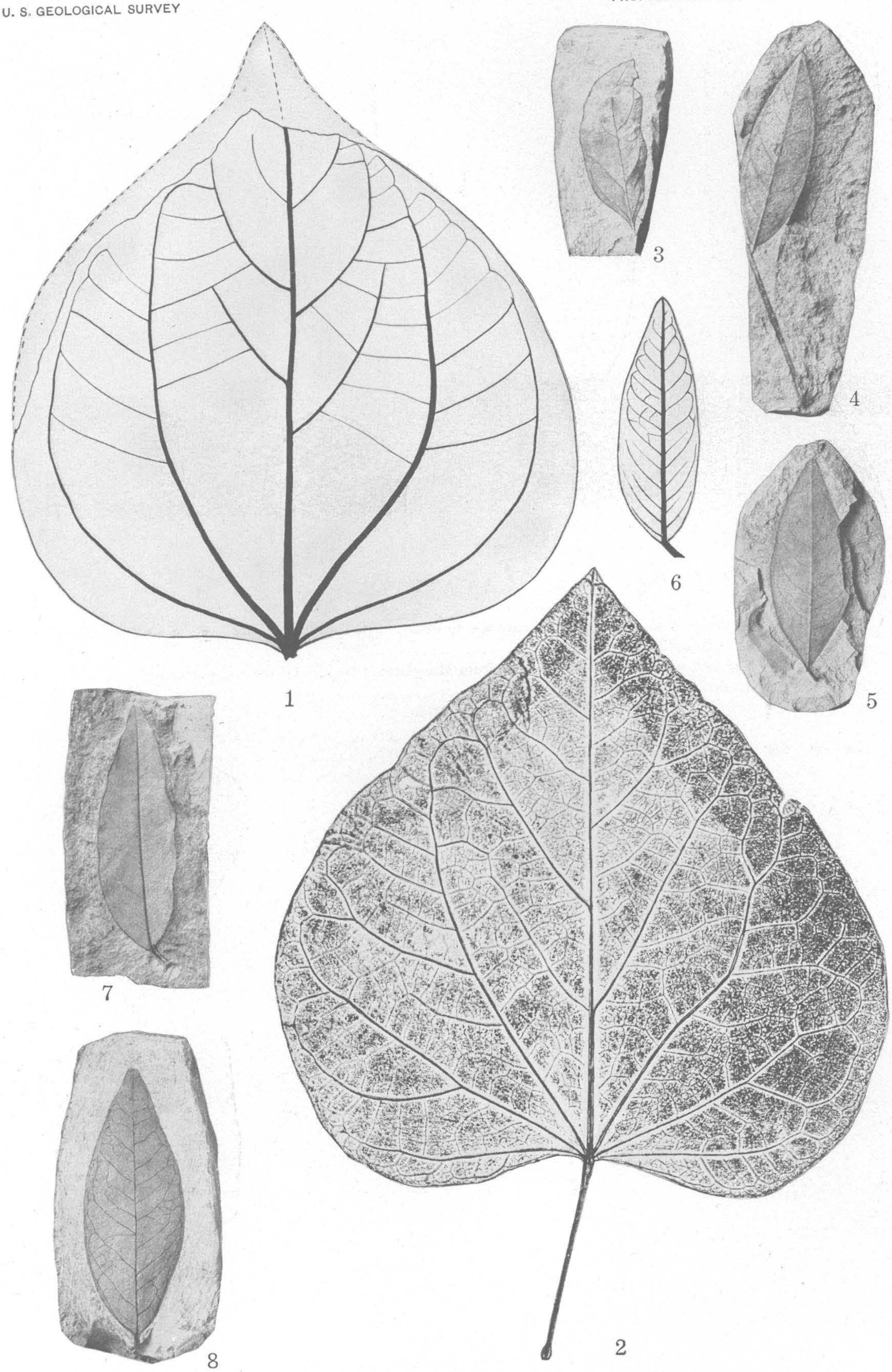

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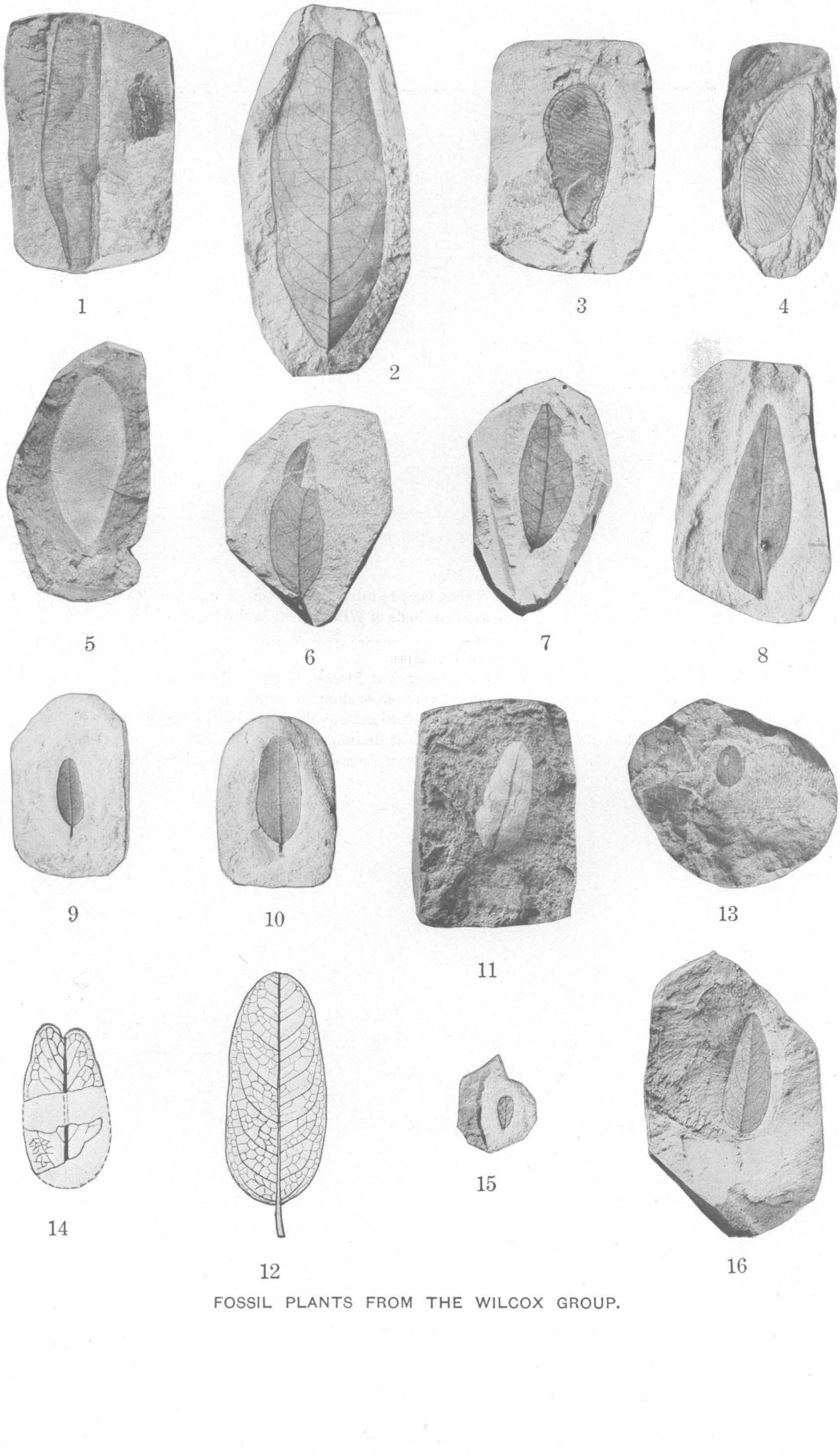

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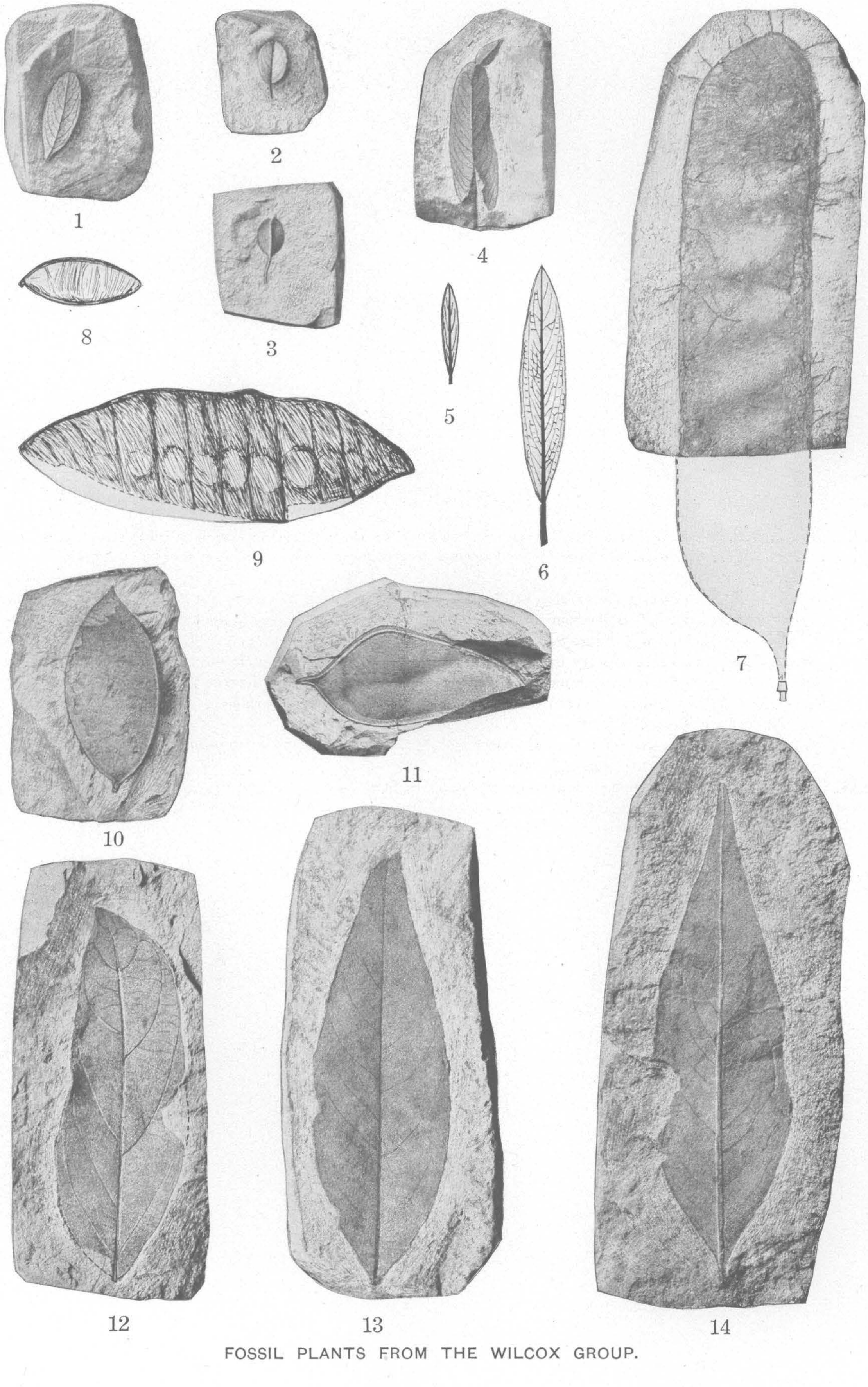
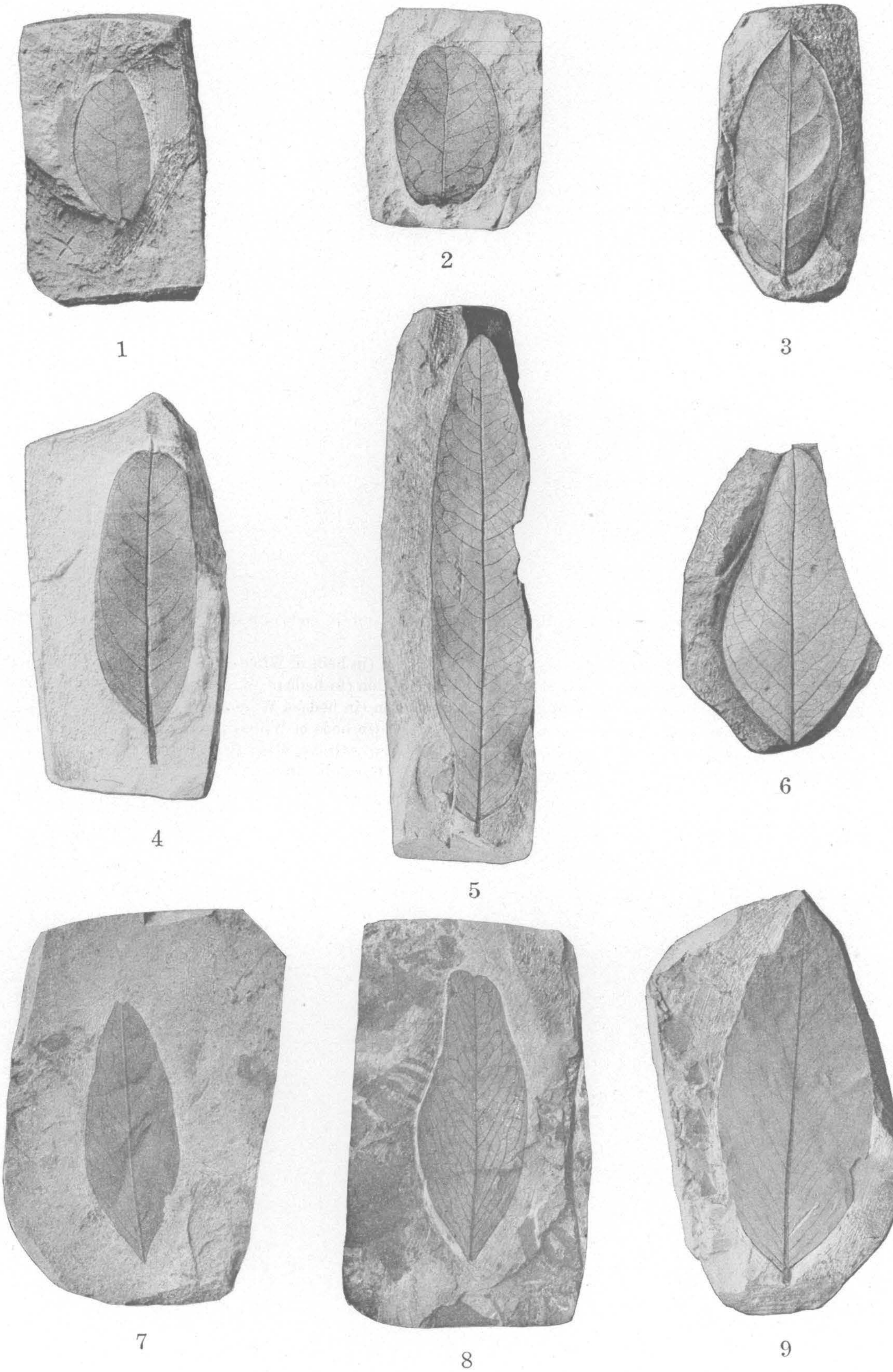


FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LII.

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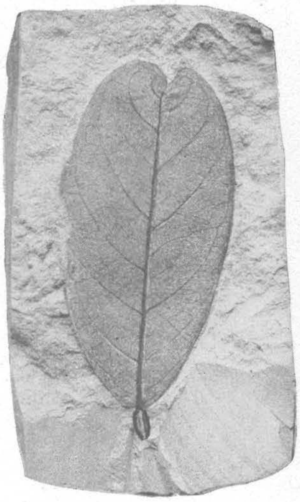
All specimens from Lagrange formation (in beds of Wilcox age) at Puryear, Tenn.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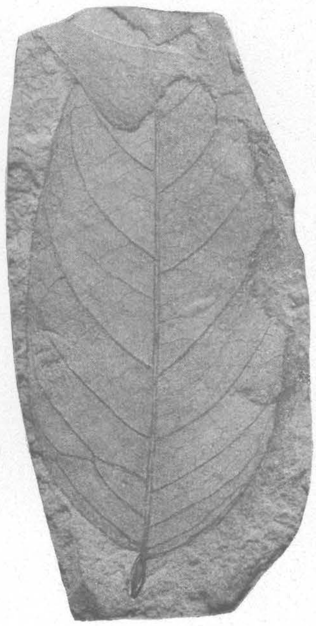
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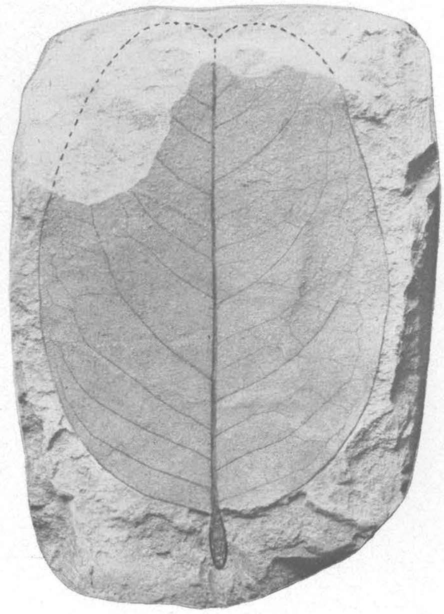
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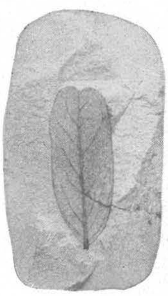
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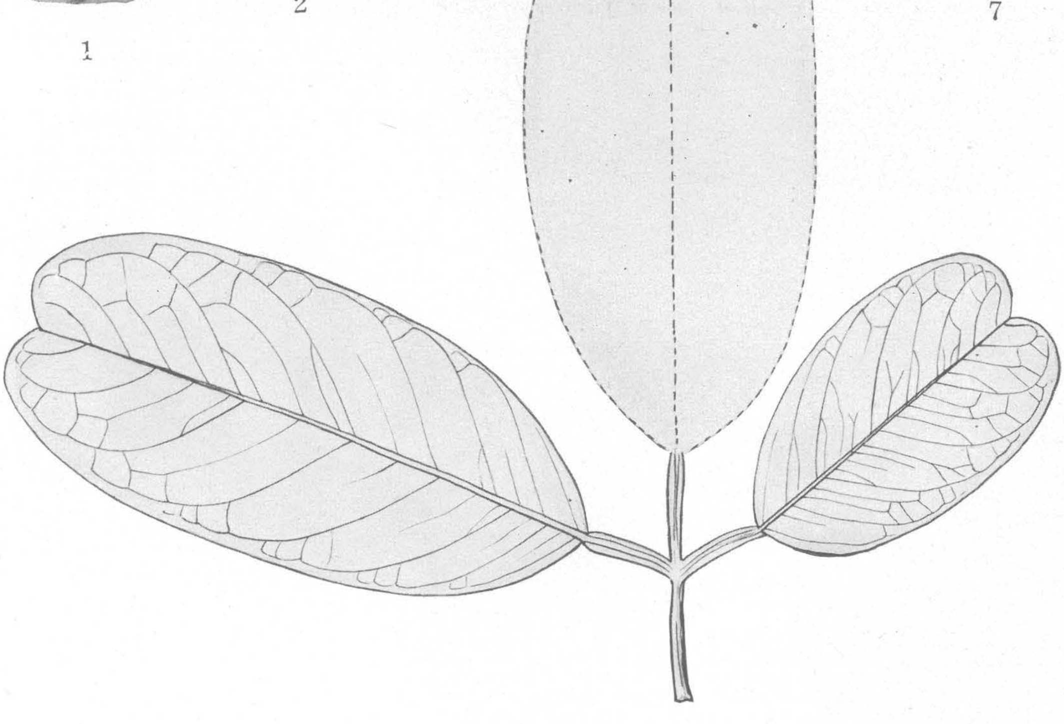
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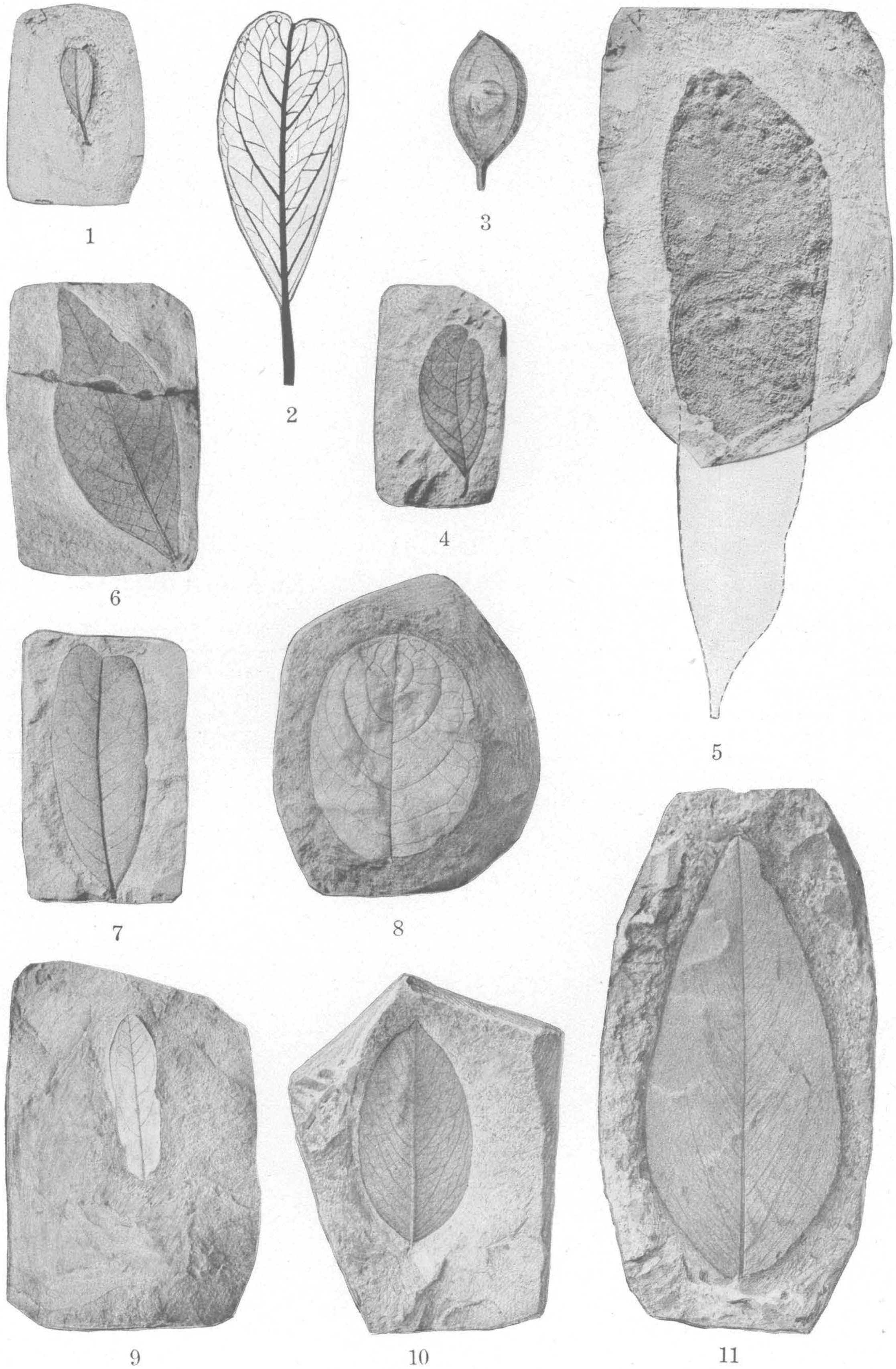
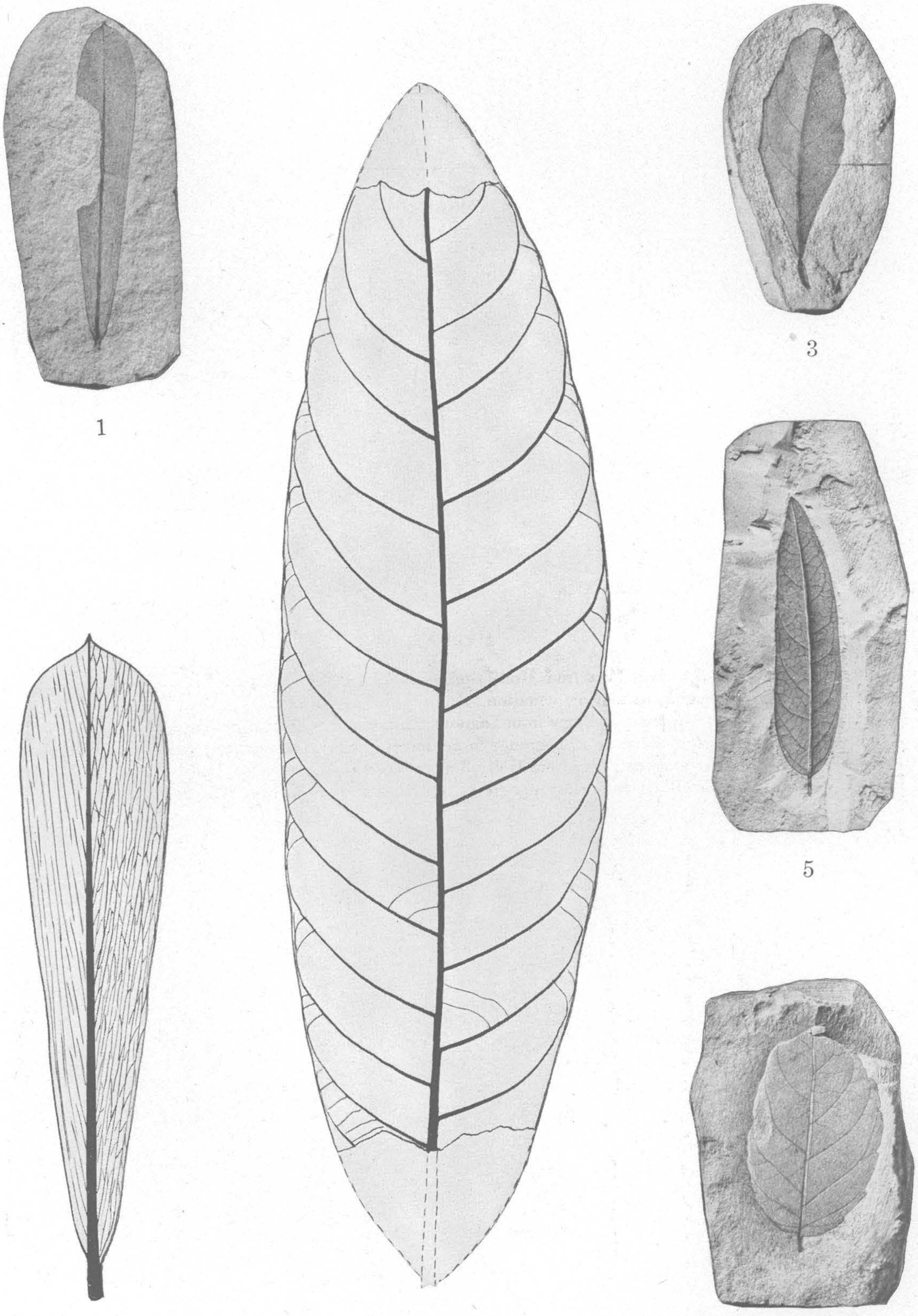
FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LIV.

PLATE LV.



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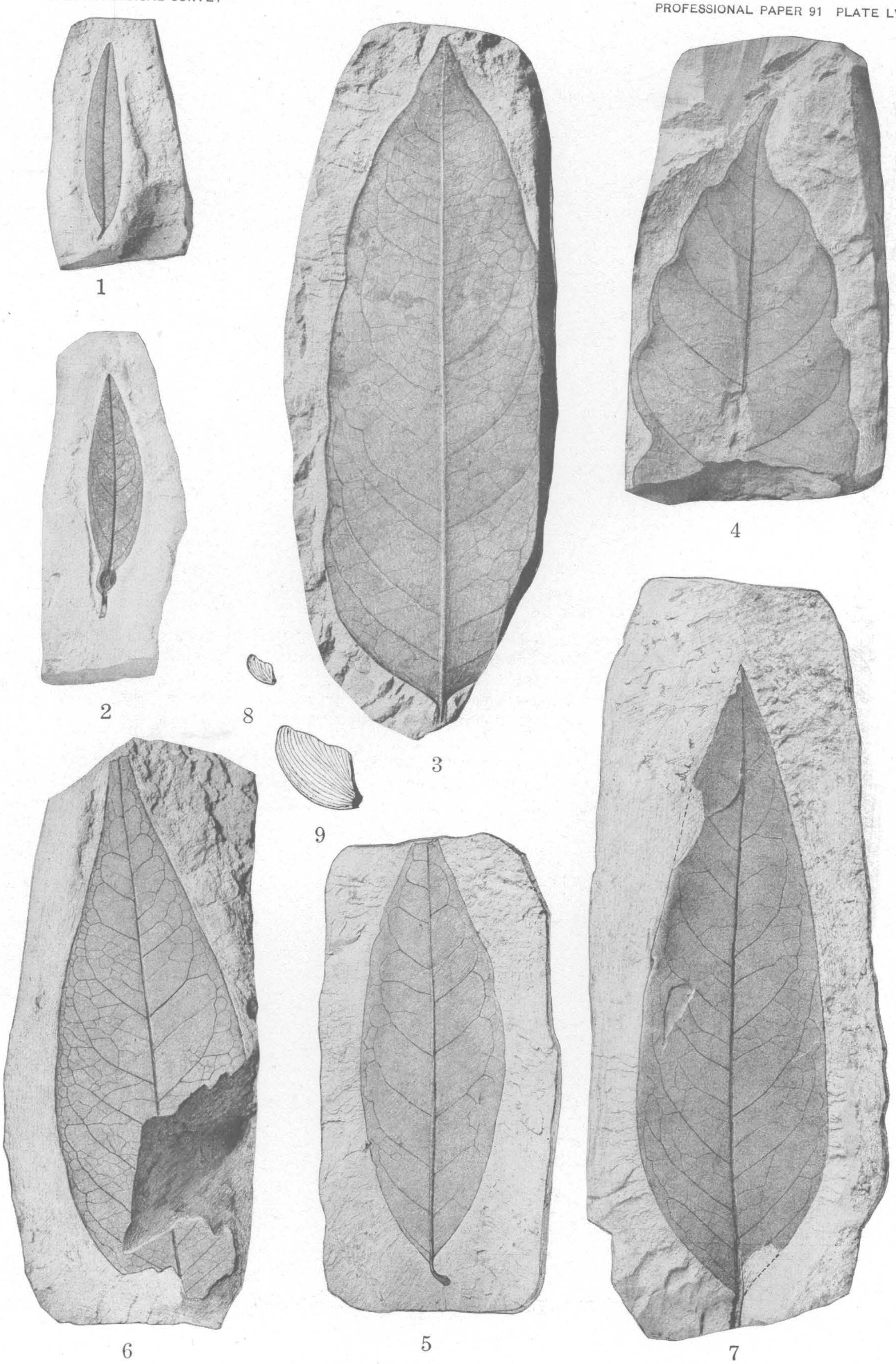

FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LVI.

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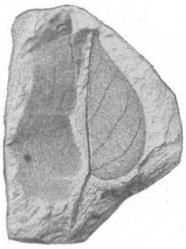
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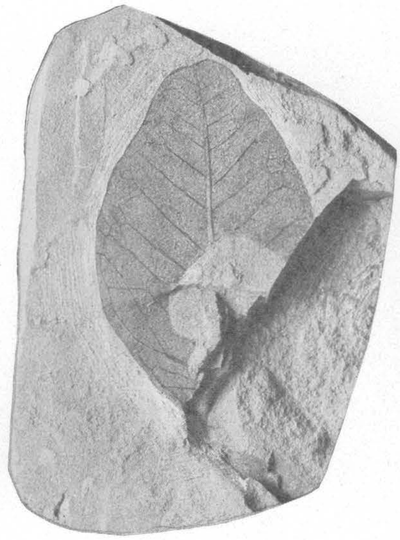
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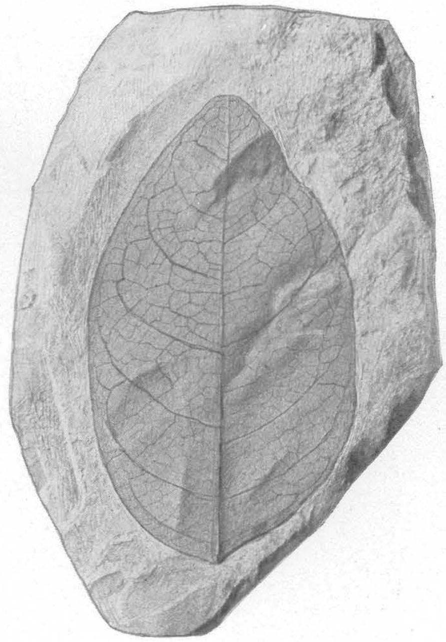
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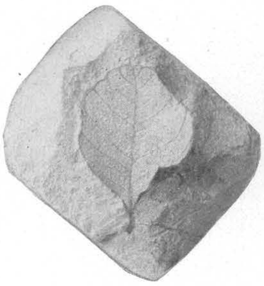
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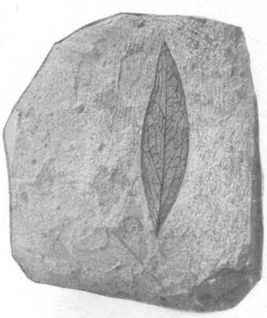
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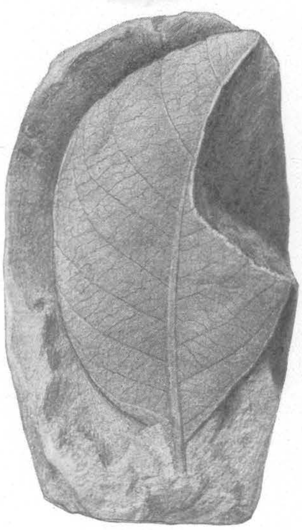
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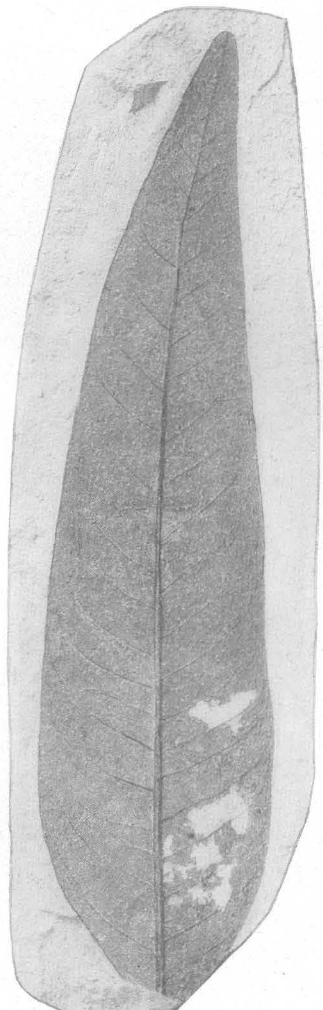
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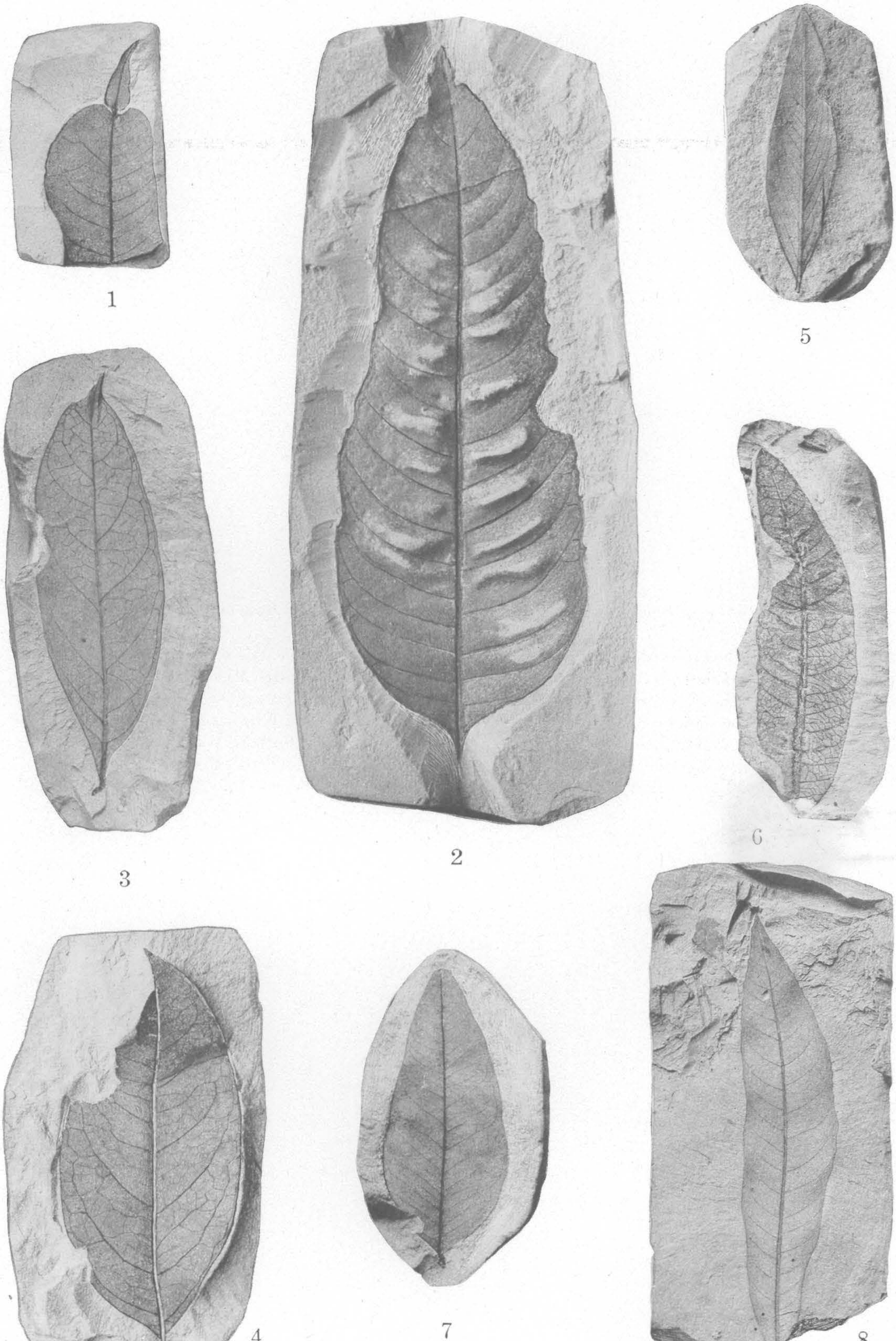

FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LVIII.

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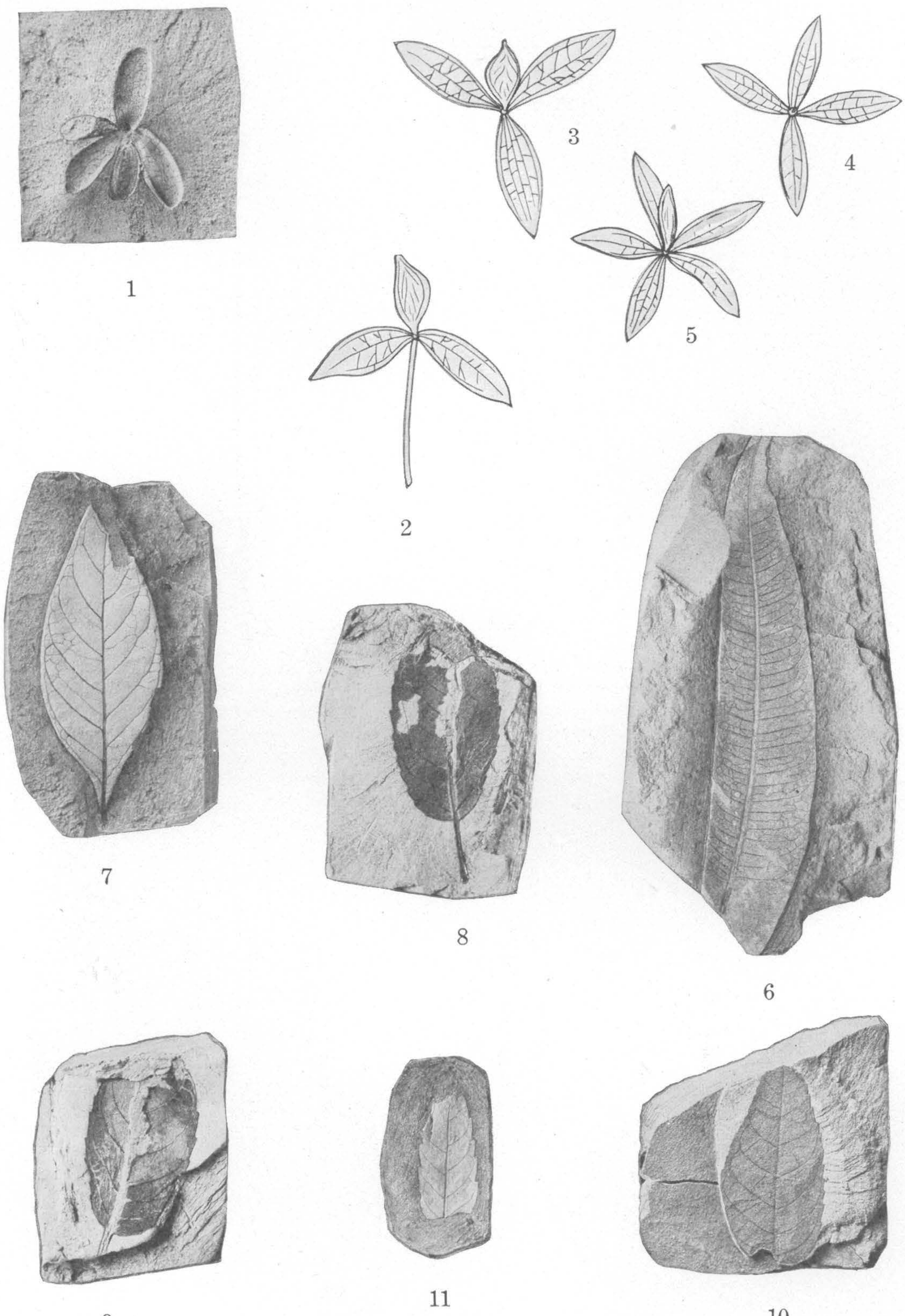

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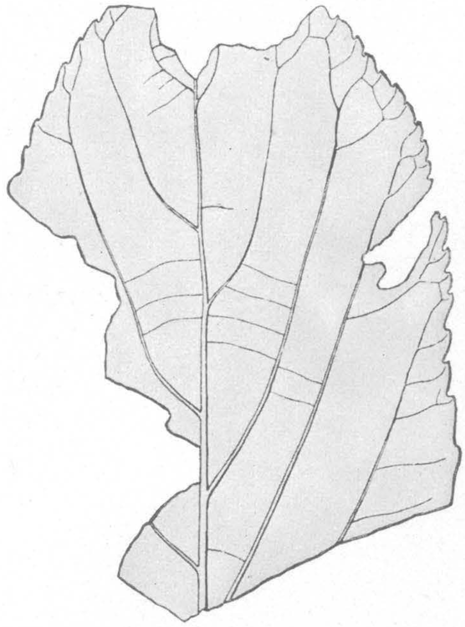

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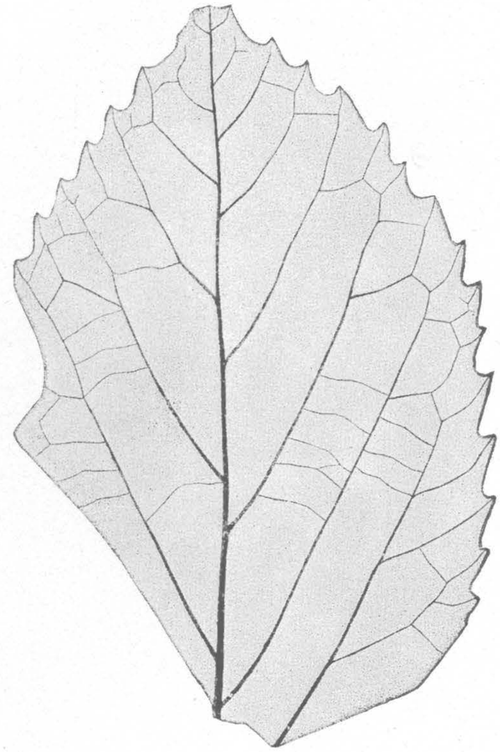

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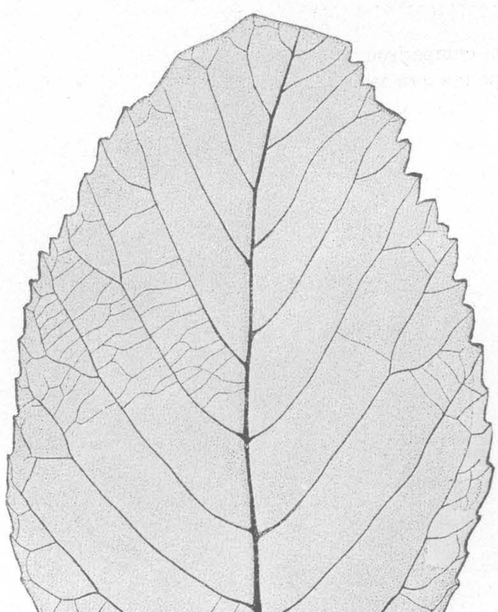

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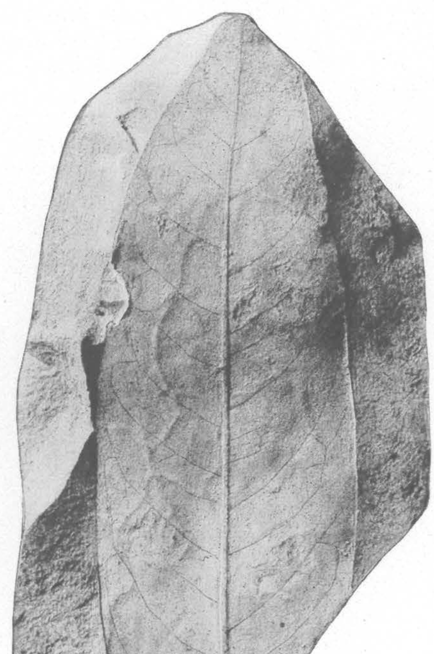

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FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LX.

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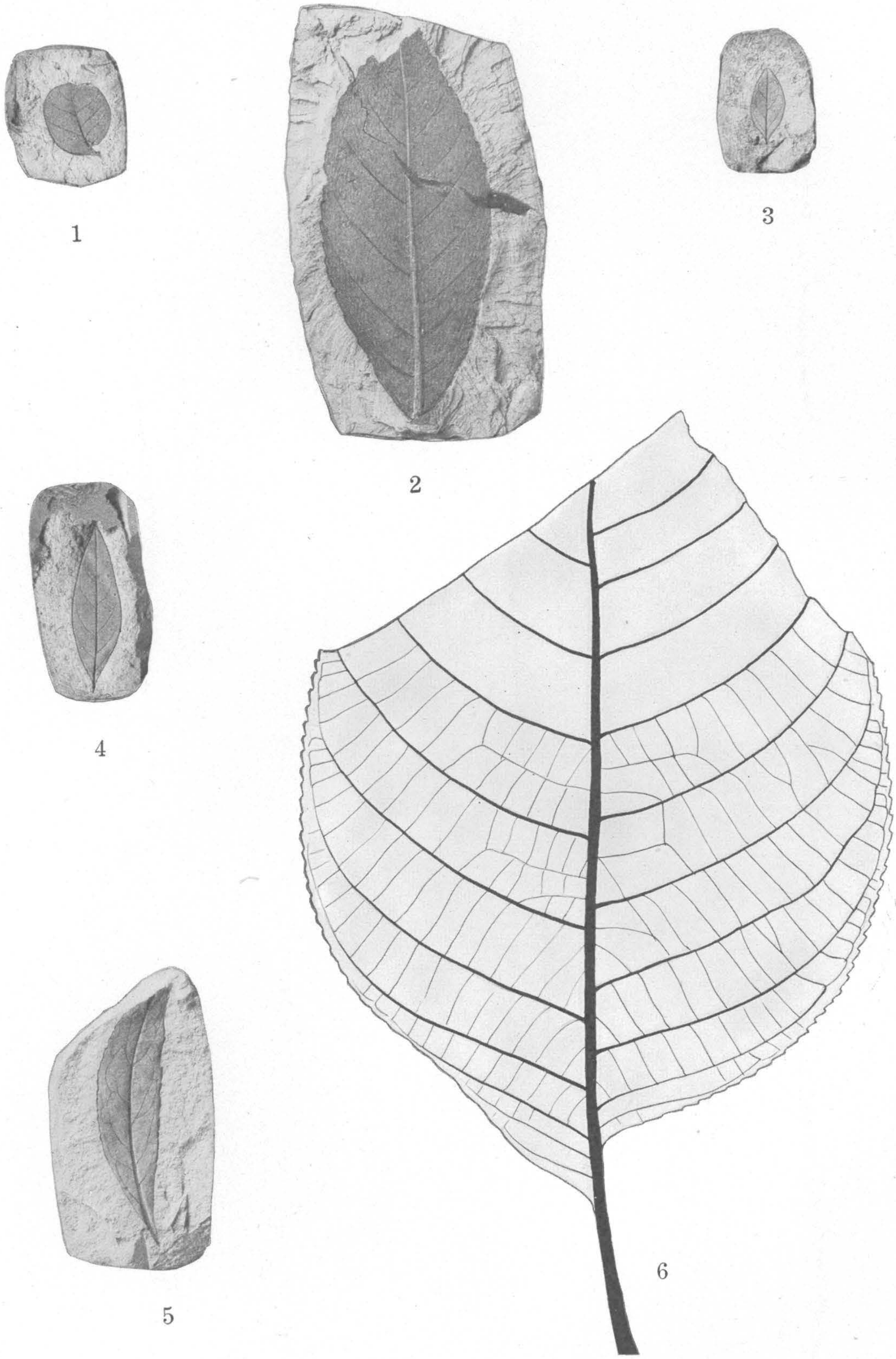

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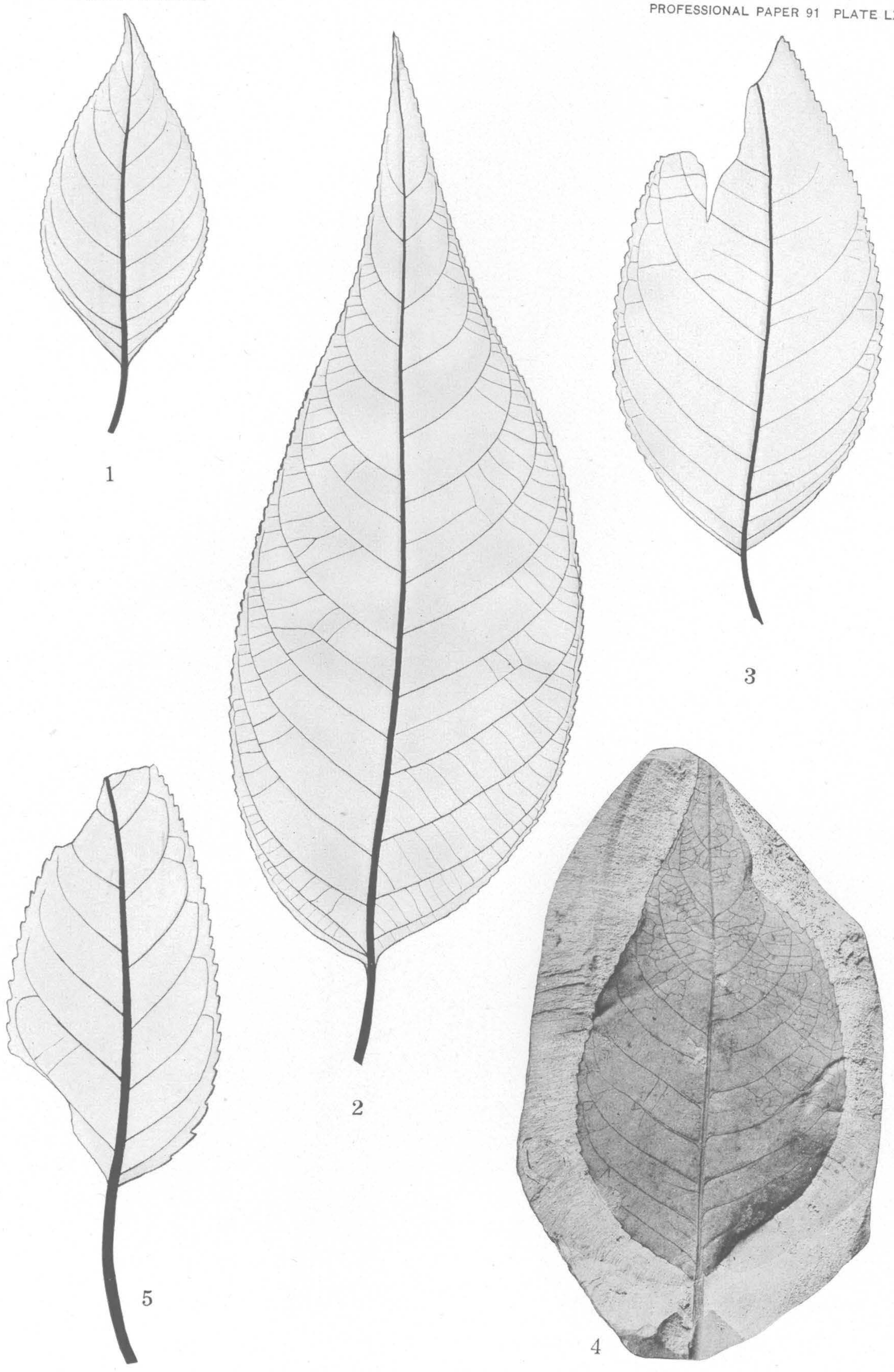

FOSSIL PLANTS FROM THE WILCOX GROUP.

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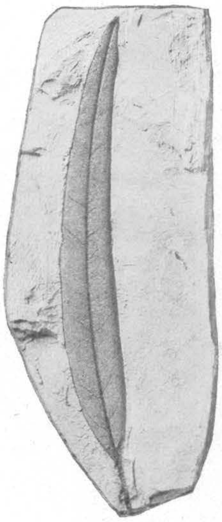
3, 4. Holly Springs sand, Early Grove, Miss.

5. Lagrange formation (in beds of Wilcox age) at Puryear, Tenn.

PLATE LXIII.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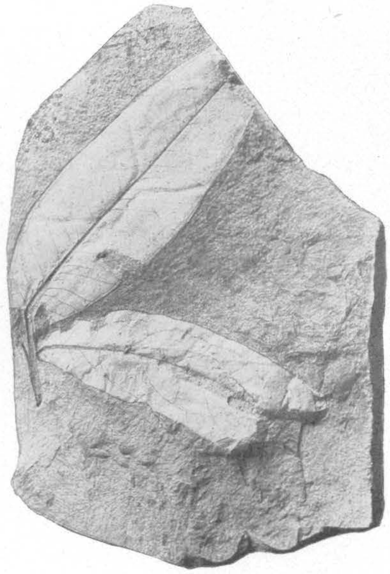
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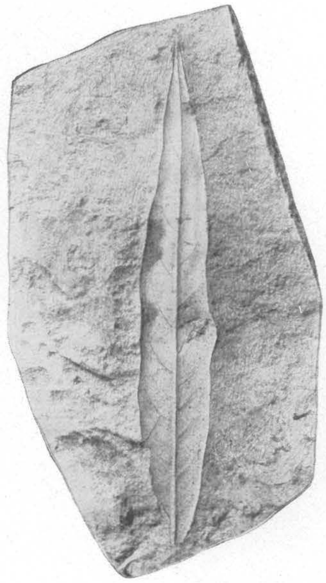
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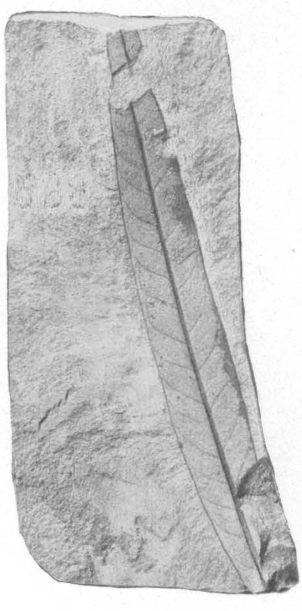
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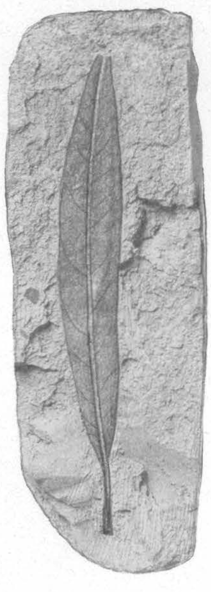
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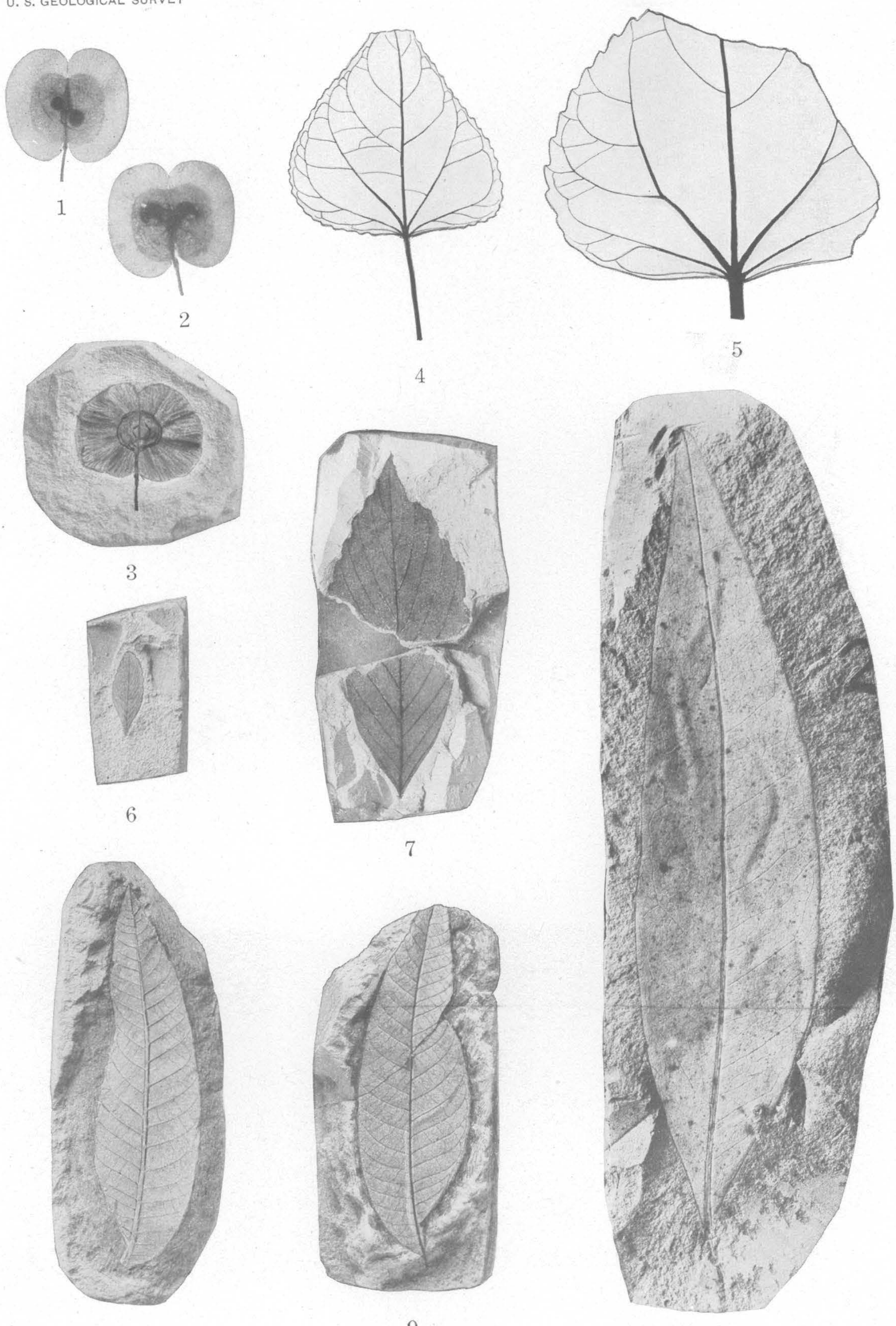
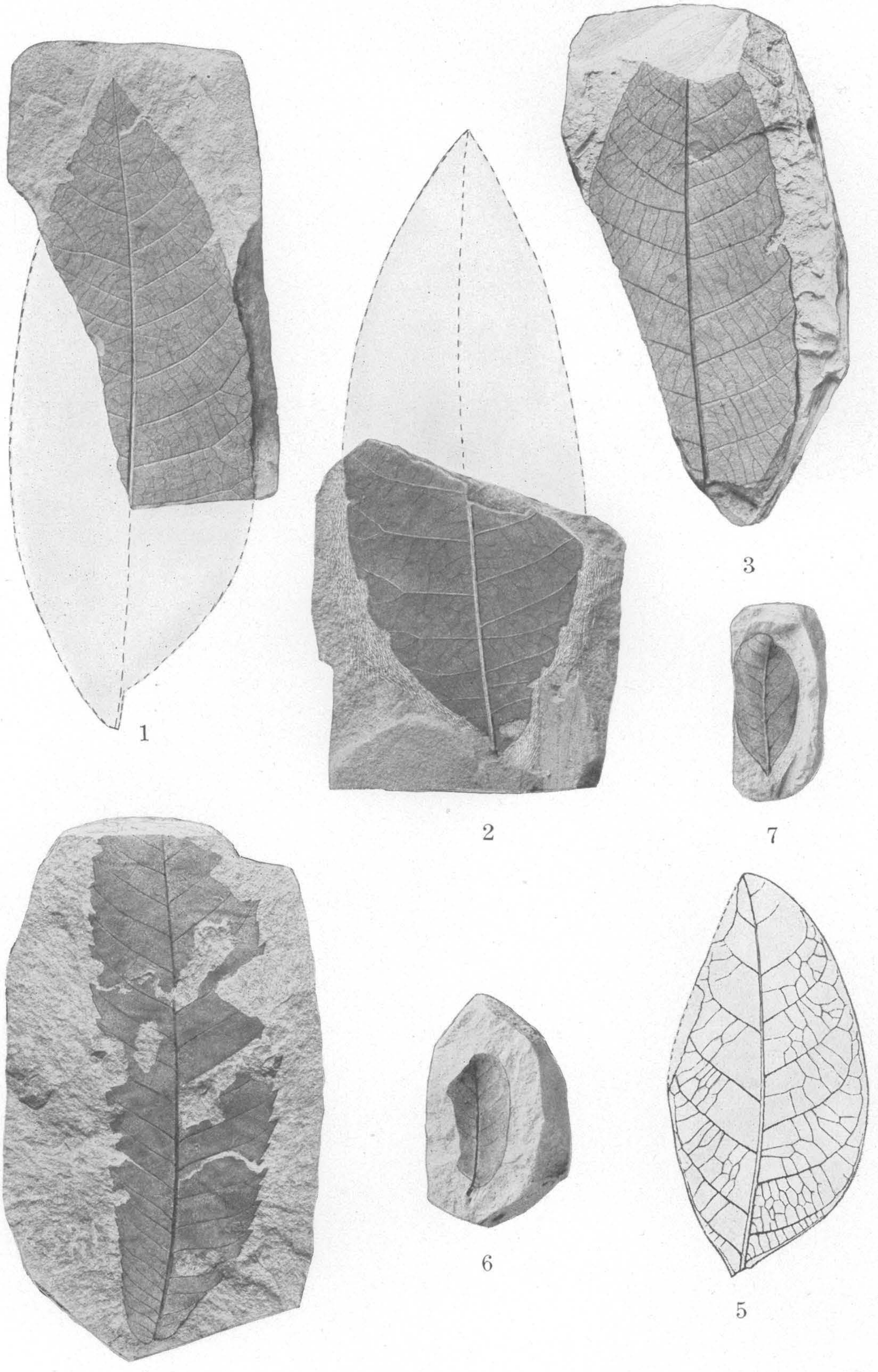
FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LXIV.

PLATE LXV.



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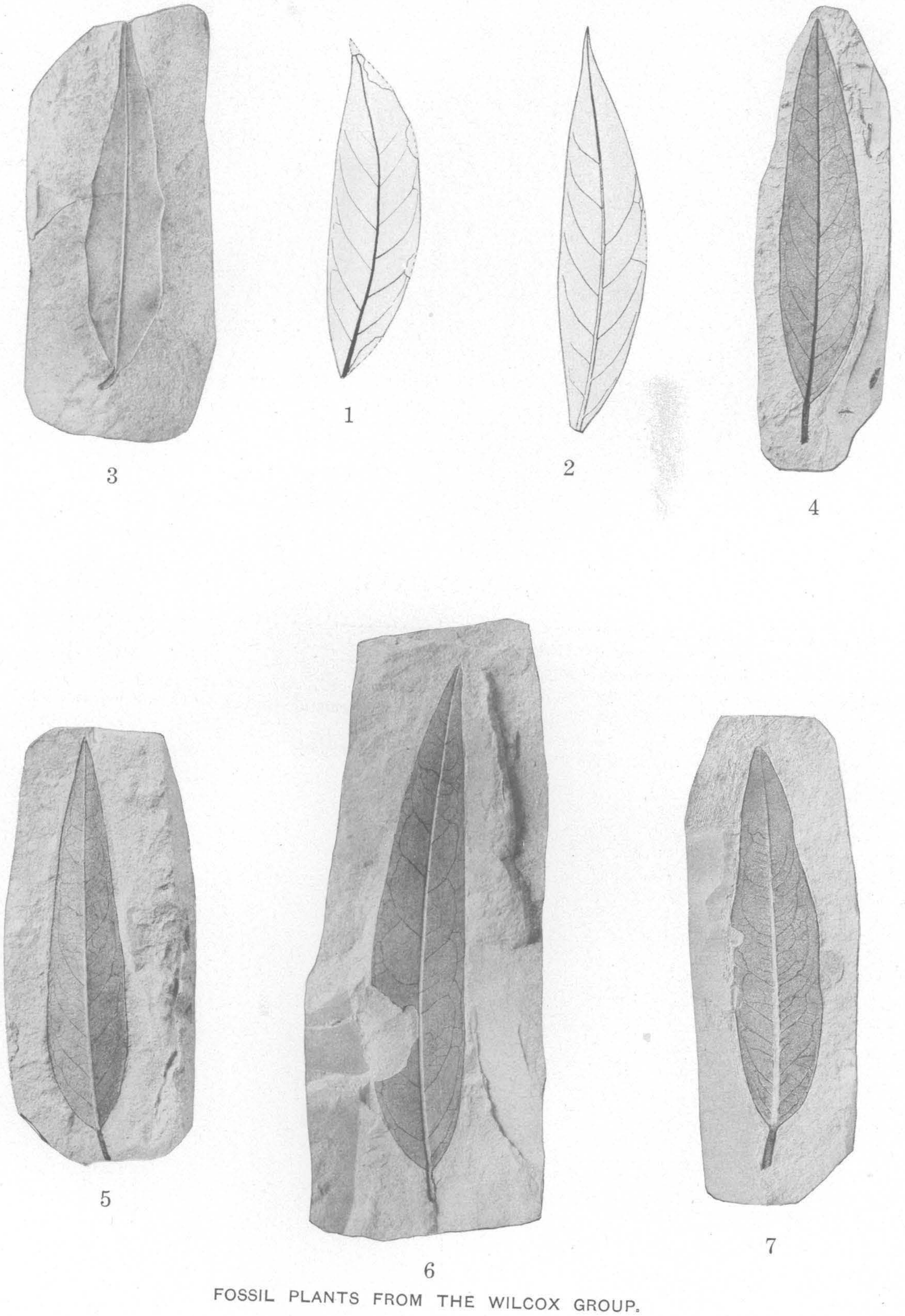

FOSSIL PLANTS FROM THE WILCOX GROUP.

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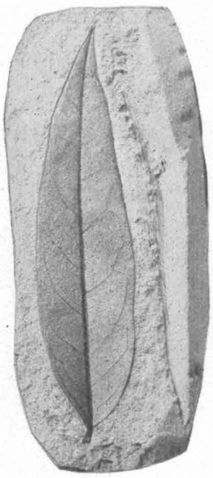

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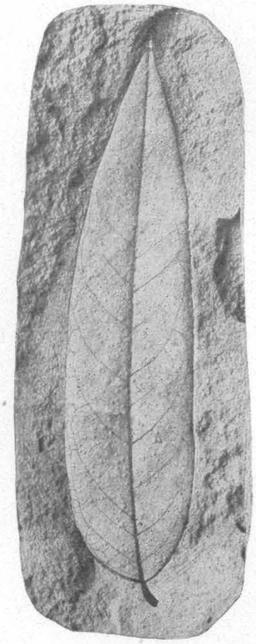

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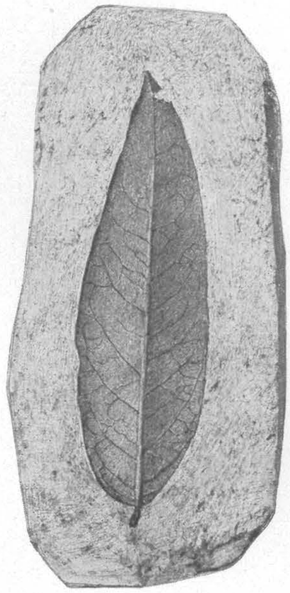

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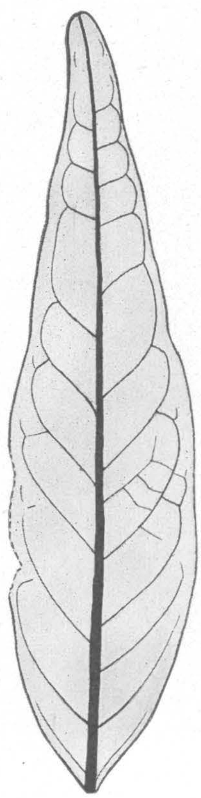

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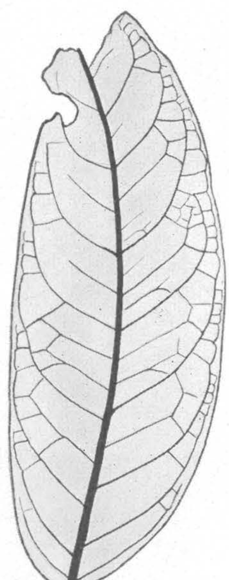

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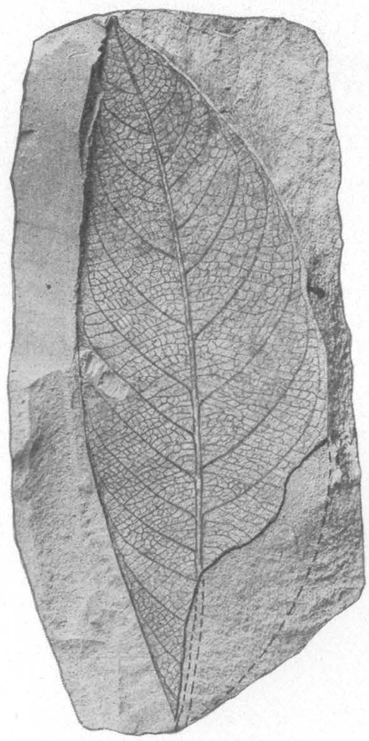

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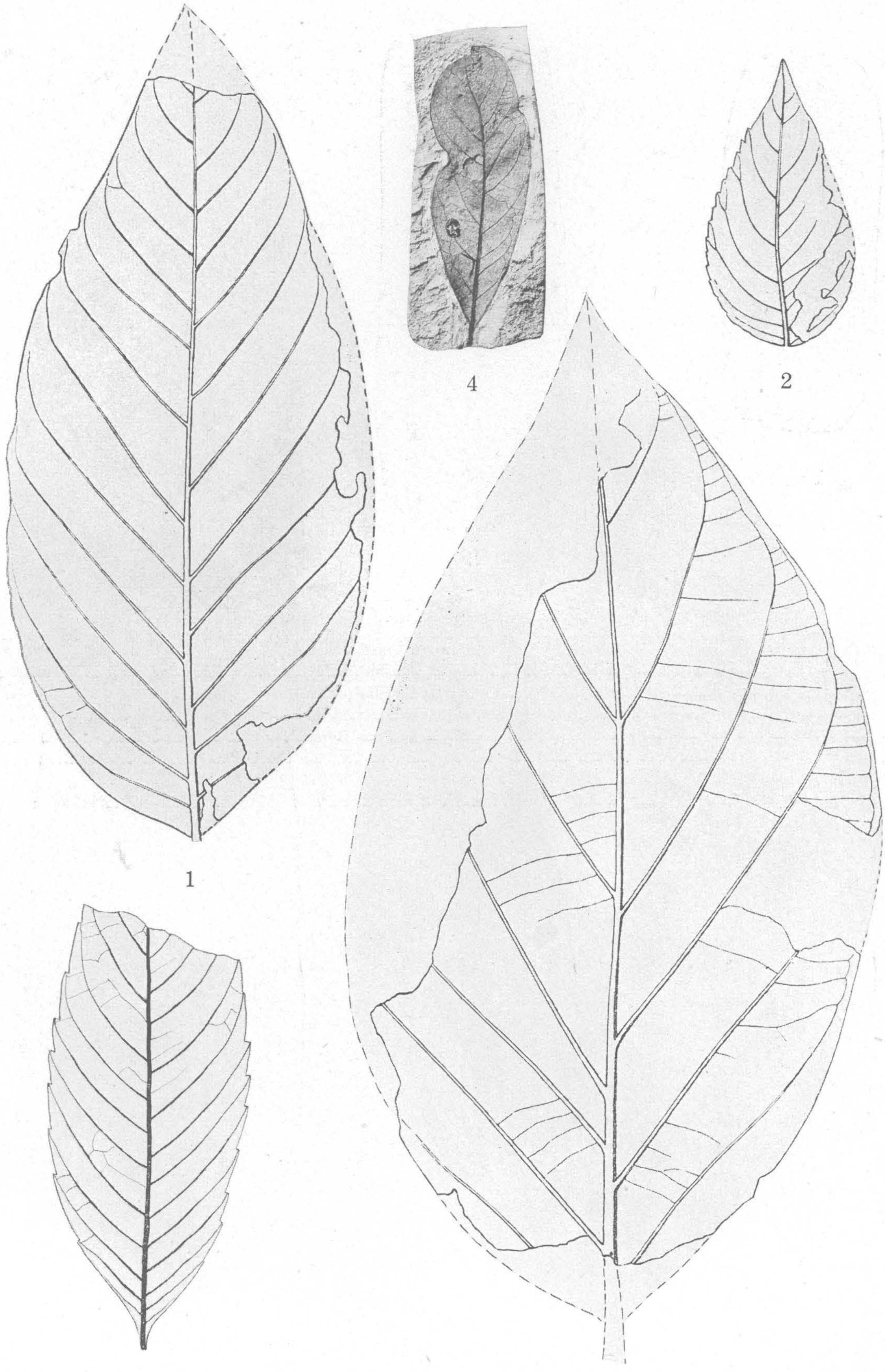
FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

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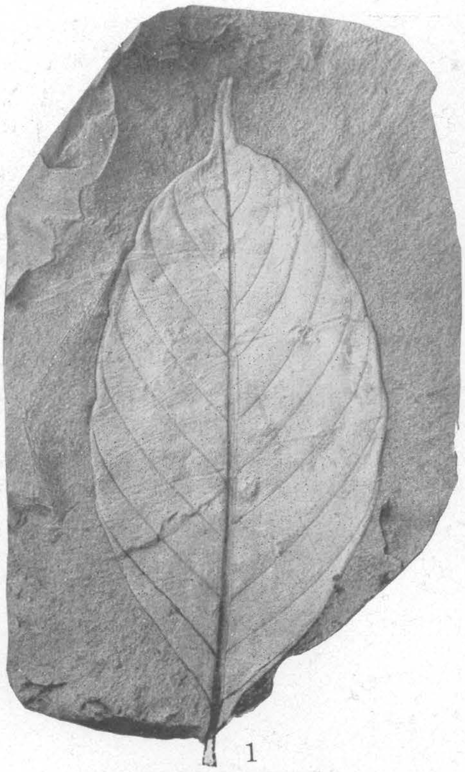
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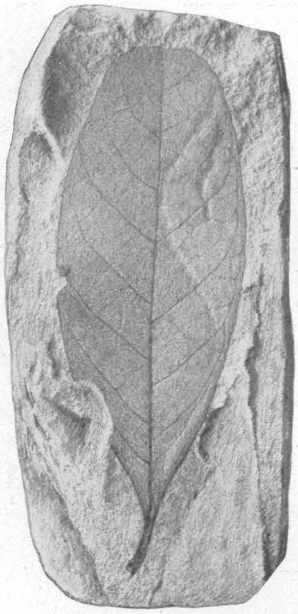
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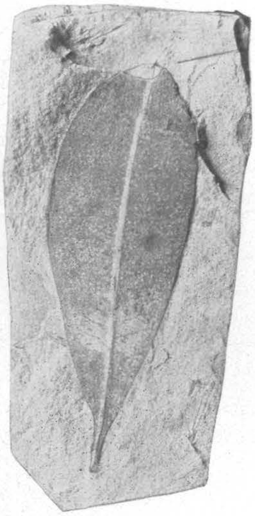
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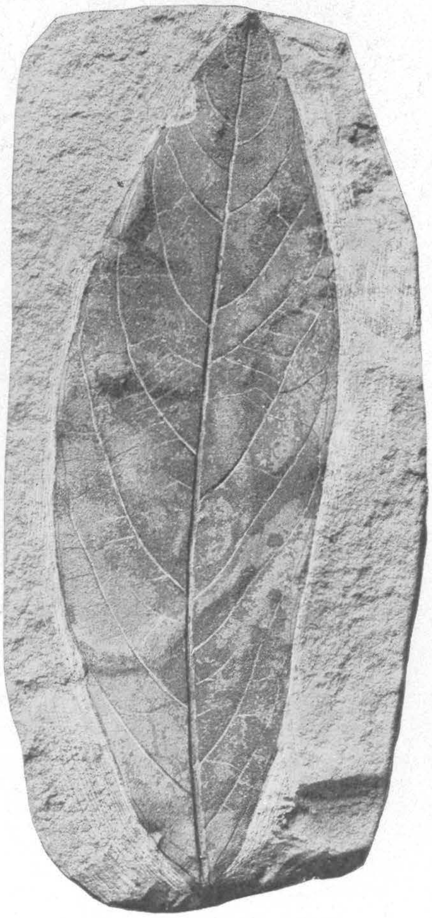
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FOSSIL PLANTS FROM THE WILCOX GROUP.

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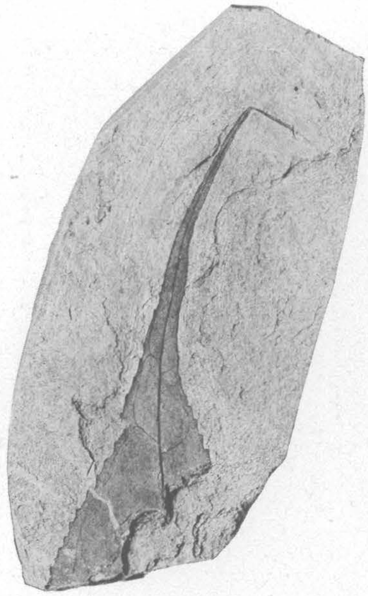

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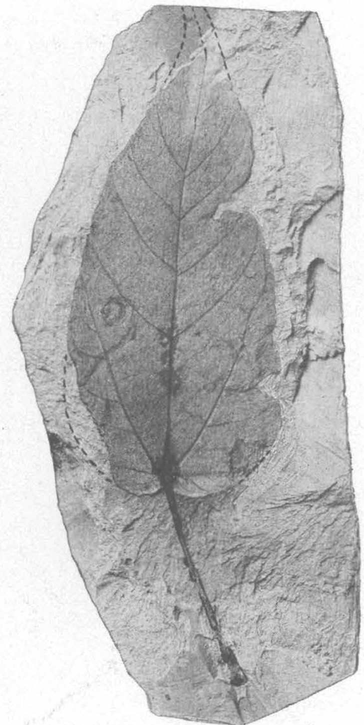

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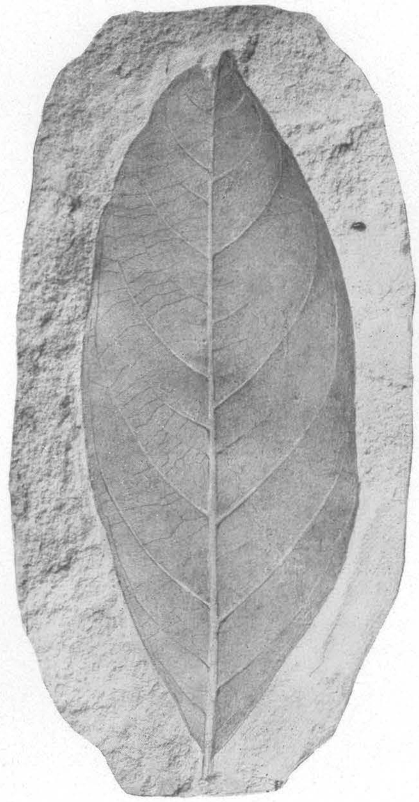

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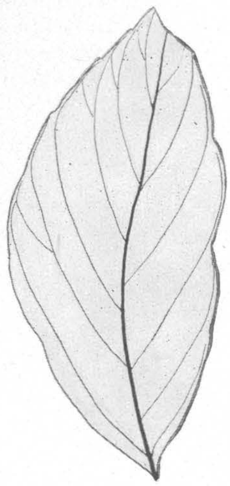

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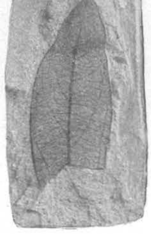

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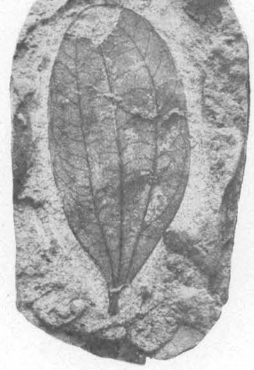

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FOSSIL PLANTS FROM THE WILCOX GROUP.

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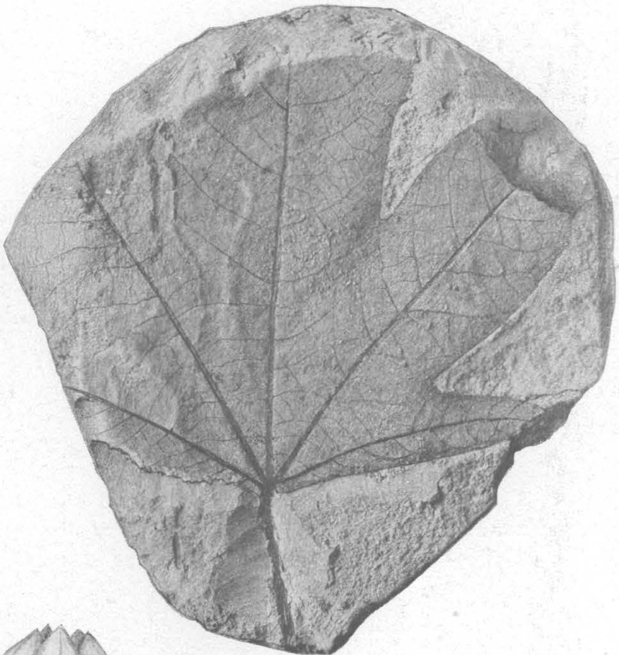

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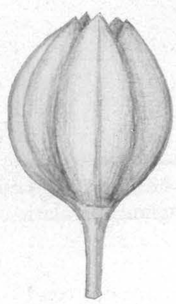

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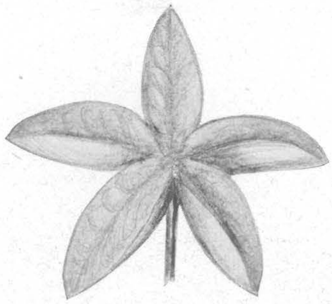

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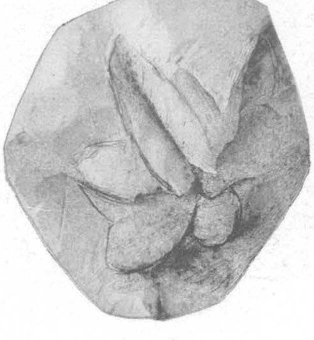

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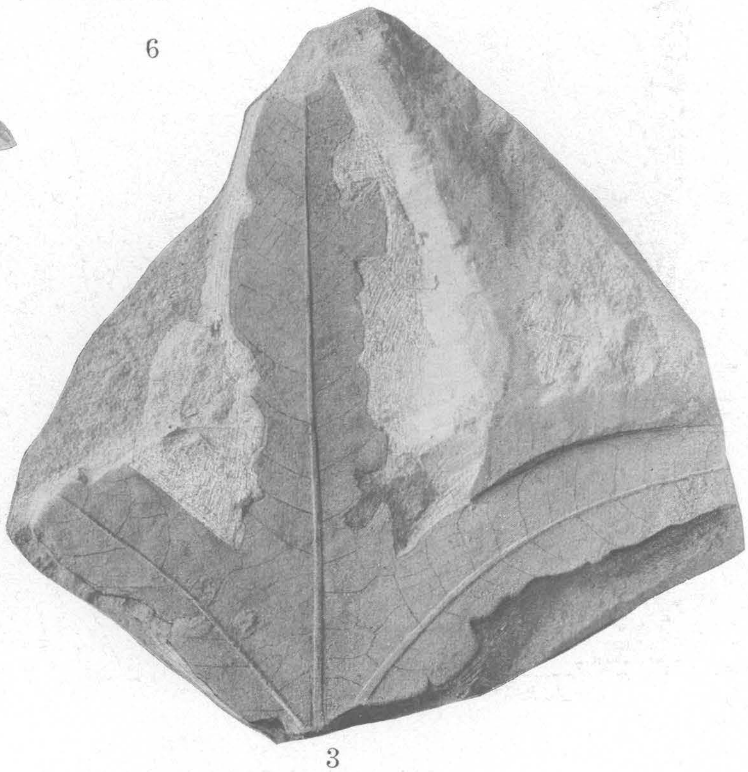

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FOSSIL PLANTS FROM THE WILCOX GROUP.

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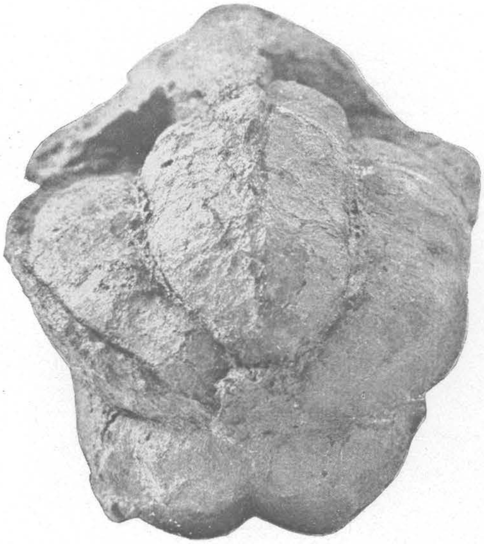
FOSSIL PLANT FROM THE WILCOX GROUP.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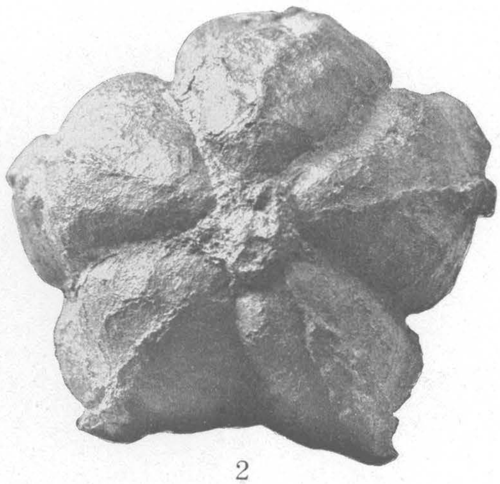
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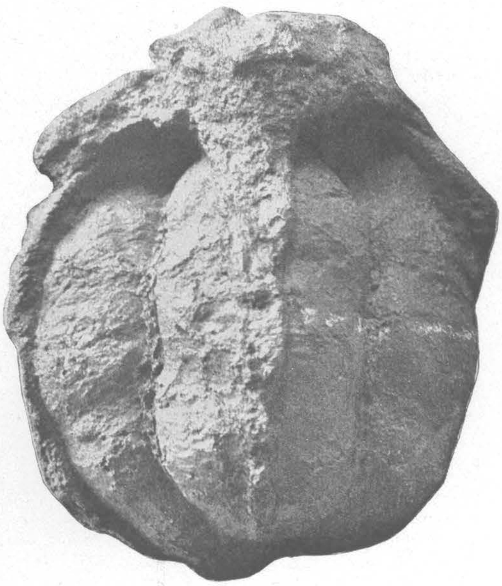
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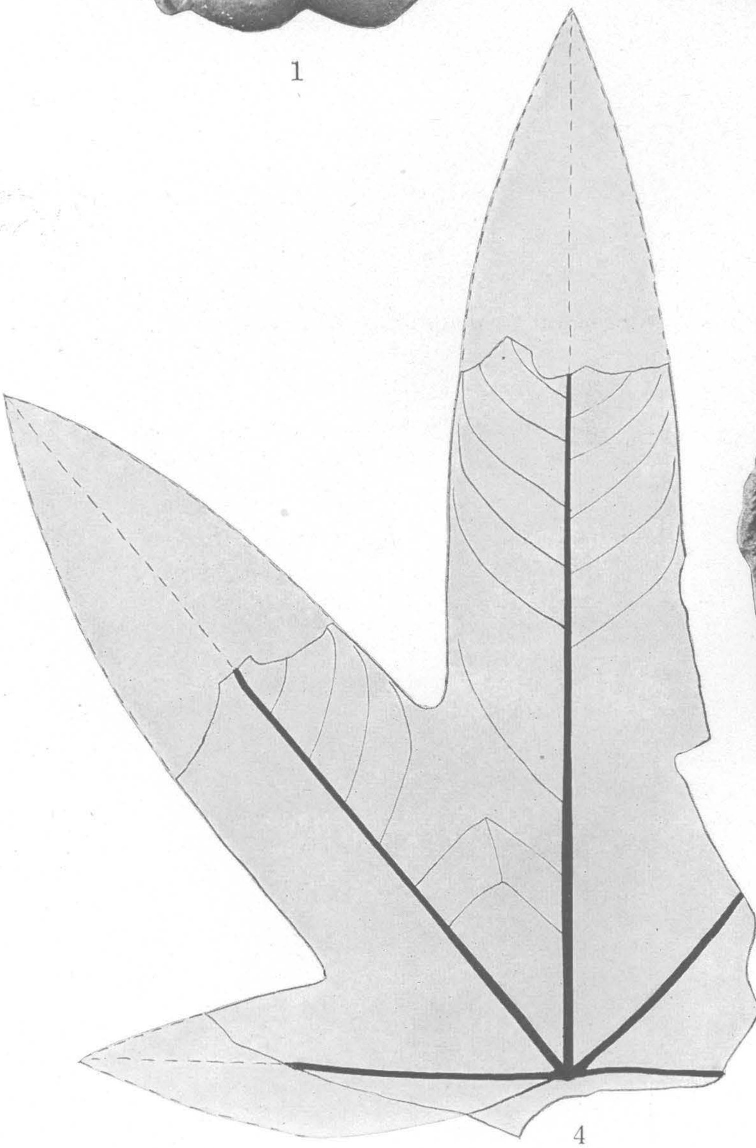
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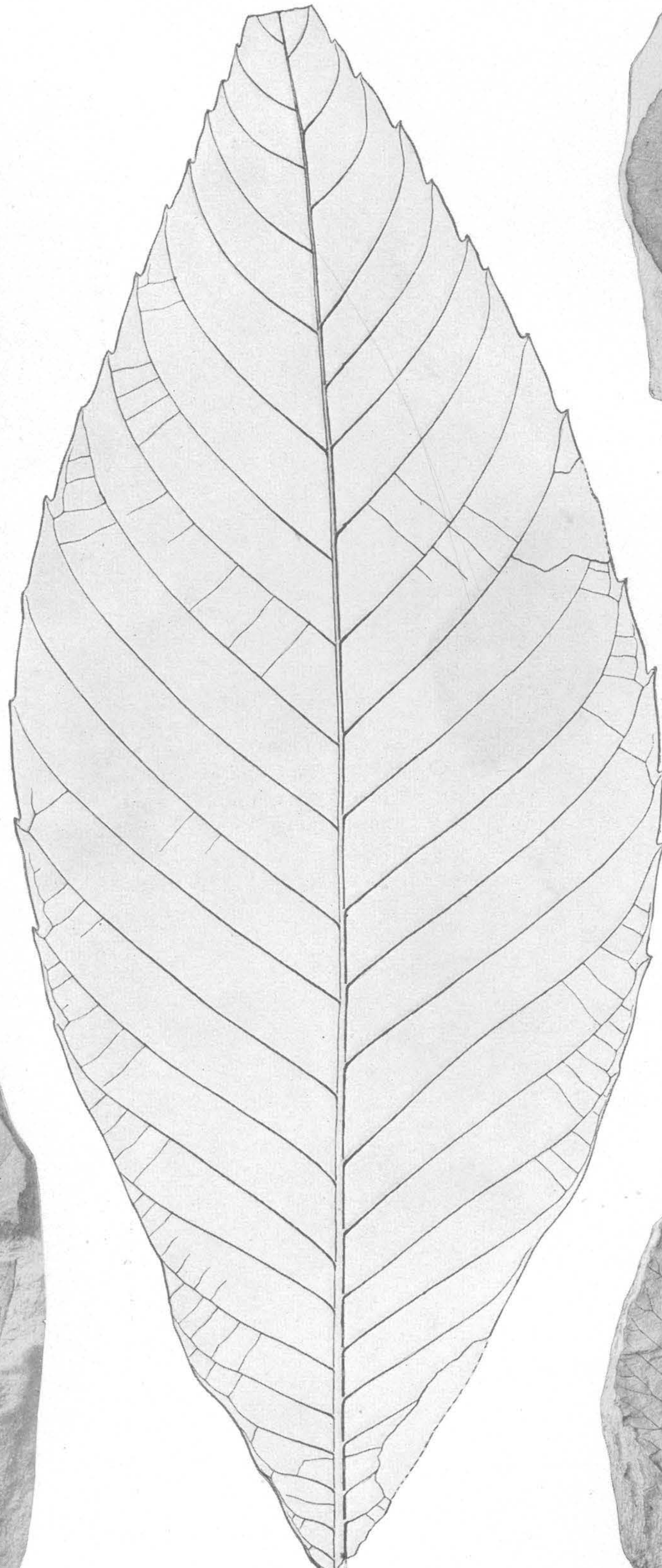

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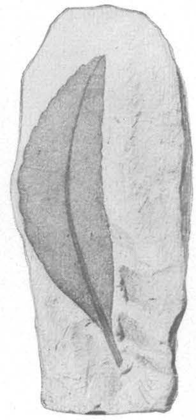

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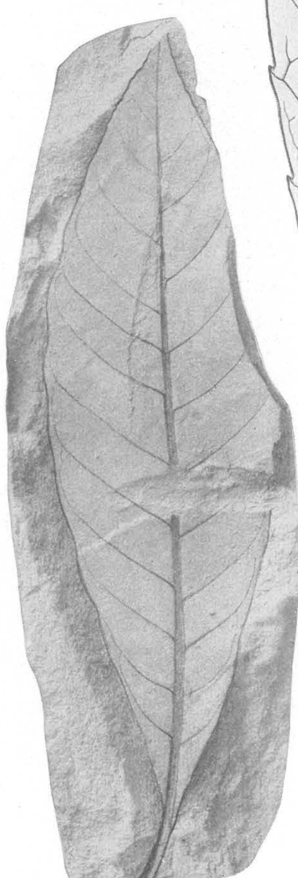

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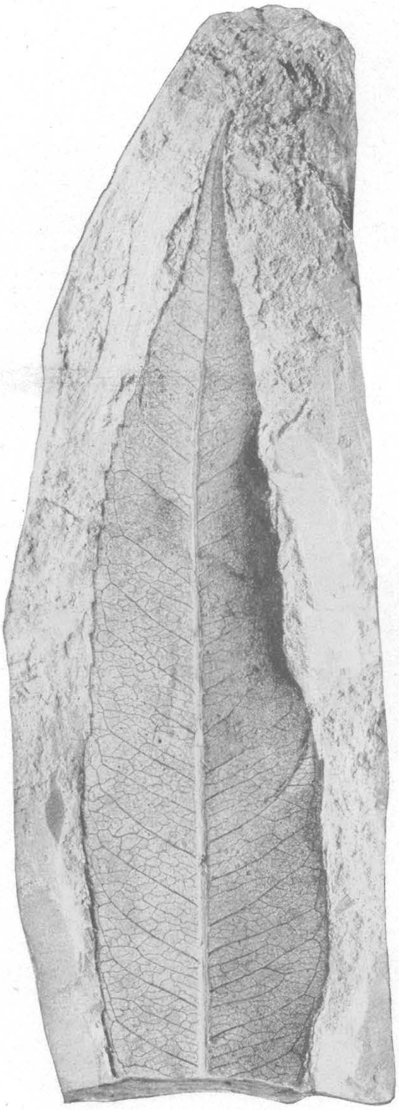
FOSSIL PLANTS FROM THE WILCOX GROUP.



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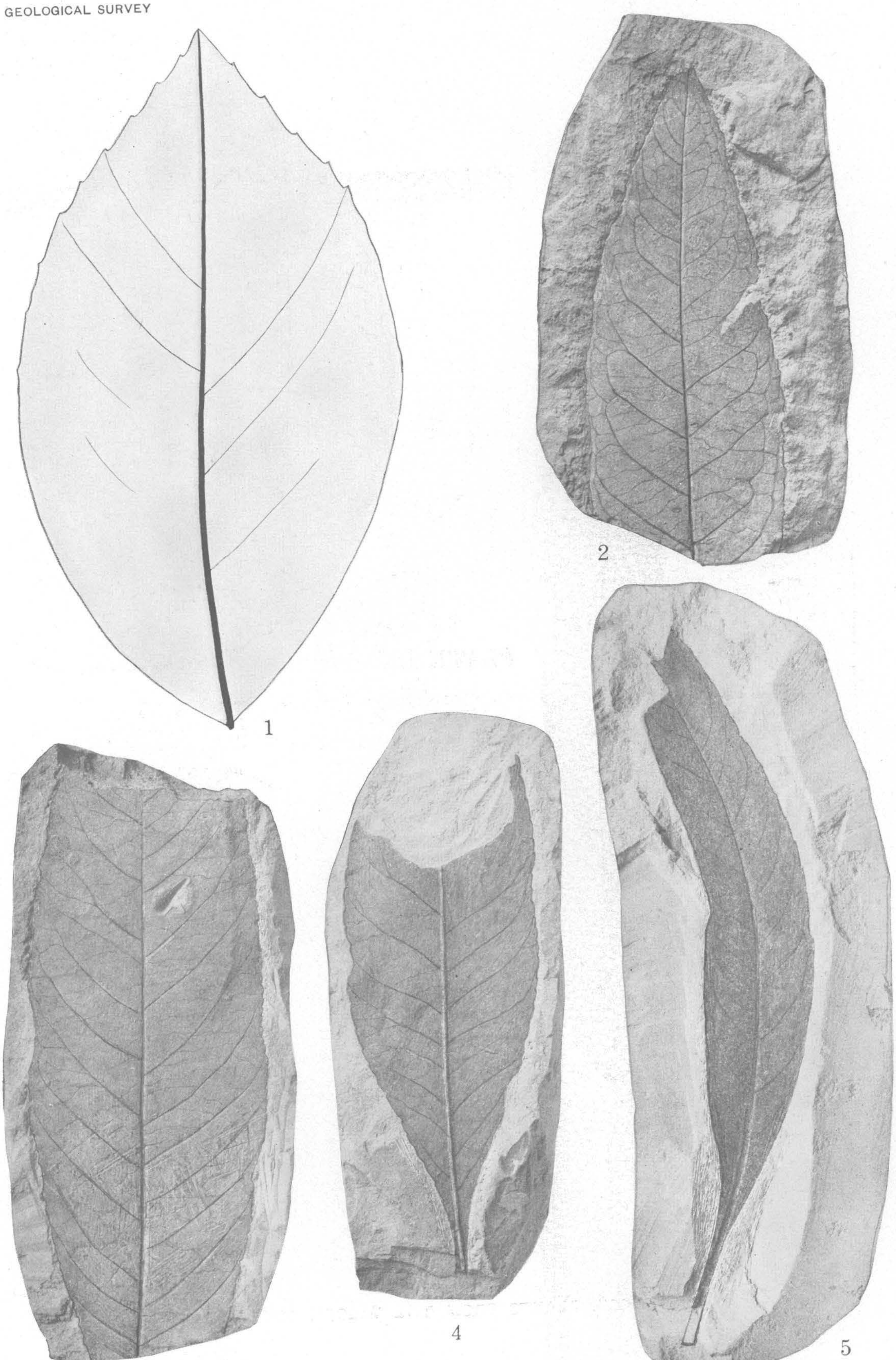
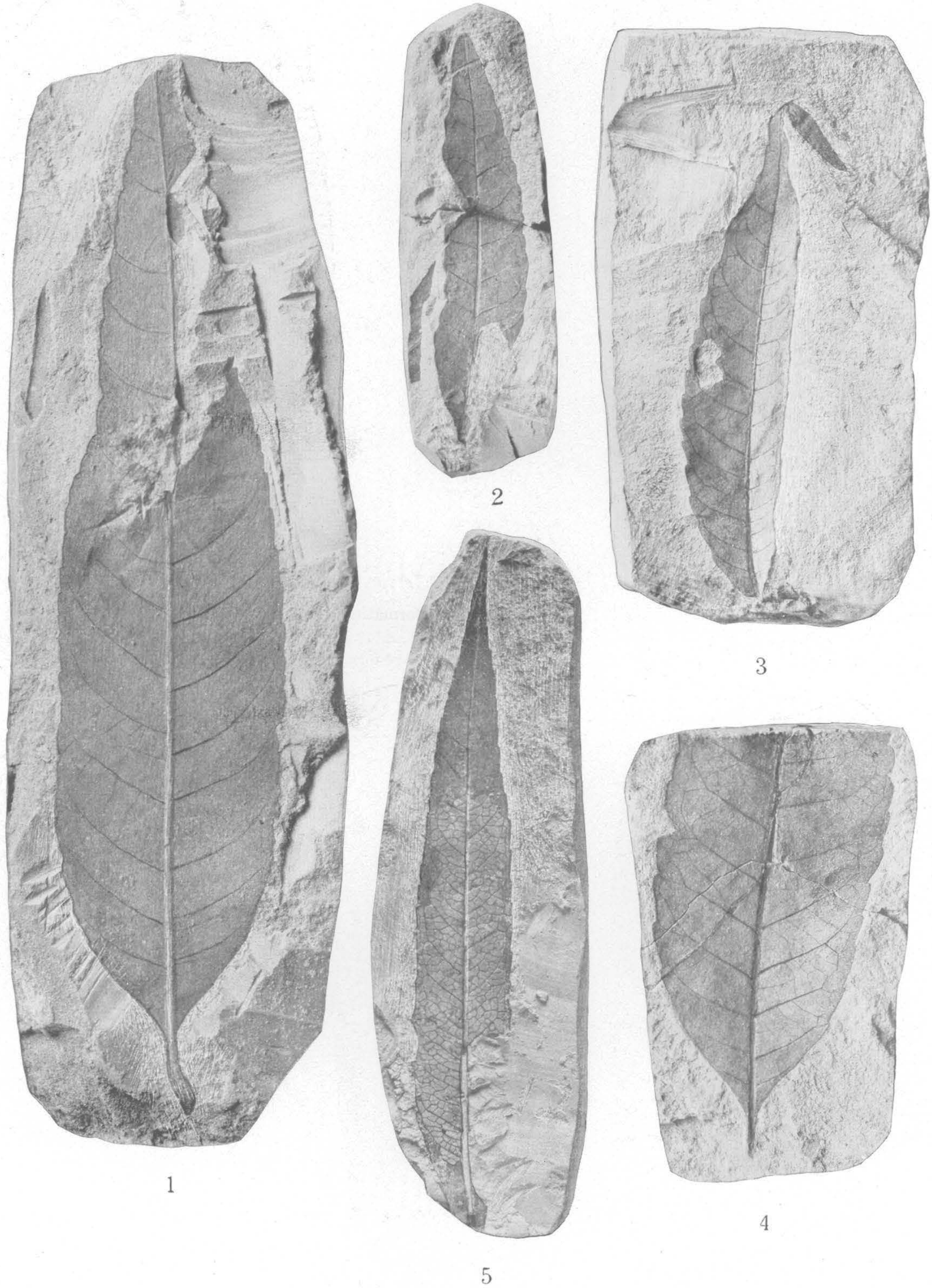
FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE LXXVI.

PLATE LXXVII.



FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

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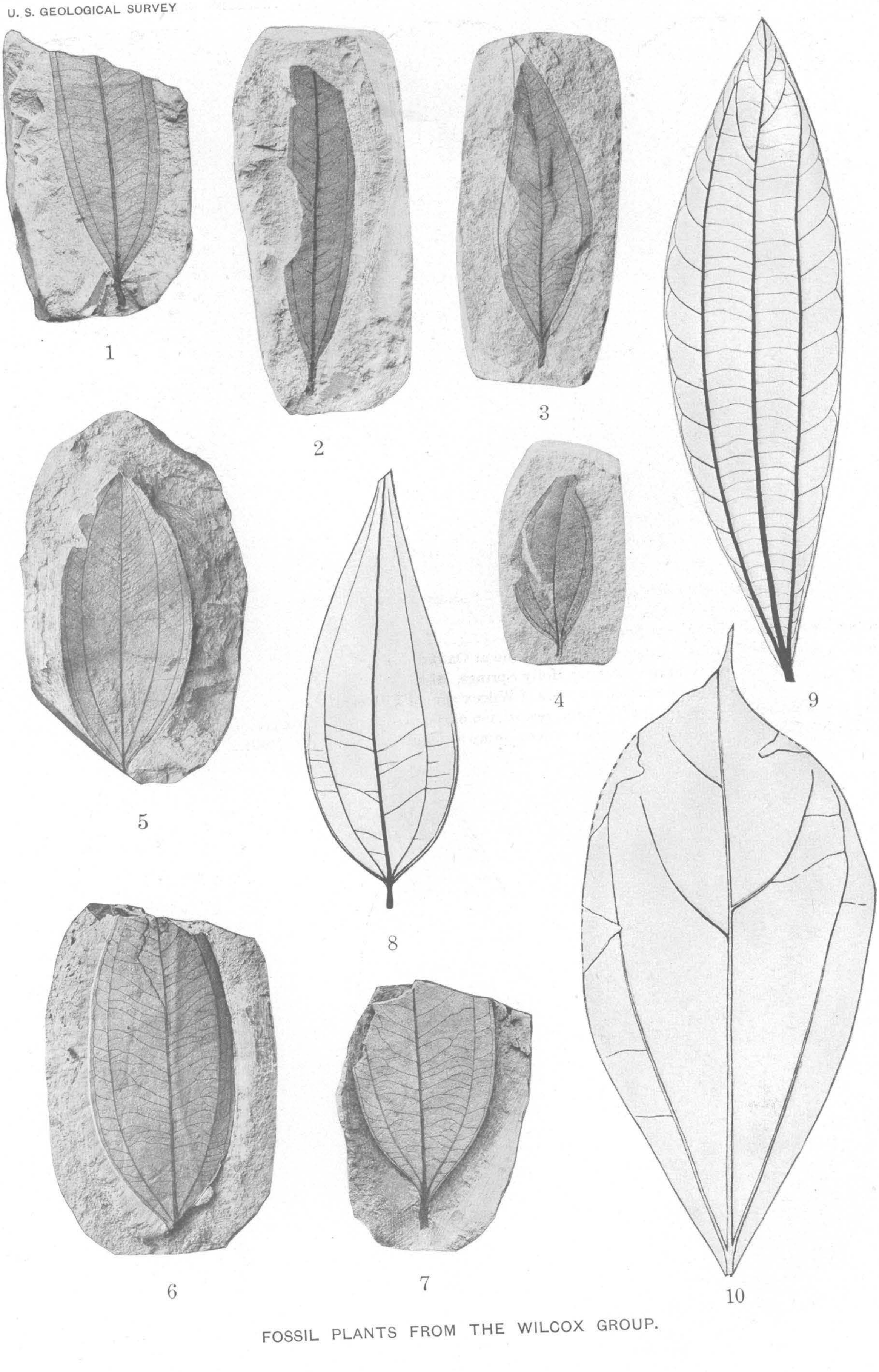
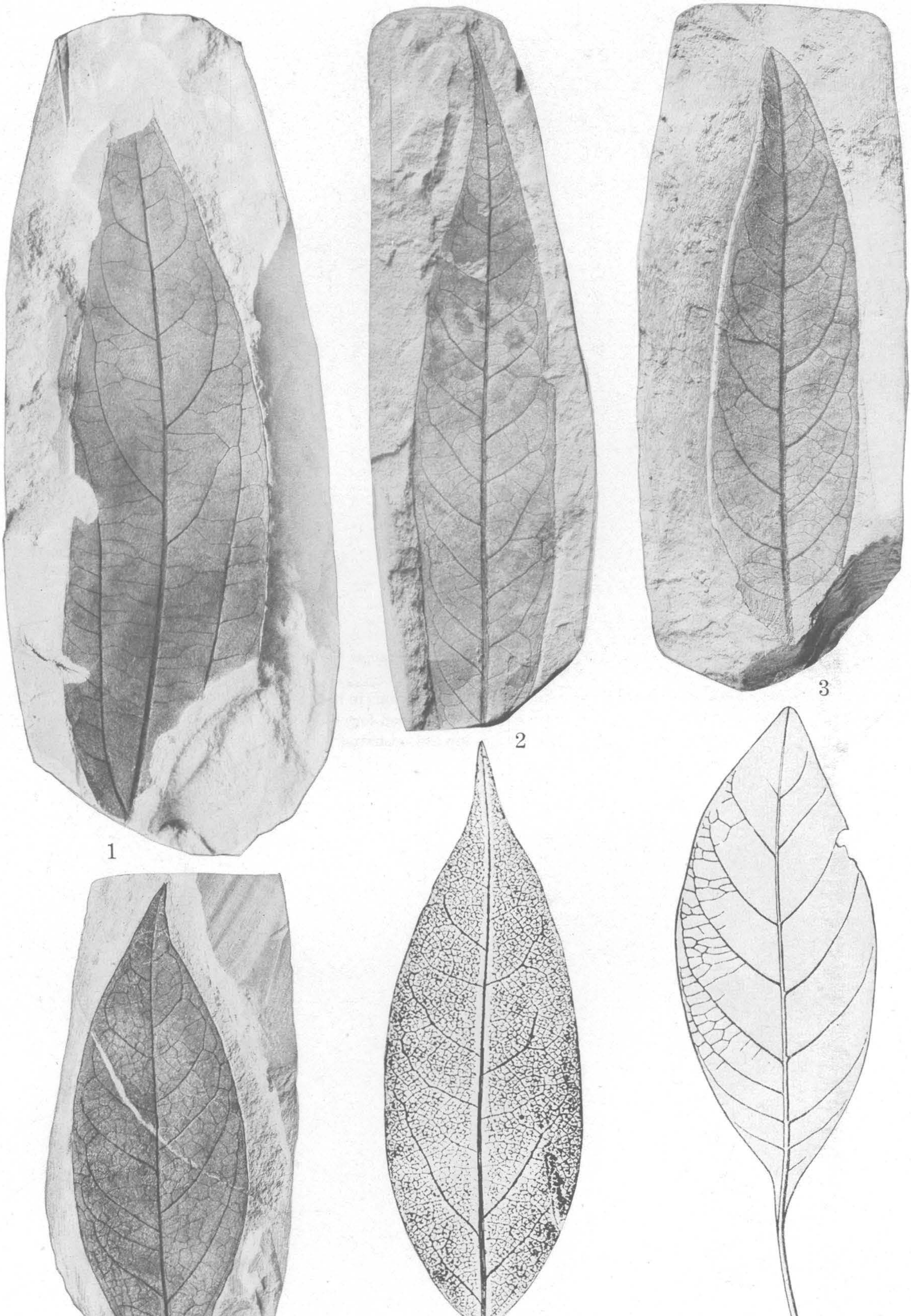


FOSSIL PLANTS FROM THE WILCOX GROUP.



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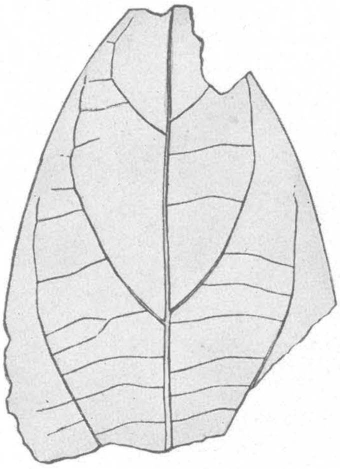

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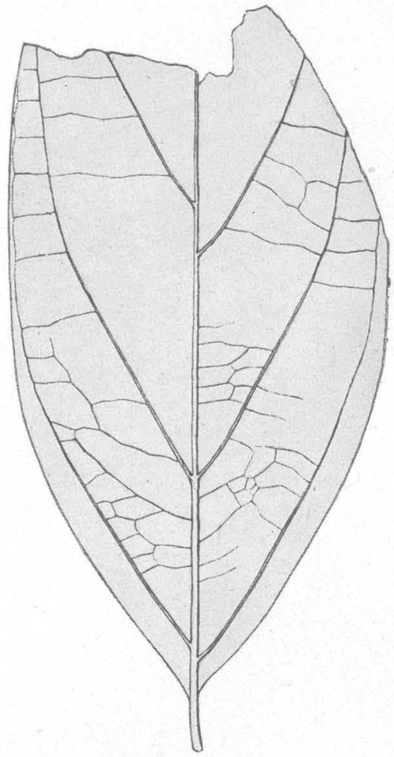

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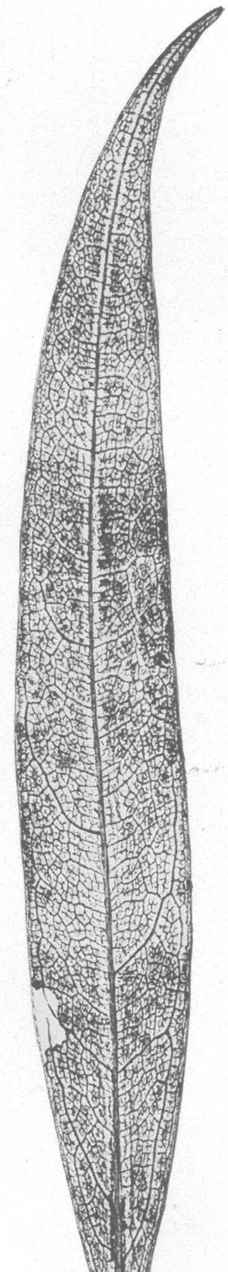

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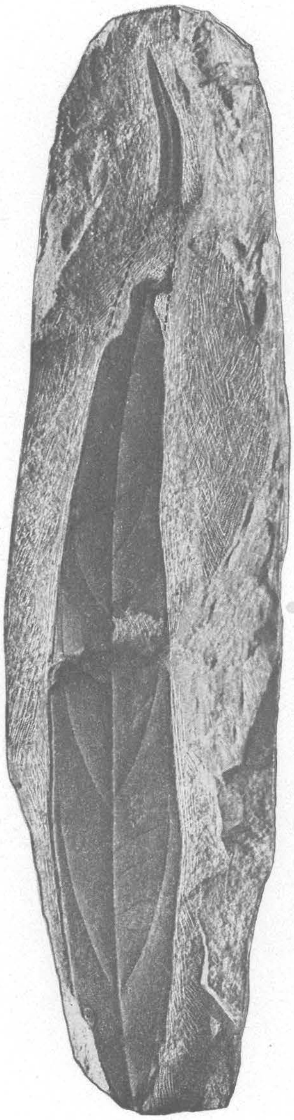

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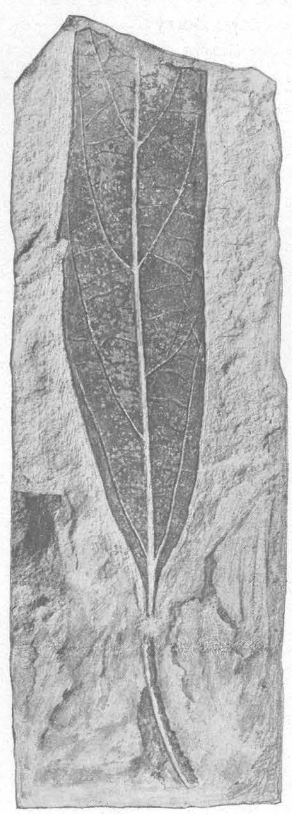

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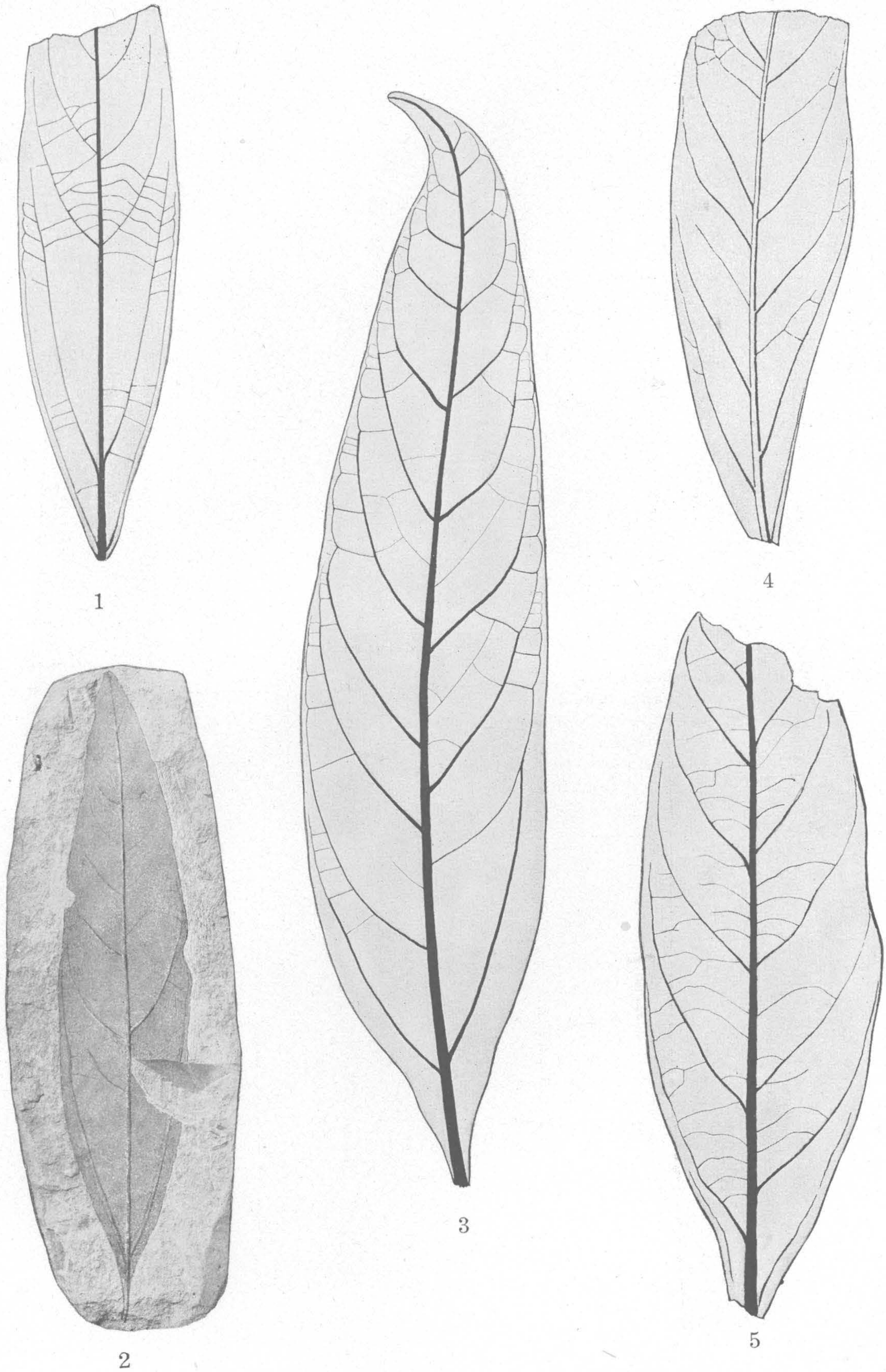

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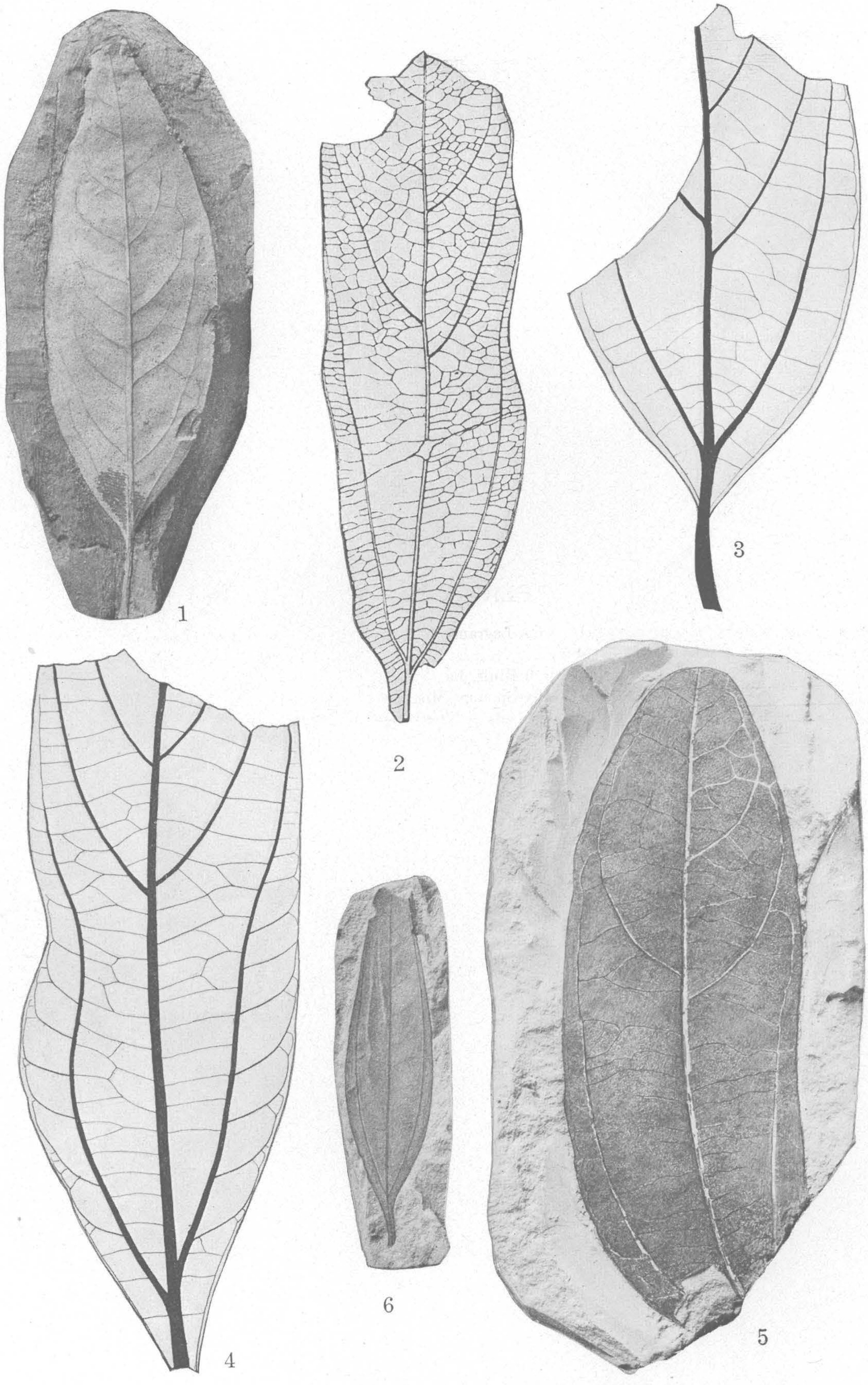

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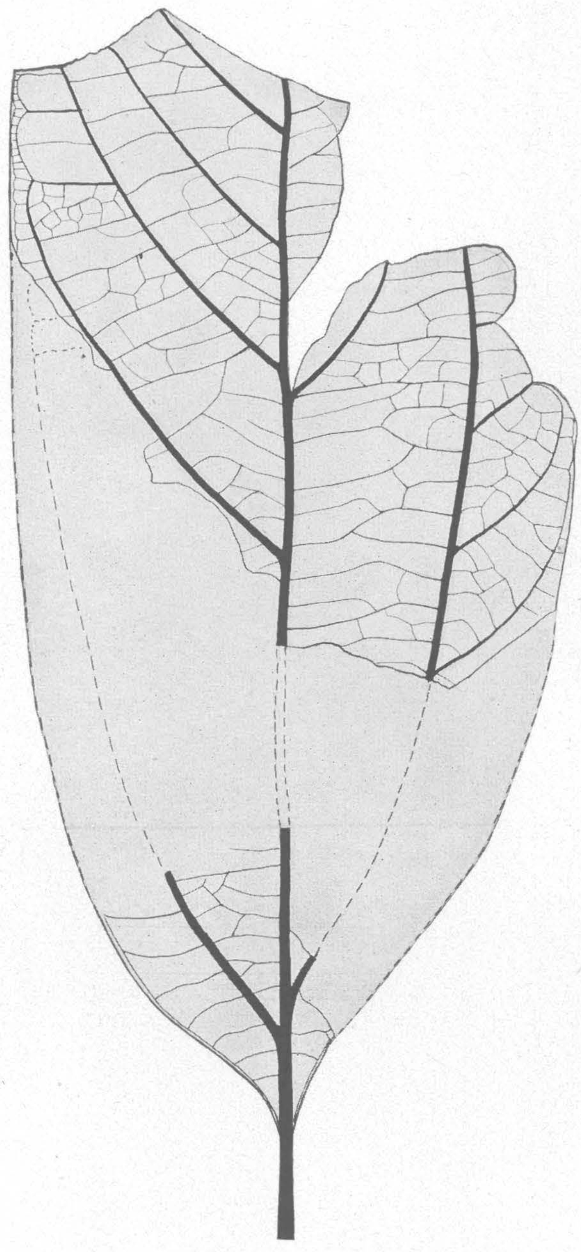

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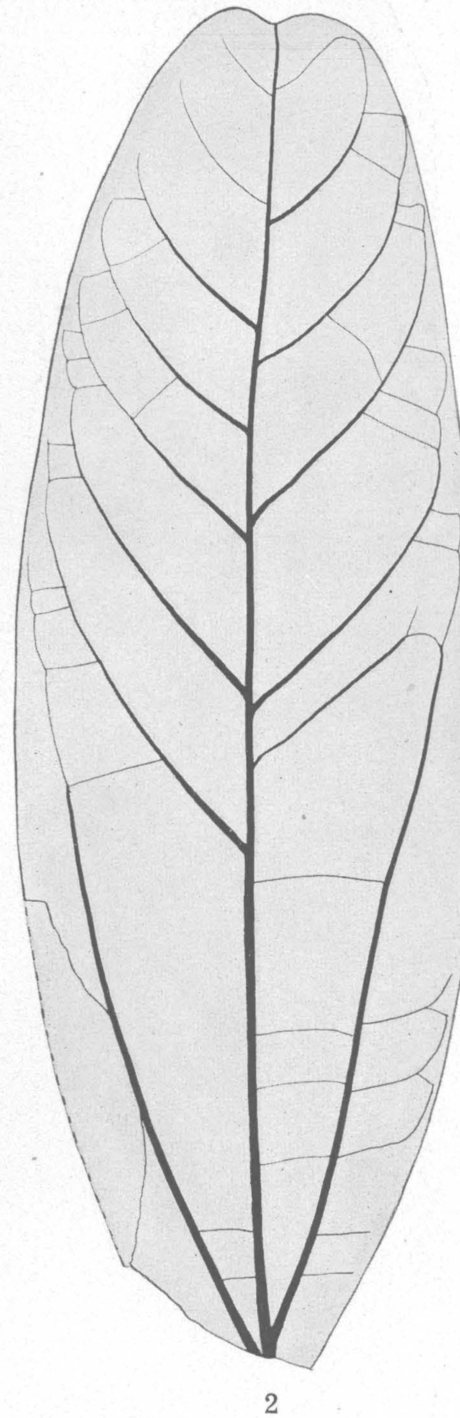

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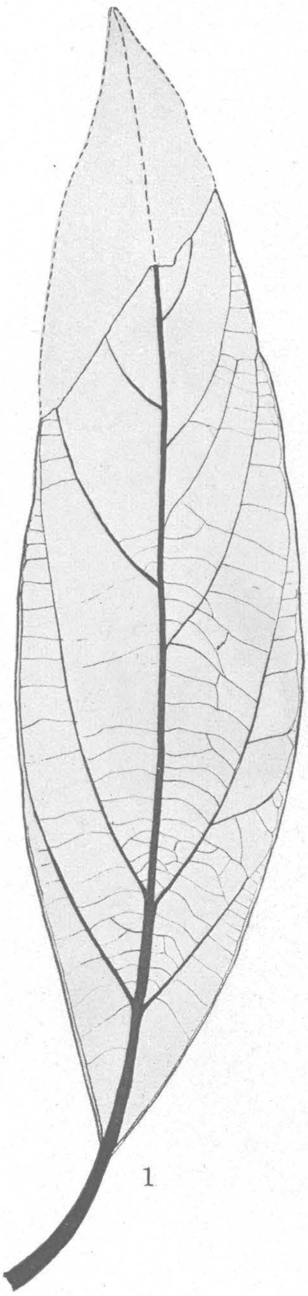

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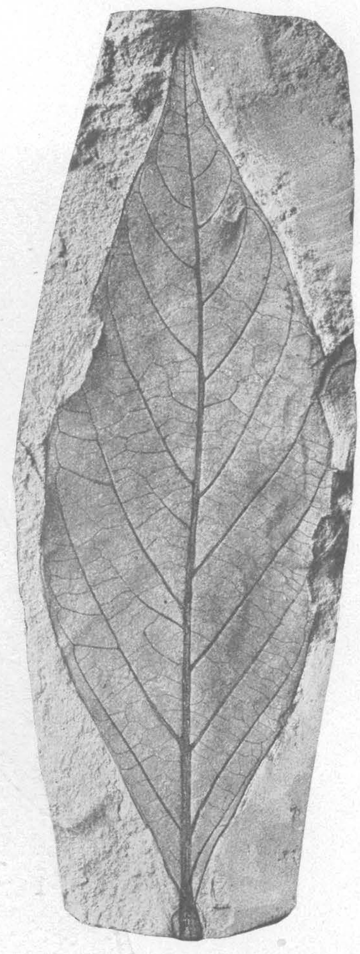

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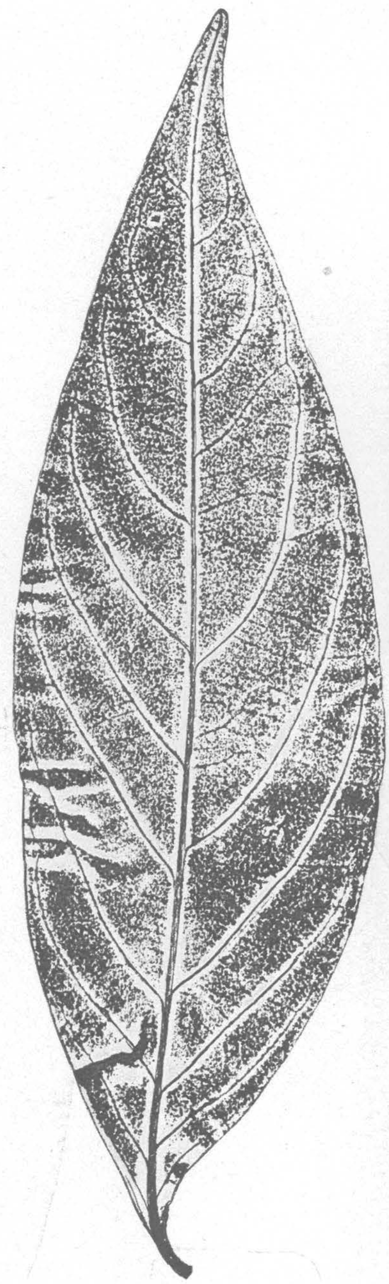

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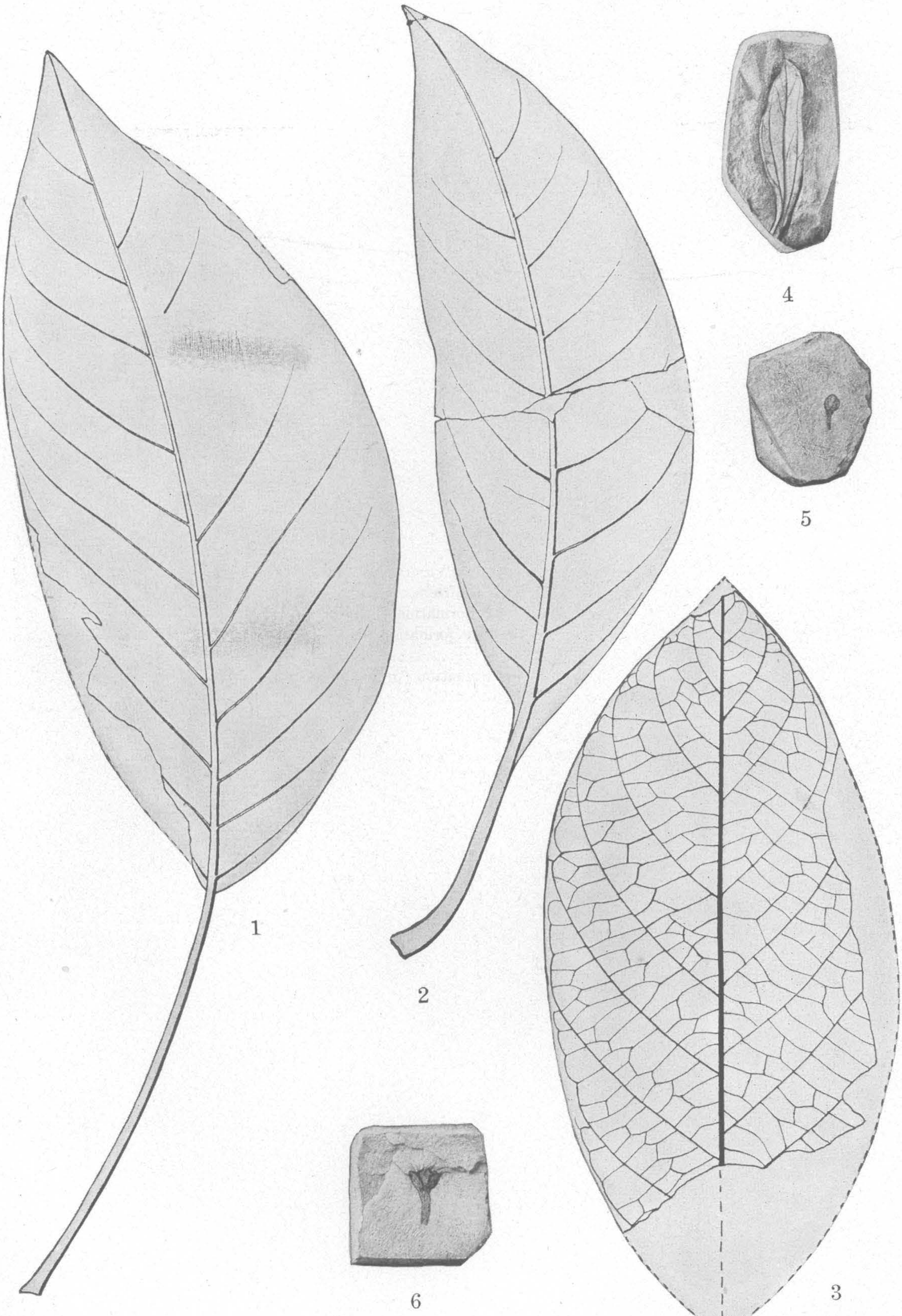

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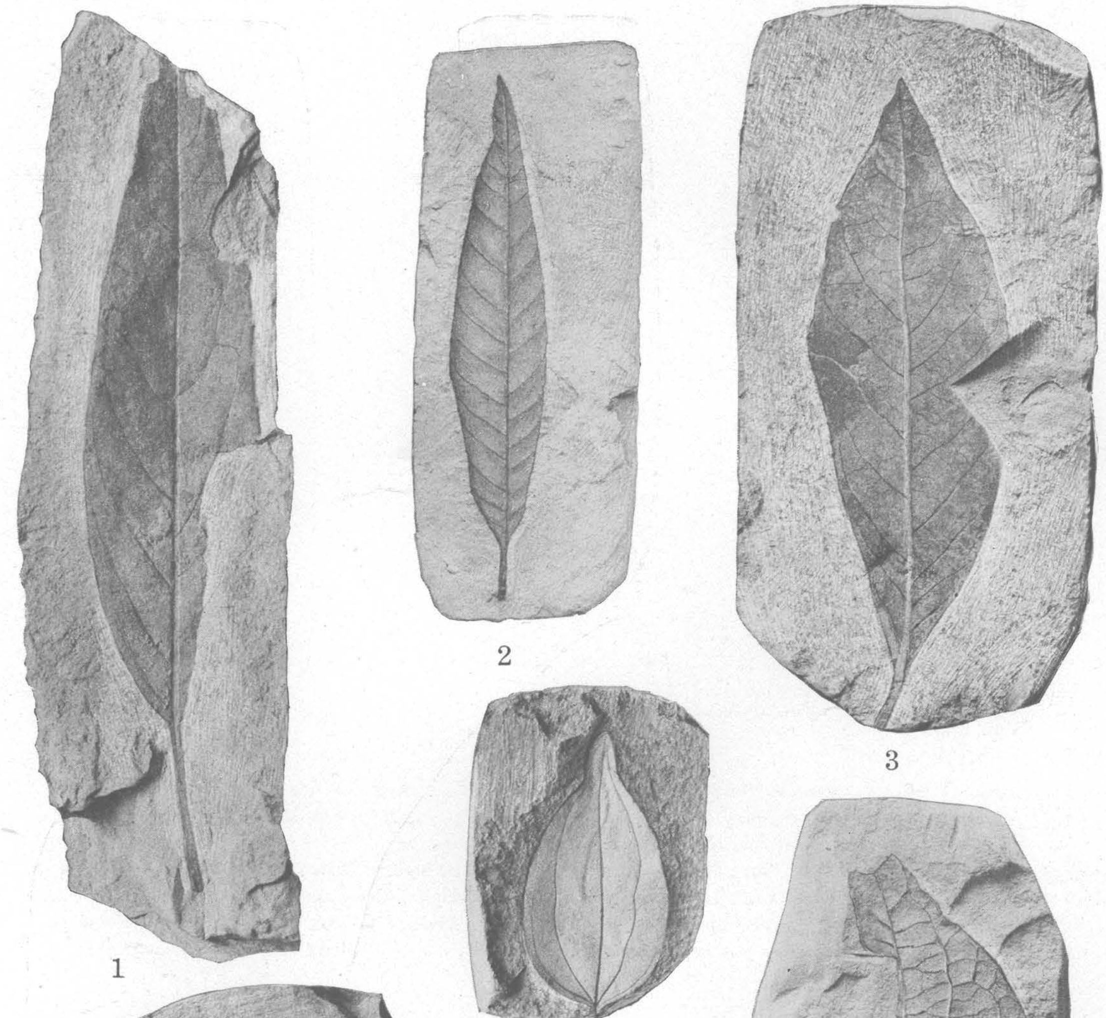

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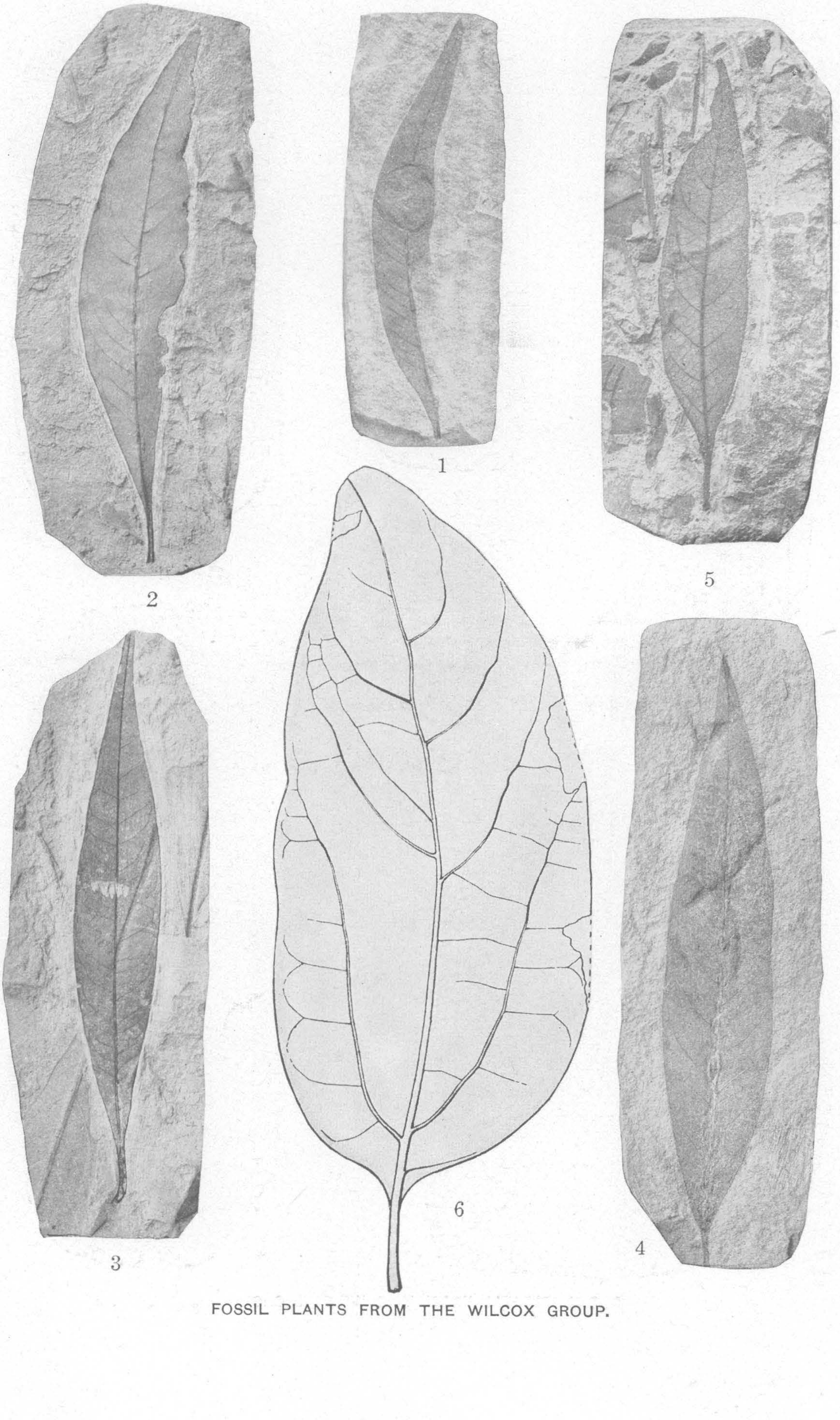

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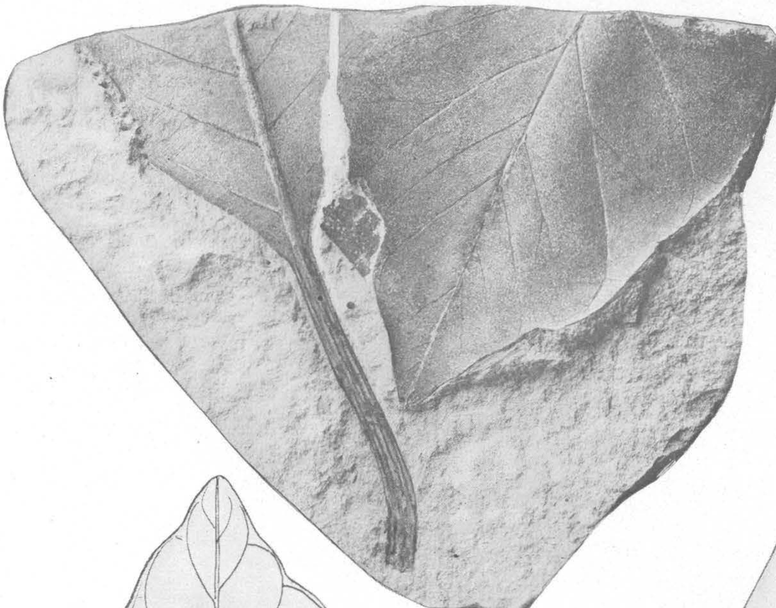

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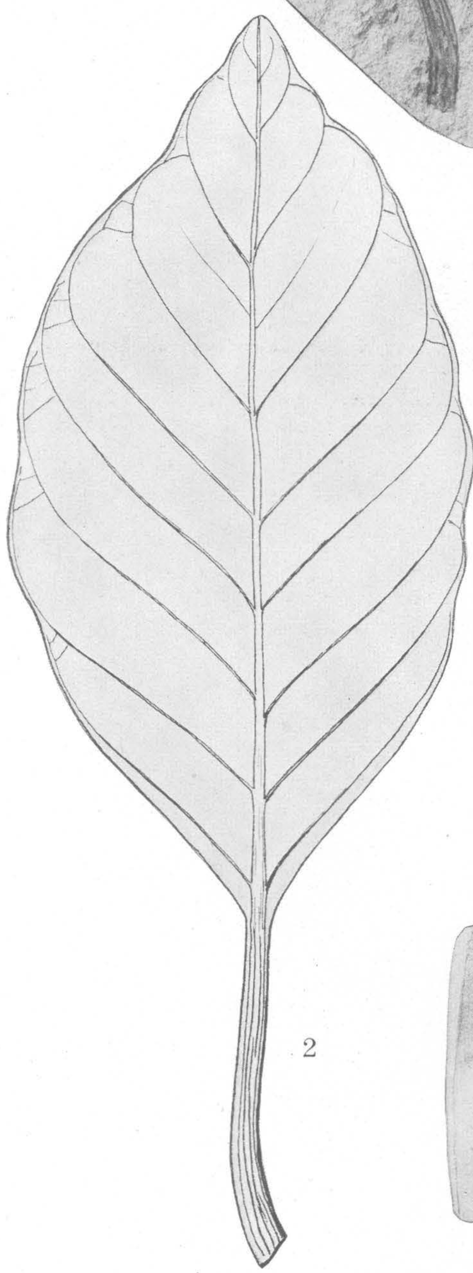

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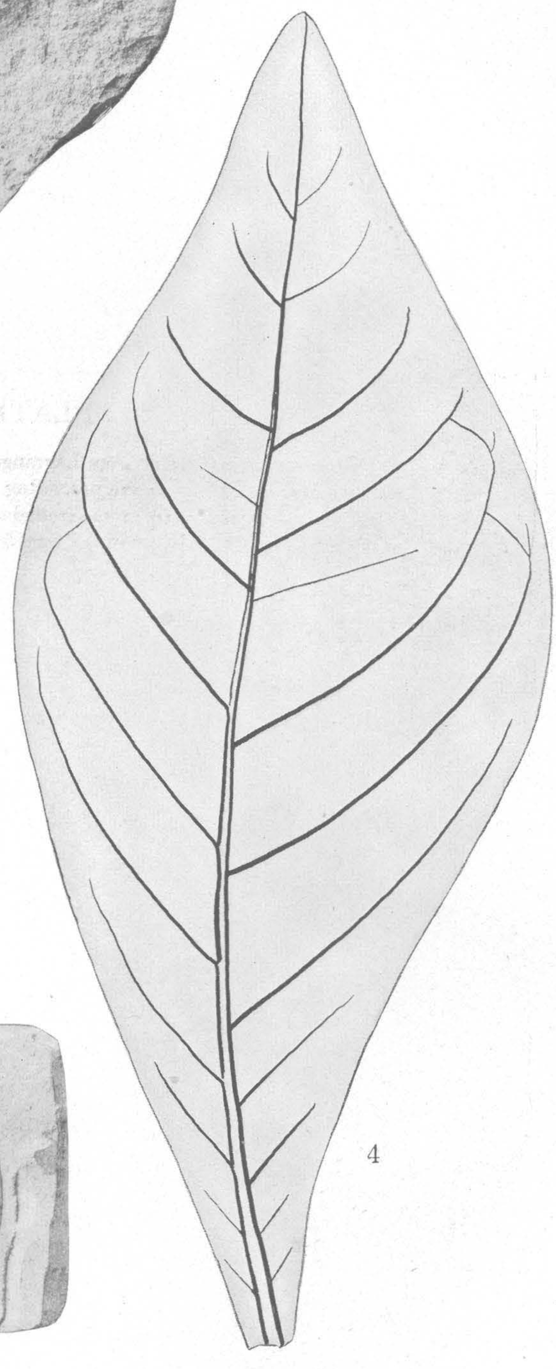

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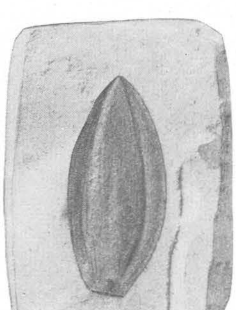

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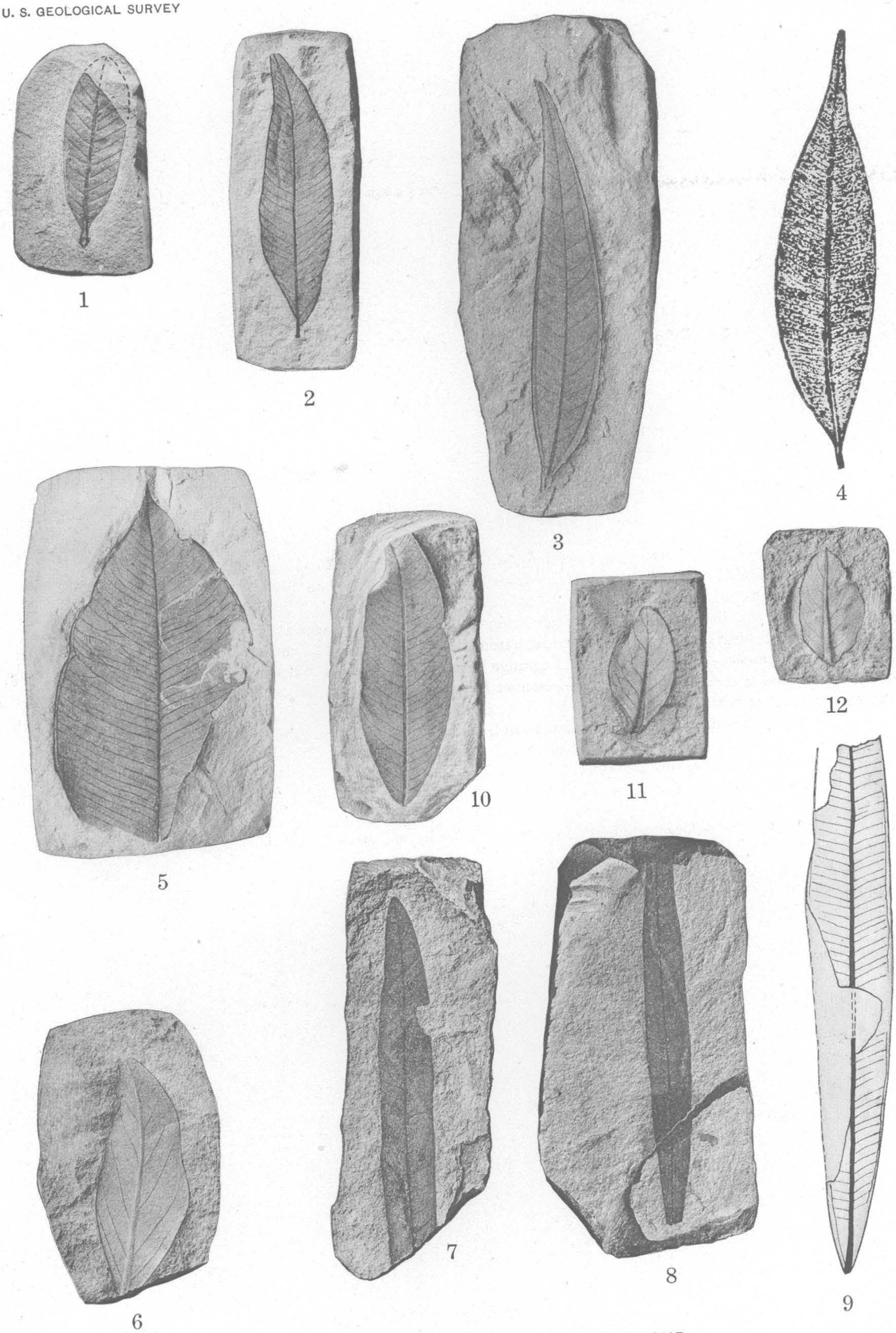

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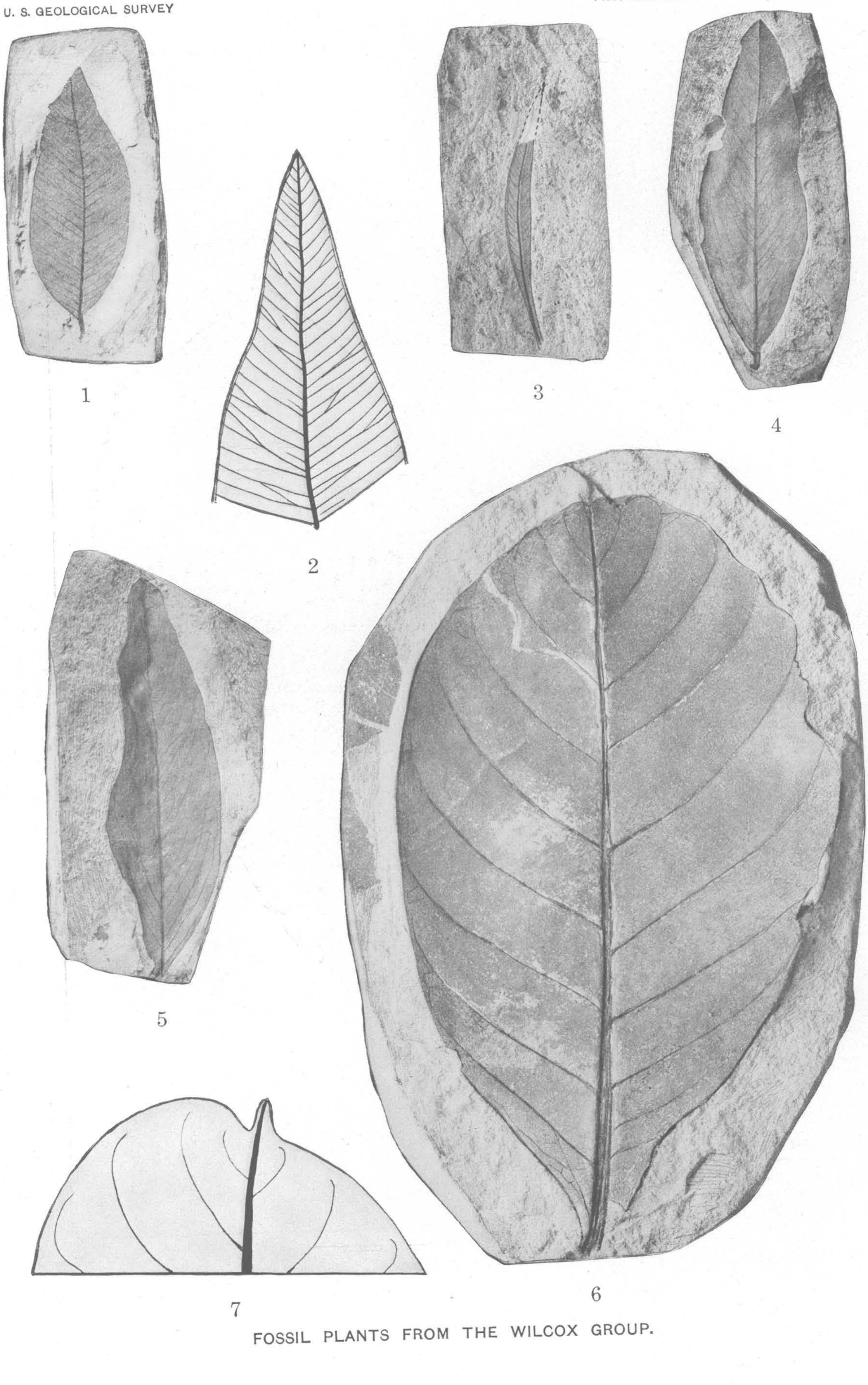

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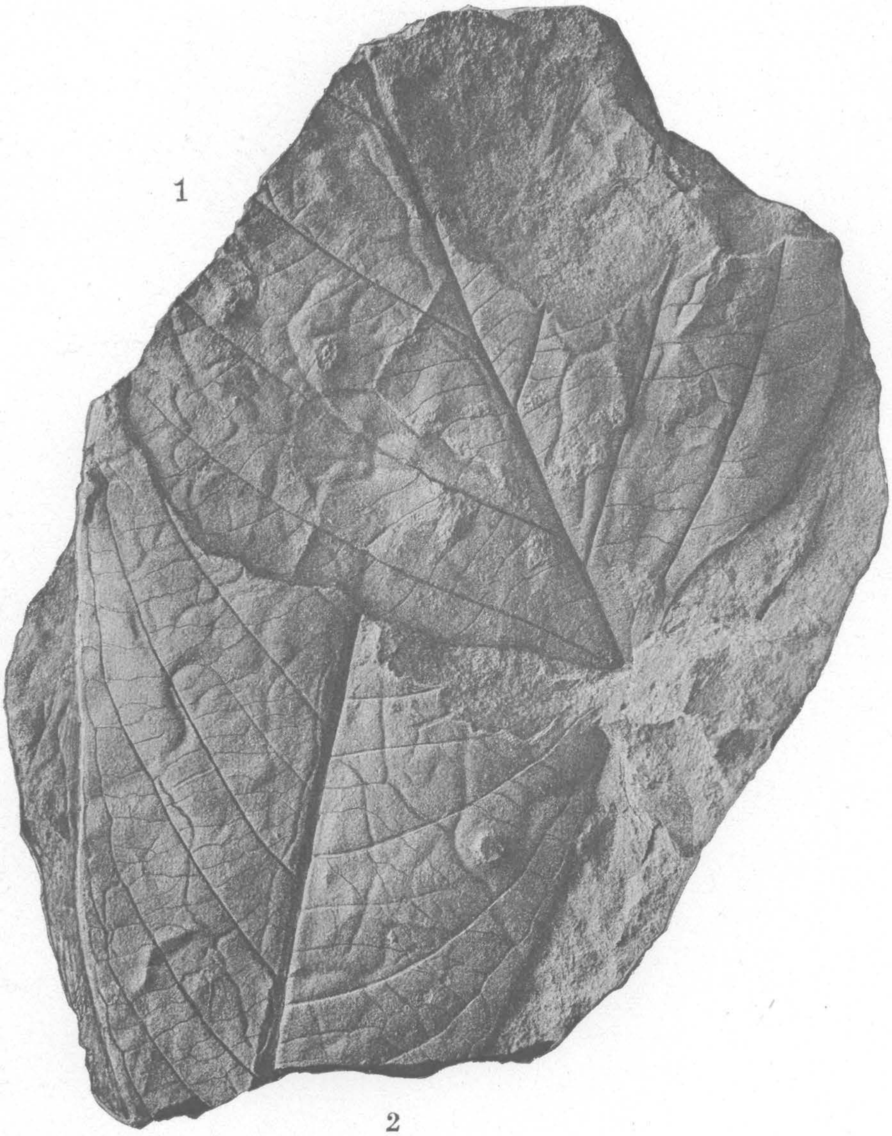

FOSSIL PLANTS FROM THE WILCOX GROUP.

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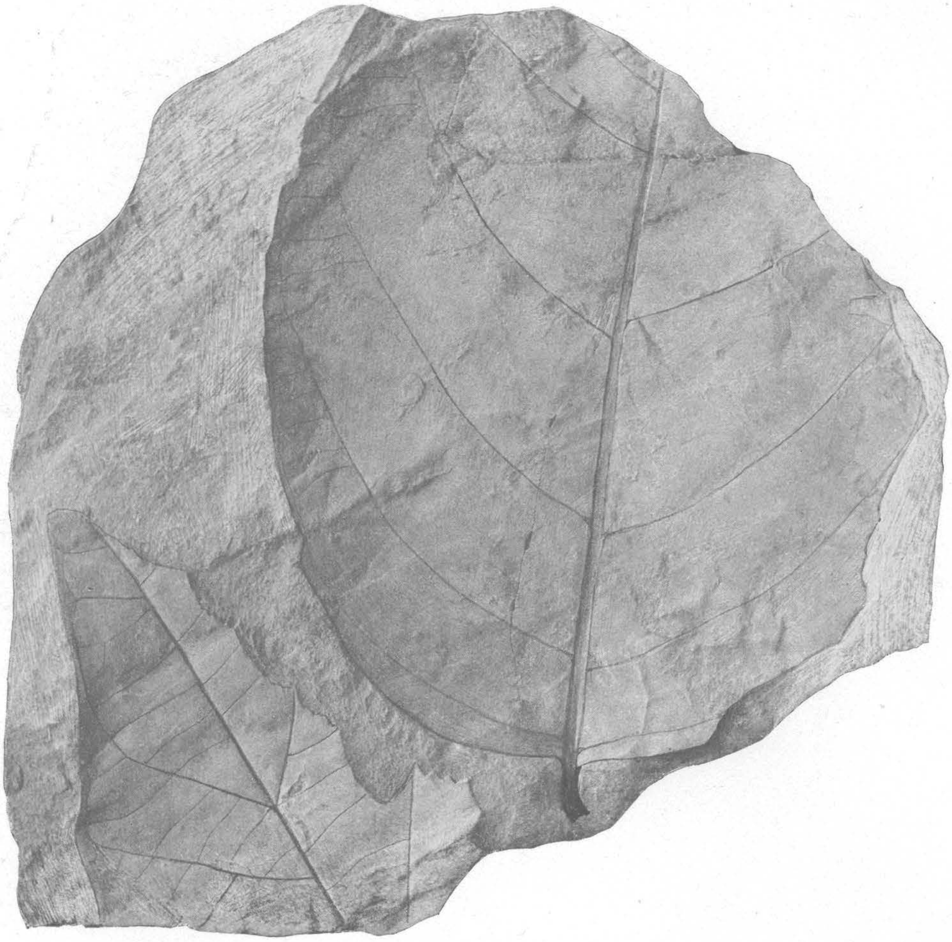

FOSSIL PLANTS FROM THE WILCOX GROUP.

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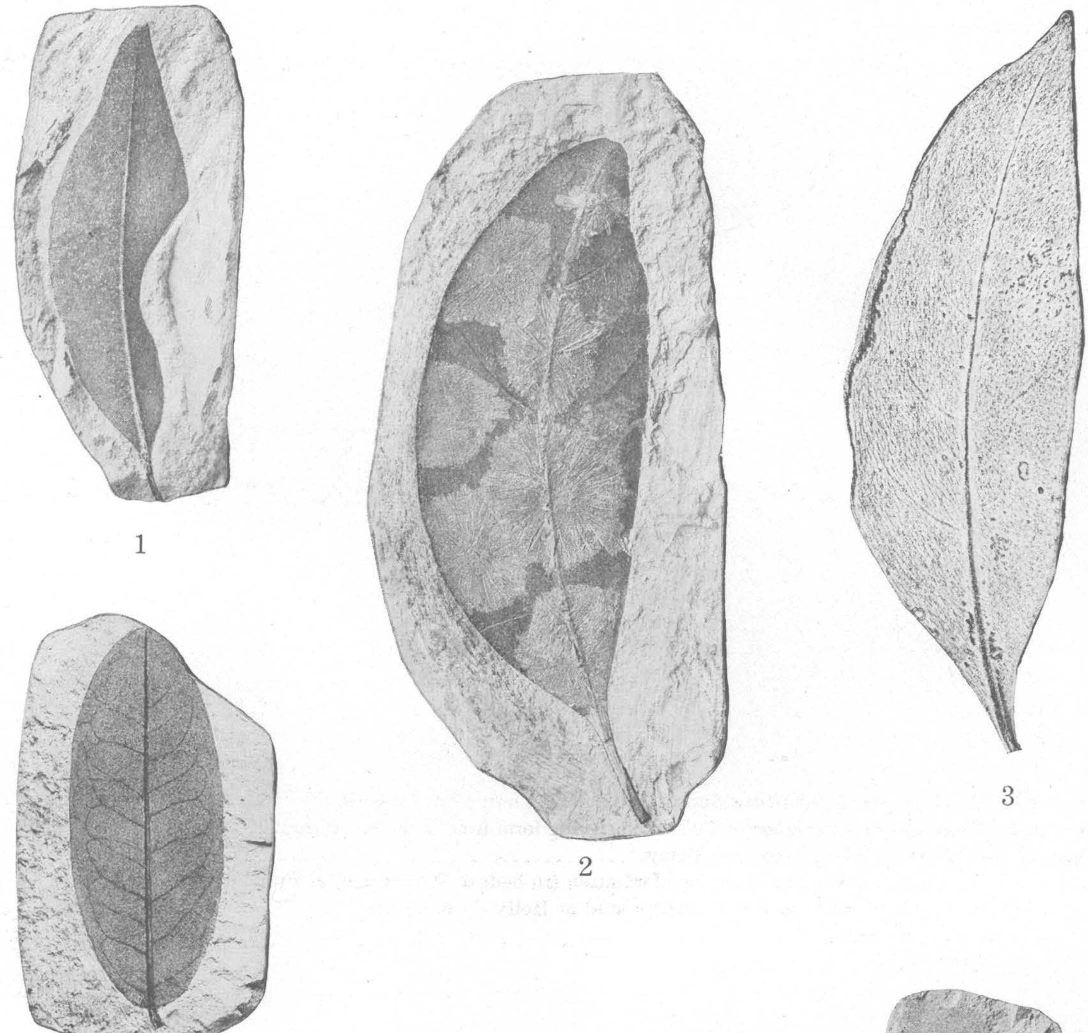
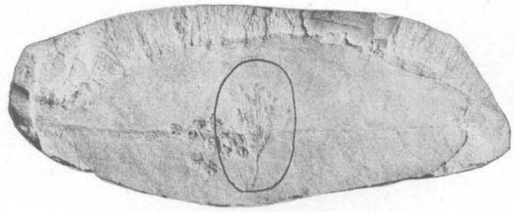


FOSSIL PLANTS FROM THE WILCOX GROUP.



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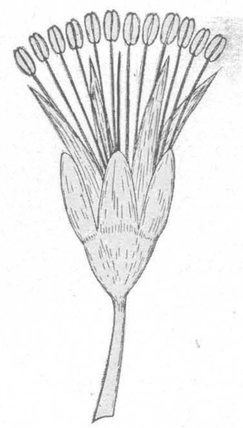

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1, 2, and 4 are reproduced from photographs that have not been retouched.

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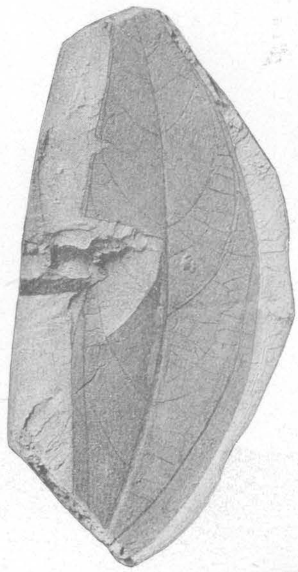
1



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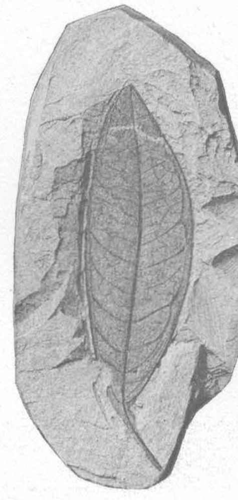

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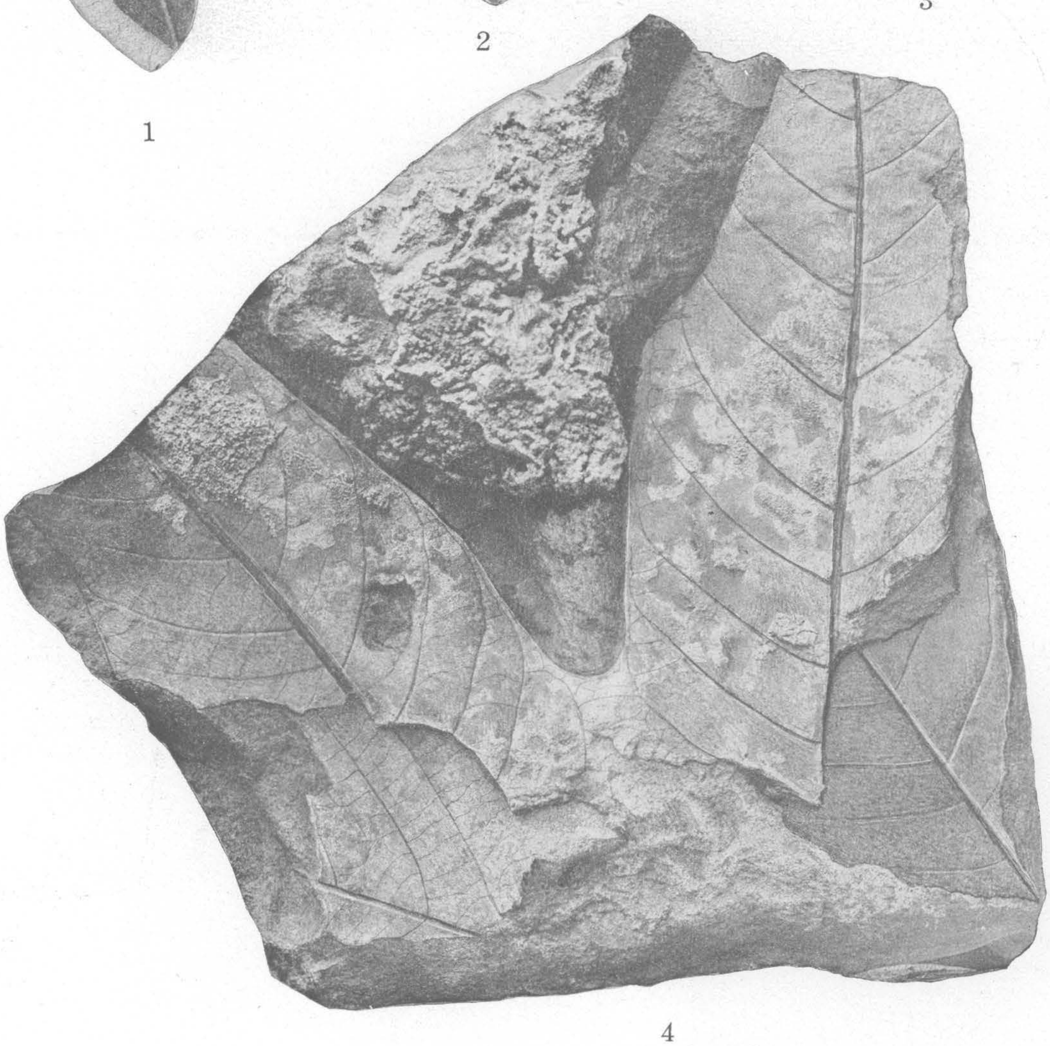

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FOSSIL PLANTS FROM THE WILCOX GROUP.

FOSSIL PLANTS FROM THE WILCOX GROUP.

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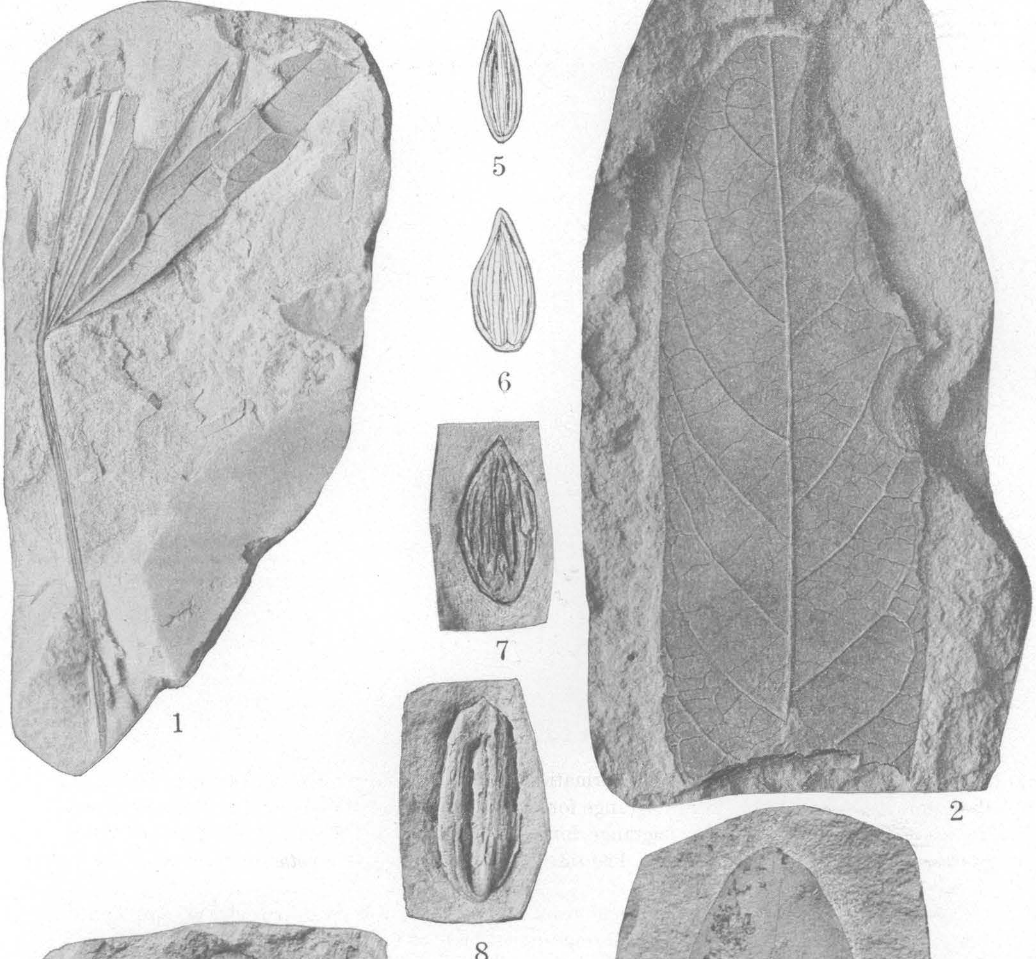
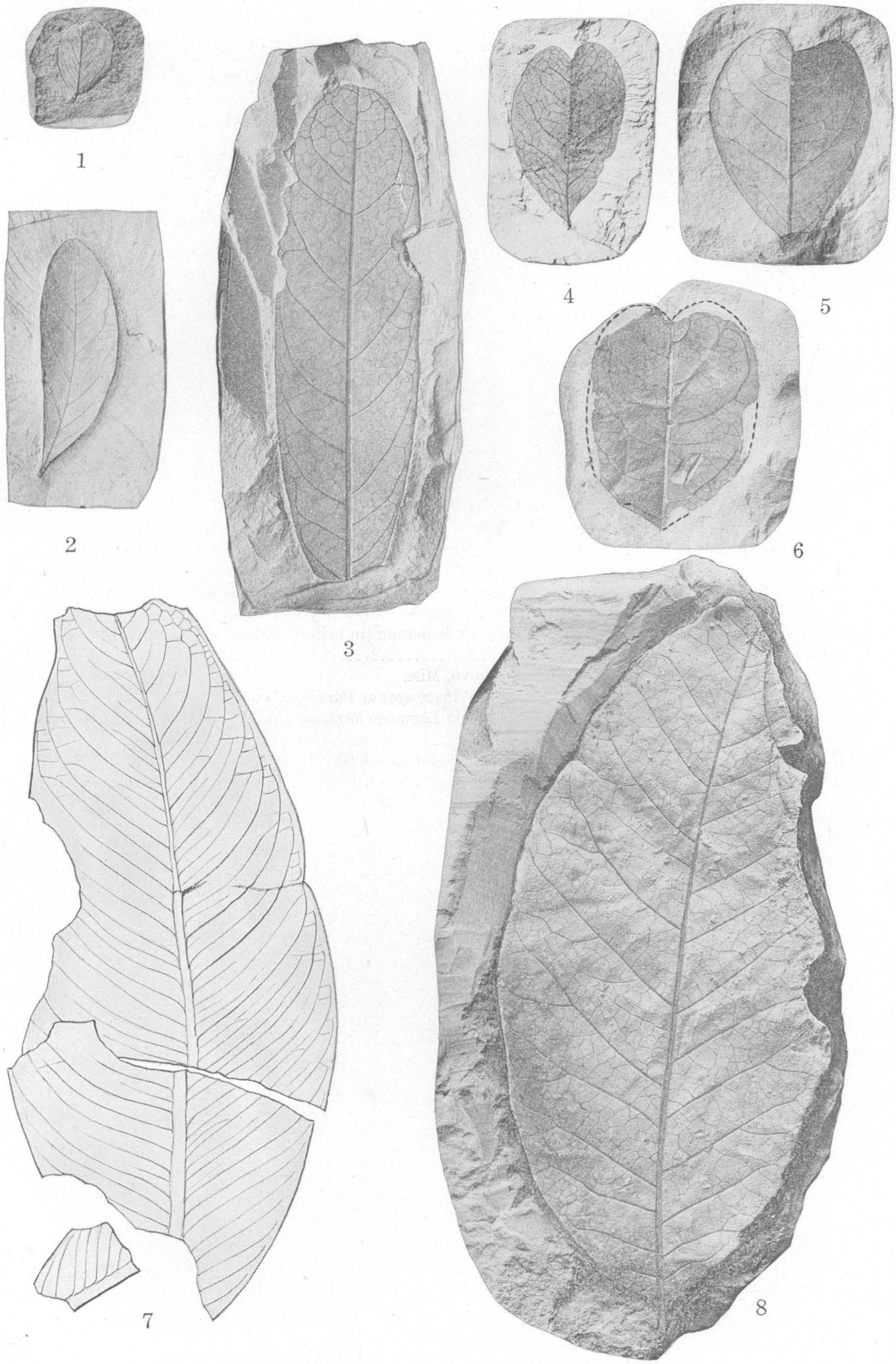


FOSSIL PLANTS FROM THE WILCOX GROUP.



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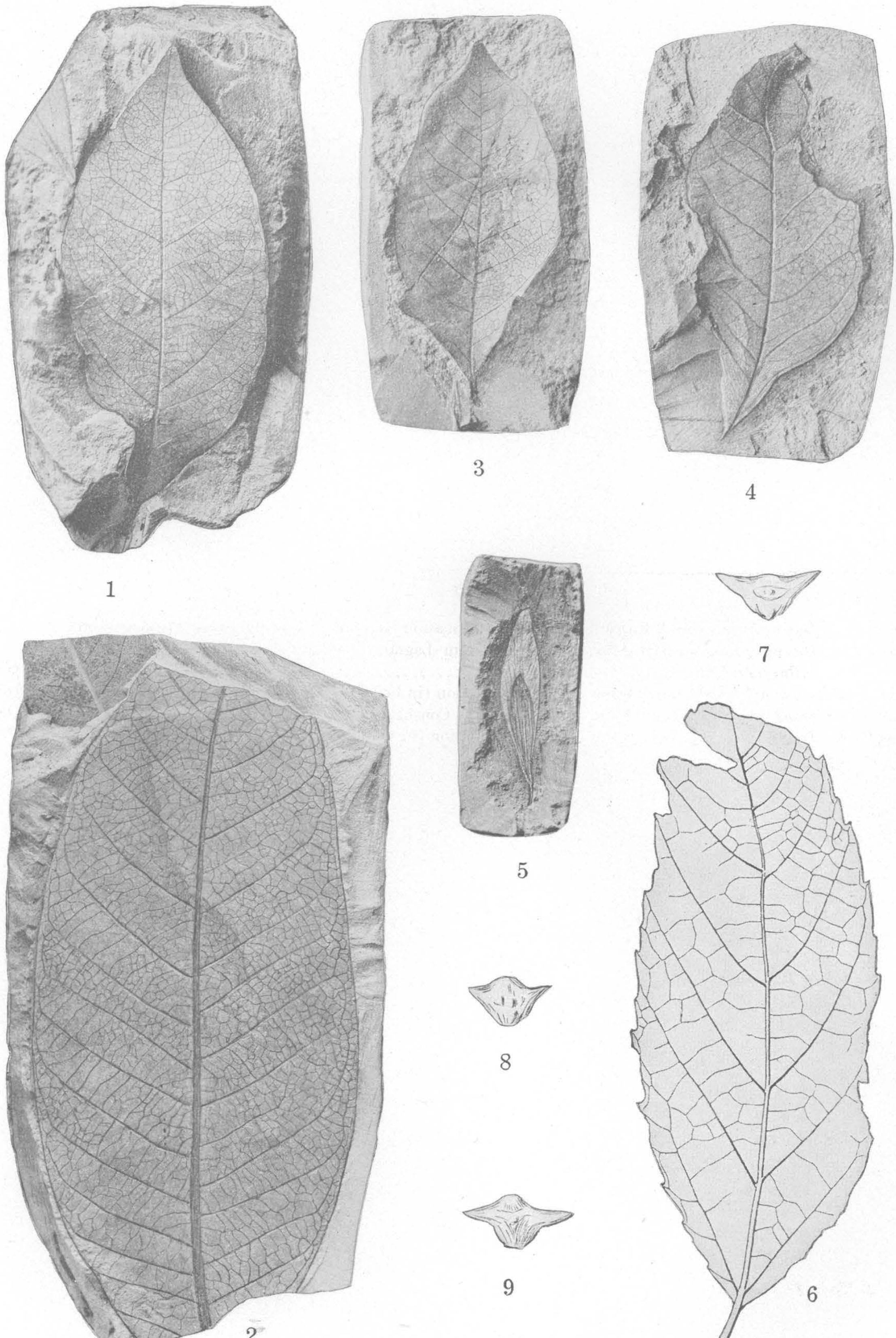
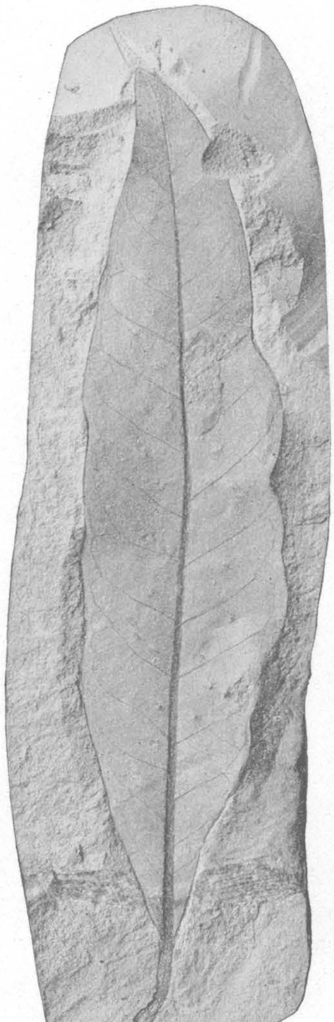


FOSSIL PLANTS FROM THE WILCOX GROUP.



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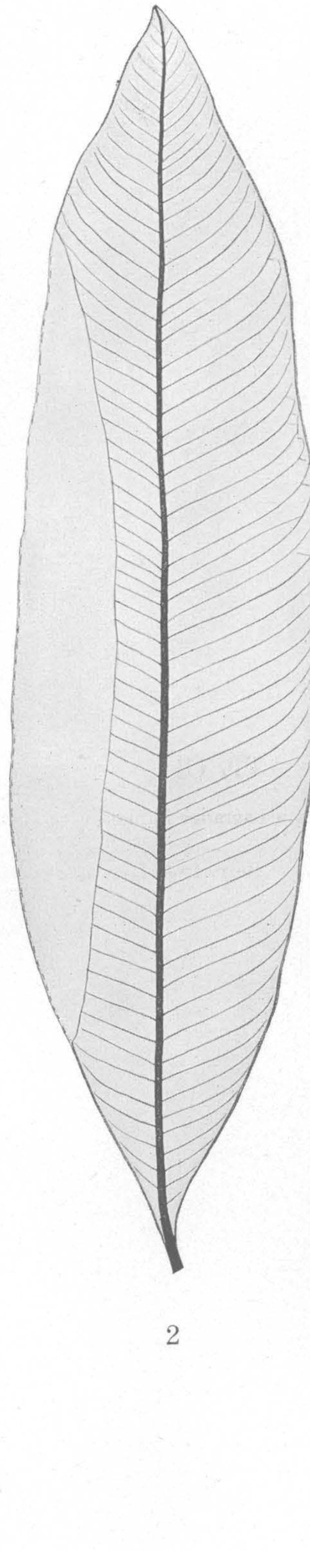

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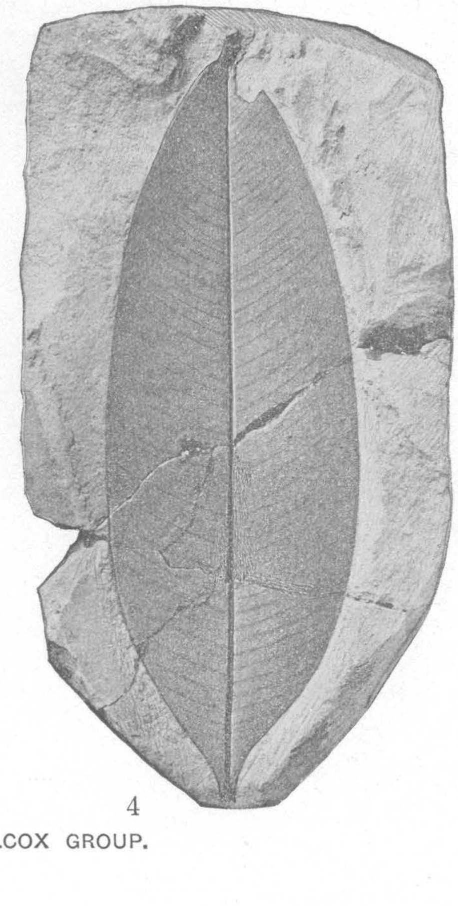

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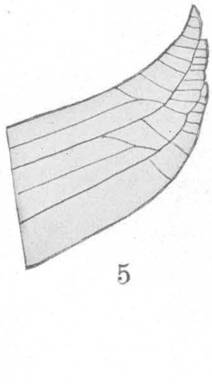

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FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE CII.

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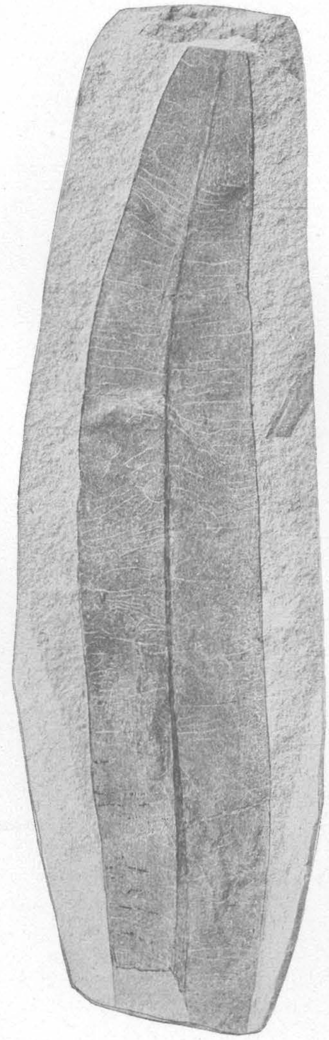

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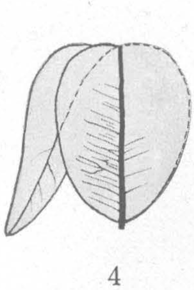

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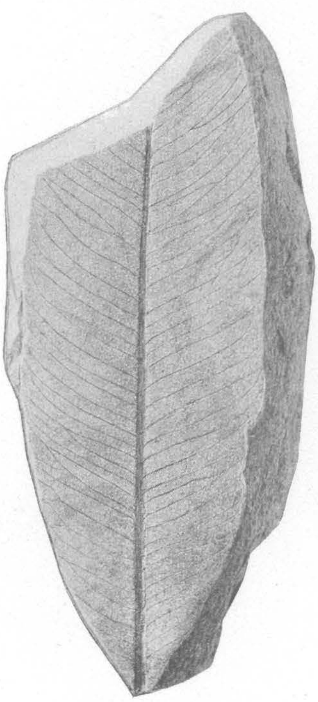

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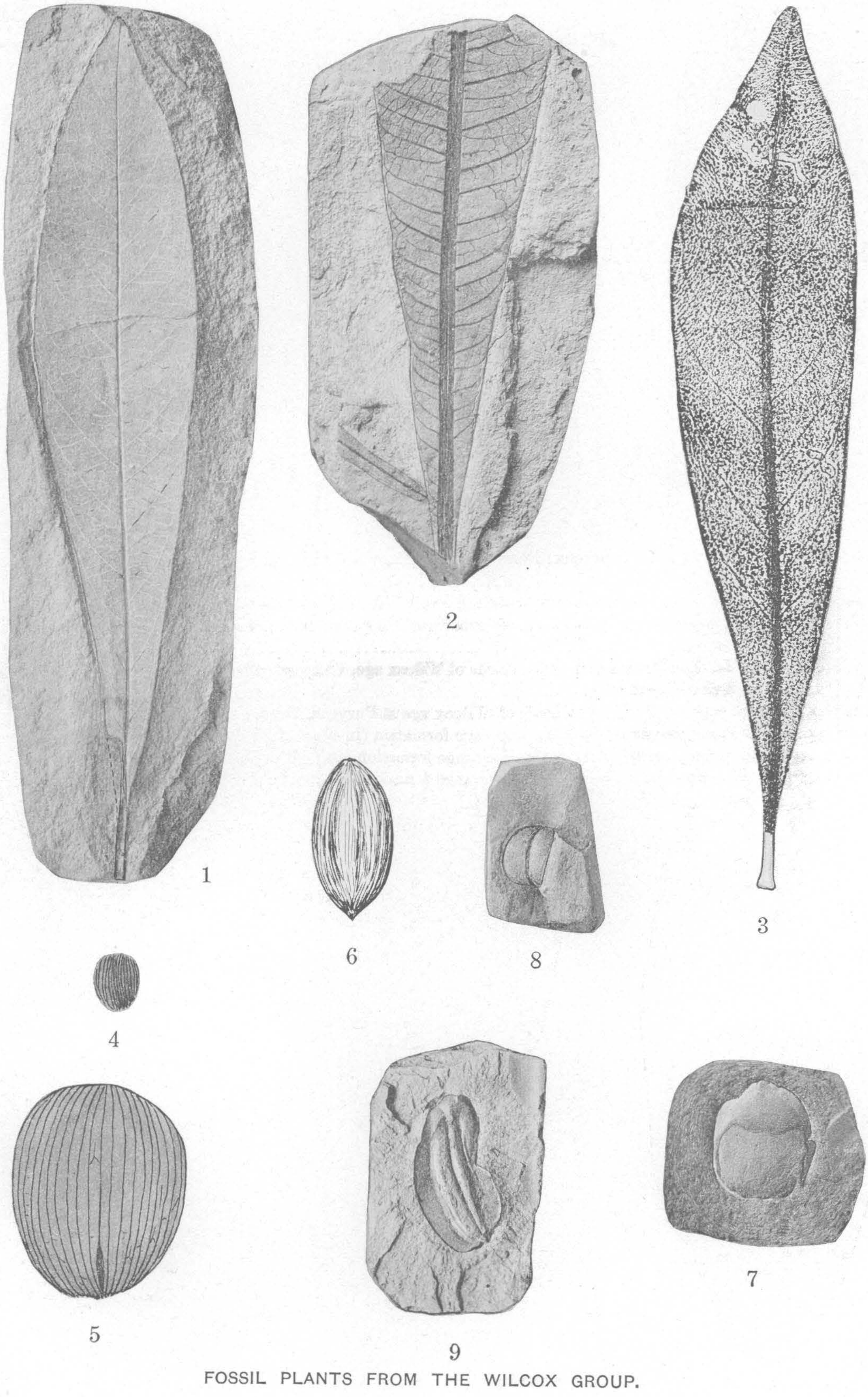

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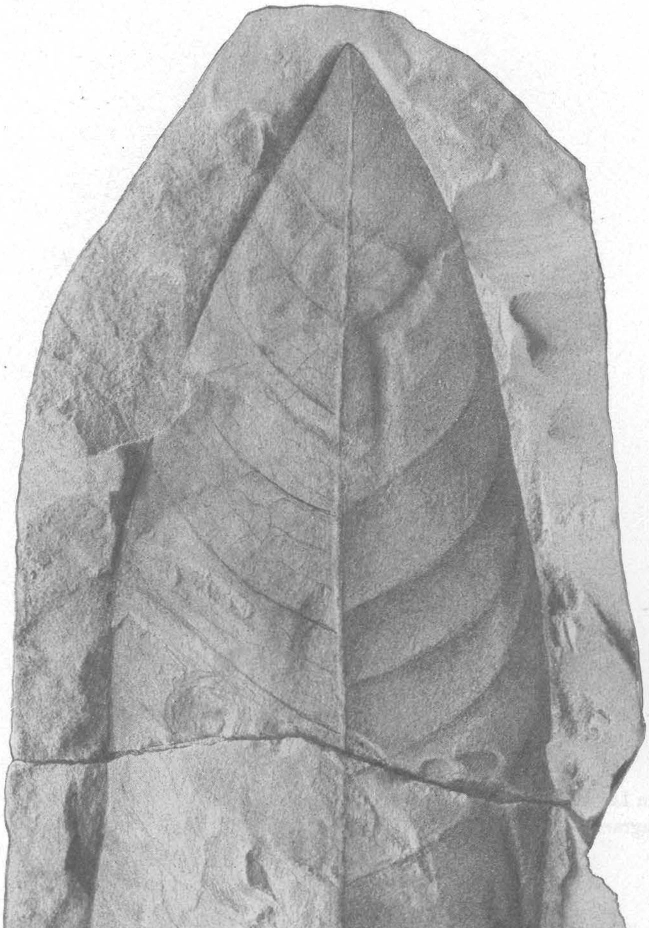

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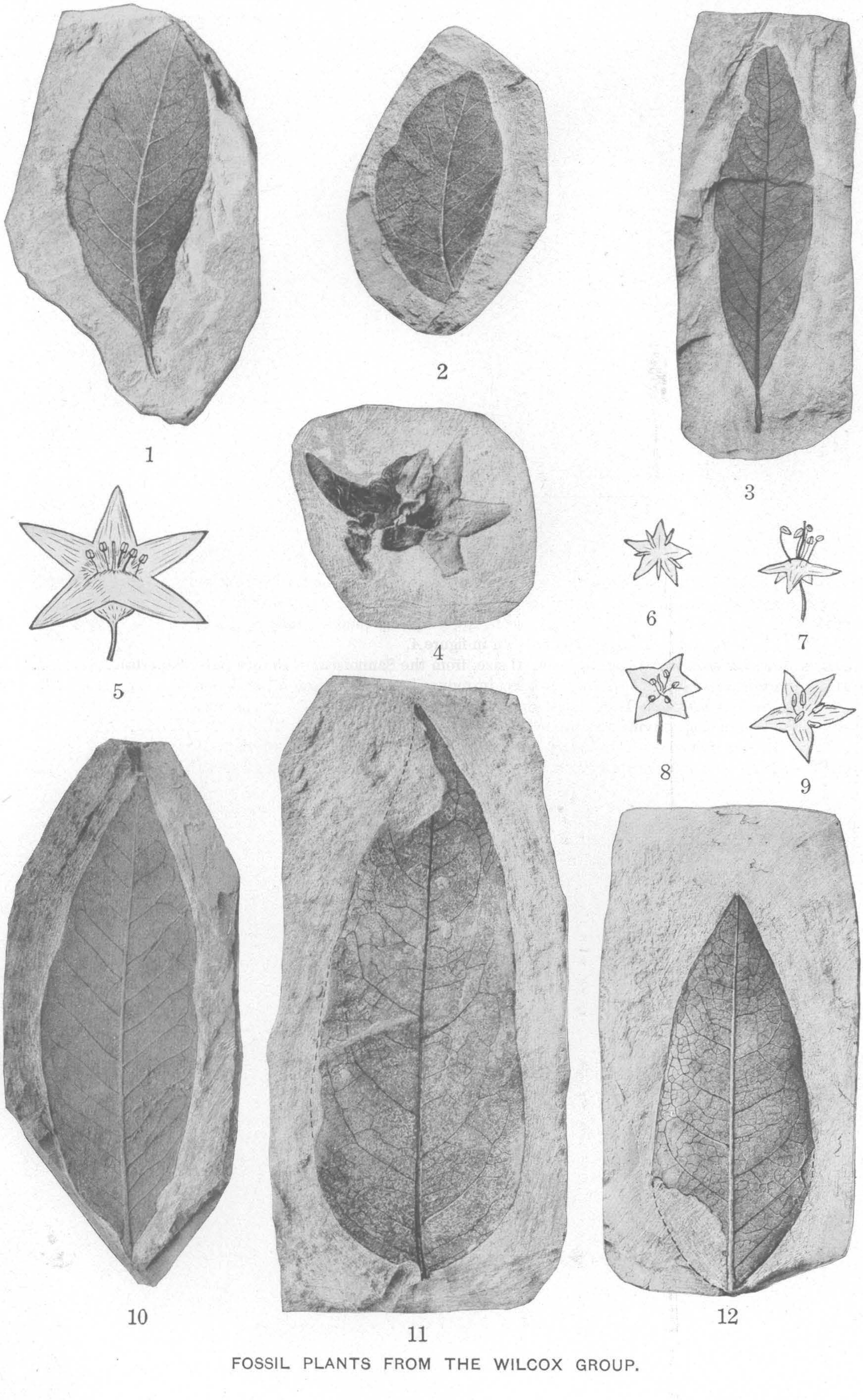
FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE CVI.

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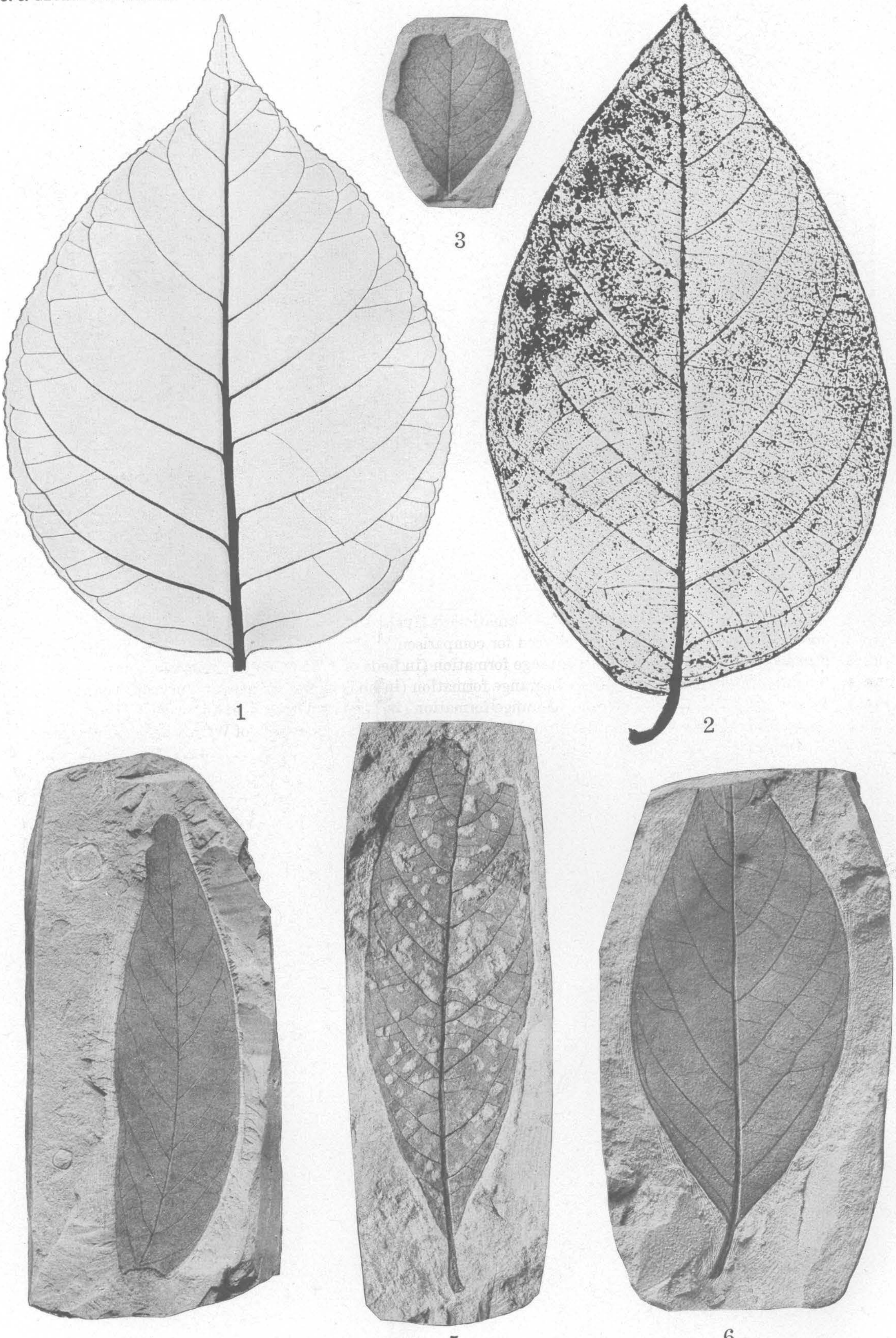

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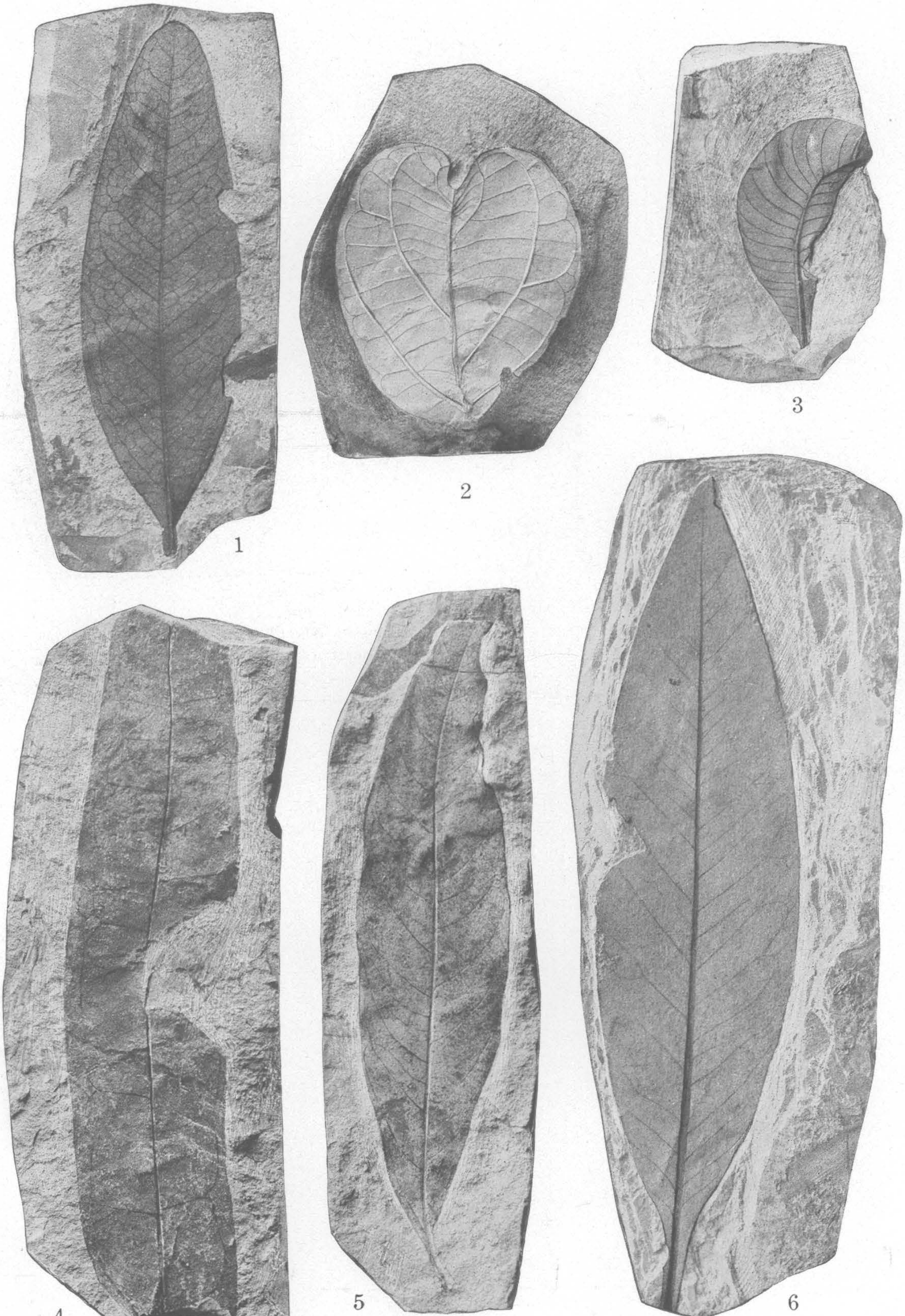

FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE CVIII.

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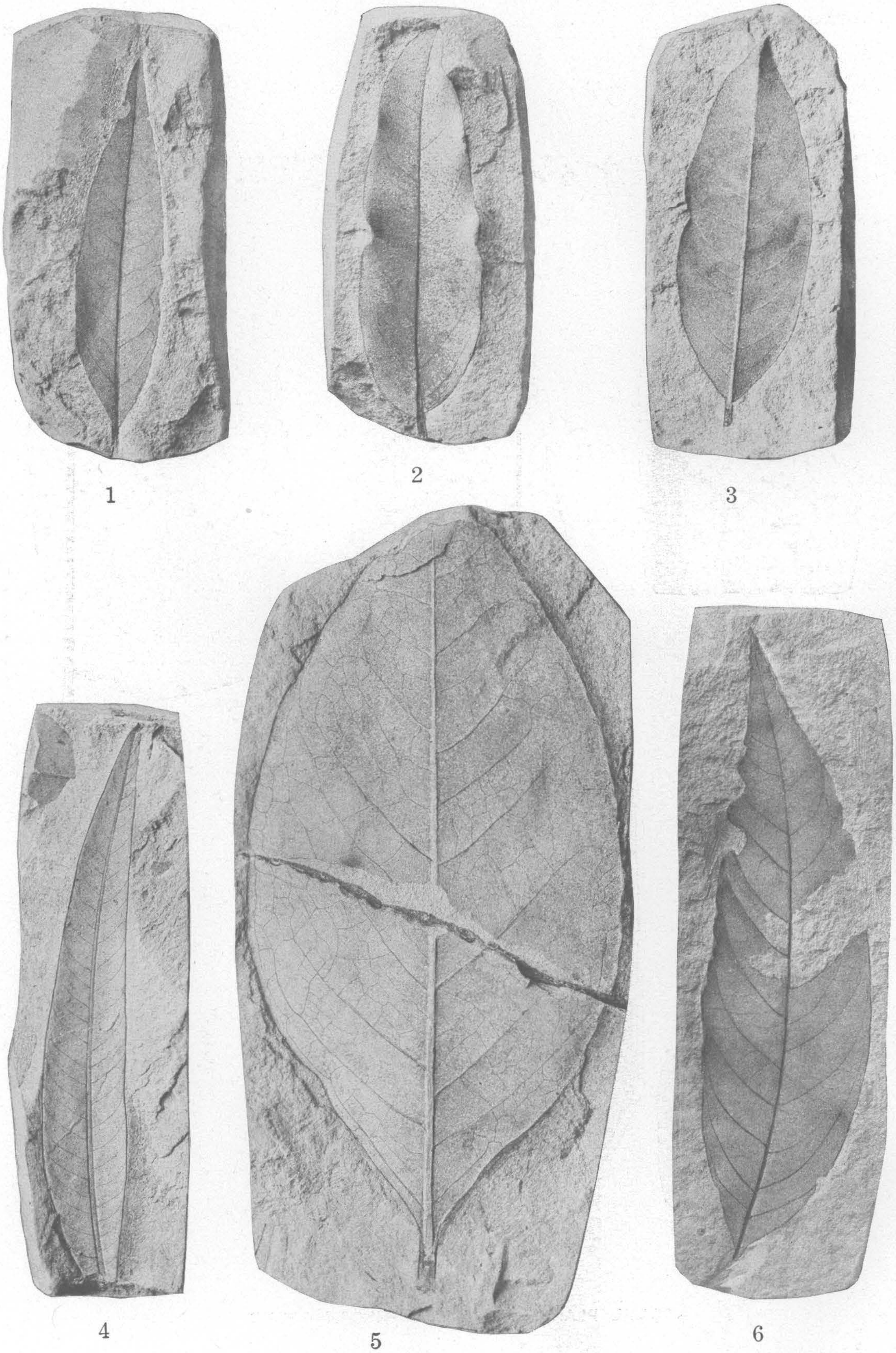
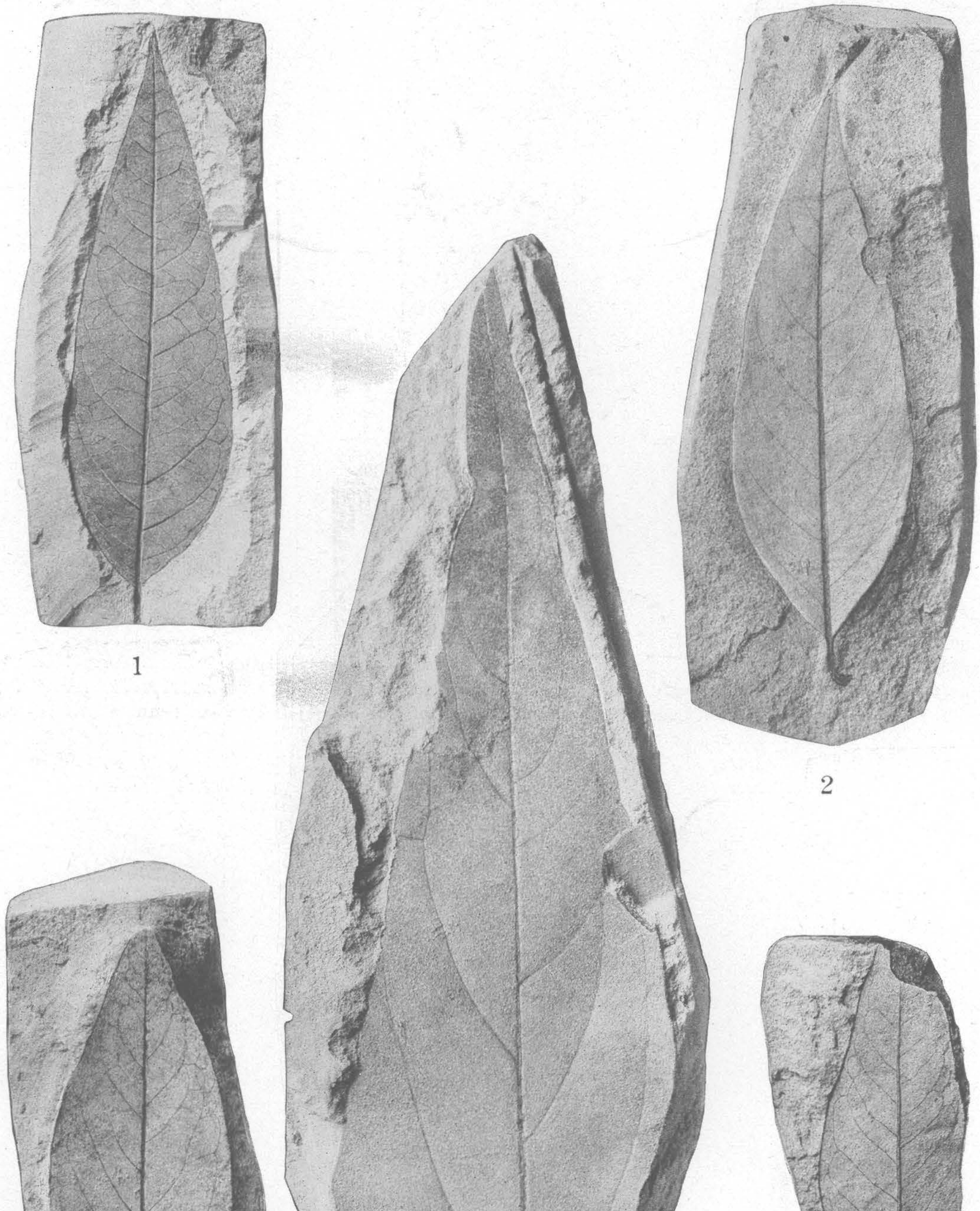
All specimens from Lagrange formation (in beds of Wilcox age) at Puryear, Tenn.



FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

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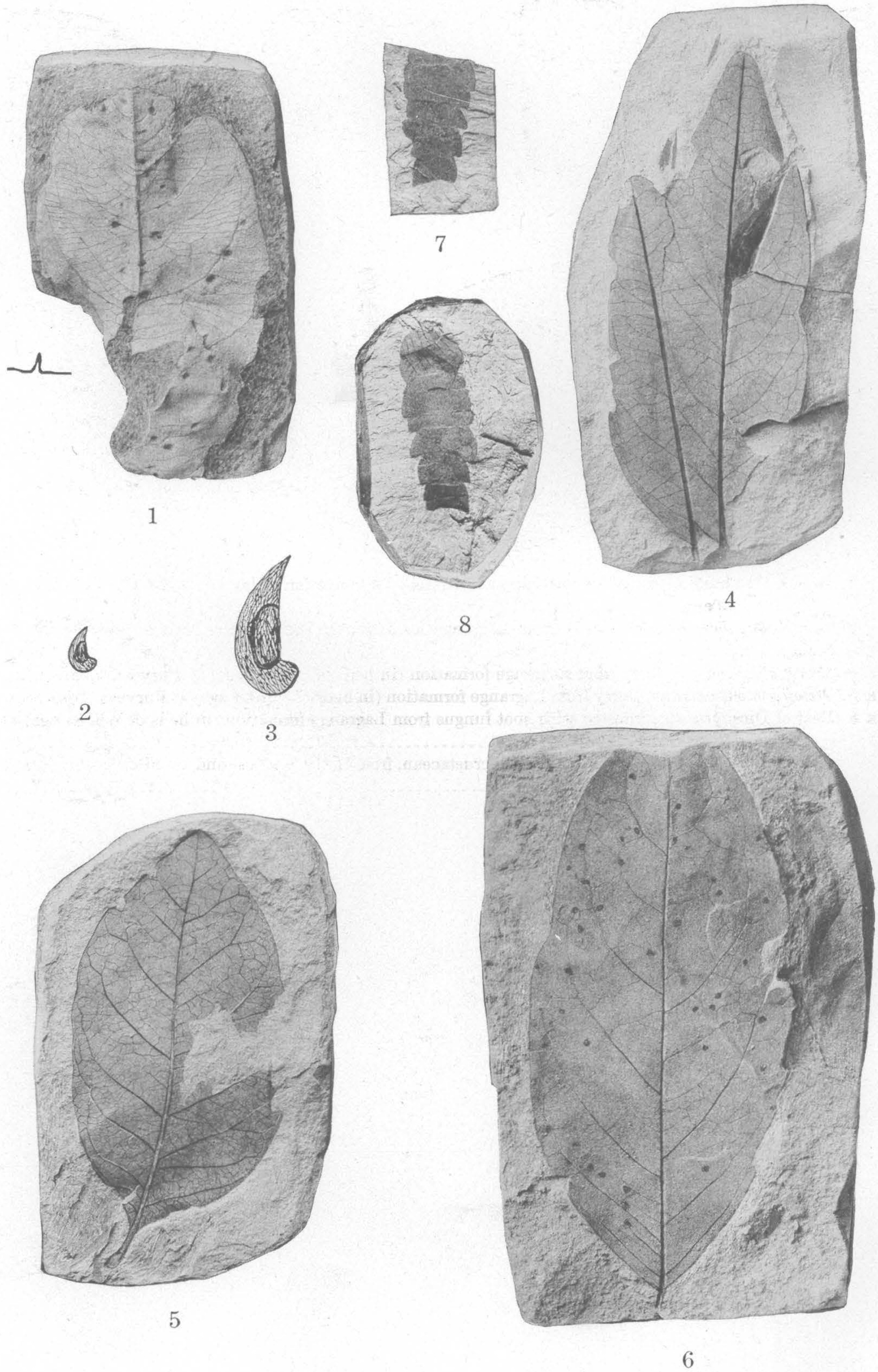
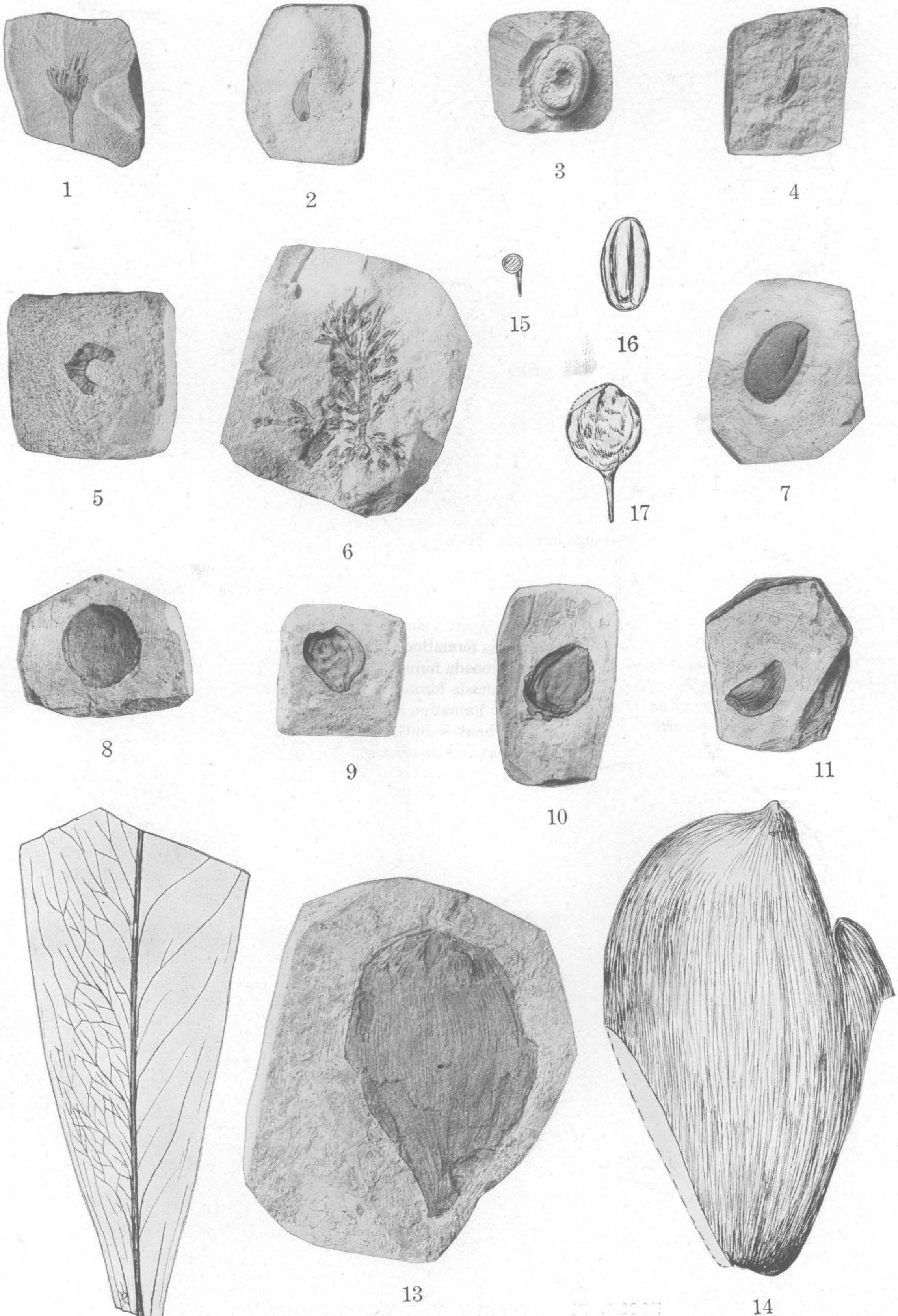


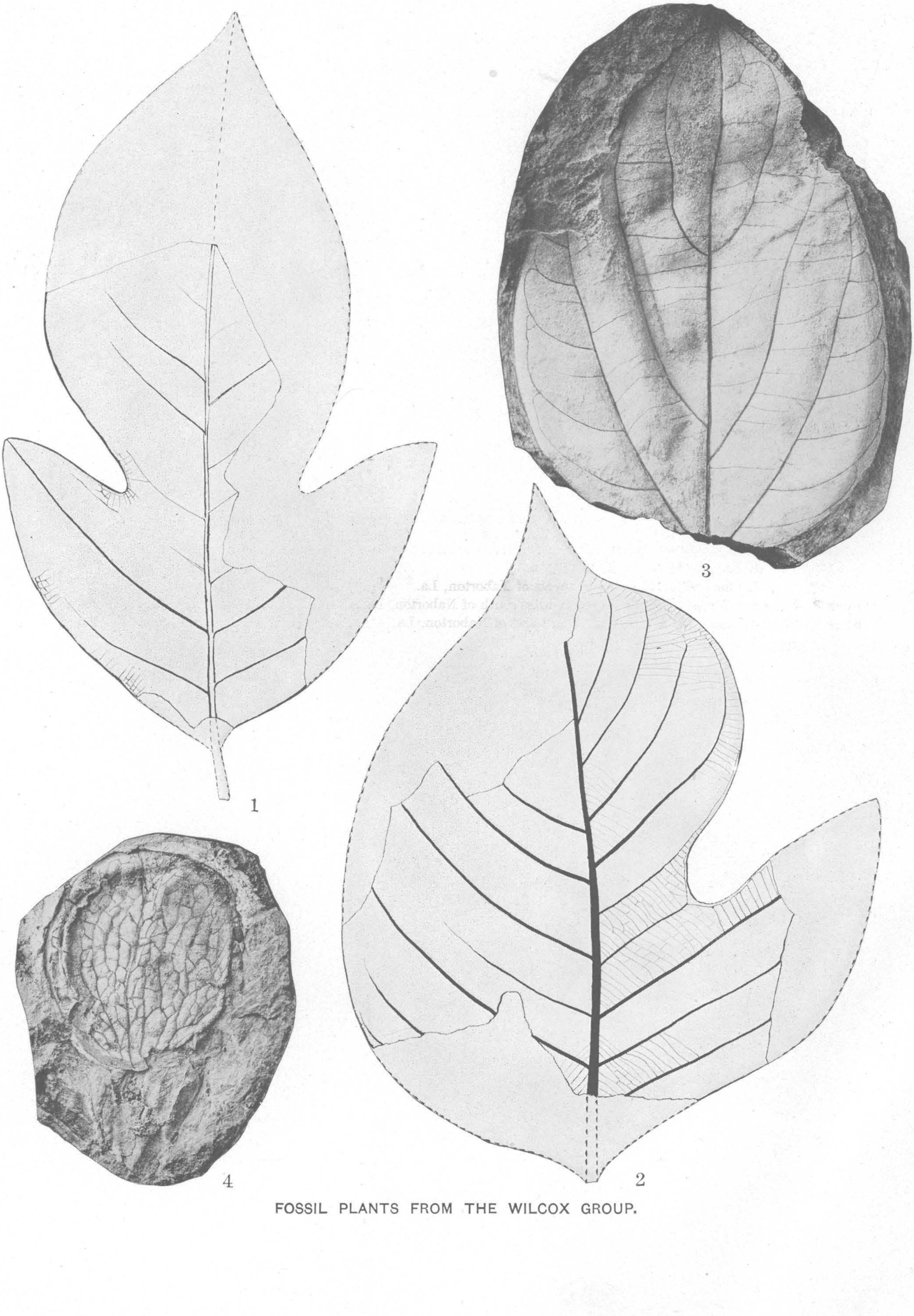
FOSSIL PLANTS FROM THE WILCOX GROUP.



FOSSIL PLANTS FROM THE WILCOX GROUP.

PLATE CXII.

PLATE CXIII.



FOSSIL PLANTS FROM THE WILCOX GROUP.

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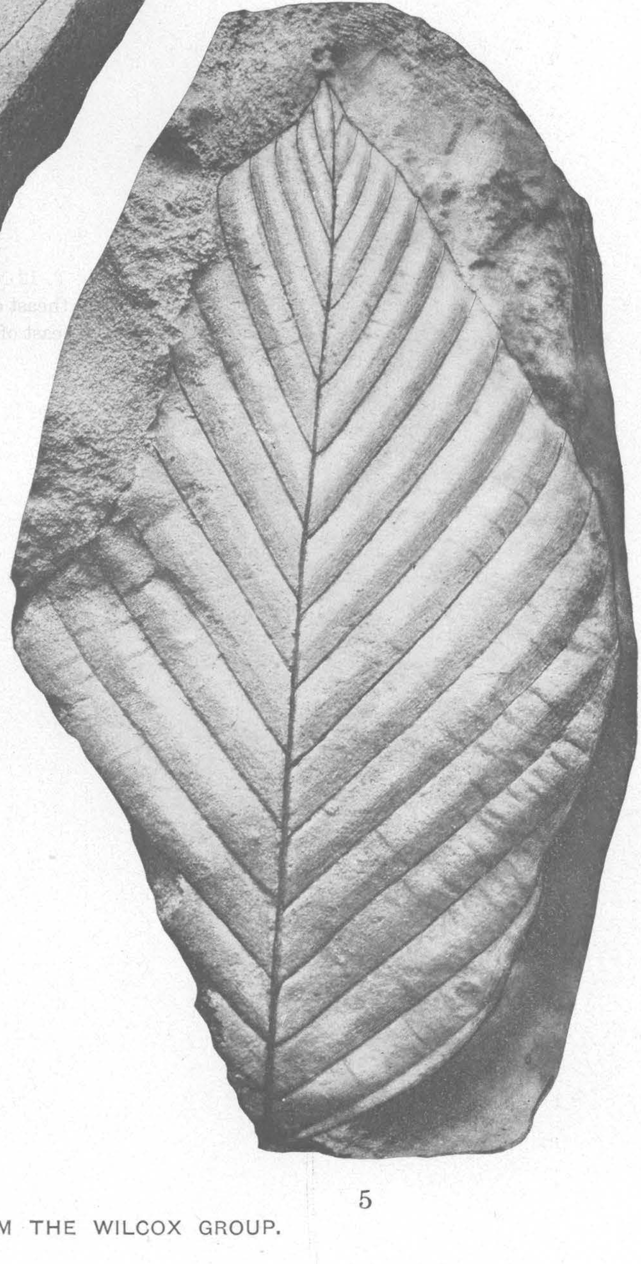

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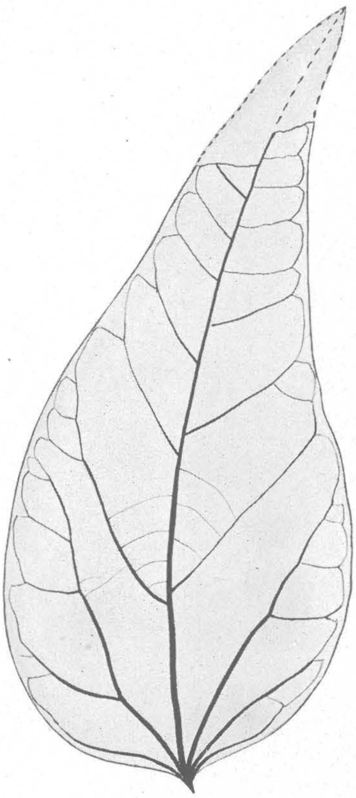

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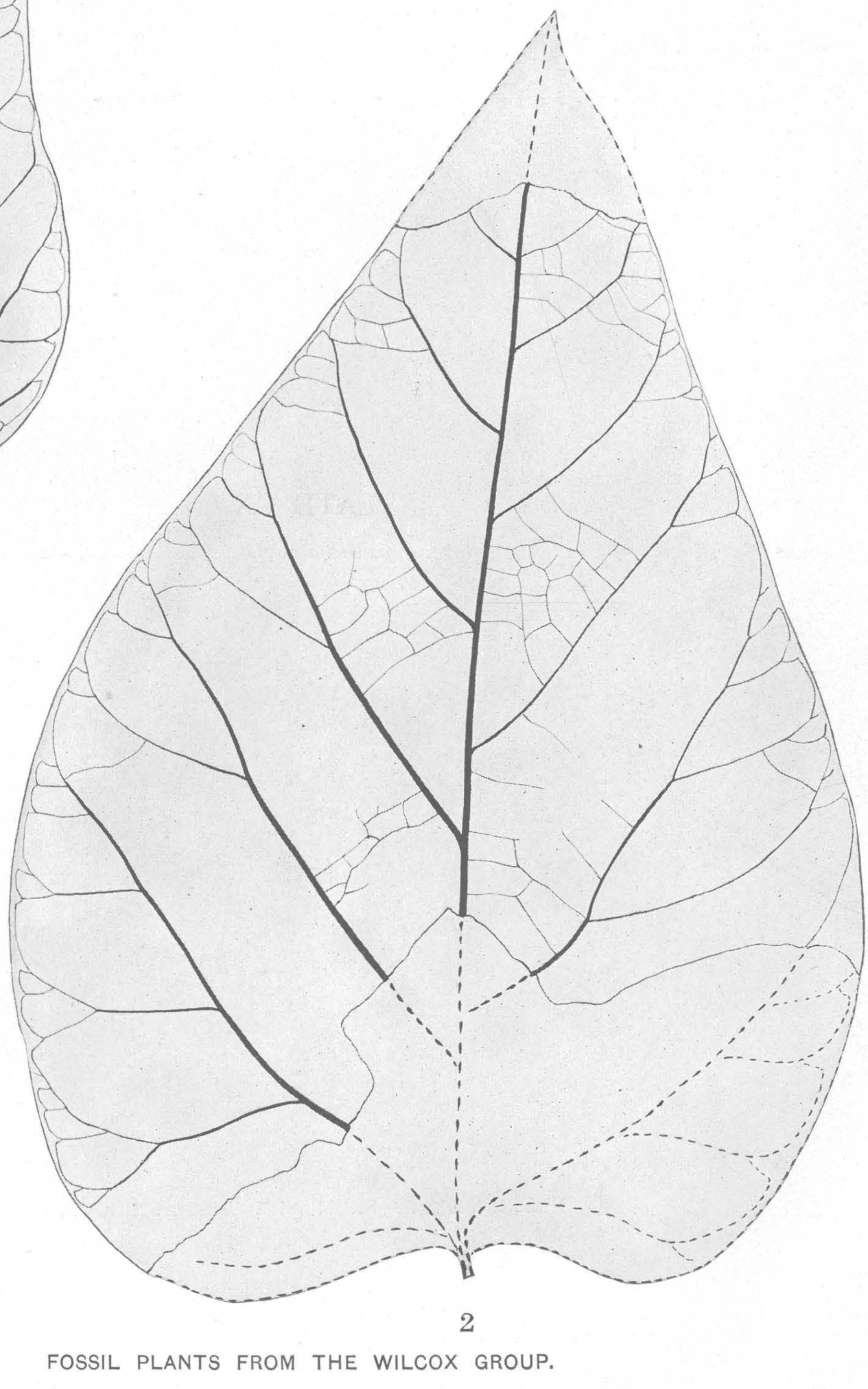

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FOSSIL PLANTS FROM THE WILCOX GROUP.

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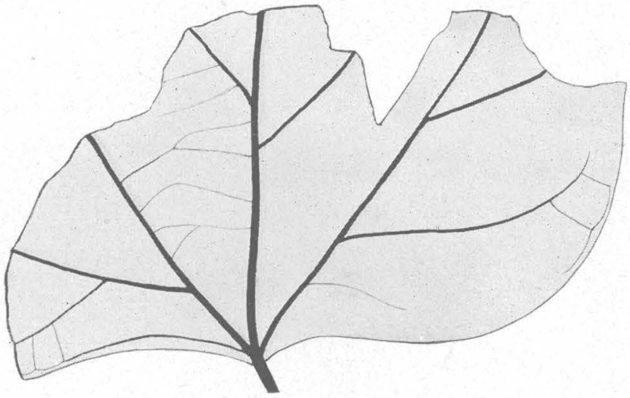

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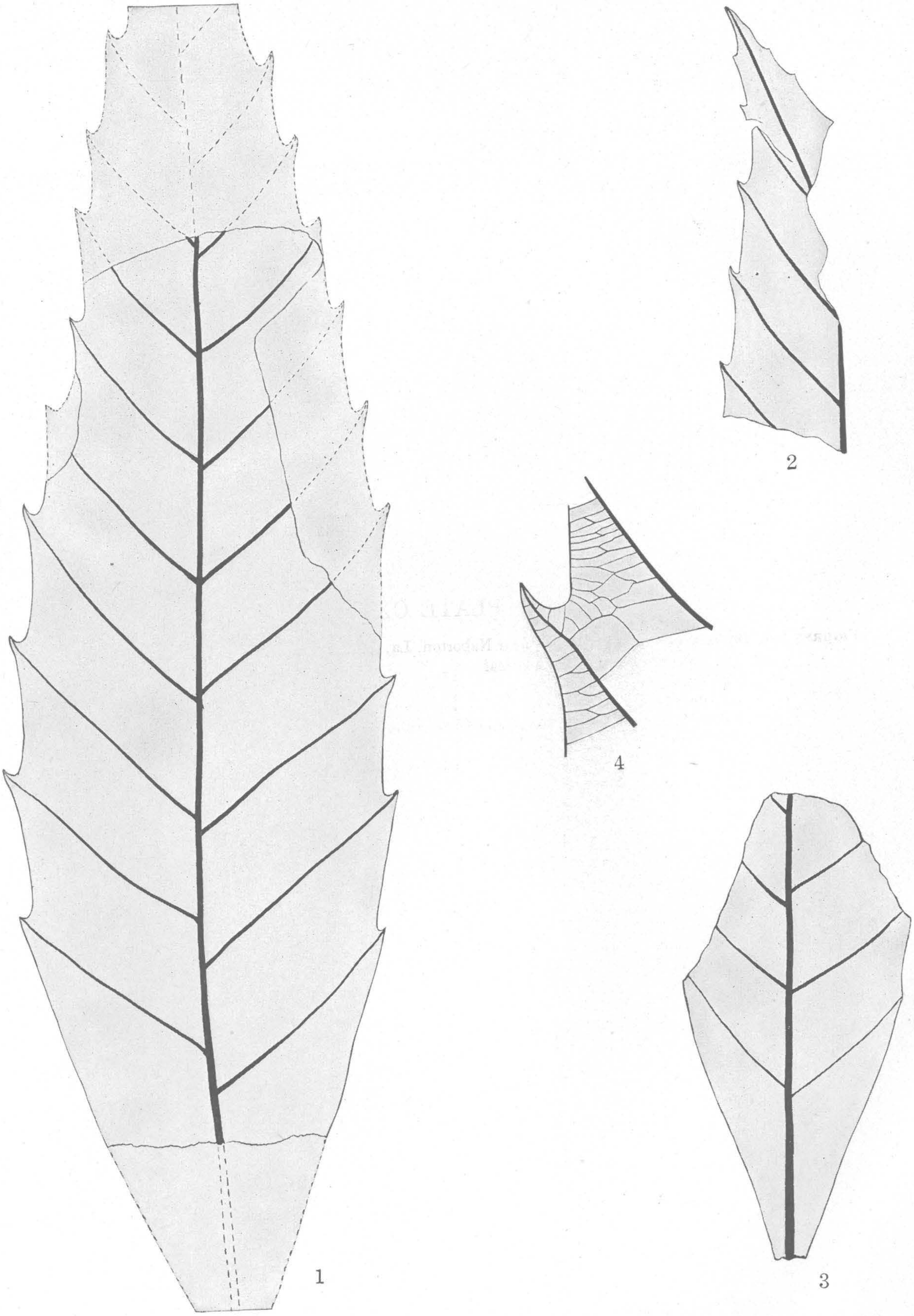

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Names in *italic* are synonyms; figures in **black face** indicate descriptions; figures in *italic* indicate illustrations.

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