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THE MIDDLE AND UPPER EOCENE FLORAS OF SOUTHEASTERN NORTH AMERICA

BY

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THE MIDDLE AND UPPER EOCENE FLORAS OF SOUTHEASTERN NORTH AMERICA.

By EDWARD WILBER BERRY.

INTRODUCTION.

SCOPE OF REPORT.

This report gives the results of several years of field and office studies of the middle and upper Eocene fossil plants of the southern Coastal Plain, most of them found in the region known as the Mississippi embayment. It may be regarded as a continuation of a report published in 1916,[1] which described and interpreted the extensive floras of the lower Eocene beds of that region.

At the time this report was written, in 1917, my botanical experience was restricted to the United States, and I based most of my ecologic or climatic deductions on the literature, which later studies, made in the Tropics, proved to be somewhat misleading or erroneous, and I am now convinced that most paleobotanists, nearly all of whom have been dwellers of the Temperate Zone, have been similarly misled. Since 1917 I have had an opportunity to see the living flora in the Antilles, in Central America, and particularly in tropical Bolivia and Peru. My study of the upland flora of those parts of Bolivia and Peru that border the basin of the Amazon disclosed some remarkable facts. Plants that are elsewhere coastal tropical types, such as *Dodonaea*, *Swietenia*, and *Sapindus saponaria*, grow on the lower slopes of the eastern Andes, as if they had been stranded there by the withdrawal of a Pliocene sea. I noted also—and this fact is more significant to the student of paleoecology—that many of the genera and even species of the lowland Tropics extend to elevations that carry them in effect well out of the Tropical Zone, and I came back from that region with the conclusion that none of the fossil floras of the Temperate Zone that paleobotanists have termed tropical are in the strict sense of the word "tropical." Most of these fossil floras contain representatives of numerous genera that are now confined to the Equatorial Zone, but many of these genera are large and contain species that are adapted to a variety of habitats.

These facts apply with particular force to the attempted interpretations of the environment of the Claiborne, Jackson, and Vicksburg floras, and although that environment may have been almost tropical, I would modify the published statements concerning it. Thus, the Jackson and Vicksburg may be considered the most nearly tropical known floras of southeastern North America, but I would no longer call them "strictly tropical." Similarly, after seeing tropical marine faunas, both Miocene and Recent, I am less inclined to classify as strictly tropical some of our fossil marine faunas, such as that of the Vicksburg, although they too may be almost tropical.

I hope to continue these studies until all the known Mesozoic and Cenozoic plants of the region have been described and their horizons determined. The work done has included descriptions and discussions of the Upper Cretaceous floras of the eastern Gulf area [2] and preliminary accounts of the Oligocene,[3] lower Miocene,[4] and Pliocene [5] floras. This series of

[1] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, 481 pp., 117 pls., 1916.

[2] Berry, E. W., Upper Cretaceous and Eocene floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia: U. S. Geol. Survey Prof. Paper 112, 177 pp., 33 pls., 1919.

[3] Berry, E. W., The flora of the Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98, pp. 227–251, pls. 55–60, 1917.

[4] Berry, E. W., The physical conditions and age indicated by the flora of the Alum Bluff formation: U. S. Geol. Survey Prof. Paper 98, pp. 61–73, pls. 7–10, 1917.

[5] Berry, E. W., The flora of the Citronelle formation: U. S. Geol. Survey Prof. Paper 98, pp. 193–208, pls. 44–47, 1917.

reports, when it is completed, will furnish a comprehensive paleobotanic history of a very large area that is to-day and was throughout Upper Cretaceous and Tertiary time a single physiographic province—the Coastal Plain.

As I have already repeatedly stated, this region is physiographically unique; it rivals the Paris Basin in the unity of its geologic history, in its stability in altitude, and in the abundance of its alternating marine faunas and terrestrial floras. Because of its large size, its proximity to the American Tropics, and its long, uniform, and relatively unbroken geologic record its fossil plants also furnish unique and invaluable suggestions as to the evolution and geographic distribution of floras. During the whole of the Tertiary period it was the low-lying southern part of a continental land mass that was bordered on the south and southeast by an ocean, so that its meteorologic conditions were comparatively uniform. Throughout its long history tectonic activity was so slight as to be negligible; no mountain ranges were formed, and the strata deposited were almost undisturbed. Whether the alternating inundations and emergences of these low-lying coastal lands were due to changes in the level of the land or to changes in the level of the sea the changes were relatively slight as compared with those that occurred, for example, in the western United States or in southern Europe, two regions whose paleobotanic history has been fairly well worked out. The record of the evolution of the successive floras in southeastern North America was therefore not complicated by a diversity of conditions, as it was in the uplifting Rocky Mountains or in the mountainous areas of central and southern Europe, and it is consequently more easily deciphered and more readily applied to the interpretation of geologic history.

I am, as usual, indebted to many friends, both at home and abroad, for assistance rendered during the progress of the work, and especially to my associates in the study of the Coastal Plain, particularly Mr. T. Wayland Vaughan, who has had general charge of the Geological Survey's Coastal Plain investigations and who, as one of the pioneers in this country in the interpretation of faunas and sediments, has been a constant source of inspiration. I am indebted to Messrs. O. M. Ball, A. C. Trowbridge, E. T. Dumble, and C. L. Baker for collections from Texas and to Messrs. E. N. Lowe, G. C. Matson, L. W. Stephenson, C. W. Cooke, and Alexander Deussen for collections and information from different parts of the Mississippi embayment.

AREA CONSIDERED.

The term "southeastern North America" as here used 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 have been found in this area except those that were preserved in coastal deposits that lie within the present Gulf and Atlantic Coastal Plain.

During the long ages of the Tertiary period the region here considered was coextensive with the floral or faunal province of which it was a part. From the end of the Cretaceous to the beginning of the Miocene it formed a part of the floral province that included also 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. So little is known of either the geologic history or the Tertiary flora of the Antillean or Central American regions that they can not yet be brought within the scope of this paper, 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 features, until these strategic areas have been studied.

Nor can the northern limit of the Tertiary floral province be fixed at latitude 41°. Obviously the coastal flora that is so largely represented in the collections here studied did not continue inland as a unit over areas remote from the estuaries and coastal lagoons in which the relics of these floras were preserved. At the same time there is much evidence that the land was generally low, at least in Eocene and Oligocene time, and the evidence afforded by traces of the inland flora that were fortunately preserved in fluviatile or lacustrine lignite at Brandon, Vt., justifies the conclusion that the pre-Miocene Tertiary flora had the same general facies throughout a large region which extended northward beyond the limits here indicated. The flora from the

lignite at Brandon has usually been considered Miocene, but I have presented evidence to show that it is Eocene.[6]

Most of the fossils here considered were collected in the region known as the Mississippi embayment, and nearly all from a relatively small area in the extensive region that now forms the States of Louisiana, Arkansas, Texas, Alabama, Tennessee, and Mississippi. The limits of this region also are fixed by its geologic history, for the shallow shifting marginal waters here furnished conditions suitable to receive and preserve the vegetable débris of the near-by mainland.

The region thus defined embraces roughly 1,500,000 square miles, and in times past it doubtless furnished a congenial habitat for several thousand specific types, of which we can hope to know only a small number.

OUTLINE OF GEOLOGIC HISTORY.

The Claiborne and Jackson epochs, together with the interval between them and the interval between the Wilcox and Claiborne epochs, correspond to the old Parisian stage of D'Orbigny and to the Mesonummulitic stage of Haug. The succession of events in the Mississippi embayment and that in the Paris Basin seem to show a striking agreement, which is considered elsewhere in this paper (p. 30). The general course of events in the Mississippi embayment may be briefly sketched as follows: After the deposition of the Wilcox sediments, which were laid down later and later along the strand as it retreated southward, there was a considerable period of emergence, during which continental deposits accumulated on the lowland surface. These were not very thick nor were they continuous over large areas, and the beds of lignite that represented palustrine accumulation, of sand that represented river deposition, or of clay that represented lake or flood-plain deposition, and that escaped erosion, are so small and scattered and so like the deposits both subjacent and superjacent to them that it has not yet been possible to differentiate them.

This post-Wilcox period of slight emergence, which corresponds to the lower Lutetian stage of Europe, was long enough to permit remarkable changes in both the marine faunas and the terrestrial floras. It was succeeded by a transgression of the sea, marked in the eastern Gulf area by the sands and associated sediments of the Tallahatta formation, by the St. Maurice formation of Arkansas and Louisiana, and by the Mount Selman formation of Texas.

The Tallahatta deposits and their equivalents, which were laid down later and later along the shore as the sea advanced northward, are succeeded by widespread marine deposits that now extend in scattered outcrops from North Carolina to Mexico, representing the maximum expansion of the Claiborne sea, the sediments of which in the eastern Gulf area Hilgard called the "calcareous Claiborne."

The deposits laid down in this great Claiborne sea are represented by the Lisbon formation and its equivalents. The waters were shallow, and the horizon is marked by great reefs of oyster shells. The strand then, in late Claiborne time, began again to retreat southward. This stage was characterized by widespread estuary, littoral, and continental deposits—lignites, clays, and sands, which contain fossil plants. This period of history is represented by the Yegua formation and its equivalents. In southern Alabama and in eastern North Carolina a slight downward movement of the land or rise of the sea was accompanied by the deposition of the marine Gosport sand in Alabama. Except for these more or less local submergences the more general movement of emergence carried the border lands of the Mississippi embayment above the sea, and it is this interval of emergence that marks the hiatus between Claiborne and Jackson time. This emergence was less extensive than that at the beginning of the Claiborne and, especially in the western Gulf area, is marked by recognizable continental deposits.

After this Claiborne-Jackson interval the sea in which the lower Jackson deposits were laid down advanced rapidly northward, its advance constituting the most pronounced transgression, by which typically marine sediments and faunas were carried farther north than at any other time since the transgression of the Midway or basal Eocene—a submergence that carried Jackson sediments northward into northeastern Arkansas and western Tennessee. This submergence was in turn followed by a withdrawal of marine waters from parts of the area, especially in the western

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

Gulf region, from Arkansas to Mexico, recorded at places, as, for example, in Mississippi, where a thick deposit of littoral sand (the Forest Hill sand) represents, in my opinion, a transition from Jackson to Vicksburg; or in Texas, where the floras found in parts of the lithologic units known as Fayette and Catahoula sandstones are in places of Jackson age and in other places of Vicksburg age. In southern Alabama and eastward marine conditions appear to have been uninterrupted from Jackson to Vicksburg time.

My correlation of the middle and upper Eocene formations of southeastern North America with those of Europe is presented in the following table. It should be borne in mind that this correlation is entirely tentative as regards the exact chronologic position of various marine units lacking fossil plants, which are introduced merely for the sake of giving the general position of the plant-bearing formations in the stratigraphic succession of the different States in the area under discussion.

Approximate relations of the formations of the middle and upper Eocene in southeastern North America and Europe as indicated by the fossil plants.

Age.	Georgia.		Alabama.		Mississippi.	Arkansas.	Louisiana.	Eastern Texas.	Europe.	
	Chattahoochee formation.		Catahoula sandstone.		Catahoula sandstone.	Catahoula sandstone.	Catahoula sandstone.	Catahoula sandstone.		
Oligocene.	Vicksburg group.		Vicksburg group.		Vicksburg group: Bryam calcareous marl. Glendon formation. Marianna limestone. Red Bluff clay.	Vicksburg formation.	Vicksburg limestone.		Sannoisian (Lattorfian).	
					Forest Hill sand.[a]			Frio clay.		
Upper Eocene.	Ocala limestone to west.	Barnwell formation to east.	Jackson formation.	Ocala limestone.	Jackson formation: Yazoo clay member. Moodys calcareous marl member.	Jackson formation.	Fayette sandstone. Jackson formation.	Fayette sandstone. Jackson formation.	Ludian. Bartonian.	Parisian of D'Orbigny = Mesonummulitic of Haug.
Middle Eocene.	Claiborne group undifferentiated to west.	McBean formation to east.	Gosport sand.		Yegua formation.	Yegua formation.	Yegua formation.	Yegua formation.		
			Lisbon formation.		Lisbon formation: "Wautubbee marl." "Decatur sand." "Enterprise green marl."			Cook Mountain formation.	Auversian.	
			Tallahatta formation.		Tallahatta formation.	St. Maurice formation.	St. Maurice formation.	Mount Selman formation.	Luletian.	
Lower Eocene.	Wilcox formation.		Wilcox group (divided into several formations).		Wilcox group (divided into several formations).	Wilcox formation.	Wilcox formation.	Wilcox group (divided into several formations).	Ypresian and older.	

[a] The Forest Hill sand is regarded by C. W. Cooke as of Vicksburg age, approximately equivalent to the Red Bluff clay, because it lies above calcareous clay of Jackson age and below the Mint Spring calcareous marl member of the Marianna limestone, of Vicksburg age. The base of the Mint Spring at Vicksburg contains carbonaceous clay lenses. The marine fauna of the Red Bluff, although predominantly Vicksburg in facies, contains some elements in common with the Jackson.

THE MIDDLE EOCENE OR CLAIBORNE FLORA.

STUDIES OF THE CLAIBORNE DEPOSITS.

A history of the study of the deposits that comprise the Claiborne group does not properly come within the scope of this report on the floras but belongs with stratigraphic and paleozoologic studies which are but briefly touched on here and which will form the basis of detailed reports by some of my associates in the study of the Coastal Plain.

With the exception of the frequent mention in geologic works of "petrified wood" or "leaf impressions," most of the latter indeterminable fragments, no definite contributions have been made to our knowledge of the paleobotany of the Claiborne or Jackson. A few specimens of petrified wood obtained from beds of this age in eastern Texas were described by Penhallow,[7] and I have published [8] several preliminary accounts of interesting forms. The supposed Claiborne flora from eastern Georgia that was described by me [9] in 1914 was obtained, as has since been shown, from deposits that are now correlated with the lower Jackson.[10] Its reference to the Claiborne was based on the marine invertebrates with which it was associated, as determined by the paleontologists of the United States Geological Survey. But additional collections and further study of the marine invertebrates by Survey paleontologists have led to the assignment of the beds to the Jackson, instead of the Claiborne.

The name Eocene was first used in American geologic literature to designate American deposits in Lea's "Contributions to geology," published in 1833, where it was applied to the classic fossiliferous outcrop at Claiborne Landing on Alabama River, in Monroe County in southern Alabama, the type locality of the Claiborne, which, however, is found also at Lisbon, Gosport, and Rattlesnake Bluffs. The next year Conrad [11] proposed the name Claiborne as a formational unit, and he referred to the subject again in the following year.[12]

CHARACTER, SUCCESSION, AND DISTRIBUTION OF THE DEPOSITS.

In the type region of the Claiborne along Alabama River the variegated laminated sandy clays and cross-bedded fossiliferous sands of the Hatchetigbee, the uppermost formation of the Wilcox group in this region, are overlain by a considerable thickness of aluminous sandstones and siliceous claystones—the "siliceous Claiborne" of Hilgard, or Tallahatta formation, as it is now known, constituting the lowermost formation of the Claiborne group as developed in this region. Except for diatoms and radiolarians these beds contain few fossils, but they become more calcareous and more fossiliferous toward the east, across southern Alabama. Near the Mississippi line in that State they contain in many places extensive beds of fossiliferous glauconitic sands. The thickness of these early Claiborne deposits ranges from about 200 feet in southeastern Alabama to about 400 feet at the place where they cross into Mississippi.

Overlying the Tallahatta formation is about 115 feet of fossiliferous calcareous argillaceous sands and sandy clays, in some places glauconitic. These beds constitute the "calcareous Claiborne" of Hilgard, which is now termed the Lisbon formation, from Lisbon Landing, on Alabama River. A large invertebrate fauna has been described from these beds, which in their upper half are crowded with *Ostrea sellaeformis* and innumerable shells of *Pecten deshayesii*. Upon the Lisbon, though not

[7] Penhallow, D. P., Notes on fossil woods from Texas: Roy. Soc. Canada Trans., 3d ser., vol. 1, sec. 4, pp. 93–113, figs. 1–8, 1907.

[8] Berry, E. W., A species of *Copaifera* from the Texas Eocene: Torreya, vol. 15, pp. 41–44, figs. 1–5, 1915; An Eocene ancestor of the *Zapodilla*: Am. Jour. Sci., 4th ser., vol. 39, pp. 208–213, pl. 1, 1915; Remarkable fossil fungi: Mycologia, vol. 8, pp. 73–78, pls. 180–182, 1916; Fruits of a date palm in the Tertiary deposits of eastern Texas: Am. Jour. Sci., 4th ser., vol. 37, pp. 403–406, figs. 1, 2, 1914; A fossil nutmeg from the Tertiary of Texas: Idem, vol. 42, pp. 241–245, figs. 1–6, 1916; A middle Eocene member of the "Sea drift": Idem, vol. 43, pp. 298–300, figs. 1, 2, 1917; A middle Eocene *Goniopteris*: Torrey Bot. Club Bull., vol. 44, pp. 331–335, pl. 22, 1917.

[9] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, 1914.

[10] Cooke, C. W., and Shearer, H. K., Deposits of Claiborne and Jackson age in Georgia: U. S. Geol. Survey Prof. Paper 120, pp. 41–81, 1919.

[11] Conrad, T. A., Observations on the Tertiary and more recent formations of a portion of the Southern States: Acad. Nat. Sci. Philadelphia Jour., vol. 7, pp. 116–129, 1834.

[12] Conrad, T. A., Eocene fossils of the Claiborne, with observations on this formation in the United States: Fossil shells of the Tertiary formations of North America, vol. 1, No. 3, pp. 29–36, 1835.

recognized outside of Alabama, lies a bed of highly fossiliferous glauconitic sand. This bed is only about 30 feet thick, but it has yielded many of the shells that have made the name Claiborne famous. It is now called the Gosport sand, from Gosport Landing, a few miles below Claiborne Landing, on Alabama River. The Gosport in this region is overlain by the argillaceous limestones of Jackson age. Thus the Claiborne in the type region of Alabama is between 350 and 550 feet in thickness and is therefore considerably thinner than it is in the region toward the center of the embayment, a feature noted elsewhere in this report. (See p. 29.)

Because of the lack of detailed areal work the character and relations of the Claiborne are obscure in Georgia, although its development in the Chattahoochee drainage basin is similar to that in southeastern Alabama. In central Georgia all traces of the Claiborne disappear by reason of the extensive overlap of the beds of lower Jackson age, which here transgress the strata of the middle and lower Eocene, as well as the Upper Cretaceous and strata that have been considered to be Lower Cretaceous.

The Claiborne reappears in South Carolina, but its development in that State is obscure because of lack of study. It is not known to be represented in North Carolina. The abundance of *Ostrea sellaeformis* and some other Claiborne Mollusca in the Eocene faunas of the Chesapeake Bay region has led some students to consider the upper part of the Chesapeake Bay section as Claiborne in age, and the same age is claimed by some students for the glauconitic sand which is exposed on Shark River, N. J., although by others it is correlated with the Midway.

As the Claiborne passes northwestward across Mississippi its character gradually changes.

Lowe [13] has recognized several lithologic divisions of the Claiborne in Mississippi. The Tallahatta formation, at the base, consists of locally fossiliferous glauconitic and argillaceous sands overlain by yellowish and grayish quartzitic nonfossiliferous sands and sandstones, in turn overlain by white quartzites and claystones or diatomaceous earth, the whole formation having an estimated thickness of probably more than 350 feet. Overlying the Tallahatta are several hundred feet of beds assigned by Lowe to the Lisbon formation. These beds he has subdivided into the following members, in ascending order: (1) "Enterprise green marl," thickness not stated; (2) "Decatur sand," 18 to 25 feet; (3) "Wautubbee marls," about 100 feet; and (4) "Cockfield member," 30 to 200 feet of lignitic clays, sands, and lignites. The lignitic clays at the top of the Claiborne are rather thin in surface exposures, but some well borings have revealed a great thickness of these materials. Thus, in the penitentiary well at Jackson, Miss., 418 feet of lignitic clay was penetrated before reaching fossiliferous marine Claiborne beds. This lignitic clay is considered by Vaughan [14] and others to represent the Yegua ("Cockfield") formation and to be younger than the Lisbon formation of Alabama, Yegua being an older name for the same beds formerly designated "Cockfield" formation in Louisiana and southern Alabama.[15]

That both the Claiborne and Jackson reach unprecedented thicknesses in western Mississippi and eastern Louisiana is well established, though the details are not entirely clear. Thus, in a well near Point Pleasant, La., a typical Lisbon fauna occurs 2,500 feet below the base of the recognizable Vicksburg, so that the combined thickness of the Claiborne and Jackson is at least 2,500 feet at this point. Other well logs in the Vicksburg area of Mississippi also show enormous thicknesses of both Claiborne and Jackson, too great to be explained by differences in lithology and in rate of sedimentation. These thicknesses indicate that sedimentation extended over a longer period in the center of the embayment, well away from its shore, or, in terms of geologic history, that the Claiborne, like the underlying Wilcox, represents an advance and subsequent retreat of the sea. The marine waters of Claiborne time fell far short of reaching the northern limits of the subsequent transgression of the lower Jackson, although the palustrine beds and sediments of the marginal flats of the Yegua or upper Claiborne can be traced well toward the head of the embayment in northeastern Arkansas. No trace

[13] Lowe, E. N., Mississippi, its geology, geography, soils, and mineral esources: Mississippi Geol. Survey Bull. 14, pp. 73–79, 1919.

[14] Vaughan, T. W., in Willis, Bailey, Index to the stratigraphy of North America: U. S. Geol. Survey Prof. Paper 71, p. 738, 1912.

[15] In a report now in course of publication, of which Lowe is a joint author, these lignitic beds are treated as a distinct formation (the Yegua) overlying the Lisbon formation.

of the Claiborne has been detected in western Tennessee. In northeastern Arkansas the Yegua has been traced by Stephenson [16] northward along Crowleys Ridge as far as Greenfield, Poinsett County, Ark., or about 30 miles beyond the most northern outcrop of the lower Jackson cover. There is therefore a possibility that a part of the Lagrange formation of western Tennessee, which lies between the paleobotanically recognizable upper Wilcox near Trenton and near Somerville and the paleobotanically recognizable lower Jackson at Randolph Bluff, may represent the upper Claiborne, although I am inclined to believe that the lower Jackson completely overlaps the upper Claiborne in western Tennessee and rests on the upper Wilcox. Neither Claiborne nor Jackson has been definitely recognized in Kentucky, although certain deposits in the southwestern part of the State are tentatively considered to be of upper Jackson age. In southern Arkansas only the lignitic sands and clays of the Yegua formation have thus far been recognized.

In central Louisiana the Claiborne group appears to be capable of a twofold division into a lower formation, the St. Maurice, and an upper, the Yegua formation. The St. Maurice comprises calcareous, glauconitic, and argillaceous beds containing marine fossils. Its thickness is about 300 feet at Monroe but increases to over 500 feet at Winnfield. On Sabine River its thickness is about 550 feet, and well records in eastern Texas indicate a thickness of 700 feet.

The Claiborne outcrops over a wide area in eastern Texas and is there capable of division lithogically, paleontologically, and genetically into three formations. The basal formation, the Mount Selman, so named by Kennedy in 1892 from the place of that name in Cherokee County, consists of 200 to 400 feet of red ferruginous indurated sand, probably an altered greensand, that contains lenses of clay and lignite and secondary beds and concretions of limonite.

The Mount Selman is overlain by the Cook Mountain formation, so named by Kennedy in 1892 from Cook Mountain, in Houston County. It consists of more than 400 feet of beds of yellow sand and clay which here and there contain lenses of calcareous, glauconitic, and fossiliferous marl and fossil-bearing calcareous concretions, as well as beds and concretions of limonite. Overlying the Cook Mountain is the Yegua formation, so named by Dumble [17] from the creek of that name in Burleson County. It consists of 375 to 750 feet of green calcareous selenitic clays and locally contains lenses of sand and much earthy lignite or lignitic clay.

From Colorado River to the Rio Grande, in Texas, the Claiborne shows a somewhat different character of materials, and its identification is complicated by the tendency of the beds to become more sandy, unfossiliferous, and indistinguishable. The Carrizo sandstone, which is typically developed toward the Rio Grande, consists of gray fine-grained micaceous sandstone, underlain by coarse cross-bedded brown sandstone, in places quartzitic. These sandstones were named by Owen [18] in 1889 from the exposures west of Carrizo Springs, in Dimmit County, and were long considered to be of Wilcox age. Dumble [19] in 1911 transferred them to the base of the Claiborne and considered them the equivalent of the Tallahatta formation of Alabama, and this correlation was accepted in subsequent reports. The beds that are considered to belong to the Carrizo are 200 feet thick along Colorado River, 450 feet thick along the Nueces, and considerably thinner along the Rio Grande.

During the field season of 1921, five years after the foregoing was written, the writer was enabled to study the Carrizo sandstone. It was found to decrease in thickness to a few feet near the Rio Grande, where it was overlain by typical Wilcox beds. Fossil plants were collected from the type locality west of Carrizo Springs and from several other localities, as well as from the immediately overlying and underlying Wilcox beds. These collections and the field study show conclusively that the Carrizo is of Wilcox age and that it is in fact a great lens of sand. The contact between the Carrizo and the Mount Selman, where the sand reaches to the top of the Wilcox, shows no physical evidence of a time interval, but the flora found near the base of

[16] Stephenson, L. W., and Crider, A. F., Geology and ground waters of northeastern Arkansas: U. S. Geol. Survey Water-Supply Paper 399, 1916.

[17] Dumble, E. T., Report on the brown coal and lignite of Texas, pp. 148-154, Texas Geol. Survey, 1892.

[18] Owen, J., Texas Geol. Survey First Rept. Progress, p. 70, 1889.

[19] Dumble, E. T., The Carrizo sands: Texas Acad. Sci. Trans., vol. 11, pp. 52-53, 1911.

the Mount Selman is clearly Claiborne in its facies and has nothing in common with that found in the underlying Carrizo or Wilcox of that region. The Carrizo plants are described in a recent paper devoted to additions to the Wilcox flora.[20]

The Mount Selman formation overlies the Carrizo sandstone in southwest Texas. It attains a thickness of 600 feet on the Brazos and 700 feet on the Nueces, and its thickness on the Rio Grande, though undetermined, is estimated by Dumble as from 800 to 1,000 feet.

The Cook Mountain overlies conformably the Mount Selman. It attains a thickness of about 800 feet on Brazos and Nueces rivers. The Yegua formation, which is said by Dumble to lie unconformably on the Cook Mountain, becomes more sandy and thicker toward the southwest. It is about 600 feet thick on Brazos River; 720 feet thick on Nueces River, according to Deussen; and from 1,000 to 1,400 feet thick on the Rio Grande, according to Dumble. In general, the Yegua is sandy at the top, lignitic in the middle, and clayey at the base. With the clayey strata gypsum and saliferous beds and limonitic concretions are associated. South of Guadalupe River the lignitic portion is near the top and is underlain by green gypsiferous clays, dark sands that are in places glauconitic, and oyster beds.

The flora found in the Yegua formation of Texas is not extensive enough to permit its exact correlation, but it indicates that the lithologic unit called Yegua is in part Claiborne and in part lower Jackson in age, and I have accordingly so considered it.

THE CLAIBORNE FAUNAS.

Except for fish teeth and similar indefinite objects and a femur of a small mammal from a coal mine at Dolores, Tex., no vertebrate remains have to my knowledge been collected from any of the Claiborne formations, although both the marine beds of Alabama and the palustrine beds of the Yegua may be expected to furnish some evidence of this sort when fully explored. The invertebrate faunas are abundant and in many places are represented by beautifully preserved material. Unfortunately our knowledge of these faunas is derived from occasional papers of very unequal value, and no monographic studies have been published, so that the bearing of the marine life upon the physical conditions of Claiborne time can not be precisely determined.

The fossil shells of the Claiborne are classic, and between 200 and 300 species of Mollusca have been described. It can scarcely be doubted that a monographic study would double the number of known forms.

LOCAL DISTRIBUTION OF THE FLORA AND LOCAL SECTIONS.

THE PLANT-BEARING OUTCROPS.

The individual exposures of the Claiborne are nowhere of very great thickness, but river cuttings furnish numerous nearly continuous sections, and well records in many places supplement the surface exposures. It is scarcely within the province of this report to furnish a full discussion of the stratigraphy, for the fossil plants are found in relatively few outcrops.

Determinable fossil plants have been found in the Claiborne at 23 localities. These localities are scattered from Chattahoochee River in Georgia to the Rio Grande in Texas and are of very unequal value, the number of species from each outcrop ranging from one to twenty. None of the Claiborne localities furnish the profusion of plant remains that is found at many localities in the Wilcox, nor is the preservation nearly as good. No plants are known from the lower Claiborne in the eastern Gulf area (Tallahatta, St. Maurice), although they should be found in deposits like those of the Tallahatta. Several small collections have been made from the Mount Selman formation in Texas.

Two localities in Mississippi have furnished fossil plants from the Lisbon—one near Lexington, in Holmes County, discovered by A. F. Crider, and the other near Newton, in Newton County, discovered by T. H. Aldrich. I have not been able to visit either of these outcrops but am indebted to Mr. Crider for collections from the locality near Lexington and to Messrs. C. W. Cooke and E. N. Lowe for collections and notes on the locality near Newton.

The following forms, preserved in a somewhat contorted condition in a gray fluffy sand,

[20] Berry, E. W., Additions to the flora of the Wilcox group: U. S. Geol. Survey Prof. Paper 131, pp. 1–21, 1923.

have been identified from the locality near Lexington, Holmes County, Miss.:

Glyptostrobus europaeus
Arundo pseudogoepperti.
Coccolobis claibornensis.
Mimosites georgianus.
Fagara claibornensis.
Dodonaea viscosoides.
Sapindus georgianus.
Sapindus affinis.
Sapindus mississippiensis.
Sapindus dentoni.
Zizyphus claibornensis.
Persea lexingtonensis.
Mespilodaphne columbiana.
Terminalia claibornensis.
Oreopanax mississippiensis.
Eoachras eocenica.
Diospyros brachysepala.
Apocynophyllum texensis.

Although for the most part the collections consist of fragments, 18 species have been recognized, a number only surpassed by the collections from the locality near Newton and the locality at Columbia, La., in the Yegua formation.

The locality near Newton is in a cut on the Alabama & Vicksburg Railway, 3¼ miles east of Newton and 200 yards west of milepost 27 west of Meridian, Miss. The section, furnished by Mr. Cooke, shows the following sequence:

Section of Claiborne deposits near Newton, Miss.

	Feet.
Yellowish-gray very fossiliferous marl, grading downward into dark sandy clay	25
Fine yellow sand that contains large oysters	6
Fine yellow sand crowded with small shells of *Ostrea sellaeformis;* few other shells are present, and the bed is evidently a young oyster reef that was buried by sandy sediments	1
Fine yellow sand	3
Sandy clay that carries many poorly preserved plants; fragments of palms are abundant, and a species of *Modiola* is present, according to Mr. Aldrich. The clay grades downward into a bluish-gray sand at the base	7

The following species have been determined from the lower member of the foregoing section:

Lygodium kaulfussi.
Acrostichum georgianum.
Goniopteris claiborniana.
Pteris inquirenda.
Thrinax eocenica.
Bactrites pandanifoliolus.
Ficus newtonensis.
Mimosites georgianus.
Sophora claiborniana.
Citrophyllum eocenicum.
Celastrophyllum gymindoides.
Dodonaea viscosoides.
Sapindus mississippiensis.
Sapindus yeguanus.
Sterculia labruscoides.
Cinnamomum angustum.
Persea gratissimifolia.
Mespilodaphne columbiana.
Nectandra gosportensis.

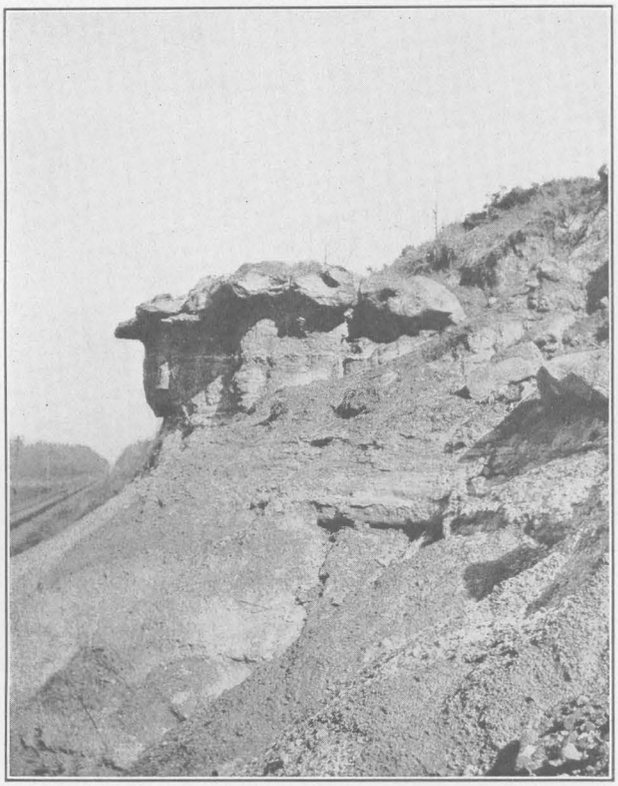
The Gosport sand, historically so important, has fortunately furnished fossil plants at the classic outcrop at Claiborne Landing, on Alabama River. The section has been described many times [21] and need not be repeated here.

It is an admirable fossiliferous exposure of the Lisbon and Gosport formations and the overlying Jackson. Near the contact of the Claiborne with the Jackson the glauconitic sands of the Gosport contain a small lens of laminated gray clay that carries an abundance of fossil plants. These plants are for the most part well preserved but difficult to collect because of the jointing of the clay. The following 15 species, over half of which are common to the Yegua formation, have been determined from this locality:

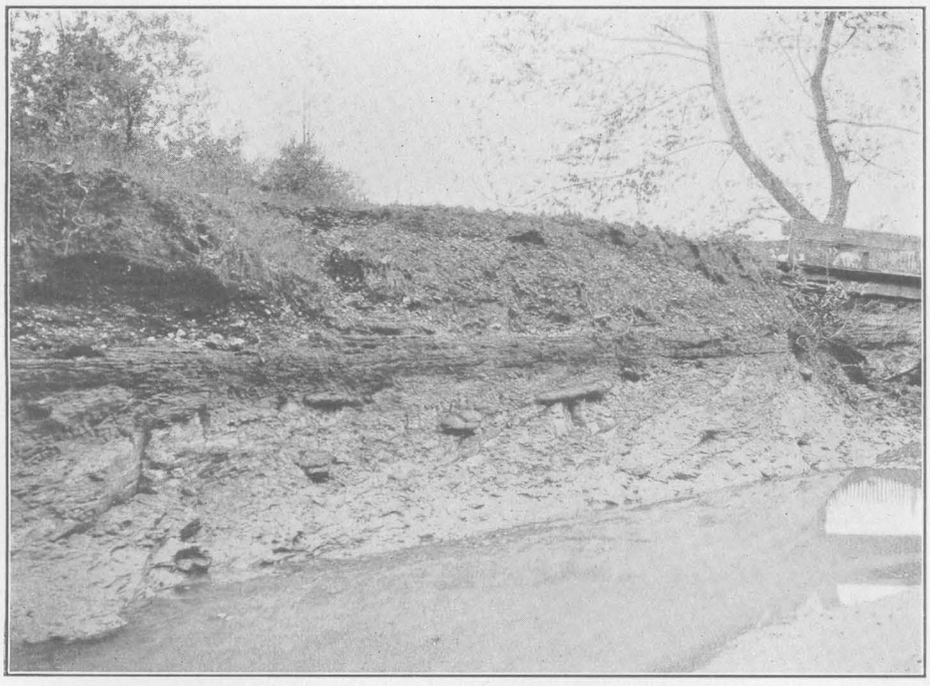
Lygodium kaulfussi.
Acrostichum georgianum.
Arundo pseudogoepperti.
Myrica claiborniana.
Ficus ungeri.
Coccolobis claibornensis.
Citrophyllum eocenicum.
Sapindus mississippiensis.
Oreodaphne inequilateralis.
Mespilodaphne columbiana.
Nectandra gosportensis.
Nectandra arkansana.
Terminalia claibornensis.
Conocarpus eocenicus.
Laguncularia claiborniana.

The Yegua formation has furnished fossil plants from about a dozen localities in Arkansas, Louisiana, and Texas—most of them in Texas—but the locality where the material is the best preserved and most abundant is that near Columbia, La. The occurrences in Arkansas furnish clear indications of the stratigraphic relations of the Claiborne to the underlying Wilcox and overlying Jackson. Two of these localities are on Crowleys Ridge in Cross County. Nothing but petrified wood has been

[21] Hale, C. S., Geology of southern Alabama: Am. Jour. Sci., 2d ser., vol. 6, p. 354, 1848. Tuomey, Michael, First biennial report on the geology of Alabama, p. 153, 1850. Smith, E. A., On the geology of the Coastal Plain of Alabama, pp. 127-132, pls. 5, 20, Alabama Geol. Survey, 1894.



A. THE TALLAHATTA FORMATION AT HOFFMAN, MISS.



B. LIGNITE AND PLANT-BEARING NODULES OF IRON CARBONATE IN THE CLAIBORNE GROUP (YEGUA FORMATION) AT CHERRY VALLEY, ARK.

found at the locality near Wittsburg, but a considerable flora has been collected from the locality near Cherry Valley. The following section, described by L. W. Stephenson,[22] is exposed along a small creek on the west side of Crowleys Ridge about three-quarters of a mile southeast of the town of Cherry Valley.

Section of Claiborne plant-bearing outcrop near Cherry Valley, Ark.

	Feet.
Pleistocene (loess):	
Brown pebbly loam, probably creep	3
Pliocene (?) ("Lafayette" formation):	
Gravel consisting of angular to partly rounded pebbles of chert and scattered well-rounded pebbles of quartz	5
Eocene (Claiborne formation):	
Fine, rather compact argillaceous faintly laminated sand, red in the upper 5 or 6 feet, grading downward through light greenish-gray sand to unweathered brown micaceous argillaceous sand with selenite crystals and scattered carbonaceous matter	14
Massive fine light greenish-gray sand	12
Laminated dark-gray to brown, very sandy micaceous clay with laminae of gray, brown, and yellow fine sand that reach a maximum thickness of 3 inches; contains scattered carbonaceous matter and a few fragments of lignite	8
Massive, finely arenaceous dark, commonly greenish-gray clay with abundant and perfect leaf impressions, preserved as films of lignite and thus impossible to procure for study. Scattered through the clay are numerous nodules of impure iron carbonate of all sizes, the largest 3 feet in diameter. These nodules contain numerous fairly well preserved plant remains. Exposed to bed of creek	5

The following plants have been determined from the basal member of the above section:

Athrotaxis sp.
Inga arkansensis.
Citrophyllum eocenicum.
Ternstroemites crowleyensis.
Ternstroemites claibornensis.
Persea gratissimifolia.
Mimusops claibornensis.

Athrotaxis sp., *Ternstroemites claibornensis*, and *Mimusops claibornensis* are peculiar to this locality. The *Persea* occurs in the Lisbon of Newton, Miss. *Ternstroemites crowleyensis* and the *Inga* occur in the Yegua, and the *Citrophyllum* occurs in the Lisbon, Gosport, and Yegua. As none of these species have been found in the Wilcox or lower Jackson and as three of the seven occur in the Yegua and the only occurrences outside of the Yegua are in the Lisbon or Gosport, the Claiborne of Crowleys Ridge is considered of late Claiborne age and referred to the Yegua formation.

The section of Eocene beds exposed along Bolivar Creek in Poinsett County is of interest in this connection. The section as described by Stephenson [23] shows the following sequence of materials:

Section of Eocene beds on Bolivar Creek, 3½ miles north of Harrisburg, Ark.

	Feet
Pleistocene (loess):	
1. Brown loam, probably creep	1
Pliocene (?) ("Lafayette" formation):	
2. Gravel, probably creep	4
Eocene (Wilcox formation):	
3. Brown-weathered fine argillaceous sand	3
4. Light-gray fine faintly laminated argillaceous sand	11
5. Light-gray fine massive sand	4½
6. Chocolate-colored fine argillaceous sand	8½
7. Brown to black lignite	5
8. Brown argillaceous lignitic sand	1
9. Chocolate-colored tough clay, lignitic above; in places the upper 2 feet contains numerous poorly preserved plant remains	3
10. Light-greenish very tough clay	2

The fossil plants preserved in layer No. 9 show conclusively that it is of upper Wilcox age. Stephenson refers the entire Eocene deposits of this section to the Wilcox, although there is a possibility that layers Nos. 3 to 7 are of Claiborne age. The lignite bed may indicate a local unconformity toward the close of the Wilcox or it may mark the unconformity at the base of the Claiborne. Under either interpretation it clearly indicates the emergent phase of the late Wilcox and thus furnishes presumptive evidence of the interval between the Wilcox and Claiborne.

The following small but typical flora has been collected from the Yegua formation near Stephens, Ouachita County, Ark.

Arundo pseudogoepperti.
Citrophyllum eocenicum.
Grewiopsis claiborniana.
Mespilodaphne columbiana.
Nectandra gosportensis.
Oreodaphne inequilateralis.

This flora is unquestionably of Claiborne age and does not show the unmistakable transitional character exhibited by the Yegua floras

[22] Stephenson, L. W., Geology and ground waters of northwestern Arkansas: U. S. Geol. Survey Water-Supply Paper 399, p. 69, 1916.

[23] Stephenson, L. W., op. cit., p. 62.

of the central part of the Texas Coastal Plain, although more extensive collections from the Yegua of Arkansas might serve to modify this statement.

The most prolific Claiborne locality is that near Columbia, in Caldwell Parish, La. Numerous good sections are exposed along the valley scarp of Ouachita River and in the cuts along the St. Louis, Iron Mountain & Southern Railway both north and south of the town of Columbia. The section from the top of the cut east of the railway depot to the terrace on which the town stands gives a thickness of about 100 feet of interbedded clays and sands. The cut at the depot shows a lignitic layer about 2 feet thick about 5 feet above the base. The vegetable matter is more or less comminuted and pressed in platy masses, consisting principally of small stems and but few traces of leaves, none of which are sufficiently preserved to be determinable. There are no roots in the underclay, and the material has every appearance of having drifted. Most of the cuts along the railroad show traces of vegetable matter, but the materials are predominantly sandy and the leaf remains broken and poor.

About a mile north of the depot a small collection of identifiable forms was made. Here the materials are variable sands and clays, mostly thin bedded, pyritiferous, and gypsiferous. They are prevailingly brown to gray in color and in places contain large septarian concretionary masses several feet in diameter.

About one-fourth of a mile south of the depot, in small gullies on the west side of the track, the material is a bluish clay, in places plastic and free from sand. This clay is much weathered, but in the more massive unweathered portions it contains an abundance of well-preserved plants. It is much jointed, however, and the specimens are not as good as those from many localities in the lower Eocene. Most of the forms recorded from Columbia came from this outcrop. The following species have been identified:

Acrostichum hesperium.
Goniopteris claiborniana.
Arundo pseudogoepperti (most abundant).
Canna flaccidafolia.
Thrinax eocenica.
Ficus unionensis.
Aristolochia claiborniana.
Coccolobis columbianus.
Pisonia claiborniana.
Cassia cockfieldensis.
Celastrophyllum gymindoides.
Celastrophyllum columbianum.
Cupanites parvulis.
Zizyphus claibornensis.
Grewiopsis claiborniana.
Sterculia labruscoides.
Ternstroemites crowleyensis.
Oreodaphne inequilateralis.
Mespilodaphne columbiana.
Mespilodaphne caudata.

The most easterly recorded outcrop of Claiborne plants is furnished by a small and poorly preserved collection made by Otto Veatch from a hill along the public road to Edison, 2½ miles east of Fort Gaines, Clay County, Ga. The section, as given by Veatch and Stephenson,[24] shows the following sequence of materials:

Section of Claiborne deposits 2½ miles east of Fort Gaines, Ga.

	Feet.
Age(?):	
Yellowish massive sand, weathering deep red	30
Claiborne:	
Greenish laminated clay	2
Sand	3
Drab laminated clay and aluminous soft sandstone that contains marine invertebrates and grades into a carbonaceous clay at the base that contains fragments of leaves and stems	15
Sand and clay, about	5
Black sulphurous sandy clay	4
Aluminous sandstone that contains casts of fossils	2½
Concealed to level of creek	4

A number of marine invertebrates, including *Plejona*, *Leda*, *Barbatia*, *Anomia*, *Venericardia*, *Cytherea*, *Metis*, *Tellina*, *Mactra*, and *Pteropsis*, have been identified from this outcrop by Vaughan,[25] who states that they represent the lower portion of the Alabama Claiborne. The fossil plants include a small leaflet of *Sapindus* (not specifically determinable), fragments of *Arundo pseudogoepperti*, broken rays of what is probably *Thrinax eocenica*, and the remarkable sea-drift fruit which I have described as *Carapa xylocarpoides*.

Fossil plants have been collected from the Mount Selman formation from two localities, Elkhart and Palestine, in Anderson County,

[24] Veatch, Otto, and Stephenson, L. W., Geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, p. 264, 1911.

[25] Vaughan, T. W., Geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, p. 264, 1911.

Tex. From the spillway of Elkhart Lake, 2 miles from Elkhart, the following species are recorded:

Citrophyllum eocenicum.
Mespilodaphne caudata.
Oreodaphne inequilateralis.

The following were collected from Palestine:

Apocynophyllum grevilleafolium.
Apocynophyllum texensis?
Citrophyllum eocenicum.
Fagara claibornensis.
Ficus newtonensis.
Gleditsiophyllum eocenicum.
Mespilodaphne columbiana.
Mimosites georgianus.
Sapindus georgianus.
Thrinax eocenica?

The following plants were collected from beds near the middle of the Yegua formation on Rock Creek, William Dunn League, Brazos County, Tex.:

Cedrela jacksoniana.
Citrophyllum eocenicum.
Combretum petraflumense.
Fagara petraflumensis.
Hicoria jacksoniana.
Inga jacksoniana.
Mespilodaphne caudata.
Mespilodaphne texana.
Nectandra antillanafolia.
Oreodaphne inequilateralis.
Palmocarpon sp.
Sapindus yeguanus.
Sophora balli.
Terminalia phaeocarpoides.

A glance at the table that shows the range of the sespecies (pp. 15–17) shows conclusively the transitional character of the Yegua flora in this part of Texas. Of the 14 species listed from this locality 3, *Fagara petraflumensis*, *Palmocarpon* sp., and *Sophora balli*, are not known from other localities. Of the remaining 11 species 4 are known only from beds of Claiborne age. These 4 species—*Citrophyllum eocenicum*, *Mespilodaphne caudata*, *Oreodaphne inequilateralis*, and *Sapindus yeguana*—are common and widely distributed, two of them being present from the Mount Selman formation upward. *Mespilodaphne caudata* has a variety in the Fayette sandstone. Others, as, for example, *Terminalia phaeocarpoides*, are characteristic of the lower Jackson of Georgia. *Hicoria jacksoniana* is present in beds in western Kentucky whose age has not been determined but which are upper Jackson or younger.

These features of the Yegua flora at Rock Creek are shared by other Yegua floras in Texas and seem to me to indicate clearly that although the lithologic unit in which they are found is the Yegua formation, this formation is partly Claiborne and partly Jackson in age and that in all probability it will never be possible to draw a time boundary in this unit of prevailingly continental deposits.

The following section of an outcrop along Colorado River containing Claiborne plants has been furnished by Mr. Deussen:

Section of the Yegua formation on Colorado River one-half mile below mouth of Rabb Creek and about 3½ miles northwest of Lagrange, Fayette County, Tex.

	Feet.
Blue clay weathering brown	15
White sulphur-stained sand that contains sticks of lignite	1
Blue clay that weathers brown	10
White sulphur-stained sand	1
Blue sulphurous clay	10
Brown clay	3
White sand	1
Blue clay that weathers brown	8
White sand	1
Blue and brown laminated sandy clay	10
Blue clay that contains impressions of leaves	1
Lignite	1
Blue clay that contains scattered impressions of leaves	12
Lignite	1
Blue clay	3
Covered	6
Lignite	1
Blue clay	6
Black lignitic clay	6

The following plants, clearly indicative of upper Claiborne age, have been identified from this outcrop:

Aneimia eocenica.
Arundo pseudogoepperti.
Thrinax eocenica.
Ficus sp. (fruit).
Coccolobis claibornensis.
Citrophyllum eocenicum.
Oreodaphne obtusifolia.
Diospyros brachysepala.

In the Nevils Prairie region the Yegua consists of unconsolidated gray clays and sands that contain limonitic concretions and large quantities of silicified wood. At the southeast margin of the prairie on Cedar Creek 5 feet of imperfectly laminated chocolate-colored clay that carries small lenses of sand is exposed.

Three-fourths of a mile down Cedar Creek from this point the following section is exposed:

Section of the Yegua formation in Nevils Prairie region, Houston County, Tex.

	Ft.	in.
Brown carbonaceous shaly clay, locally lignitic	2	
Greenish-drab plastic clay that contains impressions of leaves	1	
Brown lignite		1
Brown carbonaceous clay.		

The following plants, collected by C. L. Baker, have been determined from this outcrop:

Lygodium kaulfussi.
Arundo pseudogoepperti.
Momisia americana.
Ficus unionensis.
Inga arkansensis.
Mimosites georgianus.
Sophora wilcoxiana.
Citrophyllum eocenicum.
Sapindus georgianus.
Sapindus yeguanus.
Sterculia labruscoides.
Persea lexingtonensis.
Oreodaphne inequilateralis.
Mespilodaphne columbiana.
Mespilodaphne caudata.
Nectandra gosportensis.
Apocynophyllum texensis.

Section of Claiborne deposits 10 miles southeast of Guajolote ranch.[26]

	Feet.
Shaly sandstone, fine grained, laminated, ripple-marked in upper part, with poorly preserved leaf impressions	20
Thinly laminated sandy clay shale	15

Other sections in the vicinity of Santo Tomas are given by Vaughan in the report cited.

The fossil plants collected are few and poor. The specimen alluded to as *Celastrus* related to *rectinervis* (a misprint for *curvinervis*) is a new species of *Euonymus*. There are also present a species of *Rhamnus*, apparently new but too incomplete for satisfactory characterization, a fragment of a large leaf doubtfully determined as *Dryophyllum brevipetiolatum*, and a fragment of a fan palm, *Sabalites* sp. These plants all come from beds above the Santo Tomas coal seam.

A small collection made by Vaughan and Stanton in 1895 from a locality near the Rio Grande about 30 miles above Santo Tomas contains but three specimens, all of which appear to represent *Juglans schimperi* Lesquereux, a species which in the embayment region has thus far been found only in the Wilcox but which may well have extended into a later period in this area, for it is common in the Green River Eocene of Wyoming. It is therefore included is this report as a possible member of the Claiborne flora.

An outcrop in a draw 1¼ miles due north of the store at Palafox, Webb County, Tex., shows for several hundred feet along the creek about 10 feet of buff argillaceous rather fine grained sandstone, irregularly bedded and having the appearance of being partly wind laid, which is also suggested by the irregular position of the fossil leaves in the matrix. Plants are very abundant, but only a few species are represented. The forms identified are:

Apocynophyllum grevilleafolium.
Coccolobis claibornensis.
Ficus newtonensis.
Geonomites claibornensis.
Myrcia trowbridgi.

The last two forms are known only from this outcrop, and neither genus has been known heretofore in the Claiborne, although *Geonomites* occurs in the Upper Cretaceous Ripley of Tennessee, in the lower Eocene of trans-Pecos Texas, and in the Raton formation of New Mexico and Colorado, and *Myrcia* ranges from the Upper Cretaceous through the earlier Tertiary of southeastern North America and is common in both the Wilcox and the Jackson. Both the *Geonomites* and the *Myrcia* are the commonest forms near Palafox, and this small flora derives special interest because it is in the basal Mount Selman and not more than 200 or 300 feet above the fossiliferous Wilcox on Concillas Creek in Webb County. These two floras, so close stratigraphically, are entirely different, thus emphasizing the probability of a time interval between the Wilcox and the Claiborne.

Of the three species that have an outside distribution all occur throughout the Claiborne, and both *Apocynophyllum grevilleafolium* and *Coccolobis claibornensis* range up into the Jackson, so that the Mount Selman flora is typically Claiborne in its facies and shows slight differences when compared with those of the Lisbon, Gosport, or Yegua formations of Claiborne age.

LOCAL DISTRIBUTION OF THE SPECIES.

The species that make up the Claiborne flora are listed in the following table, which also indicates the localities at which each species has been found in the Claiborne deposits of the southeastern United States and gives its geologic range in this area and in other areas.

[26] Vaughan, T. W., U. S. Geol. Survey Bull. 164, p. 40, 1900.

Distribution of the Claiborne flora.

Species.	Near Fort Gaines, Clay County, Ga.	Alabama: Claiborne Landing, Monroe County.	Alabama: White Bluff, Clarke County.	Alabama: Willow Branch, Choctaw County.	Mississippi: Near Newton, Newton County.	Mississippi: Near Lexington, Holmes County.	Arkansas: Cherry Valley, Cross County.	Arkansas: Near Stephens, Ouachita County.	Arkansas: Near Wittsburg, Cross County.	Louisiana: Columbia, Caldwell Parish.	Louisiana: Near Bienville.	Texas: Near Cane Creek, Houston County.	Texas: Westmoreland Bluff, Houston County.	Texas: Nevils Prairie, Houston County.	Texas: Wooters Siding, Houston County.	Texas: Near Antioch, Houston County.	Texas: Near Climax Siding, Houston County.	Texas: Near Rabb Creek, Colorado River, Fayette County.	Texas: Somerville, Burleson County.	Texas: Rock Creek, Brazos County.	Texas: Near Smithville, Bastrop County.	Texas: Near Lufkin, Angelina County.	Texas: Near Palafox, Webb County.	Texas: Near Santo Tomas, Webb County.	Texas: Palestine, Anderson County.	Texas: Near Elkhart, Anderson County.	Wilcox group (Eocene).	Jackson formation (Eocene).	Catahoula sandstone (Oligocene).	Vicksburg group (Oligocene).	Green River formation (Eocene).	Beds of Fort Union (Eocene) age.	Alaska Tertiary.	Arctic Tertiary.
Cladosporites fasciculatus												×	×															×						
Lygodium kaulfussi		×			×									×														×			×	×		
Aneimia eocenica																×		×									×							
Acrostichum georgianum		×			×																						×							
Acrostichum hesperium										×																					×			
Goniopteris claiborniana					×					×																								
Pteris inquirenda					×																							×						
Athrotaxis sp							×																											
Sequoia langsdorfii																			×													×	×	×
Glyptostrobus europaeus						×																					×					×	×	×
Cupressinoxylon dawsoni												×			×				×															
Cupressinoxylon arkansanum									×																									
Arundo pseudogoepperti	×	×				×		×		×				×				×										×			×			
Canna flaccidafolia										×																								
Sabalites sp																								×										
Thrinax eocenica	×				×					×								×							×			×						
Geonomites claibornensis																							×											
Bactrites pandanifoliolus					×																													
Palmoxylon lacunosum			×																										×	×				
Palmocarpon sp																				×														
Juglans schimperi																								×			×							
Hicoria jacksoniana																				×														
Myrica claiborniana		×																																
Dryophyllum brevipetiolatum																								×				×						
Momisia americana														×														×						
Ficus unionensis										×				×														×						
Ficus ungeri		×																													×	×		
Ficus newtonensis					×																		×		×									
Ficus sp																		×																
Aristolochia claiborniana										×																								
Coccolobis claibornensis		×				×												×					×					×						
Coccolobis columbianus										×								×																
Pisonia claiborniana										×																		×						
Inga arkansensis							×							×																				
Mimosites georgianus					×	×								×		×									×			×						
Gleditsiophyllum eocenicum																												×						

Distribution of the Claiborne flora—Continued.

Species.	Near Fort Gaines, Clay County, Ga.	Alabama.			Mississippi.		Arkansas.			Louisiana.		Texas.																Wilcox group (Eocene).	Jackson formation (Eocene).	Catahoula sandstone (Oligocene).	Vicksburg group (Oligocene).	Green River formation (Eocene).	Beds of Fort Union (Eocene) age.	Alaska Tertiary.	Arctic Tertiary.
		Claiborne Landing, Monroe County.	White Bluff, Clarke County.	Willow Branch, Choctaw County.	Near Newton, Newton County.	Near Lexington, Holmes County.	Cherry Valley, Cross County.	Near Stephens, Ouachita County.	Near Wittsburg, Cross County.	Columbia, Caldwell Parish.	Near Bienville.	Near Cane Creek, Houston County.	Westmoreland Bluff, Houston County.	Nevils Prairie, Houston County.	Wooters Siding, Houston County.	Near Antioch, Houston County.	Near Climax Siding, Houston County.	Near Rabb Creek, Colorado River, Fayette County.	Somerville, Burleson County.	Rock Creek, Brazos County.	Near Smithville, Bastrop County.	Near Lufkin, Angelina County.	Near Palafox, Webb County.	Near Santo Tomas, Webb County.	Palestine, Anderson County.	Near Elkhart, Anderson County.								
Cassia cockfieldensis										×																								
Copaifera yeguana																						×												
Sophora claiborniana					×																							×						
Sophora balli																				×														
Sophora wilcoxiana														×													×							
Fagara claibornensis						×																			×									
Fagara petraflumensis																				×														
Citrophyllum eocenicum		×			×		×	×						×			×	×								×								
Cedrela jacksoniana																				×														
Carapa xylocarpoides	×																																	
Celastrophyllum gymindoides					×																													
Celastrophyllum columbianum										×																								
Euonymus santotomasensis																								×										
Cupanites parvulis										×						×																		
Dodonaea viscosoides					×	×				×																		×						
Sapindus georgianus						×								×		×									×			×						
Sapindus affinis						×																										×		
Sapindus mississippiensis		×			×	×																					×							
Sapindus yeguanus					×									×		×				×							×							
Sapindus dentoni						×																						×			×			
Zizyphus claibornensis						×				×																								
Rhamnacinium texanum																			×															
Reynosia texana																			×															
Rhamnus sp																							×											
Grewiopsis claiborniana								×		×																								
Sterculia labruscoides					×					?				×																				
Ternstroemites crowleyenis							×			×																								
Ternstroemites claibornensis							×																											
Cinnamomum angustum					×																							×						
Persea gratissimifolia					×		×																											
Persea lexingtonensis						×								×																				
Oreodaphne obtusifolia																		×									×	×						
Oreodaphne inequilateralis		×		×				×		×				×						×						×								
Mespilodaphne columbiana		×		×	×	×		×		×	×			×										×			×							
Mespilodaphne caudata										×				×						×					×		×							
Nectandra gosportensis		×			×						×			×								×												

Nectandra antillanafolia																			×															
Nectandra arkansana	×																										×							
Laurinoxylon bakeri												×			×																			
Laurinoxylon branneri																		×									×							
Laurinoxylon lesquereuxiana							×																											
Myrcia trowbridgi																						×												
Terminalia claibornensis	×				×																												
Conocarpus eocenicus	×																				×						×							
Combretum petraflumense																			×															
Laguncularia claiborniana	×																																	
Oreopanax mississippiensis					×																						×							
Nyssa texana																					×						×							
Nyssa wilcoxiana																				×						×								
Mimusops claibornensis						×																												
Eoachras eocenica					×																													
Diospyros brachysepala					×													×								×	×				×		×	
Apocynophyllum texensis					×							×												×			×							
Apocynophyllum grevilleafolium																						×		×										

COMPOSITION OF THE FLORA.

Such general considerations as would naturally form an introduction to the discussion of the composition of the flora have been rather fully presented [27] in another publication and therefore need not be repeated here. The flora of the Wilcox group, which was described in the publication referred to above, is the most extensive Tertiary flora from this region, and comprises about 350 species. It therefore furnishes the logical basis for the comparison and analysis of the subsequent less fully known floras.

The flora of the Claiborne group, although it is found at scattered localities from Georgia to southwestern Texas, is unfortunately not extensive, owing to a variety of circumstances, among which the following may be enumerated. The deposits of Claiborne age are of strictly marine origin throughout a much greater proportion of their outcrop than are those of Wilcox age, and it is only under exceptional circumstances that representative terrestrial remains of life, either animal or vegetable, are discovered in marine sediments. Such deposits of Claiborne time as were littoral or continental in type—for example, those of the upper Claiborne—are prevailingly much more sandy than the comparable deposits of Wilcox age and are thus not so favorable for the preservation of plant remains other than petrified wood. Moreover, the innumerable local clay lenses that carry fossil plants in the Wilcox sands and their considerable exploitation by clay-working industries render it feasible to explore these beds much more thoroughly. I have no doubt that when stratigraphic or commercial exigencies shall warrant a detailed areal examination of the Claiborne, especially of that great area extending from Mississippi River to the Mexican boundary, over which there is such a considerable development of the Yegua clays, the known flora of the Claiborne will be doubled or trebled.

The Claiborne flora, as described in this report, consists of but 90 species as compared with 353 in the antecedent Wilcox and 133 in the Jackson, or upper Eocene, which immediately succeeds the Claiborne beds. Ninety species is an extremely small quota of a flora which in life must have comprised several thousand species of flowering plants, and the conclusions that have been deduced from its study can only be considered tentative in character. As all the Tertiary floras of southeastern North America were composed of lowland and coastal types and as the known Claiborne forms are well distributed among the natural orders they are valuable for discussions of correlation, paleobotany, and ecology.

These 90 Claiborne species comprise 1 fungus, 6 ferns, 5 gymnosperms, 8 monocotyledons, and 70 dicotyledons. They represent 66 genera in 34 families and 24 orders. The largest orders are the Filicales, which is represented by 6 species; the Coniferales, 5; the Arecales, 6; the Urticales, 5; the Rosales, 8; the Geraniales, 5; the Sapindales, 10; the Thymeleales, 13; and the Myrtales, 5.

The largest family is the Lauraceae, which is represented by 13 species. Next in abundance of specific differentiation come the leguminous alliance, segregated into 3 families, which is represented by 8 species, and the Sapindaceae, which is represented by 7 species. Then follows the Arecaceae, 6 species; the Pinaceae, 5 species; and the Polypodiaceae, the Moraceae, the Rhamnaceae, and the Combretaceae, 4 species each. The Rutaceae and the Celastraceae are represented by 3 species each. The Schizaeaceae, Juglandaceae, Polygonaceae, Meliaceae, Ternstroemiaceae, Cornaceae, Sapotaceae, and Apocynaceae are each represented by 2 species, and the Pyrenomycetes, Poaceae, Cannaceae, Myricaceae, Fagaceae, Ulmaceae, Aristolochiaceae, Nyctaginaceae, Tiliaceae, Sterculiaceae, Myrtaceae, Araliaceae, and Ebenaceae are each represented by a single species.

A majority of those Claiborne species which have been found at several localities are also present in either the Wilcox or Jackson deposits or are present in formations of nearly the same age in other areas, thus confirming the supposition that they represent virile forms that may be considered to be the commonest Claiborne species. These forms include *Lygodium kaulfussi*, which has been collected from Alabama, Mississippi, and Texas, survives into the Jackson, and is found in the western United States and Europe; *Cupressinoxylon dawsoni*, which is found at three localities in Texas and if correctly identified is present in the Canadian Tertiary; *Arundo pseudogoepperti*, which occurs in Georgia, Ala-

[27] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 72-161, 1916.

bama, Mississippi, Arkansas, and Texas and survives into the Jackson; *Thrinax eocenica*, which occurs in Georgia, Mississippi, Louisiana, and Texas and survives into the Jackson; *Mimosites georgianus*, which occurs in Mississippi and Texas and survives into the Jackson; *Sapindus mississippiensis*, a common Wilcox species, and *Sapindus yeguanus*, which occur at three localities in the Claiborne; *Sterculia labruscoides*, which occurs in Mississippi, Louisiana, and Texas; *Oreodaphne inequilateralis*, which occurs in Alabama, Mississippi, Louisiana, and Texas; *Nectandra gosportensis*, which occurs at four localities in Alabama, Mississippi, and Texas; *Mespilodaphne columbiana*, which occurs at six localities in Alabama, Mississippi, Louisiana, and Texas and survives into the Jackson.

The commonest species, if the foregoing determinations are accepted, comprise a climbing fern, a gymnosperm, a grass, a strand palm, a sea grape, a mimosa, a small citrus tree, a *Dodonaea*, two soapberries, a *Sterculia*, and three lauraceous forms. Besides numerous traces of leaf-spot fungi the thallophytes are represented by a single species of an intracellular fungus, which is referred to *Cladosporites*. This fungus is very common in the vessels of silicified lauraceous wood and survives into the Forest Hill sand (in part of upper Jackson age, in my opinion). No traces of bryophytes have been observed. The pteridophytes comprise 6 species of ferns—2 Schizaeaceae and 4 Polypodiaceae. The Schizaeaceae include an *Aneimia* and a *Lygodium*, both of which genera are represented in the Wilcox. Both are apparently coastal types, the *Lygodium* in particular belonging to a genus that has more than 30 existing species of climbing ferns in the warmer parts of both hemispheres and is not uncommon in coastal thickets. The Polypodiaceae, a large, relatively modern family that includes hundreds of species in the American Tropics, is represented in the Claiborne by two species of *Acrostichum*, a *Goniopteris*, and a *Pteris*. The only genus common to the Wilcox is *Pteris*. Thus far no traces of the *Asplenium* or *Meniphylloides* of the Wilcox have been found in the Claiborne, although *Meniphylloides* is one of the characteristic types of the upper Wilcox. A very characteristic type that is unaccountably absent in the Wilcox but is present in the Claiborne, Jackson, and Catahoula is the genus *Acrostichum*, which has two species in the Claiborne. *Acrostichum* is a genus of swamp ferns whose commonest and widest-ranging existing species is a strictly coastal form of tidal nipa and mangrove swamps and similar situations. This type seems to have appeared in the middle Claiborne and was not associated with the nipa palms and *Avicennia* mangroves of the Wilcox, although in Europe it occurs in such associations in deposits earlier than the Claiborne. An undeterminable fragment of *Acrostichum*, however, has been found in the upper Wilcox of Louisiana. The genus *Goniopteris*, which has a fine Claiborne species, is a familiar type in Tertiary floras and contains about 60 existing species, nearly all of which are confined to the American Tropics, although a few are found in the Old World Tropics. It is related to *Meniscium*, the modern representative of the Wilcox *Meniphylloides*; in fact, Christensen, one of the foremost students of existing ferns, makes *Meniscium* and *Goniopteris* subgenera of *Dryopteris*.

Though ferns comprise 9 per cent of the known Claiborne flora, they are not as common or as varied as might be expected in the climatic environment that I have predicated for Claiborne time. However, the Claiborne flora, like that of the preceding Wilcox and succeeding Jackson, is a coastal flora and is made up very largely of strand types, whereas the great variety and abundance of ferns in the modern Tropics are those of upland or mountainous rain forests.

In conformity with the relative unimportance of gymnosperms in Tertiary floras, and particularly in those of southeastern North America, where climatic conditions appear to have been on the whole too warm, it is not surprising to find but five species in the Claiborne. There are two species of *Cupressinoxylon* that are based on petrified wood, which is not uncommon, especially in the Yegua formation, and a third variety of wood is referred to *Sequoia*, although no foliage of *Sequoia* has been discovered. A cone that has not been certainly identified is referred to *Athrotaxis*, which is represented by cone scales in the Wilcox and occurs not uncommonly in Tertiary

floras but survives in only a small mesophytic area of Tasmania. *Glyptostrobus*, which is represented in existing floras by but two species in the river bottoms of southeastern Asia, is a dominant and widespread Tertiary type in both hemispheres and one that was already present in southeastern North America during Wilcox time, and is also present in beds that are tentatively referred to the upper Jackson. It is a polymorphous species, and its identification is a matter of considerable uncertainty. Though cycads are rare fossils in the Tertiary deposits it is surprising that the *Zamia* type so common in the American Tropics has not been detected in the Claiborne, particularly as two species have been discovered in the upper part of the Wilcox.

Among the monocotyledonous seed plants only the families Poaceae, Cannaceae, and Arecaceae are represented in the Claiborne. Grasslike fragments are common in the Claiborne clays, as they are likewise in most Tertiary floras, but the only one named is a characteristic reedlike grass, which in conformity with paleobotanical usage and without signifying botanical identity is referred to the genus *Arundo*. The *Canna* is well marked and is probably descended from *Canna eocenica* Berry of the Wilcox. A third well-characterized species is present in the Jackson. Its existing representatives are numerous in coastal river swamps and are confined to the tropical and subtropical regions of America. The palms are less varied than might be expected but comprise five different forms. No traces have been found of the *Sabalites* type of fan palm except a fragment from the area along the Rio Grande. *Sabalites*, like its modern representative *Sabal*, was a coastal type, occurring in both the Wilcox and Jackson. It may therefore be presumed to have been more common during the deposition of the Claiborne than the records yet show. The three known Claiborne species of palms, based on leaves, comprise a fan palm (*Thrinax*) and two feather palms (*Bactrites* and *Geonomites*). Both *Thrinax* and *Bactrites* make their first known appearance in the geologic record during Claiborne time. Both are relatively small coastal forms, the *Thrinax* preeminently so, and although *Bactris* has its modern center of distribution in the Amazon region, many of its smaller species form tangled thickets in the swampy forests near the coast in the Caribbean region. Both genera are American in origin, although certain extinct members of the tribe Bactridae have been detected in the Oligocene of southern Europe.

The *Geonomites*, which is known only from the basal Mount Selman formation along the Rio Grande, belongs to a type represented by the existing genus *Geonoma*—a type which makes its appearance in the Ripley formation of the Upper Cretaceous but which, except for this Claiborne species, is unknown in the Coastal Plain Tertiary, although abundant and varied in the early Eocene of trans-Pecos Texas, New Mexico, and Colorado. The modern representatives are prevailingly stemless or short-stemmed palms, of different species and confined to the region extending from Central America and the Antilles to Rio de Janeiro and eastern Bolivia.

The Claiborne has also furnished petrified palm wood, which is referred to the genus *Palmoxylon*, and palm fruits of the familiar nutlike type of uncertain generic relationship, which are referred to the genus *Palmocarpon*.

The dicotyledonous seed plants are the most numerous element in the Claiborne flora and include representatives of 27 families. Twenty-four of these families, which are represented by 65 species, are Choripetalae (Archichlamydeae), and only three families, which are represented by 5 species, are Gamopetalae (Sympetalae). Thus the Gamopetalae constitute only about 7 per cent of the known flora. In the much larger Wilcox flora there are 251 species of Choripetalae and 34 species or about 12 per cent of Gamopetalae. As the Gamopetalae was probably on the increase throughout the Tertiary these facts simply illustrate the paucity of the known flora of the Claiborne.

The order Juglandales, which is represented in the Wilcox by 8 species of *Juglans*, *Engelhardtia*, and *Paraengelhardtia*, is represented in the Claiborne by a single species each of *Hicoria* and *Juglans*, although *Engelhardtia* occurs in the Jackson and must therefore have been present during Claiborne time. A rather full account of this genus has already been given.[28]

The order Myricales, which is represented by the existing genera *Myrica* and *Comptonia*,

[28] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 78–80, fig. 5, 1916.

both of which are old types that were already present in the Upper Cretaceous, is represented by a single species in the Claiborne as compared with two Wilcox species and one Jackson species. The genus is much more abundant in the European Tertiary. The existing species are relatively few in number, are widely scattered geographically, and represent survivors from a Tertiary cosmopolitanism. They are temperate and subtropical, and a number of species are coastal forms of both swamps and sand dunes. *Myrica claiborniana* is believed to have had a habitat like the existing *Myrica cerifera*, which reaches its maximum of growth in the sandy swamps along the South Atlantic and Gulf coasts or in the depressions behind dunes where the ground water is near or reaches the surface.

The order Fagales, which includes the well-known trees of the Temperate Zone of the families Betulaceae and Fagaceae, is represented in the Claiborne by a single species of *Dryophyllum*, although both families are present in the Upper Cretaceous of North America and the extinct fagaceous genus *Dryophyllum*, which includes 5 species, is one of the commonest types in the Wilcox flora. It also occurs in the Jackson flora and in the Oligocene of this area and was therefore probably present during the Claiborne in more abundance than the records indicate.

The order Urticales, which includes the families Ulmaceae, Moraceae, and Urticaceae and contains about 1,600 existing species, is represented in the Claiborne flora by the Ulmaceae and Moraceae. The Urticaceae are largely herbaceous forms that have few fossil species and are probably of relatively modern origin. The Ulmaceae, which are represented in the Wilcox by *Planera*, a warm temperate type, are represented in the Claiborne by *Momisia*, a tropical type. The very large family Moraceae is represented in the Claiborne by 4 species of *Ficus* as compared with 23 Wilcox species of *Ficus*, *Artocarpus*, and *Artocarpidium*. It is singular that no representative of the last two genera has been detected in the Claiborne, for the breadfruit is abundant in the Wilcox and reappears in the post-Eocene of this area. The Claiborne figs are all of the lanceolate, pinnate-veined type and were probably all forms that started life as parasites.

The order Proteales, which consists of the single family Proteaceae and includes about 1,000 existing species, some of which are among the prominent arborescent types of the Southern Hemisphere, has not been detected in the Claiborne, although it is abundantly represented in the antecedent Wilcox flora and is also found in the Jackson.

The order Aristolochiales, which has a species of *Aristolochia* that is represented by fruit in the Wilcox, is represented by leaves in the Claiborne. The modern species, which are numerous in the warmer regions of both hemispheres, are perennial herbs or climbing vines, and *Aristolochia claiborniana* may be regarded as one of the lianas of the Claiborne beach jungle.

The order Polygonales includes the single family Polygonaceae, which has about 800 existing species that are herbaceous in the Temperate Zone and shrubby or arborescent in the Tropics. Its geologic history is practically unknown, although the genus *Coccolobis* has two species in the Claiborne as well as two species in the antecedent Wilcox and is represented in the Upper Cretaceous of this area by the genus *Coccolobites*. *Coccolobis* has about 120 existing species, all confined to the American Tropics. Two species, the sea grape and pigeon plum, reach the Florida Keys and are widespread tropical American strand types. It is believed that the Eocene species were similar in habit and habitat to these modern forms.

The order Chenopodiales is a large alliance of ill-assorted and mostly modern forms. It was represented during Wilcox and Claiborne time by the family Nyctaginaceae, which has a single Claiborne species of *Pisonia* as compared with 3 Wilcox species and 3 Jackson species. The genus *Pisonia* includes about 40 different species, chiefly of the American Tropics. It has an extended geologic history and was already present in the Upper Cretaceous of both Europe and America. The fossil species, like the single modern form that reaches the Florida Keys, were strand types and appear to have been continuously present along the strand of the Mississippi embayment from the Upper Cretaceous through the Eocene and Oligocene.

The order Ranales, a large but probably unnatural alliance, is usually prominent in fossil floras from the Upper Cretaceous onward. No traces of Magnoliaceae, Menisper-

maceae, or Anonaceae have been discovered in the Claiborne, although all three families are present in the Wilcox.

The order Papaverales, which is represented in the Wilcox by the family Capparidaceae, is not represented in the Claiborne.

The order Rosales, which includes 18 families and over 14,000 species in the existing flora, is represented by five families in the flora of the Wilcox group. No traces of two of these families, the Hamamelidaceae and Rosaceae, have been detected in the Claiborne, although I would expect to find the genus *Chrysobalanus*, for it was a strand plant in the Wilcox, as it is along the shores of the existing American and West African Tropics. The three leguminous families Mimosaceae, Caesalpiniaceae, and Papilionaceae, which are so prominent in modern tropical forests, are represented by two or three species each in the Claiborne, as compared with more than fifty species in the Wilcox flora. The Mimosaceae include a species of *Mimosites* and one of *Inga*. The genus *Inga* appears in the Tuscaloosa formation (Upper Cretaceous) of Alabama and the Cenomanian of Saxony. It was common during the Wilcox, and its 200 existing species are confined to the American Tropics, where they are massed in the Brazilian region. *Inga* and *Pithecolobium* have been separated by Bentham [29] on the basis of leaf habit. The Caesalpiniaceae are represented in the Claiborne by leaves of *Cassia* and *Gleditsiophyllum* and by the characteristic pods of the genus *Copaifera*. These pods constitute the oldest known occurrence of *Copaifera* and are the only fossil record of this genus for North America. The genus *Copaifera* contains about 16 existing species, three-fourths of which occur in the American Tropics and the balance in tropical Africa. It has been recorded from the lower Miocene of Chile and occurs in the Oligocene and Miocene of Europe. The family Papilionaceae, which includes two-thirds of the existing Leguminosae, is the culmination of the alliance, and many of its herbaceous species are of relatively modern origin. It is represented in the Claiborne by three species of *Sophora*, one a survival from the Wilcox and the others new. These forms resemble the cosmopolitan modern strand plant *Sophora tomentosa*. The genus contains about 25 existing species of shrubs and small trees and is represented on all tropical seashores. Like them, the Claiborne species were probably plants of the strand. The genera *Dalbergia* and *Canavalia*, both strand plants and both represented by an abundance of unmistakable material in the Wilcox, should occur in the Claiborne, but they have not yet been discovered.

The order Geraniales, which includes 21 families and more than 10,000 existing species, has two families in the Claiborne, as compared with six in the Wilcox and four in the Jackson. The family Rutaceae is represented in the Claiborne by species of *Fagara* and *Citrophyllum*. The genus *Fagara*, which includes about 150 cosmopolitan tropical species, appears in the Wilcox and continues as a prominent element in the Jackson and Oligocene of this region. It is distinctly a strand type. The genus *Citrophyllum* is extinct and was confined to America. The oldest species occur in the Upper Cretaceous deposits of the Coastal Plain and along the borders of the interior Cretaceous sea. It is present in the Wilcox and is a prominent element in the Claiborne flora from Alabama to Texas. The family Meliaceae is represented by a species of *Carapa* that was very similar to the oriental mangrove, *Carapa obovata*, and, like that mangrove, it was obviously a strand plant that was dispersed by ocean currents, for only the characteristic large seeds are found as fossils in the Claiborne. The leaves, however, have been identified from the Wilcox. The genus *Cedrela*, which is confined to the American Tropics in modern floras, is represented by four Wilcox species and a single Claiborne species which survives into the Jackson. The families Humiriaceae and Malpighiaceae of this order, both of which are present in the Wilcox, have not been found in the Claiborne, although the Malpighiaceae occurs in the Jackson and should be represented in the Claiborne by *Banisteria*. The largest family of Geraniales, the Euphorbiaceae, has also not been found in the Claiborne, where at least the strand plant *Drypetes*, which is common in the Wilcox, should be found.

[29] Bentham, George, Notes on Mimoseae, with a short synopsis of species: Jour. Botany (London), vol. 4, p. 578, 1845. Pittier (Contr. U. S. Nat. Herbarium, vol. 18, pt. 5, p. 181, 1916) considers that some of the once-pinnate Ingas are referable to *Pithecolobium* on the basis of floral and fruiting characters.

The order Sapindales (Celastrales) includes over 3,000 existing species in 20 families. Of the families that usually occur in fossil floras from the Upper Cretaceous onward, the Anacardiaceae and Ilicaceae have not been found in the Claiborne, in which only the families Celastraceae and Sapindaceae are represented. The Celastraceae contains two Claiborne species of *Celastrophyllum*, which are of rare occurrence, and a single species of *Euonymus*, a common Eocene type. The Sapindaceae have seven Claiborne species that represent the genera *Cupanites*, *Dodonaea*, and *Sapindus*, all of which are common types in the Wilcox. The *Cupanites* of the Claiborne is rare, but the *Dodonaea* is common and is very close to the existing strand plant *Dodonaea viscosa* of the equatorial region of both hemispheres, and like that type it was distributed by ocean currents. *Sapindus*, which has been present along the shores of the Gulf of Mexico from the Upper Cretaceous to the present, has five Claiborne species, two of which survived from the Wilcox. They are distinctly types of the strand and are largely distributed by ocean currents.

The order Rhamnales includes about 1,000 existing species of shrubs, trees, and vines, about equally divided between the families Vitaceae and Rhamnaceae. The Rhamnaceae is the only family represented in the Claiborne and in the Wilcox. There are four Claiborne species of Rhamnaceae, two of which are based on petrified wood. These forms comprise a species of *Rhamnacinium*, a generic term for rhamnaceous wood, and *Reynosia*, a genus that consists of two existing small trees of the strand flora ranging from the Florida Keys through the West Indies. The only other fossil species of *Reynosia* are two from the Wilcox, which are based upon the foliage, whereas the Claiborne species is based on the wood. The third species of Claiborne Rhamnaceae is referred to the genus *Zizyphus*. *Zizyphus* contains about forty existing species of shrubs and small trees, mostly Indo-Malayan, though a few species occur in all tropical regions. It is present in the fossil floras of North America from the Upper Cretaceous onward and has no less than ten species in the Cretaceous. A characteristic and handsome species is found in the Tuscaloosa formation of Alabama and the synchronous Woodbine sand of Texas. There are two well-marked Wilcox species.

The order Malvales contains nine families and about 1,800 existing species. Three of the nine families—the Tiliaceae, Sterculiaceae, and Bombacaceae—are represented in the Wilcox, and the first two of these families are also present in the Claiborne. The Claiborne species of Tiliaceae, like that of the Wilcox, belongs to the genus *Grewiopsis*, an extinct genus of American origin ancestral to the genus *Grewia* of the Eastern Hemisphere. The family Sterculiaceae is represented in the Claiborne by a well-marked and common species of *Sterculia*, which belongs to the section Lobatae and which is present in southeastern North America from the Upper Cretaceous onward. The family Bombacaceae, which has not yet been found in the Claiborne, has two Wilcox species and a third in the Jackson.

The order Parietales is a complex alliance that contains 30 families and over 4,000 existing species. The single family Ternstroemiaceae has been found in the Claiborne, where it is represented by two species of *Ternstroemites* that have descended from Wilcox species. The family Dilleniaceae, which is abundantly represented in the Wilcox, has not yet been discovered in the Claiborne.

The order Thymeleales, as in most Tertiary floras, is represented in the Claiborne flora by the family Lauraceae, where it has 13 species. There is a single narrow-leafed species of camphor tree (*Cinnamomum*), two species of *Persea*, two of *Oreodaphne*, two of *Mespilodaphne*, three species of *Nectandra*, and three species that are based on the petrified woods and are referred to *Laurinoxylon*. All these genera are abundantly represented in the Wilcox and are characteristic members of the Eocene floras of this region.

The order Myrtales is represented in most Upper Cretaceous and Tertiary floras by the family Myrtaceae, whose origin and peculiar distribution has been the subject of several recent papers.[30] It has not yet been discovered in the Claiborne, except for a single species of *Myrcia* in the basal Mount Selman formation. *Myrcia* also occurs in the Upper Cretaceous and in the Jackson and subsequent Oligocene floras of

[30] Andrews, E. C., The development of the natural order Myrtaceae Linnean Soc. New South Wales Proc., vol. 38, pp. 529–568, 1913. Berry E. W., The origin and distribution of the family Myrtaceae: Bot. Gazette, vol. 59, pp. 484–490, 1915.

this region. The only other myrtaceous family thus far known from the Claiborne is the family Combretaceae, which is represented by species of *Terminalia, Conocarpus, Laguncularia,* and *Combretum.* The first is a strand type that had lower Eocene ancestors in this region, and the three last, which are also descended from Wilcox ancestors, are characteristic members of the mangrove association.

The families Hydrocaryaceae and Melastomataceae, which are usually represented in fossil floras by species of *Trapa* and *Melastomites,* as they are in the Wilcox, have not been detected in the Claiborne.

The order Umbellales consists of the three closely related families the Araliaceae, Umbelliferae, and Cornaceae. It contains more than 3,000 existing species, of which two-thirds belong to the Umbelliferae, a family which has many herbaceous extratropical forms that may be considered of modern evolution. The other two families, however, have a history that goes as far back as dicotyledons have been found. The Araliaceae are especially abundant in the Upper Cretaceous. There are several species of *Aralia* and two of *Oreopanax* in the Wilcox, and a single species from the Claiborne is referred to *Oreopanax.*

The family Cornaceae is represented in the Claiborne by a very large fruited form of *Nyssa,* or gum, which survives into the Jackson, and a second smaller species that is inherited from the Wilcox. The genus comprises seven or eight existing species of southeastern North America and eastern Asia, and about fifty extinct species that range from the Upper Cretaceous onward. It has been continuously present along the coasts of the Mississippi embayment from the time of the deposition of the Tuscaloosa formation to the present. The modern species range from shrubs to large trees, and the size of the fruit stones of the Wilcox, Claiborne, and Jackson species leads me to the conclusion that they were large trees like the modern cotton gum or tupelo gum and that like the tupelo gum they inhabited river and estuary swamps, bayous, and the wet regions behind coastal dunes and similar localities.

This list ends the enumeration of the Claiborne Choripetalae, and it may be noted that although the Choripetalae are distinctly older than the Gamopetalae, none of the families have succeeded in maintaining a world-wide distribution, as have several families of Monocotyledonae and Gamopetalae. Nor has any distinctly boreal group been developed, as among the Gamopetalae. The Choripetalae are distinctly tropical in their beginnings and largely American, for though certain great families characterize the North Temperate Zone they are almost exclusively herbaceous forms, such as the Polygonaceae, Caryophyllaceae, Cruciferae, Saxifragaceae, Onagraceae, and Umbelliferae, which are believed to be mainly of relatively recent origin.

The second grand division of the dicotyledonous seed plants—the Gamopetalae or Sympetalae—constitutes a rather well-defined group, presumably derived from the Choripetalae and characterized by cyclic flowers and usually a gamopetalous corolla. The morphologic emphasis has always been laid upon floral structure, and it is not certain that the group is monophyletic, although its compactness lends some measure of support to such a theory. There are nine or ten gamopetalous orders and more than 50,000 existing species. Herbaceous forms predominate, and several of the families are distinctly boreal. Although the Compositae, Labiatae, and Plantaginaceae have attained a world-wide distribution, this distribution fails to show the apparent anomalies that are usually shown by families that have an extended geologic history. These and many other facts suggest that the Gamopetalae, as evolutionary theory demands, were the last plants to appear in the record, and that the herbaceous extratropical families are relatively modern, and that their major specific differentiation is a part of postglacial botanic history.

Six gamopetalous orders are represented in the Wilcox, but only two of these have been observed in the Claiborne. These orders are the Ebenales and Gentianales, and no traces of the Primulales, Polemoniales, Personales, or Rubiales have been discovered.

The order Ebenales includes four families and more than 1,000 existing species. The two largest of these families are the Ebenaceae and Sapotaceae, and both are present in the Claiborne as in the Wilcox. The family Ebenaceae consists of about 8 genera and over 300 existing species of shrubs and trees, of which over half are referred to the genus *Diospyros.* They are mainly tropical and

have many extinct species, *Diospyros* being represented by calices as well as leaves from the Upper Cretaceous onward and being continuously present in southeastern North America during all that vast lapse of time. Its history has been summarized in another paper [31] and need not be repeated here. The Sapotaceae is also a tropical family. It has about 400 existing species of shrubs and trees, and many of its modern forms are coastal in habitat. Its history goes back into the Upper Cretaceous, from which time it has been continuously represented in southeastern North America. There were 4 genera and 12 species in the Wilcox, but three of these genera have not been detected in the Claiborne, although *Bumelia* was probably present and will eventually be discovered. A species of *Mimusops* is sparingly represented in the Claiborne collections, and the characteristic seed of a large-fruited ancestor of the modern sapotas and sapotillas has been made the type of the genus *Eoachras*.[32] Its size is remarkable and indicates the evolution of these modern large-fruited and few-seeded forms at such a remote period.

The order Gentianales includes 6 families and more than 5,000 existing species, of which more than a third belong to the family Asclepiadaceae, which is not represented in the Claiborne, where the only family of this order that is present is the Apocynaceae. The Apocynaceae shares with the Asclepiadaceae the development of a latex system. It has over 1,000 existing species and is generally represented in the fossil records by forms referred to *Apocynophyllum*, although several other genera occur sparingly in the geologic record. *Apocynophyllum* is known from the Upper Cretaceous onward in both Europe and America. There are five species in the lower Eocene of southeastern North America, but only two are known from the Claiborne, and both of these survive into the Jackson.

The gamopetalous families which were already present in this region during the lower Eocene but have not yet been detected in the Claiborne are the Myrsinaceae, Oleaceae, Boraginaceae, Verbenaceae, Solanaceae, and Rubiaceae, and none of these except the Solanaceae, and that one doubtfully, have been found in the equally meager flora of the overlying deposits of Jackson age.

[31] Berry, E. W., Some ancestors of the persimmon: Plant World, vol. 15, pp. 15-21, 7 figs., 1912.

[32] Berry, E. W., An Eocene ancestor of the *Zapodilla*: Am. Jour. Sci., 4th ser., vol. 39, pp. 208-213, pl. 1, 1915.

PHYSICAL CONDITIONS AND GEOLOGIC HISTORY.

There is no reason to suppose that the climate and other physical conditions during the interval between Wilcox and Claiborne time or during early Claiborne time differed materially from those that prevailed during Wilcox time. The floras found in the lower, middle, and upper Claiborne deposits are too small for precise deductions, but the great similarity between these floras and those of the lower Jackson makes it probable that the climate became gradually warmer during Claiborne time, for the lower Jackson flora is distinctly more tropical than that of the Wilcox. As I interpret the evidence, there appears to have been a steady progression throughout the Eocene in this area toward more tropical conditions. The Upper Cretaceous floras suggest the existing warm temperate rain forests, those of the lower Eocene are similar but indicative of slightly warmer climate, and those of the middle Eocene are intermediate between subtropical and tropical. The upper Eocene and lower Oligocene floras in this region are still more tropical in character, after which time the climatic curve seems to have descended until the conditions gradually approximated those that prevail at the present time in these latitudes.

One of the best criteria for forming an estimate of the character of an extinct flora is the study of the florule of a single locality like that at Claiborne Landing, Ala. The environment in this vicinity may be pictured as a small lagoon or estuary, where the characteristic marine sands were replaced by mud, which facilitated the preservation of the scraps of vegetation that floated or were blown into it. The shore was close at hand, and the time was near the end of the Claiborne, or at least after the Claiborne sea had commenced to recede. If the time for the accumulation of plant remains extends over a long period or the area of accumulation is large a fairly complete representation of the plants growing in the vicinity becomes preserved. If the area is small and the time short only the commonest plants will be preserved, and this sifting out of the less

common forms simplifies the problem for the student. The plants found in the small clay lens at Claiborne Landing fulfill in every way the latter conditions. Only 15 species have been determined from this lens, and these obviously represent the most abundant forms growing along the Claiborne shore. They comprise two ferns—a *Lygodium* and an *Acrostichum*.

Lygodium is a clambering form of tropical coastal thickets, and *Acrostichum* is the commonest modern fern element in the strand flora of the tropics, growing in swamps behind the mangrove association and in similar situations. It seems to be the one fern that tolerates brackish and salt water and is a large, gregarious, and wide-ranging form. *Lygodium* extends into the warm temperate zone and away from the coast. *Acrostichum* haunts the strand and is confined to the Tropics. The third plant at Claiborne Landing is a species of *Arundo*, a large estuary marsh grass or reed. The remaining 12 species are all dicotyledons and represent the genera *Myrica*, *Ficus*, *Coccolobis*, *Citrophyllum*, *Sapindus*, *Oreodaphne*, *Mespilodaphne*, *Nectandra*, *Terminalia*, *Conocarpus*, and *Laguncularia*. The last two are mangrove plants of brackish or salt tidal swamps of tropical and subtropical regions. *Myrica* is a coastal dune and swamp plant that extends well outside the equatorial zone. *Coccolobis* is distinctly a plant of the sandy tropical strand, as are also *Sapindus* and *Terminalia*. There remain for consideration a fig, a small citrus form, and four lauraceous forms. These all have numerous modern species in a variety of habitats, but all have representatives in the beach jungle of tropical and subtropical regions. No palms have been collected at Claiborne Landing, but *Thrinax* occurs both to the east and to the west and is a tropical American strand plant at the present day, a species of *Bactrites* occurs in eastern Mississippi, and a *Geonomites* occurs in Texas. The numerous modern species of *Bactris* furnish several small forms that are members of the strand flora in Central America and northern South America.

I conclude that the Claiborne coast of Alabama was covered with a typical subtropical strand flora made up of mangrove and *Acrostichum* swamps, alternating with beach jungle on the strand and behind the dunes.

The known middle Eocene flora of southeastern North America is much less extensive than that of the lower Eocene. The flora of the Claiborne group is less than one-third as large as that of the Wilcox group. The small number of species can not be interpreted, however, as an indication that the vegetation which clothed the Claiborne shores was less luxuriant or less varied than that which immediately preceded it. No marked climatic changes are discernible, and the other physical conditions of the environment were practically unchanged, so that the major element of this disparity must be ascribed to the imperfection of the geologic record. Besides, the area of outcrop of the Claiborne has been less thoroughly explored than that of the Wilcox, although this is in a measure due to the unpromising character of the Claiborne lithology. Nowhere in the Claiborne except in the Yegua formation do extensive leaf-bearing clays and palustrine deposits occur, such as characterize so much of the Wilcox and are so favorable for the preservation of the remains of terrestrial plants. The clays so common in the Lisbon and Tallahatta are for the most part of marine origin and have thus far furnished few land plants, although diatoms abound at some horizons, and isolated lenses containing well-preserved plants will doubtless be discovered eventually. Fossil plants are not present at all horizons within the Claiborne group, nor are they as widely or as uniformly distributed geographically as they should be to enable the student to make precise estimates of the relative duration and actual chronologic relations of the different formations of the Claiborne group in the different areas of its outcrop. As these formations are largely of marine origin and commonly contain abundant faunas, undoubtedly such determinations will in time become available as one of the results of the monographic studies of these faunas.

Though the paleobotanic evidence is thus inadequate and areal, stratigraphic, and paleogeographic studies are a long way from completion, the work has progressed far enough to enable the broader outlines of Claiborne history to be sketched and thus to afford a setting for the discussion of what is known of the Claiborne flora and its relations to the preceding and succeeding floras in this region.

EVIDENCE OF A TIME INTERVAL BETWEEN THE WILCOX AND CLAIBORNE EPOCHS.

The evidence for predicating a time interval between the deposition of the Wilcox and that of the Claiborne sediments has been partly given elsewhere.[33] It rests upon a considerable body of facts, and the conclusions from all the different classes of evidence are in perfect agreement. The withdrawal of the Wilcox strand line toward the south is indicated by the littoral character of the upper Wilcox materials; by the presence of palustrine deposits in these littoral sands and clays, as in the Bolivar Creek section (p. 11); by the thickening of the Wilcox in the direction of the dip; by the observed unconformities between the Wilcox and the Claiborne which are recorded from Georgia, Mississippi, and Texas; by the great differences between the marine faunas and terrestrial floras of the Wilcox and those of the Claiborne; and by the littoral character of the lower Claiborne as exemplified by the Tallahatta formation in the eastern Gulf area and the Mount Selman in the western Gulf area.

The following section at Meridian, Miss., well illustrates the emergence at the close of the Wilcox in that area:

Section of the Wilcox deposits at Meridian, Miss.

[Communicated by C. W. Cooke.]

	Feet.
1. Yellow, fine incoherent sand that contains flat, disklike pebbles of clay and thin beds of clay, some of which show apparent ripple marks; estimated	15–20
Probable unconformity.	
2. Gray to brown and black hackly clay, very sandy in places; contains much lignitic matter; fossil plants very abundant near the top; estimated	30
3. Greenish-yellow fine incoherent glauconitic sand which contains indurated masses that are filled with fossils of the Bashi formation.	12

This section, which has been commented upon elsewhere,[34] shows the transition from abundantly fossiliferous marine sediments through littoral sands to continental deposits of latest Wilcox age. The continental character of the sediments at the top of bed No. 2 is shown by the great abundance of *Nelumbo* with roots in place. The *Nelumbo* is a species that grows in very shallow, quiet, fresh water, rooting in the mud of the bottom by means of creeping rootstocks, and the abundance of these rootstocks indicates that the deposits are not estuary in character or that the plant material drifted in from upstream but grew where it is found. There appears to be an erosional unconformity at the top of bed No. 2, and I imagine that bed No. 1, which contains rippled clay laminae and clay pebbles, may represent the base of the Claiborne, although in the absence of fossils it is impossible to determine whether the unconformity is local near the top of the Wilcox or represents the emergence between the Wilcox and the Claiborne. Whichever it is, it shows a definite shallowing near the close of the Wilcox at a locality far south in the embayment and indicates that farther north this interval must have been considerably longer than it was in the latitude of Meridian.

The lower Claiborne has thus far failed to yield an extensive flora, and the plants that are known from the Mount Selman are decidedly Claiborne and not Wilcox in facies, so that the time required for the deposition of these lower Claiborne sediments is a modifying factor of unknown importance in comparisons of the Wilcox and Claiborne floras. That the time required for the deposition of the lower Claiborne sediments was of a different order of magnitude from that which intervened between the Wilcox and Claiborne epochs may be deduced from comparisons between the Wilcox and Claiborne floras and the corresponding comparisons between the middle and upper Claiborne floras, or between the middle Claiborne flora and that of the Jackson. There are about 350 species of known Wilcox plants, and 90 species of Claiborne plants are described in this report, which makes a total of about 440 species. Only 9 of this great variety of forms, which grew in the same general region under very similar conditions of topography, soil, and climate, are common to the two epochs. These 9 species are

Aneimia eocenica.
Glyptostrobus europaeus.
Juglans schimperi.
Gleditsiophyllum eocenicum.
Sophora wilcoxiana.
Sapindus mississippiensis.
Oreodaphne obtusifolia.
Nyssa wilcoxiana.
Diospyros brachysepala.

[33] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 37–38, 1916; Erosion intervals in the Eocene of the Mississippi embayment: U. S. Geol. Survey Prof. Paper 95, pp. 78–80, 1915.

[34] Berry, E. W., Geologic history indicated by the fossiliferous deposits of the Wilcox group (Eocene) at Meridian, Miss.: U. S. Geol. Survey Prof. Paper 108, pp. 61–63, 1918.

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As previously remarked, the *Glyptostrobus* and the *Diospyros* are probably polymorphic forms which have a wide geographic and geologic range and hence are without significance, and the *Juglans* is known to have a wide range in the Eocene of the West, so that it is unimportant in this connection. Therefore, only five or six significant species are identical in the two epochs, and all of these are very common forms during Wilcox time. Thus the two floras have only a trifle over 1 per cent of common species, a number astonishingly small when the similarity of conditions is remembered, and thus a considerable lapse of time is indicated.

On the other hand, comparisons between the flora of the middle Claiborne, as represented by the plants of the Lisbon formation of the eastern Gulf area, and the flora of the Jackson yield very different results. The Lisbon flora comprises 33 species and the Jackson flora 133 species. Five of the Lisbon species, or over 15 per cent (nearly 5 per cent of the total number of species), range into the Jackson, and between the 90 known Claiborne species and the 133 Jackson species the percentage of common forms is nearly 18 per cent, and the Claiborne forms that survive into Jackson time amount to 35, or more than one-third of the total known Claiborne flora. It will be seen that these figures are of a very different order of magnitude from those resulting from a comparison of the Wilcox and Claiborne floras.

The evidence furnished by the marine faunas is nearly as overwhelming as that furnished by the terrestrial floras.

EVIDENCE OF A TIME INTERVAL BETWEEN THE CLAIBORNE AND JACKSON EPOCHS.

The evidence for predicating the southward withdrawal of the Claiborne sea and the northward advance of the early Jackson sea is very clear in the region of Mississippi River, and a great overlap of the deposits of lower Jackson age is known to have taken place in eastern Georgia. No such evidence is available in the Alabama region or southeastern Mississippi, where marine Jackson rests upon marine Claiborne without any apparent break. The sequence of events in the western Gulf area is somewhat obscure. The fossiliferous greensand and marls of the Cook Mountain formation grade imperceptibly into the gypsiferous and saliferous clays and sands of the Yegua formation. Traces of oyster beds and estuary forms like *Corbula* reappear at a few localities in the Yegua but are more and more replaced by lignites that represent swamp deposits, and the bulk of the Yegua materials represent littoral and continental deposits. The Jackson materials which overlie the Yegua in southwestern Texas are composed of sands and clays that constitute the Fayette sandstone, which in places carries a few shallow-water marine or estuarine invertebrates like *Ostrea georgiana* and *Corbula wailesiana*, or littoral forms like *Tellina eburniopsis*. The Fayette sandstone is thin to the vanishing point in western Louisiana but thickens toward the southwest until in the Rio Grande region it is 800 feet thick. The Fayette is overlain in southwest Texas by the Frio clay, which has a maximum thickness of 500 feet and contains a few oysters in its lower part. These clays become thinner toward the northeast and disappear a short distance east of Guadalupe River, where their position is occupied by the Catahoula sandstone, which is obviously littoral and continental in origin and which outcrops from the region of the Guadalupe eastward nearly to Florida, though it becomes much changed in character and age in the eastern Gulf area.

From the preceding brief sketch it becomes obvious that the sequence of events in the western part of the area is very different from what it was elsewhere along the periphery of the Mississippi Gulf. Nowhere west of the Sabine is characteristically marine Jackson or even marine Oligocene developed, but we have instead a region where minor fluctuations of the strand line occasionally permitted slight influxes of marine waters and the temporary presence of oysters and a few other estuary forms, whereas throughout most of the time involved the region was one of swamps, flood plains, and dunes.

The evidence for a time interval in the area near the present Mississippi River is furnished by the replacement of marine Claiborne by the palustrine Yegua, followed by a great transgression of the marine lower Jackson which carried marine faunas farther northward than they had penetrated since the basal Eocene or

Midway epoch. This evidence is corroborated by enormous thicknesses of Claiborne that are disclosed by well borings in western Mississippi and eastern Louisiana.

The marine faunas of the Claiborne and Jackson await monographic study. According to C. W. Cooke,[35] who is working on this problem, there are about 200 species in the Jackson formation at Jackson, Miss., of which about 49 species survived from Claiborne time. Though the two faunas are thus well marked there is little change in their facies, for the association of genera in each is the same, and species 5 come from the Lisbon formation, 5 from the Gosport sand, and 25 from the Yegua formation. The large number of Jackson species that first appear in the Yegua formation may be partly explained by the greater abundance of plant fossils in the Yegua, but I am inclined to think that the great thickness of the Yegua in central and southwestern Texas, the fluctuating strand line in that area already mentioned, and the similar floral characters all indicate that some of the beds now referred to the Yegua formation may be of Jackson age.

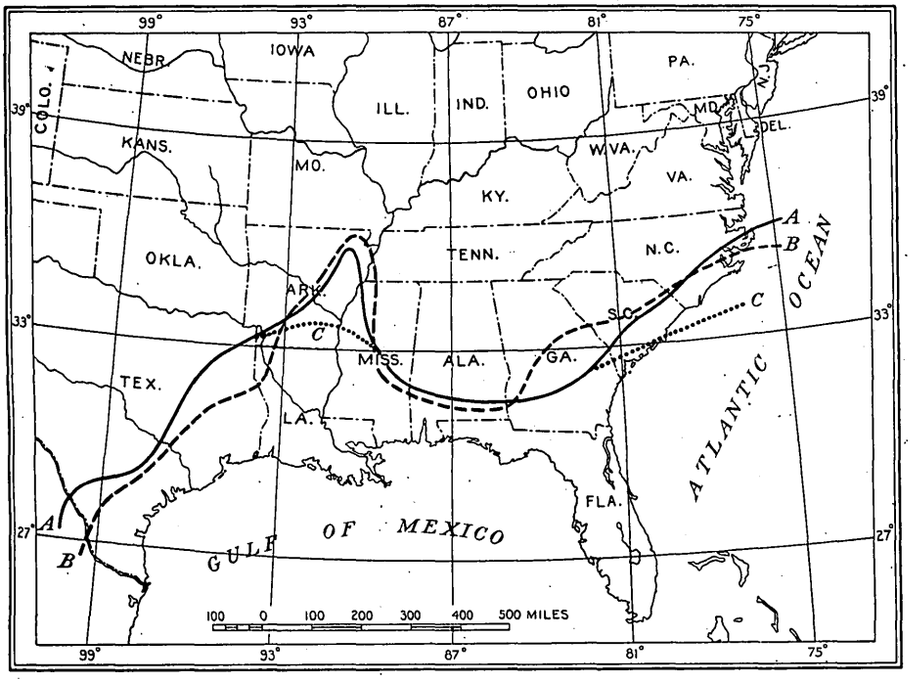

FIGURE 1.—Sketch map showing landward margin of deposits in lower and upper Claiborne time and in lower Jackson time. *A–A*, Landward margin of the upper Claiborne deposits. *B–B*, Landward margin of the lower Jackson deposits. *C–C*, Landward margin of the lower Claiborne deposits.

the differences are in general specific in character. The immigration of the active and predaceous *Zeuglodon* into the embayment area during Jackson time is a factor of some importance in contrasting the life of the two epochs.

The floras likewise are very similar in their general facies, and the distinctions are more specific than generic. The Claiborne flora, as described in this report, numbers 90 species. Thirty-five of the Jackson species make their appearance in the Claiborne. Of these 35

[35] Cooke, C. W., Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, p. 190, 1918.

The accompanying sketch map (Fig. 1) shows the landward margin of the lower and upper Claiborne, the area at the head of the embayment that represents a withdrawal of the sea, and the area in the Carolinas that represents a transgression, according to the present correlation of the beds in the latter area, which is based upon paleozoologic evidence, for there are no known floras in this region. In Figure 1 I have also endeavored to indicate the margin of the upper Claiborne and the Jackson. This sketch map shows a marked withdrawal of the Claiborne strand in the upper embayment and in eastern Texas;

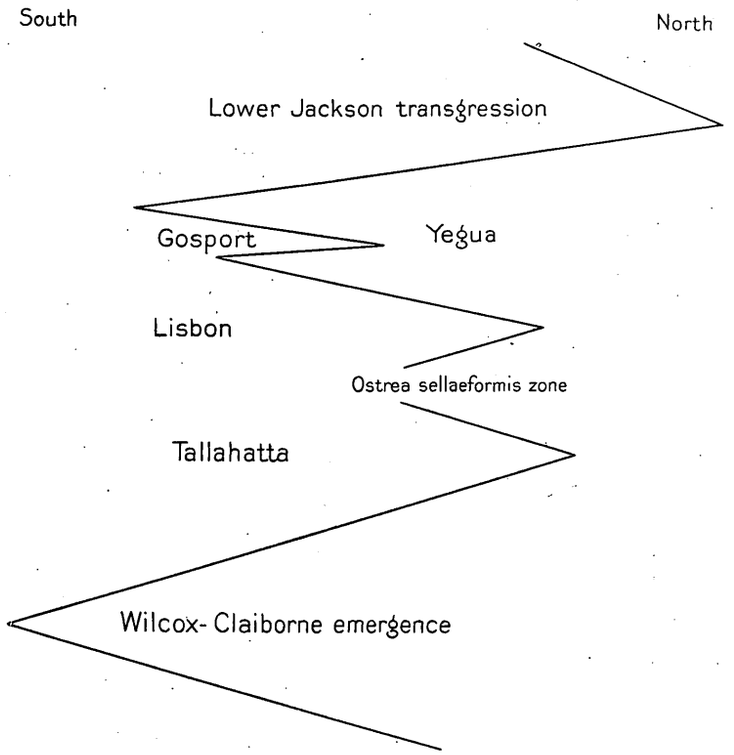

FIGURE 2.—Diagram showing movement of strand line and relation of geologic formations in the central area of the Mississippi embayment.

a marked transgression of the lower Jackson in the upper embayment and Georgia regions; and little change in the position of the strand, though there were more or less minor oscillations, in Alabama, eastern Mississippi, and southwestern Texas.

These movements are indicated diagrammatically in Figure 2 for the central embayment region and in Figure 3 for the southwestern Texas region. Figure 3 gives a somewhat tentative portrayal, but the writer believes that Figure 2 represents known facts.

CORRELATION.

NOMENCLATURE.

The Midway (?) and Wilcox floras, which were discussed in Professional Paper 91, indicate the paleobotanic history of southeastern North America during early Eocene time. In terms of European geology these deposits correspond to those of the Montian, Thanetian, Sparnacian, and Ypresian stages. Together these stages correspond to the Eonummulitic of Haug (1911), to the Suessonian of D'Orbigny, and to the Paleocene of Schimper (1874) (not that of Von Koenen, Dollo, and others, which is limited to the Montian stage). The Claiborne and Jackson, which are discussed in the present paper, include the rest of the Eocene in southeastern North America. The deposits of these epochs, together with the intervals between the Wilcox and Claiborne and between the Claiborne and Jackson, correspond to the Lutetian, Auversian (Ermenonvillian), Bartonian, and Ludian stages of the European section. Together these stages correspond to the Mesonummulitic of Haug (1911) and to the Parisian of D'Orbigny.

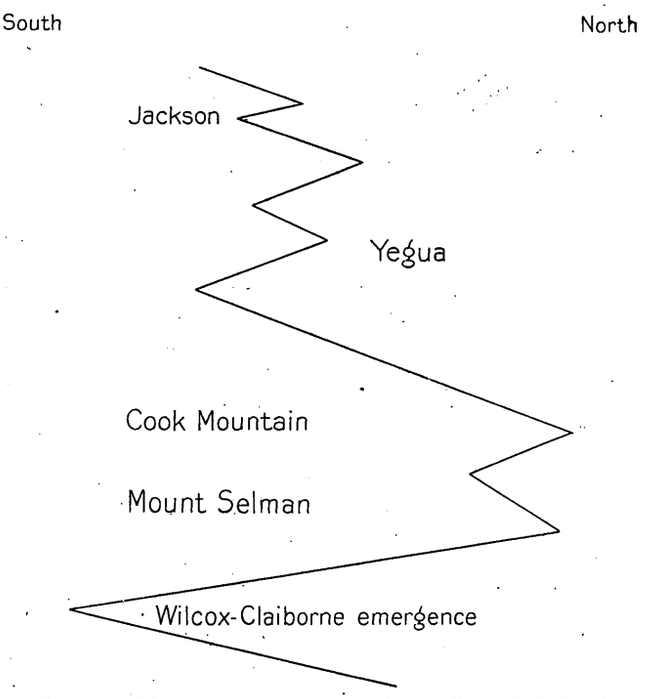

FIGURE 3.—Diagram showing movement of strand line and relation of geologic formations in the Texas area.

CORRELATION WITHIN THE CLAIBORNE GROUP.

The fossil plants have not been found in sufficient abundance nor widely enough distributed in the deposits of the Claiborne group to furnish data for precise correlation in different parts of their area of outcrop. It is possible to discriminate readily a Claiborne flora from one of Wilcox or Jackson age and somewhat empirically to differentiate middle from upper Claiborne. The following table shows the distribution of species in the four best-known formations of the Claiborne:

Distribution of species of plants in the formations of the Claiborne group.

Species.	Mount Selman.	Lisbon.	Yegua.	Gosport.
Cladosporites fasciculatus			×	
Lygodium kaulfussi		×	×	×
Anemia eocenica			×	
Acrostichum georgianum		×		×
Acrostichum hesperium			×	
Goniopteris claiborniana		×	×	
Pteris inquirenda		×		
Athrotaxis sp			×	
Sequoia langsdorfii			×	
Glyptostrobus europaeus		×		
Cupressinoxylon dawsoni			×	
Cupressinoxylon arkansanum			×	
Arundo pseudogoepperti		×	×	×
Canna flaccidafolia			×	
Thrinax eocenica	(?)	×	×	
Geonomites claibornensis	×			
Bactrites pandanifoliolus		×		
Sabalites sp			×	
Palmocarpon sp			×	
Myrica claiborniana				×
Juglans schimperi			×	
Hicoria jacksoniana			×	
Momisia americana			×	
Dryophyllum brevipetiolatum			×	
Ficus unionensis			×	
Ficus ungeri				×
Ficus newtonensis	×	×		
Ficus sp			×	
Aristolochia claiborniana			×	
Coccolobis claibornensis	×	×	×	×
Coccolobis columbianus			×	
Pisonia claiborniana			×	
Inga arkansensis			×	
Mimosites georgianus	×	×	×	
Gleditsiophyllum eocenicum	×			
Cassia cockfieldensis			×	
Copaifera yeguana			×	
Sophora claiborniana		×		
Sophora wilcoxiana			×	
Sophora balli			×	
Fagara claibornensis	×	×		
Fagara petraflumensis			×	
Citrophyllum eocenicum	×	×	×	×
Cedrela jacksoniana			×	
Celastrophyllum gymindoides		×		
Celastrophyllum columbianum			×	
Euonymus santotomasensis			×	
Cupanites parvulis			×	

Distribution of species of plants in the formations of the Claiborne group—Continued.

Species.	Mount Selman.	Lisbon.	Yegua.	Gosport.
Dodonaea viscosoides		×	×	
Sapindus georgianus	×	×	×	
Sapindus affinis		×		
Sapindus mississippiensis		×		×
Sapindus yeguanus		×	×	
Sapindus dentoni		×		
Zizyphus claibornensis		×	×	
Rhamnacinium texanum			×	
Rhamnus sp			×	
Reynosia texana			×	
Grewiopsis claiborniana			×	
Sterculia labruscoides		×	×	
Ternstroemites crowleyensis			×	
Ternstroemites claibornensis			×	
Cinnamomum angustum		×		
Persea gratissimifolia		×	×	
Persea lexingtonensis		×	×	
Oreodaphne obtusifolia			×	
Oreodaphne inequilateralis	×		×	
Mespilodaphne columbiana	×	×	×	×
Mespilodaphne caudata	×		×	
Nectandra gosportensis		×	×	×
Nectandra antillanafolia			×	
Nectandra arkansana				×
Laurinoxylon bakeri			×	
Laurinoxylon branneri			×	
Laurinoxylon lesquereuxiana			×	
Terminalia claibornensis		×		×
Myrcia trowbridgi	×			
Conocarpus eocenicus			×	×
Laguncularia claiborniana				×
Combretum petraflumensis			×	
Oreopanax mississippiense		×		
Nyssa wilcoxiana			×	
Nyssa texana			×	
Mimusops claibornensis			×	
Eoachras eocenica		×		
Diospyros brachysepala		×	×	
Apocynophyllum texensis		×	×	
Apocynophyllum grevilleafolium	×		×	
	15	33	66	15

The only known lower Claiborne plants come from the Mount Selman formation in the Coastal Plain in Texas. These are found at but few localities, are limited in variety, and are not especially well preserved. The plants found near Palafox, in Webb County, in beds of this age are of especial interest as they occur within a few feet of the contact of the Mount Selman beds with the Wilcox. The fossils found in the Wilcox in that region are entirely of upper Wilcox age, so that it may be assumed that the interval between the Wilcox and the Claiborne here was at least no longer than it was in the eastern Gulf area.

The Mount Selman flora known at the present time comprises the following 15 species:

Apocynophyllum grevilleafolium.
Apocynophyllum texensis?
Citrophyllum eocenicum.
Coccolobis claibornensis.
Fagara claibornensis.
Ficus newtonensis.
Geonomites claibornensis.
Gleditsiophyllum eocenicum.
Mespilodaphne columbiana.
Mespilodaphne caudata.
Mimosites georgianus.
Myrcia trowbridgi.
Oreodaphne inequilateralis.
Sapindus georgianus.
Thrinax eocenica?

Only two of these species—*Geonomites claibornensis* and *Myrcia trowbridgi*—are peculiar to the Mount Selman, and both represent genera not otherwise known in the Claiborne, although various species of *Myrcia* are abundant in the antecedent Wilcox and occur also in the Jackson. The genus *Geonomites* is not known from either the Wilcox or the Jackson, but it occurs in the Upper Cretaceous (Ripley formation) of Tennessee and in the lower Eocene of trans-Pecos Texas and the Rocky Mountain region. Thus neither of these genera have any special chronologic significance. Most of the remaining Mount Selman forms are common to the other Claiborne formations, and a considerable number of them extend up into the Jackson. (See table of distribution, pp. 15-17.) The only Mount Selman form that might be taken to indicate early Claiborne age is *Gleditsiophyllum eocenicum*, a common middle and upper Wilcox species, which is not known from elsewhere in the Claiborne.

It seems obvious that during the Wilcox-Claiborne emergence the flora that clothed the shores of the Mississippi embayment underwent considerable change, and that through extinction, evolution, and the introduction of new types, principally from the south, the Claiborne introduces us to a remarkably distinct assemblage, one which exhibits striking contrasts to that of the Wilcox, and that this Claiborne flora changed slowly and almost imperceptibly into that of the Jackson.

The lower Claiborne east of the Mississippi has thus far failed to yield a flora, the oldest known Claiborne flora in that region being that from the locality near Newton, Miss., which is well down in the Lisbon formation. The Lisbon and Yegua formations have 17 common species. This large number of identical species might be expected, for the Yegua is partly contemporaneous with the Lisbon.

The following 6 species are common to the Lisbon, Gosport, and Yegua:

Lygodium kaulfussi.
Arundo pseudogoepperti.
Coccolobis claibornensis.
Citrophyllum eocenicum.
Mespilodaphne columbiana.
Nectandra gosportensis.

Of these the *Lygodium* has an extensive outside distribution and all but the *Citrophyllum* and *Nectandra* range upward into the Jackson. The following 10 Lisbon species have not been found elsewhere in the Claiborne:

Pteris inquirenda.
Glyptostrobus europaeus.
Bactrites pandanifoliolus.
Sophora claiborniana.
Celastrophyllum gymindoides.
Sapindus affinis.
Sapindus dentoni.
Cinnamomum angustum.
Oreopanax mississippiensis.
Eoachras eocenica.

Six of the foregoing species occur in the Jackson and so can not be regarded as characteristic of Lisbon age, thus leaving only *Bactrites pandanifoliolus*, *Celastrophyllum gymindoides*, *Sapindus affinis*, and *Eoachras eocenica* as distinctive Lisbon species. The Yegua, on the other hand, possibly because it has a larger known flora, has furnished species which are not yet known from the Lisbon or Gosport. Three of these species, however, are Wilcox forms, and a large number range upward into the Jackson. This leaves the following 27 species which are distinctive of the Yegua:

Acrostichum hesperium.
Athrotaxis sp.
Sequoia langsdorfii.
Cupressinoxylon dawsoni.
Cupressinoxylon arkansana.
Palmocarpon sp.
Canna flaccidafolia.
Sabalites sp.
Ficus sp.
Aristolochia claiborniana.

Coccolobis columbianus.
Inga arkansensis.
Cassia cockfieldensis.
Sophora balli.
Copaifera yeguana.
Celastrophyllum columbianum.
Euonymus santotomasensis.
Cupanites parvulis.
Rhamnacinium texanum.
Rhamnus sp.
Reynosia texana.
Grewiopsis claiborniana.
Ternstroemites crowleyensis.
Ternstroemites claibornensis.
Laurinoxylon bakeri.
Laurinoxylon lesquereuxiana.
Mimusops claibornensis.

The known Lisbon flora numbers 33 species, that of the Yegua 66, and that of the Gosport 15. Of the 353 species found in the underlying Wilcox, only the following 9 forms occur in the Claiborne and the first is confined to the Mount Selman formation:

Gleditsiophyllum eocenicum.
Anemia eocenica.
Glyptostrobus europaeus.
Juglans schimperi.
Sophora wilcoxiana.
Sapindus mississippiensis.
Oreodaphne obtusifolia.
Diospyros brachysepala.
Nyssa wilcoxiana.

The *Glyptostrobus* and *Diospyros* are probably polymorphous forms that have a very wide geographic and geologic range and are thus without significance. There results a most remarkable floral contrast between the Wilcox and the Claiborne, much greater in magnitude than the marine faunas show. This great change in the vegetation must have taken place in the interval between the Wilcox and Claiborne or during the time of deposition of the Tallahatta formation, and it indicates a very considerable lapse of time for the deposition of the Wilcox and Claiborne combined, as the Claiborne flora is one that had an environment similar to that of the Wilcox, and though much less well known the majority of the genera are the same, only the species being different.

The composition of the floras thus indicates that the remarkable distinctness of the flora of the Claiborne when compared with that of the Wilcox represented a slow evolution of the Wilcox flora, rather than any sudden alteration, and not a change due to the invasion of a new flora into southeastern North America which replaced the flora of the lower Eocene. However, there must have been numerous elements that invaded this region from the south during Claiborne time. Some of these forms are probably represented among the genera that appear for the first time during the Claiborne, which include *Cladosporites*, *Acrostichum*, *Goniopteris*, *Sequoia*, *Arundo*, *Thrinax*, *Bactrites*, *Momisia*, *Copaifera*, and *Eoachras*.

None of these except the *Sequoia* and *Arundo* are known from older deposits anywhere. The *Cladosporites* is negligible, for its discovery is dependent on luck in cutting sections of petrified wood. The others appear for the first time, and though all probably came northward from the American Tropics, *Thrinax*, *Bactrites*, *Momisia*, *Copaifera*, *Eoachras*, *Acrostichum*, and *Goniopteris* appear to have originated in that region.

The following genera that are recorded from the Wilcox have not been discovered in the Claiborne:

Lycopodites.
Meniphyllioides.
Asplenium.
Zamia.
Taxodium.
Pistia.
Araceaeites.
Chamaedorea.
Nipadites.
Paraengelhardtia.
Engelhardtia.
Planera.
Hiraea.
Banisteria.
Crotonophyllum.
Euphorbiophyllum,
Drypetes.
Metopium.
Anacardites.
Heterocalyx.
Ilex.
Maytenus.
Paliurus.
Sterculiocarpus.
Bombacites.
Artocarpus.
Pseudolmedia.
Palaeodendron.
Banksia.
Proteoides.
Knightiophyllum.
Magnolia.
Anona.
Asimina.
Menispermites.
Capparis.
Parrotia.
Chrysobalanus.
Prunus.
Acacia.
Pithecolobium.
Cercis.
Dalbergia.
Dalbergites.
Canavalia.
Leguminosites.
Simaruba.
Vantanea.
Dillenites.
Calyptranthes.
Eugenia.
Combretanthites.
Trapa.
Melastomites.
Aralia.
Cornus.
Icacorea.
Sideroxylon.
Chrysophyllum.
Bumelia.
Fraxinus.
Osmanthus.
Echitonium.
Cordia.
Citharexylon.
Avicennia.
Exostema.
Psychotria.
Guettarda.

The following Wilcox genera reappear in the Jackson, so that their absence in the Claiborne collections may be regarded as accidental:

Taxodium.	Anona.
Pistia.	Banisteria.
Nipadites.	Paliurus.
Engelhardtia.	Bombacites.
Planera.	Menispermites.
Banksia.	Leguminosites.

The relation of the Claiborne flora to that of the Jackson is, on the other hand, extremely close, for the Yegua and lower Jackson in particular have many species in common. Of the 90 known Claiborne species 35, or about 39 per cent, occur in the Jackson. Of the 33 Lisbon species 5 range upward into the Jackson. Of the 15 known Gosport species 5 are found in the Jackson, and 17 of the 66 Yegua species have a similar range. The species which in the present state of knowledge serve to distinguish a Claiborne flora from one of Jackson age are as follows:

Acrostichum hesperium.
Goniopteris claiborniana.
Canna flaccidafolia.
Geonomites claibornensis.
Bactrites pandanifoliolus.
Myrica claiborniana.
Ficus ungeri.
Ficus newtonensis.
Aristolochia claiborniana.
Inga arkansensis.
Cassia cockfieldensis.
Copaifera yeguana.
Fagara claibornensis.
Citrophyllum eocenicum.
Carapa xylocarpoides.
Celastrophyllum gymindoides.
Celastrophyllum columbianum.
Cupanites parvulis.
Sapindus affinis.
Zizyphus claibornensis.
Reynosia texana.
Grewiopsis claiborniana.
Sterculia labruscoides.
Ternstroemites crowleyensis.
Persea gratissimifolia.
Persea lexingtonensis.
Oreodaphne inequilateralis.
Nectandra gosportensis.
Laurinoxylon bakeri.
Laurinoxylon lesquereuxiana.
Terminalia claibornensis.
Myrcia trowbridgi.
Laguncularia claiborniana.
Mimusops claibornensis.
Eoachras eocenica.

As none of these forms, except the *Citrophyllum*, are very abundant, they may be legitimately considered diagnostic of the Claiborne.

CORRELATION WITH OTHER AREAS.

The Claiborne flora is so distinctly a flora of the coastal region of the warmer part of North America that it has little in common with the Eocene floras that have been described from other parts of North America. These floras are, for the most part, geographically remote from the embayment region and are likewise some distance from the then existing coasts and more or less above sea level.

The flora which seems to offer the most points of contact with that of the Claiborne is that of the Green River formation of the Green River Basin in western Wyoming.

Five of the Claiborne species are found in the Green River formation. These are *Acrostichum hesperium, Arundo pseudogoepperti, Juglans schimperi, Ficus ungeri,* and *Sapindus dentoni.* Two of these species, *Arundo pseudogoepperti* and *Sapindus dentoni,* are also present in the Jackson flora of southeastern North America, thus leaving three characteristic forms that are common to the Claiborne and the Green River. This is not a large number when it is recalled that the Claiborne flora numbers 90 species and the Green River flora is an inland flora of what was probably a mountain basin, as it flourished subsequent to the period of great orogenic activity that was emphasized by the profound unconformity between the Fort Union and the true Wasatch. Our present knowledge of the flora of the Green River formation, with which the flora of the Miocene lake beds at Florissant was confused by Lesquereux, is due to the labors of Lesquereux and Newberry, published in 1883 and 1898, respectively, and to Knowlton's recent revision.[36] The Green River flora differs from that of the Claiborne in its species of *Juglans, Quercus, Alnus, Salix, Planera, Celtis, Ulmus, Ilex, Acer,* and other genera which give it a distinctly temperate facies unlike that of the Claiborne, although it appeared in a region in which palms and other warm climatic types were present. Osborn [37] from a consideration of the

[36] Knowlton, F. H., Revision of the flora of the Green River formation, with descriptions of new species: U. S. Geol. Survey Prof. Paper 131, pp. 133–182, 1923.

[37] Osborn, H. F., The age of mammals, p. 42, 1910.

not especially conclusive vertebrate remains correlates the Green River formation with the Ypresian of the European section. The floral evidence, which is somewhat more conclusive than that of the vertebrates, indicates that the Green River is considerably younger than the Ypresian. It is not very different in age from the Claiborne but may be partly synchronous with the lower Jackson and should probably be correlated with the European Bartonian. There is no necessity for discussing the extensive flora of the Fort Union formation of the Rocky Mountain province, which is so obviously older than that of the Claiborne. The species that are common to the Claiborne and Fort Union are *Lygodium kaulfussi, Sequoia langsdorfii, Glyptostrobus europaeus, Ficus ungeri, Sapindus affinis,* and *Diospyros brachysepala.* All these species except the *Sapindus* are forms that have a wide geographic and geologic range, and moreover the *Sequoia, Glyptostrobus,* and *Diospyros* are probably polymorphic forms and hence are without significance in close correlation.

Eocene plants are abundant at several horizons both east and west of the Cascade Mountains in the State of Washington. These include those of the Swauk, Roslyn, and Manastash formations east of the mountains and the Puget group west of the mountains. Descriptions of these floras have never been published, and it is possible that the flora reported from the Swauk formation may be of somewhat similar age to that of the Claiborne, for it is said to contain a remarkable array of palms and numerous tropical American types.[38]

Extensive Eocene floras have been described by Knowlton[39] from the John Day Basin in Oregon. These floras occur at two horizons. The oldest flora, which is known as the lower Clarno, is correlated by Knowlton with the Fort Union and comprises walnuts, willows, oaks, magnolias, and other forms that are indicative of a cooler climate than that of the Claiborne. The only species common to the two floras is *Lygodium kaulfussi,* which has a wide geographic and geologic range and is thus of slight significance.

[38] Knowlton, F. H., U. S. Geol. Survey Geol. Atlas, Mount Stuart folio (No. 106), 1904.

[39] Knowlton, F. H., Fossil flora of the John Day Basin, Oreg.: U. S. Geol. Survey Bull. 204, 1902.

The younger of the two Eocene floras of Oregon, that of the upper Clarno, has been compared by Knowlton to that of the Green River formation. It includes the number of species indicated in the following genera:

Acer, 2.	Grewia, 2.
Ailanthus, 1.	Hicoria, 1.
Alnus, 5.	Juglans, 4.
Berberis, 1.	Liquidambar, 1.
Betula, 4.	Myrica, 1.
Carpinus, 1.	Platanus, 2.
Cassia, 1.	Quercus, 7.
Cinnamomum, 1.	Rhamnus, 1.
Corylus, 1.	Sapindus, 1.
Crataegus, 1.	Sequoia, 2.
Ficus, 1.	Ulmus, 2.
Fraxinus, 2.	

These forms are obviously temperate types, and the only form common to the Claiborne is the wide-ranging *Sequoia langsdorfii,* which is without significance. Therefore, if the upper Clarno flora is of nearly the same age as the Claiborne—a point which is by no means settled, as it may be considerably younger—it lived in a very different environment and had a totally different botanic facies.

To the northward along the Pacific coast there is the so-called Kenai flora of Alaska, which is evidently a part of that extensive temperate flora that flourished throughout the Arctic regions during the late Eocene and possibly extended into the Oligocene. Although this Alaskan flora is being studied by Hollick, present comparisons rest on the older work of Heer,[40] Lesquereux,[41] and Knowlton.[42] The only two Claiborne species that are found in the Alaska Tertiary are *Sequoia langsdorfii* and *Glyptostrobus europaeus,* both of which are probably polymorphic, and both ranged all over the Northern Hemisphere and lived throughout the Tertiary. They are therefore without significance.

The Tertiary flora of Alaska is extensive, and when the recent collections of the Geological Survey have been described many new species will presumably be brought to light.

[40] Heer, Oswald, Flora fossilis arctica, Band 2, 1871.

[41] Lesquereux, Leo, Contribution to the Miocene flora of Alaska: U. S. Nat. Mus. Proc., vol. 5, pp. 443–449, pls. 1–5, 1883.

[42] Knowlton, F. H., A review of the fossil flora of Alaska, with descriptions of new species: U. S. Nat. Mus. Proc., vol. 17, pp. 207–240, pl. 9, 1895; Report on coal and lignite of Alaska (by W. H. Dall): U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, p. 876, 1896; Fossil plants from Ku Kak Bay: Alaska, vol. 4, pp. 149–162, pls. 22–33, Harriman Alaska Expedition, 1904.

The Alaska flora is essentially a temperate flora that has an abundance of conifers (*Picea, Pinus, Sequoia, Taxodium, Glyptostrobus, Taxites*, and others) and many species and a great individual abundance of *Populus, Salix, Fagus, Quercus, Betula, Corylus, Alnus, Juglans, Ulmus, Acer, Vaccinium*, and other forms. There are some warmer types, such as *Ficus, Pterospermites, Diospyros, Zizyphus*, and similar forms, but they lack the climatic significance of the preceding groups and represent northward extensions into a region that is characterized by a temperate climate, a long growing season, and heavy rainfall.

The Arctic flora found at the mouth of the Mackenzie, in Greenland, Grinnell Land, Spitzbergen, Franz Josef Land, throughout Siberia, and elsewhere, generally associated with great igneous activity and basic rocks, does not require any extended analysis here. The flora of the west coast of Greenland and Disco Island will indicate sufficiently the general character of these remarkable polar floras. The Greenland flora, a knowledge of which we owe almost entirely to the labors of Heer, consists of 282 species. It includes 19 ferns, 28 conifers—*Taxites, Tumion, Ginkgo, Juniperus, Libocedrus, Thuya, Widdringtonia, Taxodium, Glyptostrobus, Sequoia* (6 species), and *Pinus* (6 species)—21 monocotyledons, including two palms, and a vast abundance of dicotyledonous leaves of *Populus, Salix, Myrica, Alnus, Corylus, Fagus, Castanea, Quercus* (15 species), *Ulmus, Platanus, Juglans* (9 species), *Lauraceae* (7 species), *Andromeda* (5 species), *Fraxinus, Viburnum, Cornus, Nyssa, Vitis, Magnolia* (6 species), *Acer* (5 species), *Ilex, Celastrus, Rhamnus, Rhus, Crataegus*, and other forms. No attempt is made to revise Heer's determinations, although several—for example, his identifications of palms—have an extremely slight basis.

This flora has always excited the utmost interest. It was long considered to be of lower Miocene (Aquitanian) age—placed by some in the Oligocene—but Saporta and after him Starkie Gardner pointed out its earlier age. It has been generally considered to be of Eocene or Oligocene age in recent years, although according to Menzel [43] two horizons are represented, one Eocene and the other upper Oligocene. This statement appears to be based on no critical study of the flora but on Nathorst's separation of the Arctic Tertiary floras into a "prebasaltic" and a "younger basaltic" stage.

This display of temperate forest types at a latitude 20° to 25° north of their present limits and almost at the pole itself is an excuse for mentioning it in this report. There is no adequate basis for direct comparison between it and the Claiborne flora, but it seems clearly probable that the period of warm climate in southeastern North America, which commenced with the upper Claiborne and extended through the Jackson and Vicksburg, represents the time of the great Arctic extension of the temperate flora. This climatic amelioration in the embayment region, as attested by both the marine faunas and terrestrial floras, reached its culmination in post-Claiborne time in the Jackson and Vicksburg, and therefore the Arctic Tertiary flora is somewhat younger than the Claiborne.

COMPARISON WITH EUROPEAN FLORAS.

The middle and upper Eocene floras of Europe are not as extensive as might be wished, and where extensive plant beds occur at these horizons they are either undescribed, like those of the south of England, or very inadequately described and illustrated, like those of Venice in Italy. The middle Eocene in Europe was a time of positive movement of the strand line. Europe was separated from Asia by a broad arm of the sea which extended in the Ural region northward to the Arctic Ocean, and a great mediterranean sea extended northward in Russia to latitude 60° and southward from Vienna to Khartum; Britain and Spain were islands; the Caucasus region was an island over 250 miles from the nearest shores; the Carpathian-Balkan region was a large island, as was the core of the Swiss Alps; France was part of a peninsula that extended from the Vosges region south and southwest to Gibraltar and embraced a part of Corsica and Sardinia; and a broad strait, 175 miles wide, separated the southernmost end of the peninsula from the African shore. The broad mediterranean sea extended across northern Africa and eastward through Asia. This middle Eocene transgression was not especially favorable for the preservation of either terrestrial floras

[43] Menzel, P., Ueber arktische Fossilflora: Freiberger geol. Gesell. Jahresber. 3, pp. 46–49, 1910.

or faunas, but the seas abounded in marine life, and eventually intercontinental correlations by the faunal criteria will be possible.

Bureau [44] has described a few plants, including *Pandanus*, *Flabellaria*, *Sabal*, *Yucca*, and *Nuphar*, from these beds in the Paris Basin; and at Trocadero, near Paris, an estuary flora, largely undescribed but including *Euphorbiophyllum*, *Nerium*, *Ottelia*, *Pandanus*, *Nipadites*, *Zizyphus*, and other forms, has been recorded.

In the south of England the plants of the Bagshot sands and Bournemouth clays have never been carefully described, although the ferns and gymnosperms were rather fully treated by Ettingshausen and Gardner. The ferns number 18 species and include a fine *Acrostichum*, a tropical *Gleichenia*, a striking *Goniopteris*, a species of *Hewardia* close to existing forms of Central America, the same species of *Lygodium* that occurs in the Claiborne, and several other genera of a tropical character. The conifers include *Araucaria*, *Glyptostrobus*, *Pinus*, *Podocarpus*, *Athrotaxis*, and *Sequoia*. The palms, which are still undescribed, are said to include *Iriartaea*, *Phoenix*, *Calamus*, and *Nipa*. The dicotyledons, of which there are many, all undescribed, are said to include *Ficus*, *Myrica*, *Cinnamomum*, *Dioscorea*, and the tropical genus *Godoya*.

The lower Lutetian flora from the classic locality of Monte Bolca in Venice, Italy, is the most extensive flora known from this horizon. As somewhat overelaborated by Massalongo,[45] it contains 125 species. Six of these are gymnosperms (5 species of *Podocarpus* and 1 species of *Taxodium*). There are 33 monocotyledons, mostly of slight value, and few palms. There are 86 dicotyledons and no ferns, and the general facies is not only very different from that of the Claiborne flora but almost equally unlike the flora of the upper Lutetian of Italy.

The upper Lutetian flora of Novale in Venice is quite different from the lower Lutetian flora just mentioned. As elaborated by Visiani and Massalongo [46] it contains 138 species. These forms include 5 thallophytes; 4 ferns, including *Acrostichum* and *Pteris;* 4 gymnosperms; 15 monocotyledons, including *Arundo* and *Potamogeton;* and many dicotyledons. There are 23 species of Leguminosae and species of *Myrica*, *Ficus*, *Laurus*, *Cinnamomum*, *Sapindus*, *Cupanites*, *Celastrus*, *Zizyphus*, *Aralia*, *Eugenia*, *Myrcia*, *Dalbergia*, *Caesalpinia*, *Cassia*, *Inga*, *Bumelia*, *Diospyros*, and other genera.

This flora is distinctly like that of the Claiborne in its general composition, and the same remark is true of the small florules from the Auversian of Ronca, Vegroni, and other localities in Venice, which include species of *Acrostichum*, *Coccolobis*, *Laurus*, *Terminalia*, *Apocynophyllum*, *Cinnamomum*, *Dombeyopsis*, and other genera.

It seems conclusive that the Claiborne flora is younger than the known lower Lutetian floras, but it shows considerable resemblance to floras from the upper Lutetian and Auversian (=Ermenonvillian). I therefore reach the conclusion, admittedly tentative, that the known Claiborne flora of southeastern North America indicates an age corresponding to the Auversian stage (Dollfus, 1880) of European geology (=Lower Bartonian, Munier-Chalmas and De Lapparent, 1893; Ermenonvillian, Dollfus, 1880; Valoisian, Paul Combes fils, 1906; and Ledian, Mourlon, 1883).

THE FLORA.

THALLOPHYTA.

Fungi:
- Pyrenomycetes (?):
  - Cladosporites fasciculatus Berry.

PTERIDOPHYTA.

Filicales:
- Schizaeaceae:
  - Lygodium kaulfussi Heer.
  - Aneimia eocenica Berry.
- Polypodiaceae:
  - Acrostichum georgianum Berry.
  - Acrostichum hesperium Newberry.
  - Goniopteris claiborniana Berry.
  - Pteris inquirenda Berry.

[44] Bureau, Édouard, Études sur la flore fossil du calcaire grossier parisien: Soc. philomathique (Paris) Mém. Cent., pp. 235–264, pls. 22–23, 1888.

[45] Massalongo, Abramo, Schizzo geognostico sulla valle del Progno o torrente d'Illasi, con un saggio sopra la flora primordiale del Monte Bolca, Verona, 1850; Monografia delle Nereidi fossili del Monte Bolca, Verona, 1855; Vorläufige Nachricht über die neueren paläontologischen Entdeckungen am Monte Bolca, Neues Jahrb., 1857, pp. 775–778.

[46] Visiani, Roberto, and Massalongo, Abramo, Synopsis plantarum florae tertiariae novalensis: Flora (new ser.), Jahrg. 12, vol. 1, No. 8, pp. 113–124, Regensburg, 1854; Flora de terreni terziarii di Novale nel Vicentino: R. Accad. sci. Torino Mem., 2d ser., vol. 17, pp. 199–244, pls. 1–13, (1856), 1858.

SPERMATOPHYTA.

Gymnospermae:
- Pinaceae:
  - Coniferales:
    - Athrotaxis sp.
    - Sequoia langsdorfii (Brongniart) Heer.
    - Glyptostrobuse uropaeus (Brongniart) Heer.
    - Cupressinoxylon dawsoni Penhallow.
    - Cupressinoxylon arkansanum Knowlton.

ANGIOSPERMAE.

Monocotyledonae:
- Poales:
  - Poaceae:
    - Arundo pseudogoepperti Berry.
- Scitaminales:
  - Cannaceae:
    - Canna flaccidafolia Berry.
- Arecales:
  - Arecaceae:
    - Sabalites sp.
    - Thrinax eocenica Berry.
    - Geonomites claibornensis Berry.
    - Bactrites pandanifoliolus Berry.
    - Palmoxylon lacunosum (Unger) Felix.
    - Palmocarpon sp.

Dicotyledonae:
- Choripetalae:
  - Juglandales:
    - Juglandaceae:
      - Juglans schimperi Lesquereux.
      - Hicoria jacksoniana Berry.
  - Myricales:
    - Myricaceae:
      - Myrica claiborniana Berry.
  - Fagales:
    - Fagaceae:
      - Dryophyllum brevipetiolatum Berry.
  - Urticales:
    - Ulmaceae:
      - Momisia americana Berry.
    - Moraceae:
      - Ficus unionensis Berry.
      - Ficus ungeri Lesquereux.
      - Ficus newtonensis Berry.
      - Ficus sp. (fruit).
  - Aristolochiales:
    - Aristolochiaceae:
      - Aristolochia claiborniana Berry.
  - Polygonales:
    - Polygonaceae:
      - Coccolobis claibornensis Berry.
      - Coccolobis columbianus Berry.
  - Chenopodiales:
    - Nyctaginaceae:
      - Pisonia claiborniana Berry.
  - Rosales:
    - Mimosaceae:
      - Inga arkansensis Berry.
      - Mimosites georgianus Berry.
    - Caesalpiniaceae:
      - Gleditsiophyllum eocenicum Berry.

Dicotyledonae—Continued.
- Choripetalae—Continued.
  - Rosales—Continued.
    - Caesalpiniaceae—Continued.
      - Cassia cockfieldensis Berry.
      - Copaifera yeguana Berry.
    - Papilionaceae:
      - Sophora claiborniana Berry.
      - Sophora balli Berry.
      - Sophora wilcoxiana Berry.
  - Geraniales:
    - Rutaceae:
      - Fagara claibornensis Berry.
      - Fagara petraflumensis Berry.
      - Citrophyllum eocenicum Berry.
    - Meliaceae:
      - Cedrela jacksoniana Berry.
      - Carapa xylocarpoides Berry.
  - Sapindales:
    - Celastraceae:
      - Celastrophyllum gymindoides Berry.
      - Celastrophyllum columbianum Berry.
      - Euonymus santotomasensis Berry.
    - Sapindaceae:
      - Cupanites parvulis Berry.
      - Dodonaea viscosoides Berry.
      - Sapindus georgianus Berry.
      - Sapindus affinis Newberry.
      - Sapindus mississippiensis Berry.
      - Sapindus yeguanus Berry.
      - Sapindus dentoni Lesquereux.
  - Rhamnales:
    - Rhamnaceae:
      - Zizyphus claibornensis Berry.
      - Rhamnacinium texanum Penhallow.
      - Reynosia texana Penhallow.
      - Rhamnus sp.
  - Malvales:
    - Tiliaceae:
      - Grewiopsis claiborniana Berry.
    - Sterculiaceae:
      - Sterculia labruscoides Berry.
  - Parietales:
    - Ternstroemiaceae:
      - Ternstroemites crowleyensis Berry.
      - Ternstroemites claibornensis Berry.
  - Thymeleales:
    - Lauraceae:
      - Cinnamomum angustum Berry.
      - Persea gratissimifolia Berry.
      - Persea lexingtonensis Berry.
      - Oreodaphne obtusifolia Berry.
      - Oreodaphne inequilateralis Berry.
      - Mespilodaphne columbiana Berry.
      - Mespilodaphne caudata Berry.
      - Nectandra gosportensis Berry.
      - Nectandra antillanafolia Berry.
      - Nectandra arkansana Berry.
      - Laurinoxylon bakeri Berry.
      - Laurinoxylon branneri Knowlton.
      - Laurinoxylon lesquereuxiana Knowlton.

Dicotyledonae—Continued.
Choripetalae—Continued.
Myrtales:
Myrtaceae:
Myrcia trowbridgi Berry.
Combretaceae:
Terminalia claibornensis Berry.
Conocarpus eocenicus Berry.
Combretum petraflumense Berry.
Laguncularia claiborniana Berry.
Umbellales:
Araliaceae:
Oreopanax mississippiensis Berry.
Cornaceae:
Nyssa texana Berry.
Nyssa wilcoxiana Berry.
Gamopetalae:
Ebenales:
Sapotaceae:
Mimusops claibornensis Berry.
Eoachras eocenica Berry.
Ebenaceae:
Diospyros brachysepala Alexander Braun.
Gentianales:
Apocynaceae:
Apocynophyllum texensis Berry.
Apocynophyllum grevilleafolium Berry.

Phylum THALLOPHYTA.

Class FUNGI.

Order PYRENOMYCETES (?).

Genus CLADOSPORITES Felix.

Cladosporites fasciculatus Berry.

Plate II, Figures 1, 2.

Cladosporites fasciculatus Berry, Mycologia, vol. 8, p. 77, pl. 182, figs. 1, 2, 1916.

Mycelium intracellular, in the vessels of the secondary wood, attached to the vessel walls by haustoria, and forming small fasciculate, apparently unbranched tufts, which project freely into the vessel cavity. The hyphae are thin, and most of them taper somewhat distad, although some of them taper proximad. Septa were not observed. In only one slide was a distal branch observed (Pl. II, fig. 2). Although there are some hundreds of tufts of this fungus in the slides examined, only two of them show conidia (Pl. II, fig. 1). The conidia are terminal, fusiform in outline, and differ somewhat in length. They appear to be simple, and I am unable to assert positively that they are cut off from the hyphae by septa, although I imagined that I saw such septation. The hyphae average about 0.0013 millimeter in diameter and the conidia range from 0.002 by 0.004 millimeter to 0.002 by 0.012 millimeter.

It is found in exceeding abundance in silicified specimens of lauraceous wood from the middle Eocene (Yegua formation of the Claiborne group) of Texas and the upper Eocene (Jackson) of Mississippi and Texas and is unlike any previously recorded fossil forms. I do not know its botanic affinity, and rather than multiply generic terms of unknown botanic value I have preferred to refer it to Felix's genus *Cladosporites*, in view of the resemblance of the species to the existing *Cladosporium herbarum* (Persoon) Link.

Associated with this species are rambling mycelial hyphae, which clamber over the vessel walls. These hyphae bear numerous antheridia and oogonia or sclerotia, and their characteristic appearance is shown in Plate II, Figure 1. I do not consider it worth while to attempt to name or describe them.

Occurrence: Yegua formation, on the second creek crossing the northeast-southwest road that is parallel with Cane Creek on the north and about half a mile distant from it (No. 219); also at Westmoreland Bluff (No. 232); both localities near Trinity River, Houston County, Tex.

Phylum PTERIDOPHYTA.

Order FILICALES.

Family SCHIZAEACEAE.

Genus LYGODIUM Swartz.

Lygodium kaulfussi Heer.

Plate III, Figures 1, 5.

Lygodium kaulfussi Heer, Beiträge zur nähern Kenntnisse der sächsisch-thüringischen Braunkohle, p. 3, pl. 8, fig. 21; pl. 9, fig. 1, 1861.
Gardner and Ettingshausen, British Eocene flora, vol. 1, p. 47, pl. 7, figs. 1, 3–8; pl. 10, fig. 11, 1880; idem, p. 67, pl. 13, figs. 8, 9, 1882.
Friedrich, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen, pp. 13, 80, pl. 7, fig. 11, 1883.
Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.
Newberry, U. S. Geol. Survey Mon. 35, p. 1, pl. 62, figs. 1–4, 1898.
Knowlton, U. S. Geol. Survey Mon. 32, p. 672, pl. 80, figs. 1–3, 1899; U. S. Geol. Survey Bull. 204, p. 21, 1902.
Lygodium neuropteroides Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1870, p. 384, 1871; The Tertiary flora, p. 61, pl. 5, figs. 4–7; pl. 6, fig. 1, 1878.

?*Aneimia kaulfussi* Crié, Recherches sur la végétation de l'ouest de la France à l'époque tertiaire, p. 22, pl. A, figs. 2, 3, 1877.

?*Asplenites allosuroides* Unger, Die fossile Flora von Sotzka, p. 25, pl. 1, figs. 1–3, 1850.

?*Asplenites prae-allosuroides* Gardner and Ettingshausen, British Eocene flora, vol 1, p. 34, pl. 3, figs. 1, 2, 1879; idem, p. 68, 1882.

Heer thus described this species in 1861:

L. foliis lobatis (?); lobis lanceolatis, crenulatis, nervo medio ceteris paulo fortiore, nervis secundariis, angulo peracuto egredientibus, dichotomis.

The foregoing incomplete diagnosis was framed for the imperfect type material from the south German "brown coal." The species has subsequently been reported from a large number of localities and horizons both in this country and abroad. It may be redescribed as follows:

Twining or climbing ferns that bear sterile pinnules proximad and fertile pinnules with much reduced laminae in terminal panicles. Indusia attached by their broad bases to short oblique veinlets of the greatly reduced laminae of the fertile pinnules, imbricated and scale-like exactly as in our existing *Lygodium palmatum* Swartz, the only observable difference being the greater reduction of the laminae in *Lygodium kaulfussi*. Sterile pinnules variable in size and outline; digitately bipartite, tripartite, quadripartite, or quinquepartite; more or less cordate at the base. Lobes are unequal in length and diverge at different angles, are usually obtusely rounded distad, although some of them taper instead of being linear-oblong, and are somewhat widened at the base and separated by deep, angular or narrowly rounded sinuses. The margins are more or less undulate and in some specimens show very broad and very shallow crenations. Texture coriaceous. Venation clearly defined and strong. Two main primaries diverge from the base and give off subbasally a primary for each lobe, and all become lost in the apex of the lobes by repeated branching. The secondaries are close, diverge at narrow angles, and curve outward. They may be several times narrowly forked, a feature that depends on their position and length, and are thin but sharply defined throughout their whole course, terminating in the margins.

The present species has been recorded from a number of European localities and ranges in age from the Lutetian to the Aquitanian. It was discovered at Barrel Springs, Wyo., in shales that were long thought to be of Green River age but that are not now considered to be a part of that formation. The exact age is unknown but is probably middle or upper Eocene. The species, which is present in great abundance, was originally described by Lesquereux as *Lygodium neuropteroides*. Gardner in his discussion of the ferns of the British Eocene says that Lesquereux had material from Bournemouth and stated in a letter that the American form was "positively identical" with the European, and Newberry came to the same conclusion.[47] Fructifications are associated with these sterile pinnules at several localities. The American material is identical with the European in the character of the fertile pinnules and in the venation of the sterile pinnules. The sterile pinnules are in general broader and more obtuse in the American material. The species is exceedingly abundant in the Eocene of Wyoming. It has also been recorded from the Eocene of the Pacific coast and from the Fort Union of Wyoming, and I fail to find specific differences between these specimens and those from the Claiborne. The species has not been found in abundance in the Claiborne, probably because the small collections which have been made come for the most part from unfavorable deposits. It occurs in considerable numbers but in a fragmentary condition in the Gosport sand at Claiborne Landing on Alabama River and in a railroad cut 3¼ miles east of Newton, Miss., where it is associated with a species of *Modiola*. The bed at the locality in Mississippi is above the Tallahatta formation and below the *Ostrea sellaeformis* zone and thus lies in the lower part of the so-called calcareous Claiborne, or in what corresponds to the Lisbon formation of western Alabama. Two other species of *Lygodium* are known from the embayment area—*Lygodium binervatum* (Lesquereux) Berry, a Wilcox species, which is distinguishable by its robust form, its two relatively short and broad lobes, and its stouter and more open venation and more elongate fertile pinnules; and *Lygodium mississippiensis* Berry, from the upper Vicksburg of Mississippi, which is distinguishable by its very small size and bilobate form. The

[47] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 3, 1898.

identification of *Lygodium kaulfussi* in the upper Claiborne is of especial interest from its abundance in the Eocene of the Rocky Mountain province and also from its prominence in European middle and upper Eocene floras.

The genus *Lygodium* has between 20 and 30 existing species in the warmer parts of both hemispheres and extends outside the subtropical zone into the warmer temperate regions in southern Japan (*Lygodium japonicum* Swartz), in northern New Zealand (*Lygodium articulatum* Richard), and in eastern North America, where *Lygodium palmatum* Swartz ranges as far northward as the southern New England States. All the modern forms are lianas, either climbing or twining, and some of the tropical species are said to exceed a hundred feet in length. The Tertiary forms probably shared this habit. The present species occurs sparingly in the Forest Hill ("Madison") sand of Mississippi.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, on Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by T. H. Aldrich). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Genus ANEIMIA Swartz.

Aneimia eocenica Berry.

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

Character of frond unknown, but it is stipate, dichotomous, and bipinnate or tripinnate in the closely allied species *Aneimia subcretacea* (Saporta) Gardner and Ettingshausen,[48] which is a widely distributed and well-known species that ranges in Europe from the base of the Eocene as high as the Lutetian and is more abundant at the later rather than the earlier horizons. Pinnae ovate-lanceolate, pinnately divided almost to the rachis into lanceolate lobes. The lobes are attached very obliquely by their entire base, though possibly those lower down on the frond may have had a narrower base and been free pinnules, and are more or less confluent, becoming more and more confluent distad. The angle of divergence is about 20° or less and becomes more acute distad. Lobes linear-lanceolate, sharply pointed, with distant serrate teeth, commonly in pairs, decurrent, and separated by narrow acute sinuses. Texture coriaceous. Rachis slender, flexuous, prominent on the lower surface of the pinnae. The midrib of the lobes (pinnules) diverges from the rachis at a very acute angle (between 5° and 10°) near the lower decurrent margin and curves outward and retains its identity nearly to the tip of the lobe, although it becomes 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, and the distal branch usually forks before reaching the margin, whereas the proximal one commonly remains simple. There are five or six of these branches on each side. The veins are thin but distinct, and all terminate in the margin, one entering each marginal tooth. There are 6 or 8 marginal teeth on each margin, commonly in pairs, somewhat irregularly spaced, and in general becoming closer distad. These teeth are distinctly serrated, and the points are produced and directed upward. The apex of the lobe is gradually narrowed and acuminate.

The present species is closely allied to *Aneimia subcretacea*, which has been previously mentioned and which was described originally from the Paleocene of France by Saporta [49] as *Asplenium subcretaceum*. Shortly afterward Lesquereux described a form which subsequently was correlated with this same species as *Gymnogramma haydeni*.[50] This species came from the divide between Snake River and Yellowstone Lake. The beds at this locality, which has never been rediscovered, were formerly assumed to be Laramie, although they may be basal Eocene. In 1880 Gardner and Ettingshausen, who had abundant remains from the middle Bagshot beds of the south of England, were able to associate these occurrences and to prepare a full account of the species. The present species, though close to this widespread

[48] Gardner, J. S., and Ettingshausen, C. von, British Eocene flora, vol. 1, pt. 2, p. 45, pls. 8, 9, 1880.

[49] 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.

[50] Lesquereux, Leo, Enumeration and description of the fossil plants from the specimens obtained in the explorations of Dr. F. V. Hayden, 1870 and 1871: U. S. Geol. Survey Terr. Ann. Rept. for 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*).

lower and middle Eocene form, differs sufficiently 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 its venation is much more open. Though the lobes of some of the English material are as slender, all of the foreign material as well as the western material has crenate or dentate teeth, which pass gradually into rounded distal lobes. In *Aneimia eocenica*, on the other hand, the lobes preserve their character distad, and all have distinctly serrate teeth that are more or less produced upward.

Gardner in his work on the English material submitted either specimens 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*, for Saporta inclined toward a new genus allied to *Todea* and Stur suggested *Osmunda*. Heer also opposed *Aneimia*, and Lesquereux thought that his material was more closely allied to *Gymnogramme tartarea* Desvaux, of tropical America.

Though the majority of existing species of *Aneimia* are rather different in appearance, the subgenus *Aneimiorrhiza* J. Smith, especially the exclusively American section Cuneatae Prantl, including *Aneimia cicutaria* 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 *Aneimia subcretacea* and *Aneimia adiantifolia*. The latter is found as far northward as southern peninsular Florida and is referred by Underwood to the genus *Ornithopteris* Bernhardi.

The present species is sparingly represented in the late middle Wilcox of the upper part of the Mississippi embayment, and fragmentary specimens are abundant in the buff, finely sandy clays of the Claiborne of Texas. A closely allied species occurs in the Raton formation of the southern Rocky Mountain Province.

Occurrence: Yegua formation, 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen); 1 mile southwest of Antioch, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family POLYPODIACEAE.

Genus ACROSTICHUM Linné.

Acrostichum georgianum Berry.

Acrostichum georgianum Berry, U. S. Geol. Survey Prof. Paper 84, p. 133, pl. 27, fig. 1, 1814.

Frond large, pinnate (?). Pinnae thin but coriaceous, oblong-lanceolate, inequilateral, with an entire undulating margin, an obtusely rounded apex, and a narrowed (?) base, about 2.5 centimeters wide and of unknown length, presumably about 10 to 12 centimeters. The pinnae range considerably more and less than these dimensions, but all the collected material is fragmentary, and in some of the fragments the thin stiff edges are folded over, which indicates possibly a greater width. Midvein stout. Lateral veins numerous, 1 millimeter or less apart, very fine, intricately anastomosing, branching from the midvein at acute angles, the angle dependent upon their situation in the basal or apical part of the pinna. The basal veins subtend angles of about 60°, but those in the apex approach a position almost parallel with the midvein; the intermediate ones branch at a very acute angle and immediately diverge outward, their general direction being about 50 degrees from that of the midvein. Areolation consists of slightly elongated 5-sided or 6-sided meshes.

This handsome species is unfortunately based upon fragments, which are, however, very abundant in beds of lower Jackson age in Georgia and are also present in the Gosport sand at the historic locality of Claiborne Landing, Ala.

The species is closely related to *Acrostichum hesperium* Newberry,[51] of the Green River formation of Wyoming and the Yegua formation of Louisiana, but differs from it in being much smaller and somewhat more slender in habit and in having straighter midveins and less elongate, finer areolation. There is no evidence of the separateness or coalescence of the terminal pinnae, a feature which serves

[51] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 6, pl. 61, figs. 2–5, 1898.

to distinguish Newberry's species from all other described forms.

Almost as similar to *Acrostichum georgianum* is the European *Acrostichum* (*Chrysodium*) *lanzeanum* (Gardner and Ettingshausen),[52] which is described at length by Gardner and is common in the Lutetian and Bartonian of southern England. Remains that appear to be identical are reported from the Ligurian of Dalmatia and southern France and from the Tongrian of France and Italy. Another species is reported by Saporta from the Aquitanian of southern France, and Squinabol reports two additional species from the Tongrian of Liguria, Italy.

A second American species of lower Eocene age was described in 1902 by Hollick[53] from Colorado. In this connection mention should also be made of a form described by Lesquereux[54] as *Gymnogramme gardneri* from Sand Creek, Colo., which both Gardner and Saporta are inclined to consider an *Acrostichum* and which is of basal Eocene age.

The modern species of *Acrostichum* are swamp forms. They are few in number and include, in addition to several unimportant species of the Lesser Antilles and West Indies, the widespread tropical fern *Acrostichum* (*Chrysodium*) *aureum* Linné, a common coastal species of the mangrove and nipa swamps and similar situations, more particularly on the less saline and less wet soils. It ranges in America from peninsular Florida to Brazil, in Africa from Guinea to Natal and the Mascarene and Seychelles islands, and in the Orient from southern China and Polynesia to northern Australia.

It is very remarkable that this cosmopolitan modern genus should appear at about the same time in America and Europe and should display a number of closely allied forms at widespread localities in both the Eocene and Oligocene and should not be detected at any of the numerous outcrops of later Miocene or Pliocene plant-bearing deposits. Undoubtedly this southward retreat from 51° north latitude was due to changing physical conditions, chief of which was the lessening humidity, combined with the lowering of temperature.

[52] Gardner, J. S., and Ettingshausen, C. von, British Eocene flora, vol. 1, p. 26, pl. 1; pl. 2, figs. 1–4, 1879.

[53] Hollick, Arthur, Fossil ferns from the Laramie group of Colorado: Torreya, vol. 2, p. 146, pl. 4, figs. 3–6, 1902.

[54] Lesquereux, Leo, The Tertiary flora, p. 58, pl. 4, fig. 2, 1878.

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Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, on Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by T. H. Aldrich).

Collection: U. S. National Museum.

Acrostichum hesperium Newberry.

Plate III, Figures 3, 4.

Acrostichum hesperium Newberry, U. S. Nat. Mus. Proc., vol. 5, p. 503, 1883; U. S. Geol. Survey Mon. 35, p. 6, pl. 61, figs. 2–5, 1898.

Newberry originally described this species in 1883 as follows:

Frond large, pinnate; pinnae linear, 1½ to 2 inches wide, 6 to 12 inches long, rounded at remote extremity, those in lower part of frond rounded or wedge-shaped at base, those above united by the entire base to the rachis and with each other; rachis of frond and midrib of pinnae strong, smooth, somewhat sinuous; nervation reticulated, lateral nerves numerous, diverging from the midrib at an acute angle, anastomosing to form elongated six-angled areoles; fructification unknown.

This fine species was characterized in the foregoing brief manner by Newberry and was compared by him with *Acrostichum aureum* Linné of the existing flora and with *Acrostichum lanzeanum* Gardner and Ettingshausen of the European Lutetian and Bartonian. Newberry's material came from the Green River formation of Wyoming, and although his illustrations are considerably reduced there is no statement to that effect either on the plates or in the text.

Material that is apparently identical with this Green River species is very abundant in the Yegua formation but in a fragmentary condition, so that the method of attachment of the pinnae, a probably variable and anomalous feature in the Green River specimens, can not be made out. In their large size and elongated areolae the Yegua forms agree with the western material and differ from *Acrostichum georgianum* Berry, which is so common in the beds of Jackson age in Georgia. Still another American species of *Acrostichum* is abundant in the Oligocene subtropical flora of southern Mississippi.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum. (Some of Newberry's types are in the collections of the New York Botanical Garden and have been available for comparison.)

Genus GONIOPTERIS Presl, emended.

Goniopteris claiborniana Berry.

Plates IV, V.

Goniopteris claiborniana Berry, Torrey Bot. Club Bull., vol. 44, p. 331, pl. 22, 1917.

Fronds of large size, probably bipinnate, that have a stout, prominently winged rachis. Pinnae alternate to subopposite but in many specimens prevailingly subopposite, as in the larger figured specimen. Pinnae shortly stipitate, of large size, linear-lanceolate in outline, averaging between 10 and 15 centimeters in length by 1.5 to 3.5 centimeters in maximum width and tapering to an extended, attenuated, acuminate tip. The basal proximal pinnule in many specimens is free and entire; normally, however, the pinnae are not entirely segregated into individual pinnules, but these are more or less united, though the variation in this respect is wide. Normally the pinnae are pinnatifid, and the margins are separated into dentate inequilateral segments with upward-directed points by narrow inequilateral sharp sinuses, which extend inward one-fourth to one-third of the distance to the stipe. Some of these segments are relatively more extended, their form being aquiline-serrate. In some specimens the pinnae are but slightly pinnatifid and have short conical dentately divided margins, the sinuses extending only about one-seventh of the distance to the stipe. An enlarged segment of this type is shown in Plate V, Figure 3, in other specimens the pinnae are deeply pinnatifid, the sinuses extending about halfway to the stipe. An enlarged segment of this type is shown in Plate V, Figure 1. These three types of marginal lobulation are correlated with three types of venation, although naturally the three are connected by every intermediate gradation. These types will be discussed after what I have called the normal type has been described.

The normal type agrees in its more important particulars with the type familiar in Tertiary ferns that is referred by paleobotanists to the more or less interrelated and synonymous genera *Lastrea, Phegopteris,* and *Goniopteris*. It is a type found in modern, mostly tropical ferns that are variously segregated or aggregated by students of existing ferns in the genera *Lastrea, Nephrodium, Phegopteris, Polybotrya,* and *Dryopteris*. Christensen,[55] perhaps the foremost living student of *Dryopteris,* enumerates more than a thousand existing species, which he segregates into ten groups, termed subgenera, although most of them are admittedly of generic rank. These groups are *Endryopteris, Stigmatopteris, Ctenitis, Lastrea* Bory emended, *Glaphyropteris* Presl, *Steiropteris, Cyclosorus* Link emended, *Leptogramma* J. Smith, *Goniopteris* Presl emended, and *Meniscium* (Schreber). The Claiborne species belongs to this author's ninth subgenus, the emended *Goniopteris* of Presl, which I recognize as a valid genus, for the data which paleobotany furnishes to recent botany are obscured by the use of generic names that denote composite aggregations of living species. *Goniopteris* as delimited by Christensen[53] has about sixty mainly tropical American species, although it is represented in the Old World by at least two species in Africa, Asia, and Australia. It is an eminently natural group that has evidently inhabited southeastern North America since the middle Eocene.

The present type belongs with those fossil ferns that are characterized by a single well-marked lateral, which runs to the tip of each marginal lobule, and these laterals are more commonly opposite or subopposite than alternate. Each lateral diverges from the midrib of the pinnae at an angle of about 60° and gives off alternately proximad and distad usually simple branches, averaging about eight to ten on a side. The basal distal tertiary of one lateral unites with the basal proximal tertiary of the adjacent superior lateral somewhat above the middle point between the two laterals. This united vein, which is termed a ray by Ettingshausen, proceeds in a flexuous course to the marginal sinus and unites alternately with the distal and proximal tertiaries from the adjacent laterals. In the marginal lobe there are several simple and free tertiaries, three or four of which as a rule run to the distal margin and four to six run to the longer, because more arched, proximal margin. This type is shown by the majority of the figured specimens, and an enlarged detail is given in Plate IV, Figure 5.

[55] Christensen, Carl, On a natural classification of the species of *Dryopteris:* Saertryk af Biologiske Arbeijdner Tilegnede Eug. Warming, pp. 73-85, Nov. 3, 1911.

The pinnae with the reduced marginal lobulation have an essentially similar venation to that just described. The laterals are more nearly at right angles with the midrib of the pinnae. The tertiaries number ten or eleven alternating, rather straight pairs, and those from adjacent laterals unite midway between to form a ray that is rather straighter than the one described above. Each ray terminates at a sinus. There are usually three pairs of free simple veinlets in each lobe, although two or four pairs may be present in some specimens.

In the pinnae that are deeply pinnatifid the venation, though of the same general plan as in the types that have just been described, differs in certain rather remarkable particulars which help to distinguish the present form from all other previously described fossil species. Only one, two, or three tertiaries from each adjacent lateral are concerned in the formation of the ray that runs to the sinus, and one or the other of these tertiaries may fork, the branch uniting with a branch from the next tertiary, the resultant subsidiary ray uniting with the principal ray near the sinus, and the two inclosing a laterally elongated rhomboidal areola. The free veinlets consist of only from one to three terminal pairs; all the other tertiaries are forked at least once at a greater or less distance above their base, and each limb of the fork is united with a corresponding branch of the next adjacent tertiary, the resulting ray running directly to the margin. This is the *Goniopteris-Aspidii* type of venation of Ettingshausen.[56] The venation of this type is still further complicated in many specimens by the presence of a very fine subsidiary branch from one or the other forks of a tertiary, and this thin fine branch runs directly to the margin. This type is well shown in an enlarged detail in Plate V, Figure 1, and it is also shown in some parts of the specimen that is illustrated in Plate V, Figure 2. The principal intermediate type is one in which only a few of the forks unite with the adjacent forks to form a ray, the majority of the tertiaries being simply once forked and both branches of the fork terminating in the margin.

This handsome and characteristic species is common in the Yegua clays at Columbia, La., and occurs also in the Lisbon formation near Newton, Miss., but none of the collected material is in fruit. The form and venation are so well marked and distinctive, however, that the species is at once correlated with the rather abundant Tertiary type that under the name of *Goniopteris*, *Lastrea*, or *Phegopteris* is so characteristic of the fern floras of this age. It is at once distinguished from all of these by its peculiar venation; otherwise it shows the same habit, winged rachis, and outline as, for example, *Lastrea stiriaca* Heer,[57] of the European Oligocene, described originally by Unger[58] as a *Polypodites*, referred to *Goniopteris* by Alexander Braun[59] and to *Phegopteris* by Ettingshausen.[60] There are at least fifteen known Tertiary species of this general type, most of which are European, although several have been recorded from American localities. Most of the foreign material is somewhat younger than the present species, although two different forms are described from the Middle Bagshot beds of southern England, which lie at a homotaxial (Lutetian) horizon. Several early Eocene species have been recorded from the Rocky Mountain region. In addition to the differences in venation previously mentioned, *Lastrea intermedia* Lesquereux[61] from the Denver formation has the pinnae decurrent on the main stipe; *Lastrea polypodiodes*[62] has denticulate margins and simple tertiaries. The form from the lower Eocene of Oregon identified by Newberry as *Lastrea knightiana*[63] and commonly referred to the European early Miocene species *Lastrea fischeri* Heer[64] is much like the present species in size and general appearance but differs in venation. The American material is rather poor, and I doubt very much its identity with the European type.

A very widespread Tertiary type that is liable to confusion with *Lastrea* is *Osmunda lignitum* Stur,[65] in which the tertiaries are all

[56] Ettingshausen, C. von, Die Farnkräuter der Jetztwelt, p. xiii, pl. 123, figs. 4, 6, 7, 1865.

[57] Heer, Oswald, Flora tertiaria Helvetiae, vol. 1, p. 31, pls. 7, 8, 1855; vol. 3, p. 151, pl. 143, 1859.

[58] Unger, Franz, Chloris protogaea, p. 121, pl. 36, 1847.

[59] Braun, Alexander, Deutsche geol. Gesell. Zeitschr., vol. 4, p. 556, 1852.

[60] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, Theil 1, p. 16, pl. 2, figs. 16-18, 1866.

[61] Lesquereux, Leo, The Tertiary flora, p. 56, pl. 4, fig. 14, 1878.

[62] Idem, fig. 13.

[63] Newberry, J. S., U. S. Nat. Mus. Proc., vol. 5, p. 503, 1883.

[64] Heer, Oswald, Flora tertiaria Helvetiae, vol. 1, p. 34, pl. 9, fig. 3, 1855. Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 239, pl. 50, figs. 1, 1a, 1883. Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 10, pl. 48, fig. 6, 1898.

[65] Stur, D., Ueber zwei neue Farne aus den Sotzka-Schichten von Möttnig in Krain: K.-k. geol. Reichsanstalt Jahrb., Band 20, p. 9, pl. 2, 1870.

simple, neither anastomosing nor forming interlateral rays.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry). Lisbon formation, Alabama & Vicksburg Railway cut 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Genus PTERIS Linné.

Pteris inquirenda Berry, n. sp.

Plate III, Figure 2.

Frond habit and fruiting characters unknown. Pinnules oblong, coriaceous. Margin singly serrate. Midrib wide, channeled on upper surface and prominent on the lower surface. Laterals thin, close, equidistant, diverging at wide angles, rather straight, most of them once forked near their point of insertion, but some of them simple, rarely anastomosing. This species is represented by fragmentary material in the collections from two localities. The Mississippi material consists of a single distal fragment. The Georgia material comprises two incomplete fragments from about the middle of a pinnule. The material is entirely insufficient for a proper diagnosis and except that it represents a new type in the Claiborne flora, one that may prove of value in correlation and subsequently be represented by more complete material, I would ignore it at the present time. Its reference to *Pteris* is purely provisional, for it is similar to numerous existing and fossil species of *Asplenium*, *Osmunda*, *Gymnogramme*, *Trismeria*, and other genera. It is referred to *Pteris* in conformity with the usage of Heer, Ettingshausen, Gardner, Lesquereux, and others. It resembles several forms described by these authors, being perhaps most like *Pteris gaudini*, which is described by Heer from the Swiss Aquitanian, and is also comparable to several existing species of *Pteris*, as, for example, *Pteris crenata*.

Occurrence: Lisbon formation, Alabama & Vicksburg Railway cut 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMAE.

Order CONIFERALES.

Family PINACEAE.

Genus ATHROTAXIS Don.

Athrotaxis sp.

Plate II, Figure 3.

A single poorly preserved small cone was found in a nodule of iron carbonate at Cherry Valley. It is an elongated prolate spheroid in shape, 2.2 centimeters in length and 1 centimeter in diameter. The numerous cone scales are much weathered and replaced by iron. It can not be said to furnish any definite evidence of its botanical affinity, and *Athrotaxis* is suggested largely from the known conditions of climate and habitat, and because cone scales which suggest this genus occur in the antecedent Wilcox flora, and the other known Eocene gymnosperms of the Mississippi Gulf area are *Glyptostrobus*, *Taxodium*, and *Widdringtonia*, with none of which is it possible to confuse cones or cone scales of this type. If the genera *Alnus*, *Sequoia*, or *Betula* were even hinted at in these southern floras they might afford legitimate points for comparison.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus GLYPTOSTROBUS Endlicher.

Glyptostrobus europaeus (Brongniart) Heer.

Taxodium europaeum Brongniart, Annales sci. nat., vol. 30, p. 168, 1833.

Glyptostrobus europaeus (Brongniart) Heer, Flora tertiaria Helvetiae, vol. 1, p. 51, pl. 19, 1855.

Gaudin, Contributions à la flore fossile italienne, pt. 1, p. 26, figs. 5–10, 1858; idem, pt. 2, p. 35, pl. 1, fig. 12; pl. 2, figs. 2, 4, 14, 15, 1859.

Ettingshausen, Die fossile Flora von Köflach in Steiermark, p. 10, pl. 1, fig. 2, 1857.

Massalongo, Studii sulla flora fossile e geologia stratigrafica del Senigalliese, p. 152, pl. 5, fig. 5; pl. 40, fig. 1, 1859.

Ettingshausen, Die fossile Flora der Tertiär-Beckens von Bilin, Teil 1, p. 37, pl. 10, figs. 10–12; pl. 11, figs. 3–7, 11, 12, 1866.

Unger, Die fossile Flora von Kumi, p. 18, pl. 1, figs. 3–11, 1867.

Heer, Flora fossilis arctica, vol. 1, pp. 90, 135, pl. 3, figs. 2–5; pl. 21, figs. 10–12; pl. 45, figs. 20–22, 1868.

Newberry, New York Lyceum Nat. Hist. Annals, vol. 9, p. 43, 1868; Illustrations of Cretaceous and Tertiary plants, pl. 11, figs. 6–8a, 1878.

Saporta, École norm. sup. Paris Annales scientifiques, 2d ser., vol. 2, p. 4, pl. 2, figs. 1–4, 1873.

Saporta and Marion, Soc. géol. France Bull., 3d ser., vol. 2, p. 280, 1874.

Zwanziger, Beiträge zur Miocänflora von Liescha, p. 18, pl. 2, figs. 6, 7, 1878.

Lesquereux, The Tertiary flora, p. 74, pl. 7, figs. 1, 2, 1878.

Sieber, Zur Kenntniss der nordböhmischen Braunkohlenflora, p. 93, pl. 5, fig. 47c, 1880.

Dawson, Canada Roy. Soc. 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.

Beck, Deutsche geol. Gesell. Zeitschr., vol. 34, p. 755, pl. 31, fig. 6, 1882.

Lesquereux, The Cretaceous and Tertiary floras, p. 222, pl. 46, fig. 1, 1883.

Ettingshausen, Die fossile Flora von Schoenegg, bei Wies in Steiermark, pt. 1, pl. 10, pl. 1, figs. 23–67, 1890; Ueber Neue Pflanzenfossilien aus den Tertiärschichten Steiermarks, p. 2, 1893.

Boulay, Flora pliocène des environs de Théziers, p. 25, pl. 2, fig. 5, 1890; Flore pliocène du Mont-Dore, p. 10, 1892.

Paolucci, Nuovi materiali e ricerche critiche sulle piante fossile terziarie dei gessi di Ancona, p. 14, pl. 2, fig. 15, 1896.

Newberry, U. S. Geol. Survey Mon. 35, p. 24, pl. 26, figs. 6–82; pl. 55, figs. 3, 4, 1898.

Marty, Flore miocène de Joursac, p. 21, pl. 1, figs. 18, 19, 1903.

Palabin, Russ. k. mineral. Gesell. Verh., 2d ser., vol. 42, p. 29, 1905.

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Taxodites europaeus Endlicher, Synopsis coniferarum, p. 278, 1847.

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Cupressites racemosus Goeppert, Monographie der fossilien Coniferen, p. 184, 1850.

Glyptostrobus oeningensis Alexander Braun, in Stitzenberger's Uebersicht der Versteinerungen des Grossherzogthums Baden, p. 73, 1851.

Heer, in Regel's Gartenflora, pl. 65, figs. 1, 2.

Unger, Iconographia plantarum fossilium, p. 21, pl. 11, figs. 1–3, 1852.

Glyptostrobus ungeri Heer, Flora tertiaria Helvetiae, 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.

Dawson, Roy. Soc. Canada Trans., vol. 7, pt. 4, p. 70, 1889 (1890).

Ettingshausen, Die fossile Flora von Schönegg bei Wies in Steiermark, pt. 1, p. 12, 1890; Ueber neue Pflanzenfossilien aus den Tertiärschichten Steiermarks, p. 12, 1893.

Glyptostrobus europaeus ungeri Heer, Flora tertiaria Helvetiae, vol. 3, p. 158, 1859; Flora fossilis arctica, vol. 3, pt. 2, p. 6, pl. 1, figs. 6b, c, 1874; idem, vol. 4, p. 58, pl. 11, fig. 28; pl. 12, fig. 1; pl. 31, fig. 6b, 1877; idem, vol. 5, pt. 2, pl. 9; figs. 9a, 10–13; pl. 13, figs. 2b, 3, 4b, c, 1878, idem, vol. 7, p. 61, pl. 70, figs. 9, 10; pl. 66, figs. 5c, 9; pl. 85, figs. 6–8, 1883.

Stur, Beiträge zur Kenntniss der Flora der Süsswasserquarze, p. 71 (147), 1867.

Lesquereux, The Cretaceous and Tertiary floras, p. 222, pl. 46, figs. 1–1c, 1883.

Pilar, Flora fossilis susedana, p. 21, pl. 3, fig. 10, 1883.

Peola, Riv. ital. paleont., vol. 6, p. 81, 1900.

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, Teil 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.

Twigs slender and foliage dimorphic. One form has short, thick appressed leaves; the other has acute spreading slender leaves. Male catkins ovate, single sessile on lateral shoots, and consist of few scales. Cones ovate, relatively large, and consist of narrow imbricated scales, which are cuneate at the base, their summits expanded, semicircular, margins obtusely dentate, and the dorsum more or less longitudinally costate. Seeds inequilateral, winged.

Glyptostrobus europaeus is one of the most interesting Tertiary plants. It was discovered nearly a century ago by Brongniart and has been identified from a large number of horizons in Europe, Asia, and America. That it was a cosmopolitan type can not be doubted, for the present distribution of the Taxodieae is in itself a sufficient indication of this. I have given above a partial synonymy which must be used with caution, for it is very probable that several closely related species are inextricably tangled in it, and 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 Mis-

sissippi northwestward through the Rocky Mountain region, on the Pacific coast, and along the shore of the Arctic Ocean, at the mouth of Mackenzie River and also in Greenland. It is present but not abundant in the Wilcox of northern Mississippi, where it is very sparsely represented by the typical terete twigs with appressed leaves and by seeds. It is at present known from but a single locality in the Claiborne. *Glyptostrobus* has only two existing species—*Glyptostrobus pendulus* Endlicher and *G. heterophyllus* Endlicher, small trees known as water pines, which are inhabitants of the low river bottoms of certain parts of China.

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Musuem.

Genus SEQUOIA Endlicher.

Sequoia langsdorfii (Brongniart) Heer.[66]

Taxites langsdorfii Brongniart, Prodrome d'une histoire des végétaux fossiles, p. 108, 1828.

Sequoia langsdorfii (Brongniart) Heer, Flora tertiaria Helvetiae, vol. 1, p. 54, pl. 20, fig. 2; pl. 21, fig. 4, 1855.

Wood correlated with this species, which was founded on remains of foliage (Penhallow, 1907) and cones, was described by Penhallow in 1902 from the Tertiary of British Columbia and again the next year from the Tertiary of Saskatchewan. Some years later the same author identified similar specimens of silicified wood from the Yegua clays of east-central Texas. He described the wood as follows:[67]

Growth rings prominent, very unequal, medium to narrow. Summer wood prominent but thin, of three to six rows of thick-walled tracheids with bordered pits on the tangential walls; transition from spring wood abrupt. Tracheids of the spring wood large, upward of 70 by 84 μ, the walls upward of 21 μ thick; very uniform and equal in very regular rows; rounded hexagonal or those of the earliest growth much elongated radially. Resin canals wholly wanting. Resin cells usually numerous throughout, prominent, scattering. Resinous tracheids sometimes present and forming more or less extensive tracts. Rudimentary resin sacs sometimes appear on the outer face of the summer wood.

Medullary rays without tracheids; the parenchyma cells equal to about four wood tracheids; straight or somewhat contracted at the ends; the upper and lower walls thin and entire; the terminal walls thin and not pitted, straight or curved; the lateral walls with rather large, round pits, one or chiefly two per tracheid, bordered pits round, numerous, and chiefly in two rows.

Medullary rays one-seriate or rarely two-seriate in part, low to medium; the large cells about 31.5 μ broad, round or oval, chiefly uniform, but more or less unequal.

The remains of foliage and cones which have been referred to *Sequoia langsdorfii* are practically cosmopolitan throughout the Tertiary. No specimens of the foliage of this species are known from the Eocene of southeastern North America, although poorly preserved remains in both the Wilcox and the Claiborne have been referred to the somewhat similar appearing *Taxodium dubium* (Sternberg) Heer.

Occurrence: Yegua formation, Somerville, Burleson County, Tex.

Collection: Peter Ridpath Museum, Montreal, Canada.

Genus CUPRESSINOXYLON Goeppert.

Cupressinoxylon dawsoni Penhallow.

Plate VI, Figures 1, 2, 3.

Cupressoxylon dawsoni Penhallow, Roy. Soc. Canada Trans., 2d ser., vol. 9, sec. 4, p. 46, 1903; idem, 3d ser., vol. 1, sec. 4, p. 95, 1907.

Penhallow in 1907 thus described this species:

Growth rings broad. Tracheids of the spring wood large, about 32.1 μ by 40.4 μ; thin walled, squarish hexagonal, rather uniform and equal; the spring wood passing somewhat gradually into the thin summer wood, which is composed of two to four rows of slightly smaller, radially flattened and thicker-walled tracheids. Medullary rays resinous. Resin canals wholly wanting. Resin cells numerous throughout the growth ring, scattering or somewhat zonate.

Medullary rays very resinous, devoid of tracheids; the cells straight; the upper and lower walls thin, apparently entire; the terminal walls entire, straight or curved; the lateral walls with oval or round pits, several per tracheid, the correct number not readily determinable. Wood tracheids with large, bordered pits, numerous and compact in one or often two rows, the orifice round; one-seriate or two-seriate in part; the large cells thin walled, uniform, rather equal, broad, round or oval or somewhat transversely oval to oblong.

This species was described by Penhallow from the Eocene of the Great Valley and Por-

[66] Additional citations of this very widespread Tertiary species, based on the remains of leafy twigs and cones, are not included in the present synonymy, for it is not certain that the wood belongs to the same species as the foliage, and in fact it can not be demonstrated that all the remains of foliage represent a single botanic species.

[67] Penhallow, D. P., Notes on fossil woods from Texas: Roy. Soc. Canada Trans., 3d ser., vol. 1, sec. 4, pp. 94-95, 1907.

cupine Creek groups of Saskatchewan and subsequently identified from the Yegua clays of east-central Texas. It is not uncommon in recent collections, but most of the material is in a rather advanced stage of decay. The most perfect specimen, from which the accompanying illustrations were made, shows in the transverse section the very broad zone of spring wood and the scarcely marked growth ring. The tangential section shows the abundance of the xylem parencyhma. The radial section shows the circular bordered pits, larger in size where they are in single rows, and where double generally in pairs but in some places alternating for short distances. The medullary pits are numerous and oval, and some appear to be circular and bordered.

Occurrence: Yegua formation, Somerville, Burleson County, Tex.; Cane Creek and International & Great Northern Railway between milepost 48 and Wooters siding (figured material), Houston County, Tex. (collected by C. L. Baker).

Collections: U. S. National Museum; Peter Ridpath Museum, Montreal, Canada.

Cupressinoxylon arkansanum Knowlton.

Cupressinoxylon arkansanum Knowlton, Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 253, pl. 9, figs. 1, 2, 1891.

This species was based upon poorly preserved fragments of silicified wood that were collected from a large trunk. They show moderately thick-walled tracheids, arranged in nearly uniform radial rows and with a single row of bordered pits; pits rather distant, 0.011 to 0.0145 millimeter in diameter; medullary rays numerous, 2 to 22 cells high, generally uniseriate but in places in two rows near the center of the ray. Resin tubes are said to be moderately numerous, and growth rings are not discernible.

There is some uncertainty regarding the geologic horizon from which this species was collected, both because of the lack of detailed knowledge of the areal distribution of the different Eocene formations on Crowleys Ridge, and because silicified wood is so frequently reworked from older into younger deposits. From the size of the specimen, which was estimated by the collector to weigh 4 or 5 tons, it could hardly have been reworked. Its location points to upper Claiborne or lower Jackson age, and my own field experience in this region leads me to refer it tentatively to the former horizon.

Occurrence: Yegua formation, bed of Rice Branch, near Wittsburg, Cross County, Ark. (collected by R. E. Call).

Collection: U. S. National Museum.

Class ANGIOSPERMAE.

Subclass MONOCOTYLEDONAE.

Order POALES.

Family POACEAE.

Genus ARUNDO Linné.

Arundo pseudogoepperti Berry.

Arundo goepperti Lesquereux (not Münster), U. S. Geol. and Survey Terr. Ann. Rept. for 1871, Suppl., p. 5, 1872; The Tertiary flora, p. 86, pl. 8, figs. 3–5, 1878.

Arundo pseudogoepperti Berry, U. S. Geol. Survey Prof. Paper 84, p. 134, pl. 24, fig. 7, 1914.

Lesquereux in 1871 and again in 1878 doubtfully referred several fragments of striated stems and leaves from the Green River shales to the well-known European species *Arundo goepperti*. These fragments agree fairly well with the European material, but when it is realized that remains of this sort—that is, impressions of fragments of leaves and stems of grasslike forms—have very little to distinguish them specifically, and that these American specimens are widely removed geographically from the type forms and occur at horizons invariably of considerably greater age, the propriety of considering them distinct is obvious. Consequently in discussing the presence of remains of this sort from the Twiggs clay member of the Barnwell formation of Georgia they were set apart as a distinct species under the above name.

Remains identical with those from Georgia and the Green River of the West are common in the Claiborne of the Mississippi embayment. They invariably occur in fragments and are of little biologic interest. The use of the generic term *Arundo* is in a form sense and follows usage. It can not be claimed to have any especial significance as indicative of close botanical relationship.

Occurrence: Claiborne deposits, 2½ miles east of Fort Gaines, Clay County, Ga. (collected by Otto Veatch). Gosport sand, Claiborne Landing, Monroe County, Ala. (characteristic, but fragmentary) (collected by E. W.

Berry). Lisbon formation, Lexington, Holmes County, Miss. Yegua formation, Columbia, Caldwell Parish, La. (very common) (collected by E. W. Berry); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull); 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen); 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Order SCITAMINALES.

Family CANNACEAE.

Genus CANNA Linné.

Canna flaccidafolia Berry, n. sp.

Plate II, Figures 4 and 5.

Leaves of large size, broadly elongate-lanceolate in outline, about 30 to 35 centimeters in length by 8 to 10 centimeters in maximum width in the middle part of the leaf. Apex and base about equally pointed. Petiole thick and long. Midrib very stout, at least 5 millimeters in diameter, longitudinally striate. Laterals thin, very numerous and closely set, parallel, diverging at acute angles and curving slightly upward. Though a few laterals seem to be more prominent, there is no indication of laterals of two orders, as is the rule in most modern species of *Canna* and its allies. In this respect the fossil is identical with the existing *Canna flaccida* Roscoe, which it also resembles in size, outline, texture, character of the midrib, and other features. In fact, the Claiborne and the modern species are practically identical, which has suggested the specific name adopted for the Eocene form.

Canna flaccida Roscoe extends northward as far as South Carolina in the river swamps near the coast. Most of the cannas, of which from 25 to 50 species are known, are hygrophilous plants of the American subtropical and tropical area. *Canna flaccidafolia* is the most definite of the similar monocotyledonous forms that have been described as species of *Cannophyllites* Brongniart,[68] *Musophyllum* Goeppert, *Zingiberites* Heer, and other forms, and is clearly referable to the genus *Canna*. It is common in the clays at Columbia but is usually in a very fragmentary condition. In the absence of numerous fossil forms it is not feasible to discuss its relationships, although it is probably a descendant of the species *Canna eocenica* Berry[69] from the Wilcox group and is much finer veined than the Jackson species *Canna jacksoniana* Berry. It seems certain that the genus was continously represented in the embayment area from that time to the present.

Similar fossils are described by Saporta from the Sannoisian of Aix, in southeastern France, as *Musophyllum speciosum*[70] and *Zingiberites petiolaris*,[71] and by Ludwig from the Aquitanian of Münzenberg as *Convallaria latifolia*.[72]

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Order ARECALES.

Family ARECACEAE (PALMAE).

Genus PALMOXYLON Schenk.

Palmoxylon lacunosum (Unger) Felix.

Plate XLVII.

This species is commented upon in the section of this report dealing with the Jackson flora. A segment of a trunk received recently from E. A. Smith, State geologist of Alabama, and shown in Plate XLVII, can not be distinguished from this species. It shows numerous roots about 4 millimeters in diameter being given off. The preservation shown in two transverse sections is not especially good but clearly indicates a palm of the *lacunosum* type. The only features in which the present material differs from the splendidly preserved material from the Vicksburg deposits (unpublished) or that figured by Schenk or Stenzel is in the greater crowding of the bundles and the slightly less elongated cells of the groundmass (parenchyma), with a consequent reduction in the amount of intercellular space.

In the United States *Palmoxylon lacunosum* is found in beds which have been assigned to the Catahoula sandstone in Louisiana but which

[68] Fritel has shown that the French Ypresian species *Cannophyllites ungeri* of Watelet is based on fragments of an undeterminable palm (Revision de la flore fossile des grès yprésiens du bassin de Paris: Jour. botanique, 2d ser., vol. 2, pp. 110, 111, fig. 4, 1909).

[69] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 181, pl. 15, figs. 7, 8, 1916.

[70] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 1, p. 67; pt. 2, p. 146, pl. 10, figs. 1, 2, 1889.

[71] Saporta, G. de, idem, pt. 1, p. 103, pl. 10, figs. 3–5, 1889.

[72] Ludwig, R., Palaeontographica, vol. 8, p. 87, pl. 19, fig. 6, 1859.

carry plants of Jackson age, and in the Vicksburg group of southern Alabama. So far as species are differentiated by stem anatomy this Claiborne occurrence is specifically identical with the later occurring type, but it may well represent a distinct botanical species which is not distinguishable by its stem anatomy, as this is very similar in most palms—a fact that is especially emphasized when the material is poorly preserved.

Occurrence: Top of the Tallahatta formation or base of the Lisbon formation, White Bluff, Clarke County, Ala. (collected by E. A. Smith).

Genus THRINAX Linné.

Thrinax eocenica Berry.

Plate VIII, Figures 1, 2.

Thrinax eocenica Berry, U. S. Geol. Survey Prof. Paper 84, p. 136, text fig. 10; pl. 25; pl. 26, fig. 3, 1914.

Leaves orbicular in general outline, of relatively small or medium size, indicating in the collected material a diameter that ranges from 36 to 60 centimeters or more. Many-cleft, the numerous rays carinate, much crowded at the obtusely rounded end of the rachis, two-cleft distad. Rachis considerably flattened, smooth, entirely unarmed, 1 centimeter wide in the single preserved specimen of one of the smaller leaves. Ligule free, erect, concave, inconspicuous. Segments 25 in number on a small complete specimen; larger fragments that show about two-thirds of a leaf contain 31 rays, indicating that the complete leaf was made up of about 45 segments. The basal rays on each side are somewhat reduced in size and entirely free, and all the rays become separated about two-thirds of the distance from their base. Primary veins prominent. Intermediate veins very fine, five on each side, placed at something less than a millimeter apart, and very fine longitudinal veinlets between them.

Fossil palm leaves present few characters for their successful comparison with existing genera, hence the numerous fossil species of *Flabellaria, Sabalites, Geonomites*, and similar genera. The Claiborne material is for the most part fragmentary, and the larger the leaves which floated into the Claiborne sea the more fragmentary the preserved material. In the Gulf area they are not uncommon but are much macerated, and no complete specimens have been collected. More perfect specimens occur in the deposits of Jackson age in Georgia, and the species is also found in the Jackson of Arkansas. The collections, though leaving much to be desired, show leaves that in the sum of their characters are clearly referable to the genus *Thrinax*—a determination which has been confirmed by several botanists especially familiar with the tropical American flora.

The present species is clearly distinct from all the palms that have been described by Lesquereux or Newberry from the West, and little is to be gained by a more detailed comparison. It is equally distinct from the homotaxial European palm material, the only occurrence that suggests any relationship being the leaves from the Sannoisian of Dalmatia referred by Ettingshausen[73] to *Flabellaria raphifolia* (Sternberg) Ettingshausen, and this differs in the illustrations given by this same author of the same species in his Haering flora, in having a long acumen.

In the modern flora *Thrinax* has nine or ten species in the West Indies and Antilles, and three of them reach the Florida Keys.

Occurrence: Claiborne deposits, 2½ miles east of Fort Gaines, Clay County, Ga. (collected by Otto Veatch). Yegua formation, 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen); Columbia, Caldwell Parish, La. (collected by E. W. Berry). Lisbon formation, cut on Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke). Mount Selman formation, Palestine, Anderson County, Tex. (collected by O. C. Funderbunk).

Collection: U. S. National Museum.

Genus BACTRITES Berry, n. gen.

This generic name is proposed for fossil plants of the subtribe Bactrideae of the Arecales which do not exactly agree with any of the existing genera, whose natural limits are not defined with precision. The name is derived from *Bactris* Jacquin, the largest modern genus, which also gives its name to the subtribe.

For the present the new genus may be defined by the characters of the following type species,

[73] Ettingshausen, C. von, Die eocene Flora des Monte Promina in Dalmatien: K. Akad. Wiss. Wien, Math.-nat. Classe, Denkschr., vol. 8, p. 28, pl. 3, fig. 4; pl. 14, fig. 1, 1854.

although more abundant material may materially extend the present conception, especially as regards the habit of the complete frond.

Bactrites pandanifoliolus Berry, n. sp.

Plate VII, figures 1–6.

Fronds pinnate. The remains are all incomplete rays, so that the leaf habit is to a certain extent conjectural, and the grouping of the rays on the rachis is unknown. They differ so much in width and in primary venation, as well as in marginal characters, that it would seem that several rays are united at first and subsequently become split. Rays elongate, linear-lanceolate, at least 30 centimeters in length and probably much longer, for some specimens indicate a length of at least 60 centimeters. The rays depart but little from being flat, although some are slightly keeled. The primary veins are one to three in number, parallel. Where the primary vein is single and answering to a midrib, in no specimen in the material available for study does it lie midway between the two margins, so that the rays are not bilaterally symmetrical. Secondaries relatively fine, parallel, and placed at intervals of about five-sixths of a millimeter in both wide and narrow specimens. Nervilles thin and numerous; few of them lie at right angles to the longitudinally parallel venation; as a rule, they are curved and diverge from the secondaries at acute angles, and a considerable number pass over two interspaces. One margin is invariably entire in the collected material, and the opposite margin is somewhat thickened and beset with unequally spaced spines. These spines range from short, stout aquiline spines 1 millimeter in length to slender, nearly straight acicular spines 3.5 millimeters in length. Although these extremes have not been found on the same specimen, a single margin in some specimens shows great variation in the character of the spines. In general the short, thick spines are found toward the ends of the rays. That in a few leaves the primary veins were spined on one or both surfaces is shown by two specimens in which the spines are preserved. These spines may have been more common toward the proximal ends of the rays, but the distal parts were evidently smoother than in the corresponding modern spiny palms. In some rays the so-called midrib is nearest the smooth margin, whereas in other specimens it is nearest the spined margin. The texture is thin but stiff distad, becoming coriaceous proximad.

These exceedingly interesting materials are preserved in a very fragmentary condition in a sandy micaceous clay, and as it is unlikely that better material will be found in the near future and as they add an important element to the Claiborne flora I have described the species as well as the material will permit.

After extended comparisons I have referred this form to the subtribe Bactrideae, which in Engler and Prantl's Natürlichen Pflanzenfamilien is segregated into *Martinezia* Kunth, which includes 7 species that range from the Antilles to Peru and eastern Bolivia; *Acrocomia* Martius, which includes 7 species that range from the Antilles and Central America to Brazil and Bolivia; *Astrocaryum* Meyer, which includes 29 species that range from Mexico to southern Brazil and are most common in the Amazon Valley; *Bactris* Jacquin, which includes 90 species that range from southern Mexico through Central America to Peru and Chile, along the north coast of South America, and in the Antilles and are massed in the Amazon region, from which 53 species have been recorded, and *Desmoncus* Martius, which includes 22 species that range from southern Mexico to the Bolivian Andes and are massed in equatorial Brazil. Many of these species are based on herbarium material and are poorly described, and this is also true of several of the genera, the generic names having been applied somewhat loosely to all spiny cocoid palms. O. F. Cook proposed the additional genus *Curima* in 1901, basing it on Porto Rican material.

The tribe is thus entirely American in the existing flora and seems to have originated on this continent, although Squinabol [74] has proposed the fossil genera *Isselia* and *Perrandoa* for remains of this sort from the Oligocene of the Ligurian Apennines. *Perrandoa* has enormous fronds which have maximum dimensions of 3 meters across and 14 meters in length. Both genera are seemingly well founded and based on abundant material. The oriental spined palms of the genus *Calamus* Linné comprise more than two hundred existing species but do not offer as close parallels with the Claiborne form.

[74] Squinabol, Senofonte, Note sur quelques types de monocotylédonées de Saint-Justine et de Sassello: Soc. géol. France Bull., 3d ser., vol. 19, pp. 771–782, pls. 16, 17, 1891.

The most closely related fossil forms are those from the European Tertiary that are referred to the oriental genus *Pandanus*, which is such a striking element in the existing coastal floras of the oriental Tropics. Ettingshausen described three Upper Cretaceous (Gosau beds) and two Oligocene species of *Pandanus* from different parts of the Austrian Monarchy in 1852.[75] Subsequently Bureau [76] described a species from the Lutetian of Trocadero, in the Paris Basin, which is identical in age with the present species; Squinabol [77] described another from the Tongrian of Liguria in 1891; and Laurent [78] one from the Tongrian of Celas (Alais), France, in 1899. The Claiborne species is exceedingly close to Bureau's species, *Pandanus lutetianus*, and to that of Laurent, *Pandanus intermedius*, and I am convinced that this similarity is of a kind denoting generic relationship. I can not, however, see in these remains conclusive proof of generic identity with the modern species of Pandanaceae, although they would not seem out of place in a flora of the habitat of the Claiborne. Schenk [79] reaches similar conclusions in discussing the species which Ettingshausen referred to *Pandanus*. The leaves of *Pandanus* are coriaceous and not flat but keeled, and the keels are spined. None of the supposed fossil species show this spined keel, and several lack even a midrib, the longitudinal parallel veins being all of one caliber.

These remains have been compared with the genus *Cladium* Browne, the saw grass, of the family Cyperaceae, which is widely distributed in tropical and subtropical marshes and is so abundant in the Everglades of Florida. The largest *Cladium* leaves are narrower than some of the Claiborne specimens and are more linear. Furthermore all the existing species of *Cladium*, so far as I am aware, are gregarious, and if present in the palustrine habitat, such as the Claiborne afforded, their remains should be far more common than they actually are in the deposits. The modern genera *Agave*, *Aloe*, *Furcroya*, and similar types have thick fleshy leaves and immersed venation and usually inhabit arid regions quite unlike the humid Claiborne coast. Bureau considers and dismisses the genus *Stratiotes* of the Hydrocharitaceae, and there is really very little resemblance to the fossil shown by this form. The Bromeliaceae have mostly thick leaves, crescentic in transverse section, without a differentiated midrib and with straight, more spreading marginal spines.

It would indeed be spectacular to identify the strictly oriental Pandanaceae along the old coast line of Claiborne time, and there is a great superficial resemblance between these Claiborne fossils and such modern leaves as those of *Pandanus utilis* (Bory), as they are shown in photographs, which may be seen by comparing my figures with the figures of *Pandanus utilis* reproduced by Laurent. There are the same irregularly spaced teeth and the wavy oblique nervilles, but in examining the actual leaves of *Pandanus* the resemblance is not so striking, and I do not feel justified in claiming such a relationship for the Claiborne fossils, especially since in my judgment they agree more closely with the Bactrideae.

Many of the smaller existing species of *Bactris* that are comparable with the fossil leaves form a tangled undergrowth in the swampy forests near the coast of northern South America, as in Dutch Guiana. Schimper [80] records a species with a habitat which suggests that of *Nipa*, in brackish swamps back of the mangrove association along the coast of the island of Trinidad.

Occurrence: Lisbon formation, cut on Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke)

Genus GEONOMITES Visiani.

Geonomites claibornensis Berry, n. sp.

Plate XLVIII, Figures 1, 2.

It is a great misfortune that no good specimens of this interesting form were collected. The coarse sandstone of the Mount Selman near Palafox was crowded with its rays in places, and in one specimen the rachis was preserved for a couple of feet in length, but

[75] Ettingshausen, C. von, Ueber fossilen Pandanaceae: K. Akad. Wiss. Wien Sitzungsber., vol. 8, 1852.

[76] Bureau, Édouard, Etudes sur la flore fossile du calcaire grossier parisien: Soc. philomathique [Paris] Mém. Cent., p. 238, pl. 22, figs. 1-3, 1888.

[77] Squinabol, Senofonte, Notes sur quelques types de Monocotylédonées de Sainte-Justine et de Sassello: Soc. géol. France Bull., 3d ser. vol. 19, p. 776, pl. 16, figs. 4, a, b, 1891.

[78] Laurent, Louis, Flore des calcaires de Célas, p. 64, pl. 4, figs. 2, a, 1899.

[79] Schenk, A., Palaeophytologie, in Zittel, K. A., Handbuch der Palaeontolgie, Abt. 2, p. 375, 1890.

[80] Schimper, A. F. W., Die indomalayische Strandflora: Bot. Mitt. aus den Tropen, Heft 3, p. 68, Jena, 1891.

the attached rays were so bent and contorted that satisfactory material was not obtainable. The leaves were obviously large, the rachis slender and apparently round. The rays appear to have been separated to their base, thus differing from *Geonomites tenuirachis*, *G. schimperi*, or *G. visianii;* they range in width from 1 centimeter to 2 centimeters, are pointed, and have an indicated length of at least 30 centimeters. They are coriaceous in texture, are slightly narrowed at the base, diverge from the rachis at acute angles, and are not prominently keeled. The venation consists of thin primaries 2 to 3 millimeters apart, with still thinner parallel veins in the interspaces.

The present species, although imperfectly characterized, is clearly distinct from the previously described species, as it is also from the large species in the Raton formation which Knowlton referred to *Geonoma* [81] or the species of *Chamadorea* [82] found in the lower Wilcox of the eastern Gulf area.

The genus *Geonomites*, which receives its name from its resemblance to the existing genus *Geonoma* of Willdenow, is properly considered to represent the undifferentiated ancestry or the generically indistinguishable fossil representatives of the tribe Geonomeae. The tribe includes, according to modern systematists, 10 genera, of which 3 are monotypic West African forms. The remaining 7 genera are all confined to tropical and subtropical America, the only large genus being *Geonoma*, which has nearly 100 existing species, ranging from southern Mexico and the Antilles through Central America, along the eastern base of the Andes to Bolivia, and along the east coast of South America to Rio de Janeiro. These are prevailingly small stemless or short-stemmed palms of American origin. The oldest known species is found in the Ripley formation of Tennessee. None were previously known from the Eocene of the Coastal Plain, but the genus is present in beds of that age along the Rocky Mountain front and in trans-Pecos Texas. The earliest known European form comes from the Lutetian of Italy and is of about the same age as this Mount Selman species.

[81] Knowlton, F. H., Fossil floras of the Vermejo and Raton formations of Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 101, p. 291, pl. 61, 1918.

[82] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 179, pl. 12, fig. 4; pl. 13, figs. 1–3, 1916.

Occurrence: Mount Selman formation, 1 mile north of Palafox, Webb County, Tex. (collected by A. C. Trowbridge, L. W. Stephenson and E. W. Berry).

Genus PALMOCARPON Lesquereux.

Palmocarpon sp.

A spherical nut (?) 28 millimeters in greatest and 24 millimeters in least diameter is represented by a single specimen. The botanical position is uncertain, but the specimen strongly suggests those fruits of the Arecaceae that are commonly referred to the genus *Palmocarpon*.

In the absence of more abundant and more definite material it can not be satisfactorily described.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Genus SABALITES Saporta.

Sabalites sp.

A fragment of a fan palm, not specifically determinable, was collected immediately above the Santo Tomas coal seam near Santo Tomas.

Occurrence: Mount Selman formation, Santo Tomas, Webb County, Tex. (collected by T. W. Stanton, July 26, 1895).

Collection: U. S. National Museum.

Subclass DICOTYLEDONAE.

Superorder CHORIPETALAE.

Order JUGLANDALES.

Family JUGLANDACEAE.

Genus JUGLANS Linné.

Juglans schimperi Lesquereux.

Juglans schimperi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 8, 1872; The Tertiary flora, p. 287, pl. 56, figs. 5, 6, 9 (not figs. 7, 8, 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, fig. 2 (not pl. 33, fig. 1; pl. 35, fig. 3), 1899.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 182, pl. 18, fig. 4; pl. 19, fig. 4 (not pl. 18, figs. 3, 5), 1916.

Knowlton, U. S. Geol. Survey Prof. Paper 131, p. 159, 1923.

Juglans rugosa Lesquereux (not Lesquereux, 1878), U. S. Nat. Mus. Proc., vol. 11, p. 13, 1888.

Leaves ovate-lanceolate and slightly 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 is abundant in beds of upper Wilcox age in Tennessee, Kentucky, Louisiana, Arkansas, and Mississippi, but has not been found heretofore above that horizon in the embayment area. Three specimens from a locality near the Rio Grande 30 miles above Santo Tomas are tentatively recognized and included with the Claiborne flora, although the locality may be of Wilcox age.

Knowlton (op. cit.) has recently advocated separating certain of the leaves formerly referred to this species and regarding them as the distinct species *Juglans occidentalis* Newberry, and I have adopted this proposal.

Occurrence: Near Rio Grande, 30 miles above Santo Tomas, Webb County, Tex. (collected by T. W. Vaughan and T. W. Stanton, July 25, 1895).

Collection: U. S. National Museum.

Genus HICORIA Rafinesque.

Hicoria jacksoniana Berry, n. sp.

Plate XLIII, Figures 6, 7.

Leaves of large size, odd-pinnate. Leaflets lanceolate, falcate, sessile, generally markedly inequilateral, especially proximad. Widest at or below the middle and continued upward to a slender, gradually narrowed, and generally extended acuminate apex. Base cuneate to convex-cuneate. Margins bear remote serrate relatively small teeth. Texture subcoriaceous. Length ranges from 8 to 18 centimeters and averages from 10 to 12 centimeters. Maximum width ranges from 1.25 to 2.75 centimeters. Midrib stout, prominent on the lower surface of the leaflet, almost invariably curved. Secondaries numerous, medium stout, and prominent below; they diverge from the midrib at angles of 45° or more and are subparallel and camptodrome or craspedodrome. Tertiaries obsolete.

This species is very abundant in the sandstones of Brazos County, Tex., which are referred to the Yegua formation but which are included in that part of the Yegua which I regard as of Jackson age. These specimens are preserved in a coarse matrix in which the details of venation are somewhat obscure, and all the leaflets are found in a detached condition. Indistinguishable remains showing a greater or less number of leaflets attached to the stipe are abundant in the clays at Hickman and Columbus, Ky., where they were described as *Hicoria pecan* by Lesquereux and me and referred to the Pleistocene. The present collections from the last-mentioned localities contain many new species and suggest that the previous age determinations were erroneous and that their true age is upper Eocene or lower Oligocene.

The genus *Hicoria* has been rather generally regarded as a Temperate Zone type, largely because of its range in the existing flora, but several students have pointed out its probable tropical ancestry. Comparisons have been made between these fossil forms and various members of the Sapindaceae, in which family the habit is generally even rather than odd pinnate. The genus *Cupania* has some rather similar species, but *Hicoria* seems the more probable, as these leaves are associated in Kentucky with the characteristic and well-marked fruits which I have described as *Hicoria rostrataformis*.

The hickories are now referred to the genus *Hicoria*, proposed by Rafinesque in 1808, although many systematists, especially in the Old World, still use the name *Carya*, proposed by Nuttall in 1818 and universally used until about twenty years ago.

The genus is entirely confined to North America in the existing flora, more particularly to the eastern United States, although there is an indigenous species in Mexico (*Hicoria mexicana*), and three or four other species reach their northern limit of growth beyond the Great Lakes in eastern Canada.

The existing species number from eight to fifteen, according to the rank assigned to the varieties of the eight or nine easily distinguished main types. They fall naturally into two groups—the true hickories and the pecan hickories—groups which were already clearly defined in preglacial Pliocene time.

The true hickories are fine, slow-growing trees, with hard, strong wood, which live in general on temperate dry soils. The buds are full, with overlapping scales, and the nuts are generally thick shelled and thick husked. The leaflets number from three to nine. The pecan hickories are trees that require warmth and moisture and have relatively weak wood. The buds are thin and narrow, without overlapping scales, and the nuts have thin shells and thin husks. The leaflets are numerous, slender, and falcate.

Over a score of fossil species have been described. Unlike the walnut, the hickory is not known with certainty from the Cretaceous, but it is present in very early Eocene deposits in Wyoming and on the Pacific coast. Hickories occur in the upper Eocene of central Europe, and there is a fine large-leafed species from deposits of this age at Kukak Bay, Alaska.

Most of the Oligocene specimens are referred to *Hicoria ventricosa*, which is abundantly represented by leaves and fruit in the Oligocene brown-coal deposits of Europe.

The late Miocene appears to have been the period of widest extent of the hickories. From deposits of this age about a dozen species are known. The forms were scattered all over Europe, and the genus extended to Iceland, Greenland, and Spitzbergen. In North America there were species in Oregon, California, Colorado, and Vermont. A species very close to the existing pecan occurs in the late Miocene of New Jersey.

During the succeeding Pliocene epoch the hickories were as abundant and vigorous as in the late Miocene in Europe, although their northern limit appears to have shifted somewhat to the south. Even as late as the upper Pliocene several species of hickory were abundant in Italy and Germany, but none survived the ice age on that continent. A species resembling the pecan is represented by both leaves and nuts in a late Pliocene lagoon deposit in southern Alabama.

In America there are numerous Pleistocene records, the leaves being preserved in the clay deposits of the river terraces and the fruits in the buried swamp deposits.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Order MYRICALES.

Family MYRICACEAE.

Genus MYRICA Linné.

Myrica claiborniana Berry, n. sp.

Leaves of variable but relatively small size, linear-lanceolate in outline, base pointed and tip extended acuminate. Length estimated at 5 to 10 centimeters. Maximum width in the middle part of the leaf ranges from 5 to 12 millimeters. Small, remote, serrate teeth on margins. Texture coriaceous. Petiole not preserved. Midrib stout, prominent. Secondaries numerous, subparallel, diverging from the midrib at wide angles, curved, mostly camptodrome, but craspedodrome veins run to most of the marginal teeth. Areolation consists of fine isodiametric meshes, of a kind characteristic of the numerous Tertiary species that have been referred to this genus.

The present species is based upon very abundant but broken material. It is, however, readily recognized by the marginal characters and the well-marked but minute tertiary areolation. It greatly resembles a number of European species of *Myrica* but does not exactly agree with any one of these. The foliage of many of these species is polymorphic, however, and it is possible that the Claiborne form may represent a geographic variety of one of these, which flourished among the dunes or inner beaches that skirted the Claiborne sea.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry).

Collection: U. S. National Museum.

Order FAGALES.

Family FAGACEAE.

Genus DRYOPHYLLUM Debey.

Dryophyllum brevipetiolatum Berry, n. sp.

Plate XXIII, Figure 3.

This species is described in the section of this report that deals with the Jackson flora. The

specimen here discussed is a single fragment that is somewhat larger than the similar leaves from the Jackson and represents a leaf that reached a maximum width of 4.7 centimeters. It is clearly referable to *Dryophyllum* and is very close to if not identical with this Jackson species.

Occurrence: Mount Selman formation, sandstone on hill above Santo Tomas coal seam, Santo Tomas, Webb County, Tex. (collected by D. D. Davis, 1895).

Collection: U. S. National Museum.

Order URTICALES.

Family ULMACEAE.

Genus MOMISIA F. G. Dietrich.

Momisia americana Berry.

Momisia americana Berry, U. S. Geol. Survey Prof. Paper 84, p. 139, pl. 27, fig. 13, 1914.

Leaf ovate in outline, 6 to 7 centimeters in length by 2.6 centimeters in greatest width, which is in the lower half of the leaf. Apex not preserved, presumably acute. Base obtusely pointed. Margin entire as far as seen, but possibly it was sparsely toothed apically. Three primaries rise from the top of the petiole, the midrib the stoutest, all slender.

This species was unfortunately based on a single incomplete specimen from the lower Jackson, and a single doubtful specimen occurs in the Claiborne of Texas. It is very like the leaves ordinarily referred to the genus *Cinnamomum*, of which three or four European species have been recognized at innumerable horizons from the Eocene to the Pliocene and at a large number of localities both in this country and abroad. Some of these forms are undisputable Cinnamomums, as is attested by well-preserved fruiting specimens; others find their only relation to that genus in their palmately tri-veined character. The present species, though it may represent a *Cinnamomum*, has seemed to me to be more closely related to the Ulmaceae, for it resembles certain South American species of *Celtis*, as, for example, *Celtis iguanens* (Jacquin) Sargent, of Bolivia. It more closely resembles, however, *Momisia aculeata* (Swartz) Klotzsch, a widespread species of tropical America and the West Indies, which reaches its northern continental limits in the valley of the Rio Grande and on the Florida Keys.

In the living flora *Momisia* has more than a score of species that are confined to tropical America. Engler[82a] reduces it to a subgenus of *Celtis*, but there is little doubt that it should be accorded generic rank.

Occurrence: Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family MORACEAE.

Genus FICUS Linné.

Ficus unionensis Berry, n. sp.

Leaves of medium size, oblong-elliptical in general outline, the apex bluntly pointed or broadly rounded and the base rounded or bluntly pointed. Length about 10 centimeters. Maximum width, at or slightly below the middle, 4 centimeters. Margins entire, somewhat undulate. Texture coriaceous. Petiole stout; its length undeterminable. Midrib stout, prominent on the lower surface of the leaf. Secondaries stout, about 15 opposite to alternate pairs; they diverge from the midrib at wide angles, many of them even at 90°; as a rule they are regularly spaced and run nearly straight to the marginal region, where they curve abruptly upward, forming flat camptodrome arches that are parallel with the margins. Tertiaries immersed in the leaf substance, obsolete.

This is a typical *Ficus* of the oblong, pinnate-veined type, exemplified by the modern *Ficus ferruginea* and *Ficus angustifolia*. Among previously described fossil forms it is similar to *Ficus puryearensis* Berry, a very common species of the Wilcox group. It differs from that species in its somewhat smaller size, straighter lateral margins, and more numerous secondaries, which arch much closer to the margin than in that species. It also resembles the less elongated leaves of *Ficus claibornensis* but is somewhat broader and has a more prominent venation. It survives the Claiborne and it is not uncommon in the Jackson of Arkansas and Mississippi.

Occurrence: Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (small form, collected by C. L. Baker); Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

[82a] Die natürlichen Pflanzenfamilien, Teil 3, 1894.

Ficus ungeri Lesquereux.

Ficus ungeri Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 7, 1872; The Tertiary flora, p. 195, pl. 30, fig. 3, 1878; The Cretaceous and Tertiary floras, p. 163, pl. 44, figs. 1–3, 1883.

Knowlton, U. S. Geol. Survey Mon. 32, p. 713, pl. 91, fig. 3, 1899.

This species, which has been recorded by Knowlton from rocks of Fort Union age in the Yellowstone Park and by Lesquereux from several localities in the Green River shales of Wyoming, differs greatly in size and outline. The type shown by Lesquereux[83] as coming from the Green River beds is unmistakably present in the Claiborne. The question whether all the forms referred to this species are properly so identified is not under consideration here, but the species is briefly characterized from the Alabama material.

Leaves of prevailingly large size, oblong in general outline, rounded at the apex and base. Length about 20 centimeters. Maximum width, in the middle part of the leaf, about 6.25 centimeters. Margin entire, regularly curved. Texture coriaceous. Petiole short and stout. Midrib stout, prominent. Secondaries thin, numerous, equidistant, subparallel; they diverge from the midrib at wide angles, about 70° to 75°, slightly curved in passing outward, the curves becoming accentuated in the marginal regions, where the secondaries are camptodrome. Tertiaries thin, mostly percurrent, largely immersed. In outline this species is very close to numerous modern species of so-called rubber plants, as, for example, *Ficus elastica*. The venation is, however, more like that of the modern *Ficus ferruginea*. There are numerous existing species in the American Tropics, and numerous described fossil species are closely parallel with this type. It is much like *Ficus claibornensis* but larger, relatively longer, and less pointed at both ends.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry).

Collection: U. S. National Museum.

Ficus newtonensis Berry, n. sp.

Plate IX, Figures 1, 2, 3.

Leaves of different size, ranging from 5 to 12 centimeters in length and from 1 centimeter to 3 centimeters in maximum width, which is about midway between the apex and the base. Outline lanceolate, the margins entire and regularly curved, somewhat extended distad and decurrent at the base. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries not prominent, numerous, opposite to alternate, subparallel pairs; they diverge from the midrib at wide angles—70° to 80°—and curve slightly upward in passing outward; their tips are joined by relatively stout, scarcely ever arched marginal veins, which are acrodrome from 0.5 to 1 millimeter from the margins that they parallel. There is considerable variation in the spacing of secondaries, the intervals ranging from 1 millimeter to 4 millimeters in small leaves of approximately equal size. Tertiaries immersed. Texture subcoriaceous.

This species is based upon abundant but fragmentary material from the Lisbon formation. It is clearly marked by the wide angle of divergence of the numerous subparallel and nearly straight secondaries—a type of venation exemplified in the leaves of the existing *Ficus elastica*. The larger leaves are somewhat like those of *Ficus unionensis* Berry, which is found in both the Yegua formation and the lower Jackson in the western Gulf area, but *Ficus unionensis* is larger and more elliptical in outline and has fewer and more curved secondaries. There is some resemblance to the form described by Lesquereux[84] from the Green River formation of Wyoming as *Eucalyptus? americana?*.

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke). Mount Selman formation, 1¼ miles north of Palafox, Webb County, Tex. (collected by A. C. Trowbridge, L. W. Stephenson, and E. W. Berry); Palestine, Anderson County, Tex. (collected by O. C. Funderbunk).

Collection: U. S. National Museum.

Ficus sp.

Plate IX, Figure 4.

Small fruit, elliptical in outline, with a rounded tip and a slender short peduncle. Length about 2.3 centimeters. Maximum diameter, at or slightly above the middle, about

[83] Lesquereux, Leo, The Cretaceous and Tertiary floras, pl. 44, fig. 1, 1883.

[84] Lesquereux, Leo, The Tertiary flora, p. 296, pl. 59, figs. 11, 12, 1878.

11.5 millimeters. Surface fibrous in appearance but apparently not of a coriaceous texture, for the single specimen collected is much flattened.

This specimen represents a very obvious small-fruited species of fig. It altogether lacks specific diagnostic characters and may represent the fruit of any one of the several species of *Ficus* described from the Claiborne group and based on the remains of the foliage.

Occurrence: Yegua formation, 1 mile below the mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen).

Collection: U. S. National Museum.

Order ARISTOLOCHIALES.

Family ARISTOLOCHIACEAE.

Genus ARISTOLOCHIA Linné.

Aristolochia claiborniana Berry, n. sp.

Plate IX, figures 7, 8.

Leaves of medium or small size, broadly ovate or slightly hastate; presumably the tip was pointed and the base prominently cordate. Length about 7 centimeters. Maximum width, at the base of the leaf, about 4.2 centimeters. Margins entire, slightly undulate. Petiole long and very stout, somewhat flaccid, preserved for a length of 3 centimeters. Midrib straight, prominent, very stout. About ten pairs of stout and prominent secondaries diverge from the midrib at different angles. The lowermost three or four subopposite pairs diverge digitately from the lower 5 millimeters of the midrib, the lowest pair at angles with the midrib of about 130°, the next pair at about 100°, the next pair at about 90°, and the next pair at about 80°. The rest of the secondaries are somewhat irregularly but much more distantly spaced and diverge at angles of 45° to 60°. All are regularly curved, especially distad, where they all arch in a camptodrome manner parallel with the margins. The lower pairs give off regularly and similarly arched lateral camptodrome tertiaries. The rest of the tertiaries are thin and mostly percurrent. Leaf substance rather tough but not coriaceous.

This fine and obviously new species is unfortunately represented by only a single reasonably complete specimen and its counterpart, both of which have been reproduced photographically. There are other very fragmentary specimens in the collection from Columbia, so that the species was probably not uncommon in the Yegua flora. It seems much closer to *Aristolochia* than to any other genus with which it has been compared. Ettingshausen [85] has recorded a species of *Aristolochia* from the somwehat older Eocene horizon of Alum Bay, England, but his species has unfortunately never been described or figured.

The most of the existing species of *Aristolochia* have rather conspicuously palmately three-veined leaves, although there is considerable variation in this character, and *Aristolochia acuminata* Lamarck of the Asiatic region and *Aristolochia inflata* Humboldt, Bonpland, and Kunth of the Antilles have leaves that approach this fossil form, which is also much like the existing *Aristolochia rumicifolia*. I know of no described fossil forms that approach it at all closely. I have not discovered leaves of *Aristolochia* in the antecedent Wilcox flora, but rather characteristic fruits have been described under the name *Aristolochia wilcoxiana* Berry.[86] I have collected a very similar and possibly ancestral form from the Upper Cretaceous Black Creek formation of North Carolina, which will probably be described eventually as a new species of *Aristolochites*. Mention should also be made of the large ovate-cordate leaf so common in the Fort Union flora and described as *Aristolochia cordifolia* by Newberry.[87] Some of the smaller leaves of this form—as, for example, that shown in Newberry's Plate XL—are not unlike *Aristolochia claiborniana* Berry.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Order POLYGONALES.

Family POLYGONACEAE.

Genus COCCOLOBIS P. Browne.

Coccolobis claibornensis Berry, n. sp.

Plate IX, Figures 5, 6.

Leaves of medium size, broadly elliptical and somewhat inequilateral in outline, broadly rounded or bluntly pointed at the tip, and

[85] Ettingshausen, C. von, Report on phyto-palaeontological investigations of the fossil flora of Alum Bay: Roy. Soc. London Proc., vol. 30, p. 233, 1880.

[86] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 211–212, 1916.

[87] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 90, pl. 39; pl. 40, fig. 7; pl. 60, fig. 4, 1898.

broadly cuneate or slightly decurrent at the base. Length averages about 8 centimeters. Maximum width, in the middle part of the leaf, averages about 5 centimeters. Margins entire, slightly undulate. Texture subcoriaceous. Petiole short, stout, usually much curved, about 8 millimeters in length. Midrib stout, prominent. Secondaries well marked, about six irregularly spaced pairs; they diverge from the midrib at acute angles in a curved ascending course subparallel with the lower lateral leaf margins and are eventually camptodrome. Tertiaries distinct, mostly curved; they generally run at right angles to the principal veins, and most of them are forked and anastomose midway between the secondaries.

This species has some of the characters of several fossil forms that have been referred to *Ficus*. It is in close agreement, however, with some existing species of *Coccolobis* (*Coccoloba* Linné), two species of which, both of them arborescent strand types, reach northward as far as southern peninsular Florida. The genus has more than 120 existing species which are confined to the American equatorial region and range from southern Florida and Mexico through the Antilles and Central America to Brazil and Peru. *Coccolobis claibornensis* appears to be most similar to *Coccolobis uvifera* (Jacquin) of the Antilles and *Coccolobis punctata* (Linné) of the Antilles and northern coast of South America. I have described a fossil species from the Wilcox group, which is not, however, especially close to this species from the Claiborne group. The Claiborne species appears to have had a considerable range during Claiborne time, but it is not represented in the collections by especially complete material. It survives the Claiborne and is found in the Jackson of Arkansas and Texas.

Lesquereux [88] described a species from the late Cretaceous or early Tertiary of Wyoming in 1872, and Ettingshausen [89] described two well-marked species from the Aquitanian of the Bilin Basin (Bohemia) in 1866. Ettingshausen's species are much like *Coccolobis claibornensis*.

[88] Lesquereux, Leo, Lignitic formation and fossil flora: U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 387, 1873; The Tertiary flora, p. 208, pl. 35, fig. 7, 1878.

[89] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 1; K. Akad. Wiss. Wien, Math.-nat. Classe, Denkschr., Band 26, Teil 1, pp. 88, 89, pl. 30, figs. 1, 2, 1866.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider). Yegua formation, 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen) (?). Mount Selman formation, 1¼ miles north of Palafox, Webb County, Tex. (collected by A. C. Trowbridge, L. W. Stephenson, and E. W. Berry).

Collection: U. S. National Museum.

Coccolobis columbianus Berry, n. sp.

Plate X, Figures 1 and 2.

Leaves of relatively large size, orbicular or broadly elliptical in general outline, and the apex and base broadly rounded. Length about 12 centimeters. Maximum width, midway between the apex and the base, ranges from 10 to 11 centimeters. Margins entire, regularly curved. Texture coriaceous. Petiole missing. Midrib stout, curved or slightly flexuous, prominent on the lower surface of the leaf. Six to eight opposite to alternate pairs of stout prominent secondaries diverge from the midrib on the lower surface of the leaf at wide angles, which become less toward the tip of the leaf and average about 55°. The secondaries are rather straight proximad, the curvature increasing progressively toward the margin, where they sweep upward in broad, sharply curved arches. Tertiaries thin, percurrent.

The present species is very distinct from the other Claiborne form referred to *Coccolobis*, which is described as *Coccolobis claibornensis*.

Two species from the Wilcox group that are based upon foliage are referred to *Coccolobis*. The present species is much like one of these species, *Coccolobis uviferafolia* Berry, in size and outline but is more coriaceous and has more numerous secondaries and more prominent venation throughout. Several fossil species are known from the European Tertiary.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry), and 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen).

Collection: U. S. National Museum.

Order CHENOPODIALES.

Family NYCTAGINACEAE.

Genus PISONIA Linné.

Pisonia claiborniana Berry.

Plate X, Figure 3.

Pisonia claibornensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 140, pl. 28, figs. 3, 1914.

Leaves ovate in general outline, 1.5 to 2 centimeters in length by 0.8 centimeter to 1.1 centimeters in greatest width, which is a little above the middle to 2 centimeters. Apex obtusely pointed. Base cuneate, slightly more produced and more pointed than the apex. Margins entire. Petiole very stout, alate or slightly sheathing, expanded laterally proximate, about 5 millimeters in length. Midrib rather stout, in comparison with the small size of the leaf. Secondaries few, branching from the midrib at an acute angle, 45° or slightly less, and curving upward, camptodrome. Leaf substance thin but apparently coriaceous.

This specimen was described from beds of lower Jackson age in Georgia. Except for its smaller size, it is very similar to *Pisonia eocenica* described by Ettingshausen from the Eocene or lower Oligocene of the Tyrol.[90] Among living species it resembles *Pisonia floridana* Britton of the Florida Keys, which is, however, somewhat more rounded apically, so that its leaves have a more obovate outline. The fossil is identical in every particular with the smaller leaves of the modern Central American species *Pisonia macranthocarpa* Donnell Smith. As the fossil species is based upon a small amount of material it is impossible to tell whether the specimens collected are below the average size for the species or not. Presumably the leaves did not become more than 50 per cent larger than the one figured. In *Pisonia macranthocarpa* the leaves differ considerably in size, ranging from those somewhat larger than the fossil to those only one-third its size, though large numbers are almost identical with the fossil in size. The present species may also be compared with *Pisonia longifolia* Sargent, which extends from the Florida Keys to Brazil on sea beaches.

Several of the modern species are probably dispersed through the agency of ocean currents, and this may well have been the means adopted by *Pisonia claibornensis*, for many of its associates seem to have been similarly adapted for sea voyages.

Members of the genus are not rare in the fossil state. The oldest recorded species is based on leaves described by Velenovsky from the Chlomeker sandstone near Leipa, Bohemia, as *Pisonia atavia*.[91] They are of Upper Cretaceous and probably Senonian age. I have also described a species from the Upper Cretaceous Black Creek beds in North Carolina (probably Turonian).[92] No other Cretaceous leaves have been referred to *Pisonia*, although Lesquereux referred the only American species ever described, *Pisonia racemosa*,[93] to the Laramie. The material came from the Black Buttes coal group of Wyoming, the exact age of which has never been settled, although in my opinion it is probably basal Eocene. This species, which was based upon both leaves and fruiting specimens, had somewhat larger, more rounded leaves and more ascending secondaries than the Claiborne fossil. Five species are recorded from the European Tertiary, and I have recently described two species from beds of Wilcox age in the Lagrange formation of Tennessee.

Pisonia eocenica Ettingshausen, which is represented by leaves and fruit, occurs in the lignites of Haering in the Tyrol. These beds are referred to the Ligurian by Gümbel and Friedrich, to the Stampian by De Lapparent, and to the Sannoisian by Douxami and Marty. The same species has been identified in the Oligocene of Saxony, Styria, Dalmatia, and Switzerland and in the Miocene of Styria and Carniola, and Massalongo records it from the Messinian of Italy.

The modern species of *Pisonia* are numerous and occur in the Tropics of both hemispheres. They are largely developed in Central America and tropical South America, and several species occur in the West Indies and Antilles.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

[90] Ettingshausen, C. von, Die Tertiärflora von Häring in Tirol: K.-k. geol. Reichsanstalt Abh., vol. 2, pt. 3, p. 43, pl. 11, figs. 1–22, 1853.

[91] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, Teil 4, p. 6, pl. 8, figs. 13, 14, 1885.

[92] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain; V, North Carolina: Torrey Bot. Club Bull., vol. 37, p. 191, 1910.

[93] Lesquereux, Leo, The Tertiary flora, p. 209, pl. 35, fig. 4, 1878.

Order ROSALES.

Family MIMOSACEAE.

Genus INGA Willdenow.

Inga arkansensis Berry, n. sp.

Plate X, Figure 13.

Leaflets oblong-lanceolate in outline and somewhat inequilateral and slightly falcate, abruptly narrowed distad and then slightly produced to a bluntly pointed acumen. Base inequilateral, rounded on the outside, narrowly pointed on the inside. Margins entire, slightly undulate. Petiolule apparently wanting. Length about 5.5 to 6 centimeters. Maximum width about 1.8 centimeters. Midrib fairly stout, curved, prominent on the lower surface of the leaf. Six to eight subopposite pairs of secondaries, irregularly spaced, branch from the midrib at angles of 45° or more, especially toward the apex of the leaf, curve upward in broad subparallel curves, and arch in a camptodrome manner close to and approximately parallel with the margins. Tertiary venation obsolete. Leaf substance coriaceous.

The only fossil species with which it is necessary to compare this fine form is *Inga mississippiensis* Berry, from the Wilcox group of Mississippi, a form very much like and probably ancestral to the present species. *Inga arkansensis* is more coriaceous and has a more abruptly narrowed and more obtusely pointed acumen, stouter venation, and obsolete tertiaries. *Inga puryearensis* Berry, also from the Wilcox group, is similar but somewhat larger, coarser, and blunter.

Few fossil species of *Inga* are known, although representatives of this genus have been described from the Upper Cretaceous of Europe and America. There are more than two hundred existing species which are confined to the tropical and subtropical regions of America and which are largely developed in northern South America and are sparingly present throughout the West Indies, but apparently fail to reach the Florida peninsula.

Attention should be called to the striking similarity, amounting almost to identity, between *Inga arkansensis* and the smaller leaf from the Eocene at Carbon, Wyo., that Lesquereux [94] includes, probably unwisely, in his *Ficus oblanceolata*.

[94] Lesquereux, Leo, The Tertiary flora, pl. 28, fig. 9 (not figs. 10-12), 1878.

A number of existing species of *Inga* have leaflets similar to the present middle Eocene form. Among these may be mentioned *Inga popayanensis* Pittier,[95] described recently from Colombia, and *Inga pauciflora* Walpers and Duchassaing,[96] of Panama.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry); 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Genus MIMOSITES Bowerbank.

Mimosites georgianus Berry.

Mimosites georgianus Berry, U. S. Geol. Survey Prof. Paper 84, p. 142, pl. 27, figs. 5–9, 1914.

Leaflets of small size, ovate-lanceolate, somewhat inequilateral, sessile, ranging from 2 to 3.8 centimeters in length and from 5 to 10 millimeters in maximum width, which may be in the apical or basal portion of the leaf or halfway between. Apex rounded or obtusely pointed. Base somewhat rounded or cuneate and pointed. Some of the leaves are perfectly symmetrical, others are somewhat extended apically, and still others have the base slightly extended. Margins entire. Midrib fairly stout below, thin above. Secondaries thin, open, camptodrome.

These small leaflets are common in the Yegua and Lisbon formations and occur also in the lower Jackson. They are almost identical with the leaflets of various modern Mimosaceae. The fossil species of *Mimosites* are numerous, and many species have been described from the Wilcox group in the Mississippi embayment area.[97]

Occurrence: Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, and 1 mile southeast of Antioch, Houston County, Tex. (collected by C. L. Baker). Mount Selman formation, Palestine, Anderson County, Tex. (collected by O. C. Funderbunk). Lisbon formation, in a cut on the Alabama & Vicksburg

[95] Pittier, Henry, Preliminary revision of the genus *Inga*: Contr. U. S. Nat. Herbarium, vol. 18, pt. 5, p. 185, pl. 91, 1916.

[96] Walpers, Gerhard, and Duchassaing, Placide, Plantae novae et minus cognitae in isthmo Panamensi et in insulis Guadeloupe et Sancti Thomae collectae: Linnaea, vol. 23, p. 746, 1850.

[97] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 226-228, pl. 45, figs. 6-14, 1916.

Railway 3¼ miles east of Newton, Newton County. (collected by E. N. Lowe and C. W. Cooke); Lexington, Holmes County (collected by A. F. Crider), Miss.

Collection: U. S. National Museum.

Family CAESALPINIACEAE.

Genus GLEDITSIOPHYLLUM Berry.

Gleditsiophyllum eocenicum Berry.

Gleditsiophyllum eocenicum Berry, U. S. Geol. Survey Prof. Paper 91, p. 238, pl. 46, figs. 1–7, 1916.

This well-known species, which is exceedingly common at numerous localities in the middle and upper Wilcox of the eastern embayment area and which occurs also in the upper Wilcox of Louisiana and Wilson County, Tex., survived into the basal Claiborne Mount Selman formation of Anderson County, Tex.

It was fully described in 1916 and need not be characterized in the present report.

Occurrence: Mount Selman formation, Palestine, Anderson County, Tex. (collected by O. C. Funderbunk).

Collection: U. S. National Museum.

Genus CASSIA Linné.

Cassia cockfieldensis Berry, n. sp.

Plate X, Figure 12.

Small, comparatively flat pods, relatively few seeded, about 1.6 centimeters in length by 8 millimeters in maximum width. Base rounded. Apex slightly narrower and angled. Keel thickened. Texture subcoriaceous. Surface smooth and shows a faintly marked transverse system of forking and anastomosing veins.

Except for their smaller size, more coriaceous texture, and fainter markings these pods are much like the pods of *Cassia wilcoxiana* Berry from the Wilcox group of the eastern Gulf area and are also similar to those of numerous existing species of Caesalpiniaceae, especially those of some of the very numerous species that are referred to the genus *Cassia*. The name is given in allusion to its occurrence in what was formerly called the "Cockfield" formation, which is now considered a synonym of the Yegua formation.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus COPAIFERA Linné.

Copaifera yeguana Berry.

Plate X, Figure 4.

Copaifera yeguana Berry, Torreya, vol. 15, pp. 41-44, fig. 1, 1915.

This species is based upon the complete pod figured and one additional specimen and may be characterized as follows: Pod of relatively small size, short and broadly elliptical, greatly compressed, pedunculate, somewhat obliquely mucronate tipped, two-valved, tardily if at all dehiscent, single seeded, very coriaceous, 2 centimeters in length by 1.3 centimeters in maximum width. Seed large, elliptical, compressed, 1.1 centimeters long by 8 millimeters in maximum width.

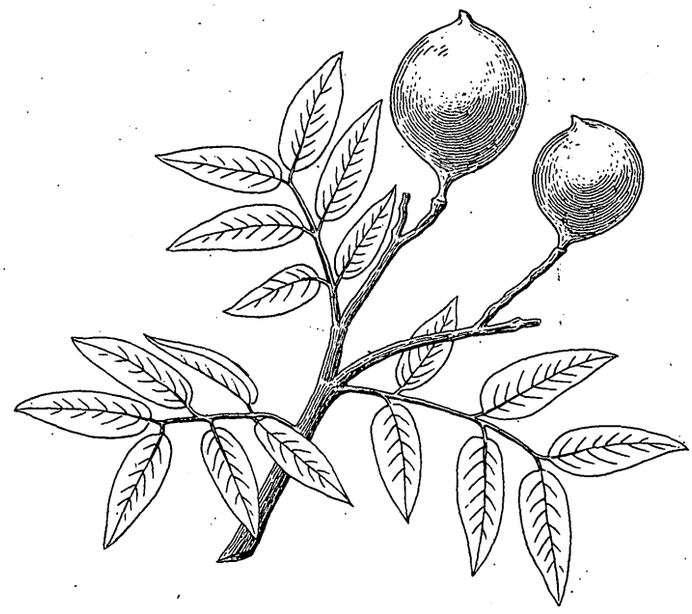

FIGURE 4.—Foliage and fruit of *Copaifera langsdorfii* Desfontaines, an existing species of *Copaifera* from Brazil much like the Yegua species.

These pods are very similar to the pods of existing members of this genus (see fig. 4) as well as to those that have been described from the Tertiary of Europe. No other genus has pods of exactly this character. Those of the tribe Dalbergieae of the Papilionaceae are com-

monly single seeded, but in that group they are less compressed and indehiscent, whereas in the present species the pod appears to have been dehiscent; at least only half of it is preserved. Whether or not the other valve was in place in the counterpart of the type I do not know, as I did not collect the material.

There are about sixteen existing species, all trees, and they are now often referred to the genus *Copaiba* Miller rather than to *Copaifera* Linné (as for example by Taubert in Engler and Prantl's Die natürlichen Pflanzenfamilien). Four of these species occur in tropical Africa and the remainder in tropical America (the West Indies, Lesser Antilles, Central America, Colombia, Venezuela, Guiana, and the Amazon Valley). They have unarmed branches, even-pinnate leaves of few small leaflets, and yield the gum or balsam used in medicine under the name copaiba. No leaves have been found with the pods in the Texas Eocene, but several fossil leaflets have been referred to this genus by European paleobotanists. Fossil forms have been referred to the genus *Copaifera* for over half a century. In 1862 Unger described, in the second part of his Sylloge, a pod of this genus from the Aquitanian of Kumi[98] and a second pod and leaflets from the Miocene of Radoboj, in Croatia.[99] Subsequently additional species have been described by Unger,[1] Saporta,[2] and Engelhardt,[3] some based on leaflets and others on pods. The genus was obviously present in Europe during the late Oligocene and Miocene. Ettingshausen[4] referred rather poorly preserved leaflets from the early Tertiary of Australia to this genus, but they are entirely unreliable, and there is no evidence that the genus was ever present in Australia. Engelhardt's records[3] from Chile (lower Miocene) are also based upon leaflets and are not entirely beyond suspicion, although from the modern range of the genus the probabilities are all in favor of the correctness of his determinations. The genus has never before been recorded from North America nor from strata anywhere as old as the middle Eocene.

A possibly allied genus found in the Tertiary of America and Europe and especially abundant in Europe is *Podogonium* Heer, which has single-seeded, more elongated, readily dehiscent, netted-veined pods.

Occurrence: Yegua formation, Cedar Creek, 2 miles south of Texas Southeastern Railroad bridge southwest of Lufkin, Angelina County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family PAPILIONACEAE.

Genus SOPHORA Linné.

Sophora claiborniana Berry, n. sp.

Plate X, Figures 9, 10.

Leaflets relatively small, inequilateral and elliptical in general outline, evenly rounded both proximad and distad. Base slightly wider and more inequilateral than the apex. One specimen has a shallow sinus on the narrower side, midway between the apex and the base, but this is a fortuitous and not a constant character. Length about 2.5 centimeters. Maximum width, at or below the middle, ranges from 8.5 to 11.5 millimeters. Margins entire. Texture coriaceous. Petiolule short and stout, slightly widened at the point of attachment, not over 1 millimeter in length. Midrib stout and nearly straight, somewhat prominent on the lower surface of the leaflet. Secondaries very thin and numerous and not prominent. They diverge from the midrib at angles of about 50°, are slightly curved, and become obsolete toward the margins, where they merge in a camptodrome manner with the tertiary areolation, which is only faintly visible in well-preserved specimens. In much of the material both the secondary and tertiary systems of venation are obsolete by immersion in the leaf substance.

Leaflets of a great variety of species of leguminous trees and shrubs are exceedingly common in the antecedent Wilcox flora. In the Claiborne flora, which is much less abundantly preserved, they are not nearly so numerous. The present species shows resemblances to several Wilcox forms, as for example *Caesalpinites pinsonensis* Berry, which is, however, slightly smaller, more equilateral, more

[98] Unger, Franz, Sylloge plantarum fossilium, Teil 2, p. 32, pl. 2, fig. 10, 1862.

[99] Idem, figs. 4–9, 11.

[1] Unger, Franz, Die fossile Flora von Radoboj, p. 154, pl. 3, fig. 13, 1869.

[2] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 375, pl. 3, fig. 14, 1866.

[3] Engelhardt, Hermann, Ueber Tertiärpflanzen von Chile: Senckenbergische naturf. Gesell. Abh., Band 16, Heft 4, p. 681, pl. 5, fig. 8; pl. 7, fig. 4, 1891.

[4] Ettingshausen, C. von, Beiträge zur Kenntniss der Tertiärflora Australiens, pt. 2, p. 56, pl. 15, figs. 23, 23a, 1886.

pointed distad, and has a coarser ventation. The most similar Wilcox form, which I regard as ancestral to the Claiborne species, is *Sophora wilcoxiana* Berry, a form that is exceedingly common in the Wilcox strand flora and is the most abundant species of *Sophora* in the Wilcox collections. Its smaller leaflets are very close to those of *Sophora claiborniana*. In general, however, the leaflets of this species are very much larger, relatively wider, and have a more prominent ventation and a tiny mucronate point at the apex of the midrib.

The present species is also much like several existing species of *Sophora* of the American Tropics. The genus has about twenty-five existing species of shrubs and small trees which are scattered over the warmer parts of both hemispheres and are found on all tropical seashores, as, for example, *Sophora tomentosa* Linné, which is perhaps the most widespread of these forms.

Numerous fossil species have been described from the European Tertiary, and I have described five species from the Wilcox group. The present species, which is found also in the Jackson, is known from the vicinity of Savannah River in Georgia to southwestern Texas, a distance of over a thousand miles.

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Sophora wilcoxiana Berry.

Plate X, Figure 11.

Sophora wilcoxiana Berry, U. S. Geol. Survey Prof. Paper 91, p. 241, pl. 47, figs. 1–13, 1916.

Leaves pinnate, rachis stout, and opposite leaflets at intervals of about 1.5 centimeters. Leaflets differing greatly in size, elliptical and nearly equilateral in outline, the apex broadly rounded, and the base broadly rounded or in some specimens slightly inequilateral and broadly cuneate. The length ranges from 2 to 6 centimeters and averages between 3 and 4 centimeters. The maximum width, about midway between the apex and the base, ranges from 8 millimeters to 2.5 centimeters and averages about 1.75 centimeters. Margins entire, full, and generally almost uniformly rounded. Petiole very short and thickened. Midrib stout and straight, prominent on the lower surface of the leaflet, extended distad as a tiny mucronate point. Seven or eight thin camptodrome secondaries diverge from the midrib at angles of 45° or slightly more. Texture coriaceous.

This fine species is exceedingly common in the middle and upper Wilcox, where nearly complete leaves are occasionally found. It is represented in the Claiborne by few and detached leaflets and has been doubtfully identified from the lower Jackson. It is comparable with the existing *Sophora secundiflora* De Candolle of the Texas region and with *Sophora tomentosa* Linné, a cosmopolitan tropical strand plant.

Occurrence: Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Sophora balli Berry, n. sp.

Plate XLIII, Figure 4.

Leaflets inequilateral, narrowly ovate in outline, with a somewhat inequilaterally rounded apex and shortly pointed base. Margins entire, evenly rounded. Texture subcoriaceous. Length about 5 centimeters. Maximum width, below the middle, about 1.7 centimeters. Petiolule wanting. Midrib medium stout and prominent on the under surface. Secondaries thin, immersed, straight and subparallel, camptodrome. Tertiaries obsolete.

This species is sparingly represented. It is narrower and more tapering than *Sophora wilcoxiana* Berry, which is doubtfully recorded from the lower Jackson of Georgia, and is not at all like the other six known Wilcox species of *Sophora*. It is a much larger and less elliptical form than *Sophora claiborniana* Berry of the Claiborne and Jackson. It is much like the form from the late Eocene of Hesse which Engelhardt [4a] identifies as *Andromeda vacciniifolia* Unger.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

[4a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, p. 79, pl. 24, fig. 9, 1922.

Order GERANIALES.

Family RUTACEAE.

Genus FAGARA Linné.

Fagara claibornensis Berry, n. sp.

Plate XI, Figure 1.

Leaves pinnate. Leaflets of medium size, sessile, elliptical in general outline, the apex and base about equally and broadly rounded, slightly decurrent at the base, and a faint mucronate point at the tip. Length about 3.5 centimeters. Maximum width, midway between the apex and the base, about 2.2 centimeters. Margins entire. Texture subcoriaceous. Midrib stout, prominent on the lower surface of the leaflet. Secondaries thin but well marked, about six subopposite to alternate pairs. They diverge from the midrib at angles of 55° to 60°, curve regularly upward, are subparallel, and are camptodrome in the marginal region. Tertiaries thin, more or less immersed, mostly percurrent, at angles of 45° to 90° with the midrib.

This well-marked species is a type of leaf that is usually referred to the genus *Berchemia* of the family Rhamnaceae and is well illustrated by the widespread *Berchemia multinervis* Heer of the European Tertiary. It is, however, so similar to the leaflets of the existing genus *Fagara* and so like the abundant leaves of this genus found in the lower Oligocene of Louisiana that I am forced to consider it referable to this genus, which appears in the flora of the Wilcox group (lower Eocene) of this area and is even indicated in the Upper Cretaceous flora of Alabama.

The genus is widely distributed in the existing flora and is largely tropical. Most of the species are endemic in tropical America.

Occurrence: Mount Selman formation, Palestine, Anderson County, Tex. (collected by O. C. Funderbunk). Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Fagara petraflumensis Berry, n. sp.

Plate XLIII, Figure 3.

Leaves small, elliptical-ovate in general outline, with evenly rounded entire margins, rounded apex, and slightly decurrent base. Widest below the middle. Texture coriaceous. Length about 3.2 centimeters. Maximum width about 2 centimeters. Petiole missing. Midrib stout but not especially prominent. Secondaries few and open, stout below, thin above, immersed; four subopposite pairs diverge from the midrib at angles of about 45°, curving regularly upward, subparallel, evenly camptodrome a considerable distance within the margins. Tertiaries obsolete.

This species is very close to *Fagara claibornensis* Berry of the Lisbon formation in Mississippi, and possibly the two are variants of a single botanic species. The present form is slightly smaller, more ovate in form, slightly thicker in texture, and with fewer secondaries. It is also similar to some of the varieties of *Fagara catahoulensis* Berry of the Jackson and Catahoula formations, and I am inclined to regard it as intermediate between *Fagara claibornensis* and *F. catahoulensis* both biologically and chronologically.

Occurrence: Yegua formation, Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus CITROPHYLLUM Berry.

Citrophyllum eocenicum Berry, n. sp.

Plate XI, Figures 2–8.

Leaves of different sizes, ovate-lanceolate in outline. Apex rather abruptly pointed. Base narrowed almost to the petiole and then rather broadly expended to form a conspicuously alate petiole. Length, 5 to 12 centimeters and averages about 7 centimeters. Maximum width, 1.5 to 3.5 centimeters and the average is about 2.5 centimeters. Margins entire, full and rounded, more or less undulate. Texture very coriaceous. Petiole stout, 1.1 to 3.5 centimeters in length, and averages about 2 centimeters or slightly less, with marginal wings on each side that reach a maximum width of 8 millimeters in some specimens but as a rule are considerably smaller and are generally inequilateral. Midrib stout, prominent on the lower surface of the leaf and more or less channeled on the upper surface. Seven to nine secondaries, opposite to alternate pairs, branch from the midrib at angles of about 60° and pursue a nearly straight ascending course for three-fourths of the distance to the margin

and then curve upward to form a broad flat arch parallel with the lateral margin and join the secondary next above. The secondaries are fairly stout but are immersed in the thick leaf substance, and the tertiary venation is practically obsolete. The wings of the petiole in some of the larger specimens show four or five camptodrome veins on each side.

This species is very characteristic, for though it exhibits considerable variation in both size and outline, as is indicated by the specimens figured, it is readily recognizable by its thick lamina, oblique, distant, and immersed secondaries, and alate petioles. Although no line of abscission is shown in the forms with the petiole preserved, a region of abscission must have been developed, for the leaves are often found without their petioles.

The present species is markedly distinct from previously described Tertiary species. It is much larger and differs in other respects from the Wilcox species of *Citrophyllum* but approaches, somewhat remotely, it is true, *Citrophyllum aligerum* (Lesquereux) Berry [5] of the Upper Cretaceous. These three species are all that are known in this genus at the present time. The genus was named from its resemblance to *Citrus*, and it is undoubtedly related to the existing tribe Citrinae of the Rutaceae. The genus *Citrus* has only a few species in the Indo-Malayan region of the Orient but is widely cultivated with many horticultural varieties in all warmer parts of the globe. Five species are more or less thoroughly naturalized in Florida.

The present species is very common at Cherry Valley and less common at Claiborne Landing and other localities in the Claiborne group. A previously described fossil form that may be congeneric is *Aralia corrugata*, which is described by Saporta [6] from the Sannoisian of Aix, in southeastern France. Saporta suggested a relationship with *Citrus* but decided, in the absence of evidences of an articulation at the summit of the petiole, that his form was a leaflet of a digitate species of *Aralia*.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull); 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen); 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, and 1 mile south of Climax siding, milepost 129, Houston County, Tex. (collected by C. L. Baker). Mount Selman formation, Palestine, spillway of Elkhart Lake, 2 miles from Elkhart, Anderson County, Tex. (collected by O. C. Funderbunk). Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

[5] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain; III, New Jersey: Torrey Bot. Club Bull., vol. 36, p. 258, pl. 18a, 1909.

[6] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 2, p. 76, pl. 10, fig. 3, 1889.

Family MELIACEAE.

Genus CEDRELA Linné.

Cedrela jacksoniana Berry, n. sp.

Plate XXXIV, Figures 4, 5; Plate XLIV, Figures 1–5.

This species is described under the upper Eocene flora (p. 174). The species is abundant in the continental deposits of the Yegua formation, which I regard as in part of Claiborne and in part of Jackson age.

The Yegua leaflets are of all sizes, from the normal size as given in the discussion of the Jackson occurrences downward to leaflets only 2 centimeters in length by 8 millimeters in maximum width, and there are very many about 6 centimeters in length by 1.8 centimeters in maximum width. As all sizes are associated in the Yegua, mere size can not be looked upon as indicative of specific variation, but it may show the range of variation that possibly occurred among the leaflets of different positions on individual leaves.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Genus CARAPA Aublet.

Carapa xylocarpoides Berry.

Plate XII, Figure 1.

Carapa xylocarpoides Berry, Am. Jour. Sci., 4th ser., vol. 43, p. 298, fig. 1a, 1917.

Seeds large, somewhat trapezoidal or pyramidal in outline, tapering toward the hilum,

rounded distad. Length about 3.5 centimeters. Maximum width about 3.5 centimeters. Thickness about 6 millimeters. The lateral margins are rounded; the distal margins tend to be somewhat angular, and there is usually an angular ridge on the proximal face of the seed. The outline and degree of rounding or angulation and the variability result from mutual pressure of the seeds in the bead and show considerable range of variation among recent forms. The texture is ligneous, and the seeds obviously formed part of the Eocene sea drift, as do those of a number of the existing species.

This striking form is unquestionably referable to the genus *Carapa* or to the allied *Xylocarpus*, which includes two existing oriental species that are often referred to *Carapa*. The differences are those of floral structure, degree of buoyancy of seeds, and manner of dehiscence of the fruit—characters which the fossil does not clearly show. The seed coat of *Carapa* is woody, whereas that of *Xylocarpus* is corky and consequently more buoyant and better adapted for dispersal by ocean currents. In this feature the fossil seed is more like *Xylocarpus*. In form *Xylocarpus* seeds are somewhat more regularly pyramidal than those of *Carapa*, and in this respect also the fossil is more like *Xylocarpus*, especially the oriental mangrove *Xylocarpus obovatus*. However, as *Carapa* is much the better-known generic name for the modern species of both *Carapa* and *Xylocarpus* and as it is represented by leaves in the lower Eocene (Wilcox) flora of this general region [7] it seems advisable to adopt the name *Carapa* for this American Tertiary fossil, which can hardly be more closely related to the oriental mangrove *Xylocarpus obovatus* Blume or the oriental beach plant *Xylocarpus moluccensis* Lamarck than to the half dozen existing species of the American and west African Tropics. The absence of the more or less massive seeds of the existing species in the larger herbaria is my reason for not making more detailed comparisons between them and the present fossil form.

Occurrence: Claiborne deposits, 2½ miles east of Fort Gaines, Clay County, Ga. (collected by Otto Veatch).

Collection: U. S. National Museum.

[7] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 253, pl. 55, fig. 4; pl. 60, fig. 4, 1916.

Order SAPINDALES.

Family CELASTRACEAE.

Genus CELASTROPHYLLUM Goeppert.

Celastrophyllum gymindoides Berry, n. sp.

Plate XII, Figure 3.

Leaves of small size, obovate in general outline, the apex broadly rounded and the base narrowly cuneate. Length about 3.5 centimeters. Maximum width, midway between the apex and the base, about 1.5 centimeters. Margins somewhat irregularly curved, with a few remote crenate-serrate teeth in the upper half of the leaf, not more than two or three on a side, irregularly spaced. Texture coriaceous. Petiole not preserved, obviously short or wanting. Midrib very stout, somewhat curved, prominent on the lower surface of the leaf. Secondaries stout, four to six pairs, irregularly spaced. They diverge from the midrib at wide but different angles, are comparatively straight and eventually camptodrome; the arches are wide and for the most part approximately equilateral. Tertiaries relatively stout and form large, nearly isodiametric quadrangular or polygonal areolae.

This well-marked species of a small, thick, remotely toothed leaf is clearly referable to the family Celastraceae. It closely resembles a number of existing species of the equatorial and subequatorial regions of America, as well as numerous fossil species from the European Tertiary that are usually referred to the genus *Celastrus*.

Among comparable modern forms with which it has been compared it is closest to *Gyminda grisebachii* Sargent, a small tree common and generally distributed over the keys of southern Florida, the West Indies to Trinidad, southern Mexico, and Central America. Some of these occurrences, however, may represent varieties or closely allied but distinct species. Because of the lack of absolute certainty in regard to the generic determination of the fossil owing to the community of foliar characters in this family, it is referred to the form genus *Celastrophyllum*, which was established by Goeppert for leaves referable to this family and used when the genus can not be satisfactorily determined. Many fossil species have been referred to *Celastrophyllum*, which is especially abundant in the Upper Cretaceous of the Atlantic

Coastal Plain, and very likely some of these forms represent the progenitor of the present species. Several species of *Celastrus* have been described from the Wilcox group, but none of these are especially close to the present form.

Occurrence: Lisbon formation, cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Celastrophyllum columbianum Berry, n. sp.

Plate XII, Figure 4.

Leaves of small size, ovate in general outline, the tip narrowed and extended acuminate, and the base broadly rounded. Length about 5 centimeters. Maximum width, in the lower half of the leaf, about 2.3 centimeters. Leaf substance thin. Margins have large dentate teeth, which become more remote and flattened distad. Petiole missing. Midrib thin, not prominent. Secondaries thin; three or four alternate pairs diverge from the midrib at angles of about 50°, curving regularly upward and camptodrome. Tertiaries obsolete.

The present species is clearly new and very unlike the other members of the Claiborne flora. Unfortunately, it is based upon incomplete material from a single locality, so that its sum of characters and range of variation can not be fully determined. It is not especially close to any of the numerous species of Celastraceae that have been described from the Wilcox group.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus EUONYMUS Linné.

Euonymus santotomasensis Berry, n. sp.

Plate XXIII, Figure 1.

Leaves ovate-lanceolate in outline, the tip acuminate and the base presumably blunt, apparently somewhat inequilateral. Length apparently about 11 centimeters. Maximum width in the middle part of the leaf. Margins have close-set denticulate teeth. Leaf substance thin. Petiole missing. Midrib stout, prominent, and somewhat flexuous. Secondaries thin; about ten subopposite to alternate regularly spaced pairs branch from the midrib at different angles, which are acute in the upper part of the leaf and become more open proximad. They form sweeping subparallel curves and are camptodrome in the marginal region. Tertiaries obsolete.

Euonymus is well represented in the Tertiary floras of the Northern Hemisphere, especially in the European area. There is a well-marked species, *Euonymus xantholithensis* Ward,[8] in the Eocene of western North America, which is a relatively shorter and broader and much coarser form than the present species. A very similar species, possibly ancestral to the present form, is *Euonymus splendens* Berry,[9] which is very common throughout the Wilcox of southeastern North America. This form as a rule has much larger leaves, which are relatively shorter and wider than those of *Euonymus santotomasensis*, and the venation is more prominent, the secondaries are less ascending, and the margins are generally more distinctly denticulate. A species contemporaneous with the present Claiborne form is *Euonymus flexifolium* Lesquereux,[10] which is a larger leaf and has fewer secondaries and very prominent, upwardly prolonged, serrate marginal teeth.

The present species is much like the leaves from the late Eocene of Hesse that Engelhardt [10a] refers to the European Miocene species *Rhamnus gaudini* Heer.

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 55 and are widely distributed throughout the Northern Hemisphere, becoming massed in the southeastern Asiatic region. Many species live in the uplands of India and China and throughout Malaysia. There are five indigenous species in 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 member of the strand flora, but for the most part it inhabits open mesophile forests and broken thickets of the warmer temperate and tropical zones.

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[8] Ward, L. F., Types of the Laramie flora: U. S. Geol. Survey Bull. 37, p. 82, pl. 27, figs. 1, 2, 1887.

[9] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 267, pl. 61, fig. 6, pl. 62, figs. 1–5, 1916.

[10] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 183, pl. 381, fig. 13, 1883.

[10a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, p. 99, pl. 33, figs. 3, 5, 1922.

The present species may be matched by the leaves of several existing American species, both of the tropical and warm temperate types.

In the report on the Rio Grande coal fields of Texas [11] this species is discussed as coming from the upper member of the section, 10 miles southeast of the Guajolote ranch. The specimen bears the locality number 1045, however, and the matrix is identical with specimens from Santo Tomas. It is therefore cited from Santo Tomas.

Occurrence: Mount Selman formation, Santo Tomas, Webb County, Tex. (collected by T. W. Stanton, July 26, 1895).

Collection: U. S. National Museum.

Family SAPINDACEAE.

Genus CUPANITES Schimper.

Cupanites parvulis Berry, n. sp.

Plate XII, Figure 5.

Leaves pinnate. Leaflets small, sessile, markedly inequilateral, falcate, lanceolate in outline, the tip narrowed acuminate and the base broadly rounded or truncate and very inequilateral. Length about 4.5 centimeters. Maximum width, at or below the middle, about 1.5 centimeters. Margins finely serrate. Texture subcoriaceous. Petiolule absent. Midrib stout, prominent, curved. Secondaries rather stout, numerous, equidistant, subparallel. They diverge from the midrib at wide angles, about 60°, are rather straight and craspedodrome. Tertiaries thin, mostly obsolete. Areolation fine, mostly obsolete.

The present species is clearly unlike previously described forms but unfortunately is based upon very incomplete material. Two large-leafed species have been described from the Wilcox group, and other fossil species are recorded from the Ypresian of the south of England.

Leaves of this type are referable to the Sapindaceae and find their closest living analogues in the genus *Cupania* Linné, which has about thirty species that are confined to the tropical and subtropical regions of America.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry); 1 mile southeast of Antioch, Houston County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

[11] Vaughan, T. W., Reconnaissance in the Rio Grande coal fields of Texas: U. S. Geol. Survey Bull. 164, p. 40, 1900.

Genus DODONAEA Linné.

Dodonaea viscosoides Berry.

Plate XII, Figure 7.

Dodonaea viscosoides Berry, U. S. Geol. Survey Prof. Paper 84, p. 142, pl. 28, figs. 4–8, 1914.

Leaves somewhat variable in shape, generally obovate but some of them lanceolate. They range from 4 to 7.5 centimeters in length by 1 centimeter to 2 centimeters in maximum width, which as a rule is above the center of the leaf. Sessile or nearly so. Apex pointed or rounded, in many specimens broadly so. Base extended, more or less narrowly cuneate and decurrent, with straight sides. Texture coriaceous. Midrib medium but becomes attenuated apically. Secondaries slender, commonly obscure in the specimens, particularly in impressions of the upper surface of the leaves; 6 to 10 pairs, indifferently opposite, subopposite, and alternate, camptodrome; they branch from the midrib at angles which may be as small as 12° or as large as 70°, the basal ones becoming very ascending in specimens in which the base is much produced, the normal angle of divergence being about 45°. The basal secondaries commonly branch from a point near the base of the midrib and take a nearly straight ascending course parallel with the leaf margin and 1 millimeter to 2 millimeters from it, connecting often almost a third of the length of the leaf from the base, with a short outwardly and downwardly directed branch from the secondary next above. The rest of the secondaries are placed at regular intervals. They are more or less straight halfway to the margin, at which point each curves upward in a wide arch to join an outwardly directed branch from the next succeeding secondary, beyond which they form a series of very small arches parallel with the margin and of a caliber which might well be termed tertiary. Tertiaries straight, lateral or transverse in direction. Areolation fine, four or five sided.

This species was described from beds of lower Jackson age in Georgia, and it is one of the commonest forms at all the localities where fossil plants have been observed in the beds of that age in Georgia. It occurs in the Yegua and Lisbon formations of the Claiborne group but not as profusely as in the Jackson.

Recently I have described two perfectly characteristic species, one based upon the

unmistakable remains of fruits, from the Wilcox Eocene,[12] a third from the Pliocene of Bolivia,[13] and a fourth from the late Tertiary of Brazil.[14] The genus was evidently much more abundant in the warmer parts of America during the Tertiary than we were formerly led to suspect. It has remained more abundant in the Western Hemisphere than would be gathered from the general statements of the distribution of the existing species as given by systematists. In particular I was greatly surprised to find *Dodonaea viscosa* exceedingly abundant in eastern Bolivia at altitudes of over 8,000 feet.

The other fossil species of *Dodonaea* that have been described, numbering about 15, are European, except one rather doubtful fruit that is almost certainly an *Ulmus* from Florissant, Colo.[15] Seven of these species, including both leaves and characteristic fruits, are Oligocene and are recorded from Styria, Prussia, France, the Tyrol, and Switzerland. Seven species are Miocene and include both leaves and fruits. Of these European forms *Dodonaea venusta* Heer,[16] from the Aquitanian of Switzerland, and *Dodonaea prisca* Weber,[17] from the Aquitanian of Rhenish Prussia, are very similar to this species and clearly represent the same type of leaf, although with well-marked specific differences; they come from Baden, Croatia, Switzerland, Prussia, and Bohemia. It seems probable that some of the leaves from the American Eocene and the European Gypse (Sannoisian) that are commonly referred to the willow oaks represent *Dodonaea*. For example, Saporta described two species of *Dodonaea* fruits from St. Zacharie, France, but no leaves, although the late Eocene and early Oligocene have furnished a number of suggestive leaves usually referred to *Quercus*. Abundant leaves and characteristic fruits of *Dodonaea* are present in the Wilcox deposits of the embayment region.

In the modern flora there are more than fifty species of *Dodonaea*, and the majority, over forty in number, are Australian. There is a single species in the Hawaiian Islands and another in Madagascar. The Claiborne and Jackson form closely resembles the modern *Dodonaea viscosa* Linné, which is found in peninsular Florida and on the keys as well as in the oriental and occidental Tropics. It ranges as far north as Bermuda (latitude 32°), where it frequents the inner edges of the sand dunes. It is a small sapindaceous tree of the "beach jungle" and is one of the prominent forms in the oriental tropical-plant association that is termed the *Barringtonia* formation by Schimper. It is protected from the strong insolation by varnished leaves that have a thick epidermis and reduced stomata, and like so many strand plants it is largely distributed through the agency of ocean currents. The present species is also close to the modern *Dodonaea angustifolia* Swartz, of the West Indies.

In conformity with so many other late Cretaceous and Tertiary dicotyledonous genera a world-wide cosmopolitanism has given place to the modern massing of the species of *Dodonaea* in a single region in the Southern Hemisphere, though there are a few outlying and scattered species in other regions, relics of the day of wide geographic range.

Occurrence: Lisbon formation, cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke); near Lexington, Holmes County, Miss. (collected by A. F. Crider). Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus SAPINDUS Linné.

Sapindus georgianus Berry.

Sapindus georgianus Berry, U. S. Geol. Survey Prof. Paper 84, p. 143, pl. 27, figs. 11, 12, 1914.

Leaflets small, sessile, lanceolate, falcate, 4 to 5.5 centimeters in length by 0.5 to 0.9 centimeter in maximum width, which is in the middle part of the leaf. Apex and base both acuminate. Margins entire. Midrib stout below, becoming thin above. Six to eight alternate pairs of secondaries branch from the midrib at acute angles and curve upward. They are camptodrome, very fine, and made out with difficulty. The two extremes of form are shown in the specimens

[12] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 270, pl. 38, fig. 2; pl. 64, fig. 3, 1916.

[13] Singewald, J. T., jr., and Berry, E. W., The geology of the Corocoro copper district of Bolivia: Johns Hopkins Univ. Studies in Geology, No. 1, p. 107, pl. 7, fig. 17, 1922.

[14] Hollick, Arthur, and Berry, E. W., The Pliocene flora of Bahia Brazil, pl. 7, figs. 11–13 (in press).

[15] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 182, pl. 36, fig. 5, 1883.

[16] Heer, Oswald, Flora tertiaria Helvetiae, Band 3, p. 64, pl. 121, figs. 13, 14, 1859.

[17] Weber, C. O., Palaeontographica, Band 2, p. 85, pl. 5, fig. 8, 1852.

previously figured. It will be seen that the shortest forms are also widest and thus much more robust than the elongate linear-lanceolate forms. A large and still more elongated variety of this species has been collected from a somewhat younger horizon (Jackson) in Webb County, in southwestern Texas.

The modern species of *Sapindus* number about ten and inhabit warm temperate and tropical Asia and America. At least four species are found within the limits of the United States, and it would not be difficult to select leaflets from the common *Sapindus marginatus* Willdenow from the same area as the fossil species that would approach it very closely. The fossil is, however, more nearly related, in all probability, to *Sapindus saponaria* Linné, a common West Indian and South American tree which reaches the Florida Keys and which has become a widespread member of the littoral flora through the agency of ocean currents. Hemsley states that seeds of this species were once washed ashore on the south coast of Bermuda and afterward germinated.

Occurrence: Lisbon formation, Lexington, Holmes County, Miss. (collected by A. F. Crider). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, and 1 mile southeast of Antioch, Houston County, Tex. (collected by C. L. Baker). Mount Selman formation, Palestine, Anderson County, Tex. (collected by O. C. Funderbunk).

Collection: U. S. National Museum.

Sapindus affinis Newberry.

Plate XII, Figure 8.

Sapindus affinis Newberry, Notes on the later extinct floras of North America: Lyceum Nat. Hist. New York City Annals, vol. 9, p. 51, 1868; Illustrations of Cretaceous and Tertiary plants, pl. 25, fig. 1, 1878; U. S. Geol. Survey Mon. 35, p. 116, pl. 30, fig. 1; pl. 40, fig. 2, 1898. Knowlton, U. S. Geol. Survey Mon. 32, p. 736, pl. 102, figs. 1–3, 1899.

This species, which is described by Newberry from the mouth of Yellowstone River, is abundantly represented in the collections of the National Museum, and the figures published by Knowlton are much more adequate than those of Newberry. Indistinguishable leaflets occur abundantly in the Lisbon formation near Lexington, Miss. Like the western material they show considerable variation in size but retain their characteristic outline and venation. The present species is much like the Wilcox form *Sapindus oxfordensis* Berry.

It seems incredible that a single outcrop should furnish so many species of a single genus, and it is probable that individual variations have been made the basis for specific differentiation; at the same time, the large number of species of *Sapindus* that have been recognized in the Claiborne as well as in the earlier Wilcox flora are justified in the present state of our knowledge. In the Gulf region this species has not been detected except at this middle Eocene horizon, whereas in the Yellowstone Park section it is said by Knowlton to range from rocks of Fort Union Eocene age to the Miocene, although there seems to be considerable doubt regarding this late age for any of these plant-bearing beds.

Occurrence: Lisbon formation, Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Sapindus mississippiensis Berry.

Sapindus angustifolius Hollick (not Lesquereux), in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 286, pl. 35, fig. 5, 1899.
Veatch, U. S. Geol. Survey Prof. Paper 46, pl. 17, fig. 6, 1906.
Sapindus mississippiensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 274, pl. 63, fig. 1; pl. 64, fig. 10; pl. 66, figs. 1, 2; pl. 109, fig. 1, 1916.

Leaflets sessile, slightly inequilateral, of small size, 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. 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, which eventually becomes approximately parallel with the lateral margins and camptodrome. Tertiaries obsolete.

This form is a characteristic species of *Sapindus* with numerous small falcate leaflets. A

specimen of it from Louisiana was referred by Hollick to *Sapindus angustifolius*, a species which comes from the Miocene of Colorado, and though all the species of *Sapindus* that have small falcate leaflets are much alike, this Wilcox and Claiborne 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.

The present species may be distinguished from the several other small species of *Sapindus* from the Eocene by the same features that distinguish it from *Sapindus angustifolius* Lesquereux. It is common in the Lisbon formation near Newton, Miss., and is also present in the Gosport sand at Claiborne Landing, Ala.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, and at Lexington, Holmes County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Sapindus yeguanus Berry, n. sp.

Plate XII, Figure 6; Plate XLIII, Figures 1, 2.

Leaflets petiolulate, lanceolate-falcate and somewhat inequilateral in outline. Length averages less than 5 centimeters. Maximum width, in the lower half of the leaflet, about 1 centimeter. Apex gradually narrowed and sharply pointed. Base more shortly and broadly pointed. Margins entire, in a few specimens slightly irregular, rounded and full basally, rather straight, distad. Texture subcoriaceous. Petiolules, where present, relatively stout, generally straight, about 3 millimeters in length. Midrib stout, curved, prominent on the lower surface of the leaflet. Secondaries thin, about eight subopposite to alternate pairs; they diverge from the midrib at angles of about 45°, curve upward, in places somewhat irregularly, and are camptodrome a considerable distance from the margins. Tertiaries obsolete.

This species resembles the smaller leaves of *Sapindus affinis* Newberry from the Claiborne and Fort Union but is less inequilateral and more regularly falcate. It is also comparable with *Sapindus formosus* Berry from the Wilcox and with *Sapindus angustifolius* Lesquereux from Florissant but is readily distinguishable. Among the species of *Sapindus* from the Wilcox it is of approximately the same size as *Sapindus mississippiensis* Berry and *Sapindus eolignitica* Berry. It differs from *Sapindus mississippiensis* in being widest below the middle with straight-sided narrowed tip, broader base, and long petiolule. It differs from *Sapindus eoligniticus* in being less 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.

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke). Yegua formation, 1 mile southeast of Antioch and 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker); Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Sapindus dentoni Lesquereux.

Plate XII, Figure 9.

Sapindus dentoni Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 3881, 1876; U. S. Geol. and Geog. Survey Terr. Ann. Rept., 1874, p. 315, 1876; The Tertiary flora, p. 265, pl. 64, figs. 2–4, 1878.

Leaves elongate-lanceolate in outline, widest at or below the middle and tapering upward in a long acumen, markedly inequilateral. Length ranges from 5.5 to 10 centimeters. Maximum width ranges from 7.5 millimeters to 1.75 centimeters. The Claiborne material is especially inequilateral, a specimen 1.6 centimeters in maximum width having one side 1.1 centimeters wide and the other 4 to 5 millimeters wide. Apex elongated, acuminate. Base rounded, bluntly pointed. Margins undulate. Petiole fairly stout, 6 to 10 millimeters in length, usually somewhat curved. Midrib medium stout, usually more or less flexuous. Secondaries thin, numerous, rather uniformly spaced, and subparallel; they diverge from the midrib at angles that are between 45° and 50° and are but slightly curved to the margin, where they curve abruptly upward to form camptodrome arches.

The present species was described by Lesquereux from the supposed Green River beds at the mouth of White River in Utah, and identical remains, generally near the maximum in size, are common in the buff argillaceous Claiborne sands near Lexington, Miss., and occur also in the Jackson of southwestern Texas. It is also present in the Wind River Basin of Wyoming.

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Order RHAMNALES.

Family RHAMNACEAE.

Genus ZIZYPHUS Linné.

Zizyphus claibornensis Berry, n. sp.

Plate XII, Figures 10, 11.

Leaves of medium size, comparatively elongated, ovate-lanceolate, slightly inequilateral, and more or less falcate in outline, the tip gradually narrowed and acuminate, and the base rounded or broadly cuneate, slightly decurrent. Length ranges from 10 to 12 centimeters. Maximum width, below the middle, about 2.5 centimeters. Margins with unequally spaced serrate teeth of variable size, mostly directed outward. Texture subcoriaceous. Midrib stout, prominent, curved. Lateral primaries thin, diverging at acute angles at or near the base of the midrib, parallel with the lower lateral margins, joining branches from the lowest secondaries near the middle part of the leaf. Five or six opposite to alternate pairs of thin, unequally spaced secondaries diverge from the midrib at angles of about 35°, ascend in long, regular sweeping curves, and become subparallel with the margins, along which they arch in a camptodrome manner. Tertiaries very fine and comprise ascending flexuous nervilles from the midrib which anastomose with upwardly directed branches from the secondaries; most of the angles are acute, and the interspaces are filled with a fine areolation of minute meshes.

Two large-leafed species of *Zizyphus* have been described from the Wilcox group, and one of these, *Zizyphus falcatus* Berry,[18] is much like the present species. It is, however, more coriaceous in texture and has less prominent teeth and stouter and longer lateral primaries. The most similar fossil form is *Zizyphus longifolia* Newberry,[19] which is common in the Green River shales of Wyoming but which has stouter lateral primaries and less prominent marginal teeth than the Claiborne species and is usually narrower and more distinctly lanceolate. The common European Oligocene species, *Zizyphus ungeri* Heer,[20] is the most similar European form. *Zizyphus* has numerous fossil species that range from the middle Cretaceous (Woodbine sand) to the Pleistocene. The existing species number about two score and are largely Indo-Malayan forms. Only one or two species of tropical America represent the abundant American Tertiary ancestry.

Occurence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry). Lisbon formation, Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Genus RHAMNACINIUM Felix.

[Deutsche geol. Gesell. Zeitschr., vol. 46, p. 89, 1894.]

Rhamnacinium texanum Penhallow.

Rhamnacinium texanum Penhallow, Roy. Soc. Canada Trans., 3d series, vol. 1, sec. 4, p. 96, figs. 1–3, 1908.

Penhallow describes the wood of this species as follows:

Growth rings medium, not very prominent, but defined by an abrupt alteration in the size of the vessels and by a zone of two to four cells which are distinctly smaller and compressed radially. Wood cells round or hexagonal, thick walled, very unequal and often in very unequal radial rows. Wood parenchyma wanting. Vessels at first medium to large, single or upward of four, radially seriate, radially oval and generally with conspicuous, thin-walled thyloses; thus continuing until the region of the summer wood without obvious alteration; chiefly one, sometimes two, or rarely three rows of vessels between two of the principal rays. Medullary rays prominent, one or more generally about four cells wide, the cells short, thin walled, and with squarish termination.

Ray cells all thin walled and very variable, from four times longer than high to short and twice higher than long, the two kinds mingled. Thyloses in the vessels numerous, large, thin walled. All other structural details obliterated.

[18] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 277, pl. 69, fig. 5; pl. 70, figs. 1, 2, 1916.

[19] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 119, pl. 65, figs. 3–5, 1898.

[20] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 74, pl. 122, fig. 25, 1859.

Medullary rays of two kinds—(1) one-seriate rays upward of 12 cells high; the cells all thin walled, oblong or rectangular, uniform but unequal; (2) multiseriate rays composed of three to five rows of high thin-walled very unequal and very variable cells which often become one-seriate and much larger at one or both extremities of the ray. Vessels bearing numerous thin-walled thyloses and, upon their radial walls, numerous hexagonal, bordered pits, which occupy the entire area of the wall.

This species was described from the Claiborne of Texas by Penhallow, who had already described *Rhamnacinium triseriatum* and *R. porcupinianum* from beds of Fort Union age in Saskatchewan. A third species was described by Felix and by Knowlton from the Tertiary of the Yellowstone Park, and there are one or more Eocene species described from the European area.

Occurrence: Yegua formation, Somerville, Burleson County, Tex.

Collection: Peter Ridpath Museum, Montreal, Canada.

Genus REYNOSIA Grisebach.

Reynosia texana Penhallow.

Reynosia texana Penhallow, Roy. Soc. Canada Trans., 3d ser., vol. 1, sec. 4, p. 97, figs. 4, 5, 1908.

Penhallow describes the wood of this species as follows:

Growth rings narrow and poorly defined, with no obvious distinction between spring and summer woods, but the outer limits of the ring are generally marked by the presence of more or less numerous, radially flattened and tangentially extended wood cells which form a disconnected zone, upward of four cells thick. Wood cells small, very unequal, about 14 μ broad, hexagonal in irregular radial rows, the wall very thick, the cavity reduced to about 2.63 μ. Vessels rather numerous throughout, very resinous and thick walled, round or oval, single or radially two-seriate, at first relatively large but toward the outer limits of the ring somewhat abruptly reduced to one-half size; often inclosed more or less completely by an irregular layer of rather larger and thinner-walled wood parenchyma. Medullary rays numerous, prominent, somewhat resinous, two cells wide, distant upward of 12 rows of wood cells. * * *

Medullary rays all of one kind, two- or three-, rarely one-seriate, the breadth varying much, according to the size of the component cells, fusiform, low to medium; the cells very unequal and variable, chiefly rather thin walled.

The genus *Reynosia* contains four existing species of coastal shrubs and small trees which range from southern Florida through the Bahamas and the Antilles. The present Claiborne species is the first recorded occurrence of fossil wood of this genus. Its structure is according to Penhallow very close to that of *Reynosia septentrionalis* Urban, the only recent species that reaches the United States, which is found along the coast and keys of southern Florida from the Marquesas group to Biscayne Bay and occurs also on the Bahamas, Cuba, and neighboring islands. A species of *Reynosia*, named *praenuntia* because of its probable ancestral relationship, has been described by me from leaves preserved in the Wilcox deposits of northern Mississippi.

Occurrence: Yegua formation, Somerville, Burleson County, Tex.

Collection: Peter Ridpath Museum, Montreal, Canada.

Genus RHAMNUS Linné.

Rhamnus sp.

Plate XXIII, Figure 2.

A broken leaf, apparently referable to *Rhamnus* and representing a new species. The specimen shows an ovate-lanceolate leaf which has about eight pairs of ascending subparallel curved camptodrome secondaries. The tip and base are acuminate, and the petiole is short, curved, stout, and about 5 millimeters long. The leaf is about 10 centimeters in length and 4.25 centimeters in maximum width, somewhat below the middle. The tertiary venation is obsolete, and it is impossible to describe the material with sufficient detail to warrant the erection of a new species.

Occurrence: Mount Selman formation, Santo Tomas, Webb County, Tex. (collected by T. W. Stanton, July 26, 1895).

Collection: U. S. National Museum.

Order MALVALES.

Family TILIACEAE.

Genus GREWIOPSIS Saporta.

Grewiopsis claiborniana Berry, n. sp.

Plate XIII, Figures 1–4.

Leaves orbicular in general outline. Length about 9 centimeters. Maximum width about 11 centimeters. Apex broad and almost truncate in outline. Base truncate or subcordate. Margins full rounded and entire below, elsewhere with broad and shallow dentate teeth.

Primaries three from the top of petiole or suprabasilar, stout, prominent on the lower surface of the leaf, all three of the same caliber; the laterals diverge from the midrib at acute angles and pursue a nearly straight ascending course that terminates in a marginal tooth at the upper lateral angle of the leaf on each side. These marginal teeth are slightly produced, giving the leaf a suggestion of three distal faint, broadly conical lobules. Secondaries numerous, prominent. The midrib gives off about six subopposite to alternate pairs at acute angles. These secondaries are but slightly curved and are approximately parallel to each other and to the lateral primaries. They are rather closely and evenly spaced and craspedodrome. Each lateral primary gives off externally at acute angles six or seven slightly curved craspedodrome secondaries, which terminate in marginal teeth. The tertiary system consists of a distal craspedodrome branch from some of the upper secondaries, increasing regularly in number toward the base; the lowermost secondary gives off about five such branches, the distal four or five being craspedodrome, whereas the lowermost one or two are camptodrome. Nervilles thin but distinct, mostly close set, approximately parallel and percurrent. Texture subcoriaceous.

The present species, which is obviously new, is based on numerous fragmentary specimens from the upper Claiborne of Louisiana, the three most complete specimens being those figured. Plate XIII, Figure 1, shows the character of the lower lateral margin and base in a leaf in which the primaries diverge from the top of the petiole. Plate XIII, Figure 2, also shows the character of the base. Plate XIII, Figure 3, shows the marginal characters and the blunt, foreshortened apex. From these and other less complete specimens Plate XIII, Figure 4, has been built up to show the character of the complete leaf.

The present species is rather larger than most recent species of *Grewia* or fossil species of *Grewiopsis*. Among the species of *Grewiopsis* it is similar in size and general character to *Grewiopsis anisomera*, *Grewiopsis tiliaceae*, and *Grewiopsis credneriaformis*, described by Saporta[21] from the Paleocene of France, and to *Grewiopsis platanifolia* and *Grewiopsis populifolia*, described by Ward[22] from the Fort Union of Montana. It is, however, distinct from these related forms and may be separated by its closer secondaries and more prominent percurrent tertiaries as well as by the peculiar three-angled truncate upper margin. This species in all its characters, except in its basal venation, is very suggestive of the American Upper Cretaceous species of *Protophyllum* Lesquereux or the closely related abundant and chiefly European types referred to Zenker's genus *Credneris*. A smaller species of *Grewiopsis* is not uncommon in the Wilcox deposits of Louisiana and Tennessee.

Occurrence: Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull).

Collection: U. S. National Museum.

Family STERCULIACEAE.

Genus STERCULIA Linné.

Sterculia labruscoides Berry, n. sp.

Plate XIV, Figure 1.

Leaves of small size, digitately trilobate, about 5.25 centimeters in length by about 4 centimeters in maximum width from tip to tip of the lateral lobes. Margins entire. Texture subcoriaceous. Base rounded. Petiole not preserved, stout, presumably long. Lobes narrow, conical, acuminate, of unequal lengths. They diverge at angles of about 50°, but the lateral ones immediately curve upward, and their general courses subtend angles of about 30° with the midrib. Secondaries numerous, thin, mostly immersed in the leaf substance; they diverge from the primaries at angles that average about 55°, are almost straight in their courses, and have their tips connected in the marginal region by broad flat arches.

This species is clearly allied to the modern species of *Sterculia* and is very close to *Sterculia labrusca* Unger,[23] which is so abundant in the Styrian Oligocene and is recorded from a large number of European localities and horizons, ranging from the Paleocene of Belgium to the Sarmatian or latest Miocene of Croatia. This wide range in time is represented, how-

[21] Saporta, G. de, Prodrome d'une flore fossile des travertins anciens de Sézanne, pp. 116, 118, 121, pl. 12, fig. 9; pl. 13, figs. 7–9, 1868.

[22] Ward, L. F., Types of the Laramie flora: U. S. Geol. Survey Bull. 37, pp. 89, 90, pl. 40, figs. 1, 3–5, 1887.

[23] Unger, Franz, Die fossile Flora von Sotzka, p. 45, pl. 28, figs. 1–11, 1850.

ever, by forms that are grouped under five varieties, which probably represent more than a single species; the typical forms are confined to the late Eocene and early Oligocene. The type forms from Sotzka show bilobate or trilobate leaves, scarcely distinguishable in any particular from those of the existing *Sterculia diversifolia* Don, of the Australian flora. The only conspicuous difference between *Sterculia labrusca* Unger and *Sterculia labruscoides* of the American middle Eocene is the relatively shorter and more conical lobes and less deeply cut sinuses of *Sterculia labruscoides*. Another European Tertiary species that greatly resembles *Sterculia labruscoides* is *Sterculia tenuiloba* Saporta,[24] which is described from the Sannoisian of Aix, in southeastern France, more particularly the leaves from this same horizon at Bornstedt, in Saxony, that Friedrich[25] identified with Saporta's species.

Sterculia labruscoides is represented by an identical or closely related but fragmentarily preserved form in the upper Jackson of Texas.

The existing species of *Sterculia* number more than one hundred forms segregated into three sections—Digitatae, Lobatae, and Integrifoliae. Most of the forms of the American Tropics belong to the section Lobatae, which also includes the bulk of the fossil forms. The fossils number over 40 species and appear in abundance and variety in the middle Cretaceous, especially in North America. One form, *Sterculia minima* Berry,[26] which characterizes the Magothy formation from New Jersey to Maryland, is so like *Sterculia labruscoides* that it must be regarded as ancestral to that form. It has from two to four lobes, as does also *Sterculia labrusca* Unger, the large-leafed *Sterculia puryearensis* Berry from the Wilcox group, and *Sterculia diversifolia* Don. Probably if *Sterculia labruscoides* were represented by more material it too would be found to show similar variation in this feature, which is a characteristic of the lobate-leafed Sterculias. The type came from immediately below a bed that carries *Ostrea sellaeformis* and thus corresponds to the Lisbon of the Alabama section. An incomplete specimen, which appears to belong to this species, is present in the collections from the Yegua formation in Louisiana, and it is also present in that formation in Texas.

A Wilcox species, *Sterculia puryearensis* Berry, is much larger than this Claiborne species and appears to be genetically related to the abundant Upper Cretaceous *Sterculia snowii* Lesquereux.

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker); Columbia (?), Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Order PARIETALES.

Family TERNSTROEMIACEAE.

Genus TERNSTROEMITES Berry.

Ternstroemites crowleyensis Berry, n. sp.

Plate XIV, Figures 2, 3.

Leaves of medium size, broadly lanceolate in general outline, the apex acuminate and the base narrowly cuneate. Length ranges from 14 to 20 centimeters. Maximum width, in the middle part of the leaf, ranges from 2.75 to 4 centimeters. Margins prominently serrate; the teeth are close set and aquiline in the middle part of the leaf but become less prominent and more distant toward the tip, still less prominent and more distant toward the base, and entirely obsolete close to the base. Texture coriaceous. Petiole missing. Midrib stout, curved or flexuous, and prominent on the lower surface of the leaf. Secondaries thin, largely obsolete. They are numerous and subparallel and diverge from the midrib at angles of about 45°, and pursue a nearly straight, ascending course until the marginal region is reached, where they curve upward and are camptodrome. In places short tertiary branches run from the secondaries to the teeth.

The present species is readily distinguishable from the associated *Ternstroemites claibornensis* Berry, or from the Wilcox species that have been referred to this genus, by its size, its prominently and differently toothed margins,

[24] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 1, p. 120, pl. 10, fig. 2, 1863.

[25] Friedrich, Paul, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen: Geol. Specialkarte Preuss. Abh., Band 4, p. 141, pl. 18, fig. 8, 1883.

[26] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain, I: Torrey Bot. Club Bull., vol. 33, p. 177, 1906.

and its different venation. It is a thick-leafed form and is not uncommon at Cherry Valley, on Crowleys Ridge, Ark., for which it is named. It is not unlike several European Tertiary forms that have been referred to *Banksia* and *Dryandroides*, and it is also somewhat like the Wilcox species of *Dillenites* and *Dryophyllum*. Its resemblance to *Banksia dillenioides* Ettingshausen [27] and *Banksia haidingeri* Ettingshausen,[28] from the European Oligocene, is worth mentioning.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry); Columbia, Caldwell Parish, La. (collected by E. W. Berry).

Collection: U. S. National Museum.

Ternstroemites claibornensis Berry, n. sp.

Plate XIV, Figure 4.

Leaves oblong-lanceolate in outline, long and narrow and many of them falcate. Length about 11 centimeters. Maximum width, in the basal half of the leaf, about 1.6 centimeters; the width narrows gradually upward to the slender, elongated, acuminate apex. Base rounded or bluntly and shortly pointed. Margins entire for a short distance proximad; above the entire portion they are regularly but not prominently crenate. Leaf substance thick. Texture coriaceous. The surface of the impressions minutely mammillated by the tiny-meshed areolation of the leaf. Secondaries thin, immersed in the leaf substance, numerous about thirty opposite to alternate pairs; they diverge from the midrib at wide angles, commonly 90° toward the base of the leaf but more ascending distad; they are but slightly curved, and abruptly camptodrome about two-thirds of the distance from the midrib to the margin.

This species is markedly distinct from the associated *Ternstroemites crowleyensis* Berry, a much larger leaf with prominent serrate margins. It is, however, very similar to the smaller leaves of *Ternstroemites preclaibornensis* Berry and probably represents a middle Eocene descendant of this early Eocene species.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

[27] Ettingshausen, C. von, Die tertiäre Flora von Häring in Tirol, p. 55, pl. 18, fig. 7, 1853.

[28] Ettingshausen, C. von, Die fossile Flora von Sagor in Krain, Theil 1 p. 198, pl. 10, fig. 29, 1872.

Order THYMELEALES.

Family LAURACEAE.

Genus CINNAMOMUM Blume.

Cinnamomum angustum Berry, n. sp.

Plate XIV, Figure 6.

Leaves narrow and elongated, linear-lanceolate in outline, the tip gradually narrowed and acuminate and the base more abruptly rounded but recurved and decurrent close to the petiole. Length about 10 centimeters. Maximum width, at or below the middle, about 1.2 centimeters. Margins entire and subparallel. Texture coriaceous. Petiole stout, curved, about 1 centimeter in length. Midrib stout, prominent on the lower surface of the leaf. Lateral primaries subopposite, suprabasilar, considerably thinner than the midrib, from which they diverge at angles of about 30° about 5 millimeters above its base; they are long ascending, parallel with and close to the lateral margins. In the distal half of the leaf five or six pairs of thin alternate secondaries diverge from the midrib at angles of about 40° and run upward in long, sweeping, eventually camptodrome curves. From the outside of the lateral primaries small thin camptodrome branches fill the marginal area. The tertiary venation is peculiar and serves to distinguish this from all previously described lanceolate species of *Cinnamomum*. The areolae are small, four or five sided, and the long axis is generally more or less parallel with the long axis of the leaf. The veins are thin, and those which are longitudinal or oblique in direction are more pronounced than those which are transverse. All are relatively prominent on the lower surface of the leaf.

This species is very close to the very common and wide-ranging European *Cinnamomum lanceolatum* Heer.[29] The European species is, however, more lanceolate in outline, is relatively shorter and wider, and has a more acute base and different tertiary venation. There are six species of *Cinnamomum* in the Wilcox flora, and one of these, *Cinnamomum oblongatum* Berry,[30] is similar enough to this Claiborne and Jackson species to be regarded as its immediate ancestor. It is more variable in size and

[29] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 86, pl. 93, figs. 6–11, 1856.

[30] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 297, pl. 79, figs. 1, 2; pl. 83, fig. 6, 1916.

differs in the basilar primaries and in the details of venation. That the present species was consistently narrow and linear-lanceolate is indicated by the preservation of leaves of this kind only at localities that are about 500 miles apart along the Claiborne-Jackson coast.

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Genus PERSEA Gaertner (son).

Persea gratissimifolia Berry, n. sp.

Plate XIV, Figure 5.

Leaves of large size, elliptical or obovate in general outline, the apex broadly rounded and the base slightly narrowed and broadly pointed. Length about 14 centimeters. Maximum width, which is in the middle part of the leaf, about 6 centimeters. Margins entire, full, and regularly rounded. Texture subcoriaceous. Petiole stout, tumid proximad, about 1.75 centimeters in length. Midrib stout, somewhat flexuous. Secondaries rather stout, about ten, nearly regularly spaced, subparallel, opposite to alternate pairs. They diverge from the midrib at angles of 45° to 50° and curve regularly upward more or less parallel with the margins and are camptodrome. Tertiaries thin but distinct, percurrent.

This handsome species is common at the Cherry Valley locality, particularly in the clays, but the leaves are represented by a carbonaceous film that soon weathers, and the clay slacks, leaving but a poor impression. The figure of this species is made from a careful sketch of a specimen that was made in the field when it was collected. The present species is obviously congeneric with the rather numerous Tertiary forms that are usually referred to this genus and is perhaps most like *Laurus* (*Persea*) *superba*, which was described by Saporta [31] from the lower Miocene of Armissan, France, and compared by that author with the existing tropical American species *Persea gratissima* Gaertner, with which the Cherry Valley form may also be compared. The treatment of the existing species of *Persea* has varied greatly since Gaertner characterized the genus in 1805. Engler and Prantl refer to it a rather large number of southeastern Asiatic and but few American species. Sargent and Britton include in it but one species of the Old World, that indigenous in the Canary Islands, and the rest, more than fifty species, are confined to America, where they are distributed from the coast region of Virginia to Brazil and Chile.

A species somewhat like the present occurs in the Wilcox of northwestern Louisiana, and a similar form with relatively shorter and more pointed leaves is found at about the same horizon as the Cherry Valley outcrop in Mississippi.

Occurrence: Yegua formation, Cherry Valley, Cross County, Ark. (collected by E. W. Berry). Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke).

Collection: U. S. National Museum.

Persea lexingtonensis Berry, n. sp.

Plate XV, Figures 1, 2.

Leaves of medium size, ovate-lanceolate in general outline, the apex shortly pointed and the base somewhat extended and more narrowly pointed. Length about 12 to 13 centimeters. Maximum width, in the middle part of the leaf, about 4.5 centimeters. Margins entire, somewhat undulate distad, full and evenly rounded, slightly straightened proximad. Leaf substance thin but coriaceous in texture. Midrib stout. Secondaries rather stout; five or six alternate pairs, unequally spaced, diverge from the midrib at angles of 45° to 50°, curved, camptodrome. The basal secondaries are longest and subparallel with the lower lateral margins; they become progressively shorter toward the apex. Tertiaries thin but distinct, mostly percurrent.

The present species is not very different from *Persea gratissimifolia* Berry, which is common in the Yegua formation at Cherry Valley, Ark., and in the Lisbon formation of Mississippi, but *Persea gratissimifolia* is larger and is obovate in outline and has a broadly rounded apex, less straight lower lateral margins, more numerous secondaries, more uniformly percurrent tertiaries, and thicker leaf substance. The present species is also much like the Wilcox species *Persea wilcoxiana*

[31] Saporta, G. de, Etudes, sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 273, pl. 7, fig. 4, 1866; idem, vol. 3, pt. 1, p. 76, pl. 15, fig. 5, 1867.

Berry,[32] and the one is undoubtedly the direct descendant of the other. *Persea wilcoxiana* has thinner, more numerous, and more regular secondaries and a more entire and symmetrically curved outline.

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker).

Collection: Johns Hopkins University.

Genus OREODAPHNE Nees.

Oreodaphne obtusifolia Berry.

Oreodaphne obtusifolia Berry, U. S. Geol. Survey Prof. Paper 91, p. 301, pl. 80, figs. 1; pl. 83, figs. 2–5, pl. 84, figs. 1, 2, 1916.

Leaves of variable size and form, elongate-elliptical to ovate-lanceolate in outline. Length 12 to 25 centimeters, and the average is about 16 centimeters. Maximum width, about midway between the apex and the base, 3.4 to 7.5 centimeters, and the average is about 4 centimeters. Apex variable; pointed in some specimens, usually broadly rounded, retuse in one specimen. Base more acute than the apex, varying 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; in some places they show an undulation. Texture coriaceous. Petiole short and stout, 1.5 to 2 centimeters in length, curved. Midrib stout but prominent. Primaries suprabasilar, subopposite, diverging from the midrib at angles of about 30°, curving slightly upward and then running nearly straight to or above the middle of the leaf, where they unite with outer tertiary branches from the lowest secondaries near the margins. Secondaries four to seven pairs, opposite to alternate, thin but prominent; they branch from the midrib at an angle of about 50°, sweep upward in a broad curve, and are ultimately camptodrome. Internal tertiaries thin, numerous, and percurrent. Marginal tertiaries from outside of primaries for the most part camptodrome, generally almost straight. Epidermal cells very small but have thin walls. They differ on the upper and lower surface of the leaf, the substance of which is sometimes 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 most of the existing Lauraceae, for they have the exact appearance of the secretory cells of the Lauraceae. Areolae minute, isodiametric, strongly marked in good material.

The present species was described from the Wilcox group, where it constitutes a very distinct type that is easily distinguishable from the numerous other lauraceous forms of the Eocene, especially when complete specimens are available for comparison. The species is exceedingly common in the Wilcox group. The specimens from the Claiborne are not positively determined, for only the lower parts of the leaves are represented. They show, however, the minute incised areolation, the percurrent nervilles between the primaries, and the comparatively straight marginal tertiaries, as well as the straight upper lateral primaries that approach close to the margins—all characteristic of this species.

The species is very similar to *Cinnamomum sezannense* Watelet [33] of the European Eocene; in fact a fragment from the Wilcox of Louisiana was identified as that species by Hollick.[34]

Occurrence: Yegua formation, 1 mile below mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen).

Collection: U. S. National Museum.

Oreodaphne inequilateralis Berry, n. sp.

Plate XVI, Figures 4–6; Plate XLIV, Figure 6.

Leaves of medium or large size, ovate and usually markedly inequilateral in general outline, the apex acuminate and the base similar. Length ranges from 11 to 15 centimeters. Maximum width, at or slightly below the middle, ranges from 3.5 to 5 centimeters. Margins entire, slightly undulate. Texture coriaceous. Petiole in no specimen preserved, which may indicate that it was long. Midrib stout, prominent, usually somewhat curved.

[32] Berry, E. W.: The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 300, pl. 86, fig. 3, 1916.

[33] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 175, pl. 50, fig. 2, 1866.

[34] Hollick, Arthur, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 42, fig. 2, Louisiana Geol Survey, 1899.

Secondaries of medium size, 10 to 12, mostly alternate, pairs; they diverge from the midrib at angles of 50° to 60°, curve regularly and considerably upward, usually subparallel, although somewhat unequally spaced, camptodrome in the marginal region. Tertiaries thin, typically lauraceous in their areolation.

The present species is clearly new and markedly unlike any of the other Lauraceae known from the Claiborne group, although it greatly resembles several of the species of *Oreodaphne* and *Nectandra* described by me from the antecedent Wilcox group. Though not rare it is, like most of the Claiborne plants, rather poorly preserved. The figured specimen from Claiborne Landing, owing to a deposit of ferruginous material along its secondaries, appears somewhat different from the specimens figured from Columbia.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker); Rock Creek, William Dunn League, Brazos County, Tex. (common) (collected by O. M. Ball); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull); Columbia, Caldwell Parish, La. (collected by E. W. Berry). Mount Selman formation, spillway of Elkhart Lake, 2 miles from Elkhart, Anderson County, Tex. (collected by O. C. Funderbunk). Lisbon formation, roadside north of Willow Branch about 4 miles southwest of Silas on road to Fail, Choctaw County, Ala. (collected by W. C. Mansfield).

Collection: U. S. National Museum.

Genus MESPILODAPHNE Nees.

Mesilodaphne columbiana Berry, n. sp.

Plate XV, Figures 3–5.

Leaves narrowly elongate-lancelote in outline, some of them somewhat inequilateral and slightly falcate. Length about 14 centimeters. Maximum width, in the middle part of the leaf, about 2 centimeters. Margins entire, irregularly and shallowly undulate. Leaf substance thin, subcoriaceous. Apex elongated, gradually narrowed, acuminate. Base elongated, gradually and narrowly cuneate, decurrent nearly to the base of the petiole. Petiole short and stout, tumid proximad, about 7.5 millimeters in length. Midrib stout proximad but becomes thin distad, prominent on the lower surface of the leaf. Secondaries thin, about ten distant, irregularly spaced, mostly alternate pairs; they diverge from the midrib at angles of about 45° and almost immediately curve sharply upward subparallel with the margins, at length camptodrome. Tertiaries obsolete.

This handsome species is widespread but not individually abundant, which may be due to the generally small collections from the sandy deposits of the Claiborne group. It survives into the Jackson of Arkansas. It greatly resembles *Mespilodaphne eolignitica* (Hollick) Berry [35] of the Wilcox group, which is a slightly larger, more coriaceous leaf that has somewhat less ascending secondaries, a stouter midrib, and a more distinct tertiary system but may represent the ancestral form of the Claiborne species. Among recent species *Mespilodaphne columbiana* is much like the existing *Mespilodaphne sassafras* Meissner, of the Brazilian Tropics.

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider); in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County Miss. (collected by E. N. Lowe and C. W. Cooke); roadside north of Willow Branch about 4 miles southwest of Silas on road to Fail, Choctaw County, Ala. (collected by W. C. Mansfield). Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry); 1½ miles northeast of Bienville in cut on railroad between Bienville and Hodge, La. (collected by Sidney Powers); 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull. Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry)

Collections: U. S. National Museum, Johns Hopkins University.

Mespilodaphne caudata Berry, n. sp.

Plate XV, Figures 6, 7.

Leaves of small size, elongate-lanceolate in general outline, the base narrowed and pointed and the tip extended, gradually narrowed, acuminate, and caudate. Length ranges from 6 to 8 centimeters. Maximum width, at or below

[35] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 307, pl. 80, figs. 2, 3, 1916.

the middle, about 1.1 centimeters. Margins entire. Texture coriaceous. Petiole missing, obviously stout and probably short. Midrib stout and prominent, curved. Secondaries stout but not prominent, about eight pairs; they diverge from the midrib at angles of about 45°, rather straight at first, eventually camptodrome. Tertiaries mostly obsolete.

This small coriaceous species had developed a conspicuous dripping point. It is clearly unlike previously described fossil forms, although it is not unlike a large number of existing species of *Mespilodaphne* of the American Tropics. It is smaller than any of the numerous Wilcox species of Lauraceae, although it has the form of *Oreodaphne pseudoguianensis* Berry.[36] It is not uncommon in the Yegua clays of eastern Texas and Louisiana and survives into the beds of lower Jackson age in the Lagrange formation of western Tennessee.

Occurrence: Mount Selman formation, spillway of Elkhart Lake, 2 miles from Elkhart, Anderson County, Tex. (collected by O. C. Funderbunk). Yegua formation, Columbia, Caldwell Parish, La. (collected by E. W. Berry); 1 mile below the head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker); Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus NECTANDRA Roland.

Nectandra gosportensis Berry, n. sp.

Plate XVI, Figures 1–3.

Leaves of medium size, lanceolate in general outline; the apex and base are about equally acuminate and the lateral margins full and equally rounded. Length about 10 centimeters. Maximum width, midway between the apex and the base, 2 to 2.8 centimeters. Margins entire. Texture coriaceous. Petiole short and very stout, curved and somewhat tumid proximad, about 1 centimeter in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, not prominent, more or less immersed, numerous; they diverge from the midrib at angles of about 50°, curving gradually upward, and are camptodrome in the marginal region. Tertiary areolation fine, typically lauraceous. Specimens collected near Bienville, La., have much fuller basal margins than normal.

This species is represented by abundant but fragmentary material from the Lisbon formation in Mississippi, the Gosport sand in Alabama, and the Yegua formation in Texas. A somewhat larger and more attenuated variety has been discovered in the upper Jackson of Texas. It is very distinct from other members of the Claiborne flora but resembles *Ficus newtonensis* Berry and *Nectandra lowii* Berry of the Wilcox flora and is undoubtedly descended from one or the other of these antecedent species. The genus *Nectandra* has about seventy existing species, which are confined to tropical and subtropical parts of America. I have described several species from the Wilcox group, and numerous comparable forms have been described from the Tertiary of the western United States and Europe and referred to the form genus *Laurus*

Occurrence: Lisbon formation, in a cut on the Alabama & Vicksburg Railway 3¼ miles east of Newton, Newton County, Miss. (collected by E. N. Lowe and C. W. Cooke). Gosport sand, at Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex.; Cedar Creek, 2 miles south of Lufkin, Angelina County, Tex. (collected by C. L. Baker); 1½ miles northeast of Bienville, in cut on railroad between Bienville and Hodge, La. (collected by Sidney Powers); near Stephens, Ouachita County, Ark. (collected by J. P. D. Hull.)

Collection: U. S. National Museum.

Nectandra arkansana Berry, n. sp.

Leaves of medium size, ovate-lanceolate in general outline, sides full and rounded, tip narrow, incurved, acuminate, and somewhat extended, base acuminate and decurrent. Length about 12 centimeters. Maximum width, midway between the apex and the base, about 3.5 centimeters. Margins entire, slightly undulate. Leaf substance not thick but of a firm consistency. Petiole very stout, at least 1.25 centimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries stout but become thin distad; about eight subopposite, irregularly spaced pairs. They diverge from the midrib at angles of about 45° and curve regularly upward in a

[36] Berry, E. W., op. cit., p. 305, pl. 81, figs. 3, 4, 1916.

subparallel manner; eventually they become parallel with the margins, along which they form a series of diminishing flat camptodrome arches. Tertiaries thin, percurrent, more or less transverse to the long axis of the leaf.

This well-marked species of *Nectandra* is very similar to *Nectandra lancifolia* (Lesquereux) Berry, of the Wilcox group, which has the same general character and elegant outline. *Nectandra arkansana* is slightly smaller and relatively somewhat narrower and has fewer secondaries, the basal ones diverging at a wider angle; it also has a longer petiole and a somewhat thinner texture. Among existing species it greatly resembles a number of American tropical forms and is especially close to *Nectandra antillana* Meissner, a common tree of the woods and river banks throughout the West Indies. Its points of dissimilarity are its somewhat smaller size, less coriaceous texture, and longer petiole. It survives the Claiborne and is not uncommon in the Jackson.

Occurrence: Gosport sand, Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry).

Collection: U. S. National Museum.

Nectandra antillanafolia Berry, n. sp.

This species is described under the Jackson flora (p. 187).

Occurrence: Yegua formation, Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus LAURINOXYLON Felix.

This genus was proposed by Felix[37] for lauraceous woods where the specimens were too imperfect or too little known to warrant generic determination. It has served a very useful purpose, and a large number of species have been described, ranging in age from the top of the Lower Cretaceous (Albian of Madagascar) to the Recent but chiefly Tertiary. Some of the features which serve to distinguish the secondary wood of the Lauraceae are the uniform size of the vessels, their simple or sparingly scalariform perforations, the one-seriate to three-seriate rays of varying height and differentiated marginal cells, the septate prosenchyma, and the abundance of gum.

[37] Felix, Johannes, K.-ungar. geol. Anstalt Jahrb., Band 7, p. 27, 1884.

Laurinoxylon bakeri Berry, n. sp.

Plates XVII, XVIII, XIX, XX.

Transverse section: Vessels single or in radial pairs or triplets; here and there a radial row consists of five vessels or there may be a tangential pair with a radial one on each side. Some of the pairs are eccentric or tangential. The vast majority are single or radially double, however. Well distributed; no zonal arrangement or diminution in size throughout the year. Oval in cross section, averaging 0.10 to 0.15 millimeter in diameter, thin walled.

Xylem parenchyma scattered through the prosenchyma, not arranged in definite bands or tracts, thin walled, oval in cross section, about 0.025 millimeter in diameter. Prosenchyma abundant, somewhat thicker walled. Diameter about 0.012 millimeter, walls about 0.004 millimeter in thickness.

Rays undulating, one to three cells wide, full of gum, about 0.2 millimeter apart but showing considerable variation in this respect.

Radial section: Vessels are full of tyloses and have considerable fungal mycelia. Their walls are covered with polygonal or hexagonal simple pits, which are better seen in the tangential sections. The rays differ greatly in height, from two cells to eighteen cells. These rays consist of one or more rows of marginal cells, square or rectangular in radial outline and from twice to three times the height and about half the length of the more central cells. Marginal cells, height 0.032 millimeter, length 0.024 millimeter. Central cells, height 0.016 millimeter, length 0.04 to 0.06 millimeter.

Prosenchyma irregularly septate with attenuately pointed ends, no markings observable. Parenchyma abundantly septate and shows numerous round simple pores. Rays partly filled with gum. A constant feature that is well shown in the drawing of this section is the single series of large vertical ray cells that serve to connect the rays in vertical series. This series may consist of but three or four cells or it may be as much as 10 cells high. These stringers of ray cells are less numerous and less constant a feature in this species than they are in a remarkable new species of *Laurinoxylon* from Hope, Ark. (No. 239). All the walls of the large marginal and inframarginal ray cells are perforated by numerous round simple pores. The sketch of a radial

ray section shows them in the radial, tangential, and upper and lower walls. They are sometimes seen in the central ray cells but usually can not be distinguished, possibly because these cells are generally filled with gum.

Tangential section: The photograph reproduced in Plate XVIII, Figure 2, brings out clearly the essential features of this section. The pores on the walls of the vessels come out beautifully, but the character of the end partitions can not be made out. The abundance of tyloses is a feature of this section, as is the pitting on the radial and tangential walls of the xylem parenchyma. The rays are closely crowded, generally in alternating series but somewhat irregular in height. They are one, two, or three cells in width and have one or more larger marginal cells on each end. Some of the rays consist of two fusiform parts of equal size that are connected by large uniserial cells. Short uniserial rays are occasionally seen. These variations as well as the character of the marginal cells are shown in the illustrations. All are almost invariably wholly or partly filled with gum.

This species is rather well preserved and clearly distinct from previously described forms. It resembles somewhat the antecedent Wilcox species *Laurinoxylon wilcoxianum*. Without more comparative material of recent species it is impossible to discuss this phase of the subject. This new species represents, however, either *Cinnamomum*, *Persea*, *Oreodaphne*, or *Nectandra*.

It is named for Charles Laurence Baker, formerly of the University of Texas, in recognition of his valuable assistance in furnishing collections from inaccessible localities in the east Texas Tertiary.

Occurrence: Yegua formation, in a cut on the International & Great Northern Railway at milepost 44 (No. 217); Westmoreland Bluff, Trinity River (No. 230); head of Cedar Creek, one-half mile south of Antioch, Houston County, Tex. (No. 251).

Collection: U. S. National Museum.

Laurinoxylon branneri Knowlton.

Plate XXI.

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, sec. 4, p. 98, figs. 6–8, 1908.

Knowlton describes the wood of this species 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 one to three or rarely four. 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 six to thirty or more cells. They are very numerous.
>
> * * *
>
> The large vessels are provided with net-form thickenings 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 or 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.

This species was based upon silicified specimens from two different horizons in Arkansas and was probably represented by poorly preserved lignified material from which sections were cut. The exact age of these horizons can only be approximately determined. The locality in Poinsett County is either near the top of the Wilcox or the base of the Yegua, whereas that in St. Francis County is at the top of the Yegua or the base of the Jackson, probably the latter. 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 [38] from the Tertiary of Prussia.

In east-central Texas *Laurinoxylon branneri* has been described by Penhallow from the Yegua formation.

Occurrence: Yegua formation, Somerville, Burleson County, Tex.

Laurinoxylon lesquereuxiana Knowlton.

Laurinoxylon lesquereuxiana Knowlton, Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 258, pl. 10, figs. 3, 4; pl. 11, figs. 3, 4, 1891.

Knowlton's description follows:

The annual ring is very indistinct yet clearly observable. It consists of a layer of two or three more compressed cells in which the lumen is almost entirely closed. The wood cells are much larger than in *L. branneri* and much thicker walled, and they are less clearly arranged in radial rows. They are more nearly square or by mutual pressure six-sided. The medullary rays are very numerous, three or four cells broad, and run with but slight undulations amongst the wood cells. The vessels are also large and usually in twos, although it is not rare to find them single or in threes. In exceptional cases there may be four in one row and three smaller ones in another contiguous row, when the entire space between two medullary rays is filled by them. It is somewhat difficult to determine but apparently the rays have consisted of rather short cells.

Again on account of the poor state of preservation of the specimen it is impossible to determine with confidence the shape of the wood cells as seen in this section. That some of them have had the ends square is certain, and also some of them have been sharp jointed, but the relative proportion or distribution of the various modifications can not be satisfactorily made out. The vessels have been numerous and large, but if there have been markings on the walls it is impossible to make them out. The vessels were filled with amorphous quartz before solidification and now appear filled with rounded drops of greater or less size. The medullary rays as observed in this section are large, moderately short celled, and filled with a black substance. Above and below many of the medullary rays is a single or rarely double layer of large rectangular cells, likewise filled with an intensely black substance.

The medullary rays are numerous, of three or not rarely four series of superimposed cells, which are large and very thick walled. The rays are from twenty to thirty or more cells high, and very regular.

This species is, on the whole, very distinct, although it shows points of resemblance with described forms. Thus *L. diluviale* Unger sp.[39] has the peculiar large rectangular cells on each side of the medullary rays but differs in most of the other characters. *Laurus triseriata* Caspary,[40] recently described from Prussia, resembles it yet differs in important points.

This species is based on silicified material of either upper Claiborne or lower Jackson age, and of these alternative horizons the former is more probable.

Occurrence: Yegua formation, bed of Rice Branch, near Wittsburg, Cross County, Ark. (collected by R. E. Call).

Collection: U. S. National Museum.

Order MYRTALES.

Family COMBRETACEAE.

Genus COMBRETUM Linné.

Combretum petraflumenses Berry, n. sp.

Plate XLV, Figures 1–4; Plate LVIII, Figures 2–4; Plate LIX, Figures 1–5.

Leaves of variable size, elliptical in general outline, though having a cuneate vase and an apiculate tip. Margins entire, in many specimens somewhat irregular in contour. Texture coriaceous. Length ranging from 7 to 13 centimeters. Maximum width, in the median part of the leaf, ranging from 3 to 7 centimeters. No definite petiole is preserved, but several specimens show a decurrence at the base, indicating a very short and stout petiole. The midrib is stout and generally somewhat curved, prominent on the under surface of the leaf. The secondaries are stout but in most specimens not prominent; they number six or seven subopposite to alternate pairs, which are subequally spaced; their angle of divergence differs somewhat according to the relative width of the leaves, though in general it is about 60°; they curve regularly upward in a subparallel course and are camptodrome. The tertiaries are obsolete, but whether because of the coarseness of the matrix or because of immersion in the substance of the leaf can not be certainly determined. The name proposed is given in allusion to the locality.

This species is very abundant in the outcrop of the Yegua on Rock Creek, where it is represented by leaves of all sizes and a considerable variety of form. It represents the first record of the genus in beds later than the Wilcox, but it is quite distinct from the three

[38] Caspary, R., Einige fossile Holzer Preussens: Geol. Specialkarte Preuss. Abh., Band 9, Heft 2, pp. 54–60, pl. 10, figs. 10–17; pl. 11, figs. 1–5, 1889.

[39] Felix, Johannes, Untersuchungen über fossile Hölzer: Deutsche geol. Gesell. Zeitschr., Band 35, p. 59, pl. 2, figs. 2, 3; pl. 3, fig. 1, 1883.

[40] Caspary, R., op. cit., pp. 60–67; pl. 11, figs. 6–12; pl. 12, figs. 1–5.

known species from that horizon, although it shows considerable resemblance to all three in one or another of its characteristic features. The genus has been recognized in the Miocene of Chile and in the Miocene and Pliocene of Europe. There are about 130 existing species in all the Tropics, except Australia and Polynesia, and about one-third of these are endemic in South America. The genus appears to have been of American origin during basal Eocene time.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus TERMINALIA Linné.

Terminalia claibornensis Berry, n. sp.

Plate XXII, Figure 1.

Leaves of medium size for this genus, oblong-ovate in general outline, the apex abruptly pointed and the base gradually narrowed and cuneate. Length about 15 centimeters. Maximum width, above the middle, about 5 centimeters. Margins entire, regularly curved. Texture coriaceous but leaf substance relatively thin. Petiole short and stout. Midrib very stout, about ten to twelve subopposite to alternate pairs, which diverge from the midrib at angles that range from 35° in the relatively narrower leaves to 70° in the broader leaves, the average angle measuring about 40°. The secondaries are relatively straight and ascending, curve gradually upward in the marginal region, and eventually become camptodrome. Tertiaries thin, the prominent nervilles being mostly percurrent, the areolation being open and prevailingly quadrangular.

The genus *Terminalia* is an important member of the pre-Miocene floras of southeastern North America. There is one species in the Midway (?) of Texas which becomes commoner and more widespread in the Wilcox. A second Wilcox species, not greatly different from the present form, has been described, and a third is based on fruit. A larger and broader form is found in the lower Jackson. The present species is very similar to the common *Terminalia radobojensis* Unger,[41] of the European Oligocene and Miocene. More than one hundred existing species are almost equally divided between the tropical and subtropical regions of Asia, Africa, Australia, and America.

Occurrence: Gosport sand, at Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

[41] Unger, Franz, Chloris protogaea, p. 142, pl. 48, fig. 2, 1847.

Genus CONOCARPUS Linné.

Conocarpus eocenicus Berry.

Conocarpus eocenica Berry, U. S. Geol. Survey Prof. Paper 84, p. 147, pl. 28, figs. 4–7, 1914.

Leaves of medium and small size, lanceolate and generally inequilateral in outline, the apex and base obtusely pointed, margins entire. Length 6 to 10 centimeters; greatest width, which is about midway between the apex and the base, 1.5 to 2.6 centimeters. Midrib stout. Secondaries remote, about six pairs, opposite or subopposite; they branch from the midrib at angles of about 50°, extend outward, and then sweep upward in a broadly rounded curve, parallel with the margin and approximately parallel with their fellows, ultimately camptodrome. Tertiaries fine, forming a polygonal areolation.

This species was based on considerable material from beds of lower Jackson age in Georgia, where it appears to be more common than it is in the Mississippi embayment region. It is obviously related to *Conocarpus*, both in outline and in venation, and probably had a similar habitat.

Conocarpus is a monotypic genus in the existing flora, and the single species, *Conocarpus erectus* Linné, is widespread along low muddy or sandy tropical shores in Central America and South America and on the west coast of Africa (Guinea and Senegambia). It is found in the Galapagos Islands and extends northward from the West Indies to the Florida Keys and to Bermuda, where it is found on the sand dunes. Its distribution has been effected through the agency of ocean currents. The fossil form appears to be closest to the modern variety *arboreus* Grisebach, of Central America. The modern species is not only a typical member of the mangrove association of Africa and America but much

more widespread than the mangroves, for it is equally a plant of strand and dunes. The texture and anatomy of its leaves differ somewhat according to their degree of exposure to the rays of the sun.

This species may be compared with certain European Tertiary forms that are referred to the allied genus *Eugenia*, of which several have been described, more especially from the Oligocene. Both *Eugenia aizoon* Unger and *Eugenia haeringiana* Unger are somewhat similar. A species of *Conocarpites* is recorded from the Tuscaloosa formation of western Alabama, and a typical and possibly ancestral species of *Conocarpus* is present in the flora of the beds of Wilcox age in the Lagrange formation of western Tennessee.

Occurrence: Gosport sand, at Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry). Yegua formation, on Cedar Creek, 2 miles south of Lufkin, Angelina County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Genus LAGUNCULARIA Gaertner.

Laguncularia claiborniana Berry, n. sp.

Plate XXII, Figure 2.

Leaves of small size, elliptical in general outline, the apex and base broadly rounded. Length about 5 centimeters. Maximum width, in the middle of the leaf, about 2.5 centimeters. Margins entire, regularly rounded. Texture extremely coriaceous. Petiole very stout, length unknown. Midrib extremely stout, somewhat curved, very prominent on the lower surface of the leaf. Secondaries stout but immersed in the thick leaf substance; about six pairs diverge from the midrib at angles of 45° to 60°, curve regularly upward, and are camptodrome but largely effaced by immersion toward the margins. Tertiaries irregularly percurrent. Areolation extremely minute, almost isodiametric, giving the surface a minutely rugose appearance.

This well-marked species is unfortunately represented by much broken material. It is, however, clearly referable to the genus *Laguncularia* and is almost identical in all its characters with *Laguncularia racemosa* Gaertner. The genus is monotypic in the existing flora, and the single species is common along muddy tidal shores of estuaries and lagoons from the Florida Keys to northern South America and along the equatorial part of the west African coast. I have described, as *Laguncularia praracemosa*,[42] both leaves and fruit of an ancestral species from the Wilcox group. The present species may be a descendant of this Wilcox species, and it is even more like the modern form than the Wilcox species.

Occurrence: Gosport sand, at Claiborne Landing, Monroe County, Ala. (collected by E. W. Berry).

Collection: U. S. National Museum.

Family MYRTACEAE.

Genus MYRCIA De Candolle.

Myrcia trowbridgi Berry, n. sp.

Plate XLVIII, Figures 3–5.

Leaves of different sizes, lanceolate-falcate in outline. Apex and base equally acute, but as the leaf is widest below the middle the upper part is consequently more tapering than the lower. Length ranges from 4 to 14 centimeters. Maximum width ranges from 8 to 30 millimeters. Margins entire. Texture coriaceous. In no specimens is a petiole preserved; if present it must have been short and stout, as indicated by the way the midrib swells proximad. Midrib stout, prominent, and curved. The secondaries are largely immersed in the leaf substance and are numerous, closely spaced, and subparallel. They diverge from the midrib at angles of about 45° to 55°, are rather straight in their courses after diverging outward from the midrib, and their distal ends are connected by an acrodrome marginal vein. The tertiaries are obsolete by immersion.

These leaves, which are very abundant and which comprise the vast majority of the specimens collected at the locality cited, resemble the leaves of a number of unrelated genera, as might be expected from their lanceolate form and coriaceous texture. They are, however, entirely distinct from previously known forms and clearly related to numerous species of *Myrcia*, both fossil and existing. The genus, which includes several hundred existing species that are confined to the Western Hemisphere, is found in both the Wilcox and Jackson but has not heretofore been found in the Claiborne, although its presence was suspected. Six

[42] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 320, pl. 95, figs. 4–8, 1916.

species of *Myrcia* are known from the Wilcox. Among these *Myrcia vera* Berry[43] is very similar in form to *Myrcia trowbridgi*, but it has fewer secondaries and its average size is smaller. Among numerous existing forms, such a leaf as that of *Myrcia rostrata* from South America, previously figured,[44] may be compared with the present fossil.

Occurrence: Mount Selman formation, 1¼ miles north of Palafox, Webb County, Tex. (collected by A. C. Trowbridge, L. W. Stephenson and E. W. Berry).

Collection: U. S. National Museum.

Order UMBELLALES.

Family ARALIACEAE.

Genus OREOPANAX Decaisne and Planchon.

Oreopanax mississipiensis Berry, n. sp.

Plate XXII, Figures 3, 4.

Leaves digitately compound. Leaflets of medium size, slightly inequilateral, ovate-lanceolate in general outline. Apex acute. Base narrowly decurrent to or nearly to the base of the petiole. Length about 10 centimeters. Maximum width, in the middle part of the leaf, about 3.5 centimeters. Margins entire below for about one-fourth of their length; above this entire portion they are characteristically and prominently toothed. The usual form is a regular alternation of a short, serrate, outwardly directed tooth and a large, narrow, aquiline-serrate tooth; in some places two small teeth intervene between successive large teeth; the sinuses are all narrowly rounded. Petiole very stout, margined by the narrow wings of the decurrent leaf base, at least 2.5 centimeters in length. Midrib stout, prominent on the lower surface of the leaf. Secondaries thin, very numerous, and subparallel. They diverge from the midrib at angles that range from 45° in the tips of the leaflet to about 70° in the base, at rather uniform intervals of about 2 to 3 millimeters. They curve upward, become subparallel to the margins and camptodrome, and send short tertiary branches into the larger teeth. Tertiary venation consists of intermediate veins, as a rule one to each interval between adjacent secondaries, and thin close-set percurrent nervilles. Texture subcoriaceous.

This very characteristic form is a strikingly distinct element in the Claiborne and Jackson floras. Two species of *Oreopanax* are found in the antecedent Wilcox flora, but neither is close to the present species, which resembles somewhat remotely *Panax latifolium*, which was described by Friedrich[45] from the Oligocene of Saxony, and the existing *Panax gaudichaudi* De Candolle, of the Hawaiian Islands. It may also be compared with the leaflets of certain tropical American species of *Symplocos*.

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: Johns Hopkins University.

Family CORNACEAE.

Genus NYSSA Linné.

Nyssa texana Berry, n. sp.

Plate XXII, Figure 5.

Stones very large, elliptical in outline, some of them pointed at the distal end, and a few of them at both ends, circular in transverse outline. Length ranges from 2.5 to 3.6 centimeters. Diameter, 1 centimeter to 1.5 centimeters. Longitudinally ribbed with 8 to 10 prominent broad, rounded ridges that are separated by furrows of about the same form and dimensions as the ridges, as a rule more prominent toward the distal end of the stone. Substance thick and ligneous. This is the largest *Nyssa* stone known to the writer. It resembles somewhat *Nyssa lescurii* (Hitchcock),[46] from the lignite of Brandon, Vt., but is larger. It is also similar to the stone from beds of Wilcox age in Tennessee that has been described as *Nyssa eolignitica* Berry,[47] but is larger and more prominently ribbed. It is abundant in the Yegua clays of Angelina County southwest of Lufkin, Tex., and in the Fayette sandstone of Trinity County, Tex. It is evidently represented by the material mentioned by Buckley[48] in 1874 as follows:

In none of the Tertiary coals of the State have we seen vegetable remains in good preservation in the

[43] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 314, pl. 90, fig. 3, 1916.

[44] Idem, pl. 90, fig. 4.

[45] Friedrich, Paul, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen: Geol. Specialkarte Preuss. Abh., Band 4, p. 188, pl. 24, figs. 7, 8, 1883.

[46] Hitchcock, C. H., A new species of *Carpolithes:* Portland Soc. Nat. Hist. Proc., vol. 1, pt. 1, p. 95, pl. 1, fig. 5, 1862.

[47] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 332, pl. 99, fig. 8, 1916.

[48] Buckley, S. B., Report of reconnaissance in part of eastern Texas: Texas Geol. and Agr. Survey First Ann. Rept., p. 25, Houston, 1874.

shales in contact with the coal, excepting in Fayette County, where are oblong ribbed fruits about an inch in length.

These stones are of special interest, for in the dense carbonaceous brown clays of the Yegua they lie horizontal and are thoroughly lignified, whereas in the Fayette sandstone they are represented exclusively by casts without a trace of carbonaceous material and are oriented at all angles, as if they had been preserved in wind-blown deposits.

I have referred these fossils to *Nyssa* only after some hesitation and after comparing them with the fruits of *Anona*, *Terminalia*, *Chrysobalanus*, and other genera with which comparisons seemed promising. They have, however, exactly the characters of large *Nyssa* stones and do not greatly exceed in size some of the numerous remains of this genus that are preserved in the lignites of Brandon, Vt. The specimens preserved in the clays are conclusive in indicating that the remains are stones and not ligneous ribbed capsules, as the specimens from the sandstones might be interpreted. The most similar foreign fruits are those described in 1833 from the Sannoisian of Saxony, which are named by Zenker [49] *Baccites cacaoides*. These fossils have since been found at a number of localities in the European Oligocene and lower Miocene and have been generally referred to the genus *Anona*.[50] They are somewhat smaller, more globular, and less strongly ribbed, as well as somewhat younger than the Texas species.

The genus *Nyssa* is represented in fossil floras from the late Upper Cretaceous onward, for the water-side habitat of many of the species and the resistant nature of the fruit stones are 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: Yegua formation, beneath lignite in bed of Cedar Creek about 2 miles south of the Texas Southeastern Railroad bridge and about 2 miles southwest of Lufkin, Angelina County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

[49] Zenker, J. C., Beiträge zur Naturgeschichte der Urwelt, p. 10, pl. 1, figs. 4–16, 1833.

[50] Friedrich, Paul, Beiträge zur Kenntniss der Tertiärflora der Provinz Sachsen: Geol. Specialkarte Preuss. Abh., Band 4, p. 218, pl. 6, fig. 16, 1884.

Nyssa wilcoxiana Berry

Nyssa wilcoxiana Berry, U. S. Geol. Survey Prof Paper 91, p. 331, pl. 99, figs. 5–7, 1916.

Stones medium-sized to large, terete or more or less compressed, ovate in general outline, widest in the middle, rounded at the base, acuminate distad. Texture ligneous. Surface ornamented with close-set, narrow, longitudinal ridges. Length from 1.6 to 2.25 centimeters and width from 4.5 to 10.5 millimeters.

This species is not uncommon toward the top of the beds of middle Wilcox age in the Lagrange formation of Tennessee and is also found in the upper Wilcox of Louisiana. A single well-preserved specimen has been found in the lower Yegua of Texas. The Texas specimen is 2 centimeters in length by 9 millimeters in maximum diameter and has 14 or 15 well-marked ribs. It differs from *Nyssa texana* Berry in its smaller size, more pointed apex, and more numerous ribs.

Occurrence: Yegua formation, about 7 miles southwest of Smithville, Bastrop County, Tex. (collected by Frank Rundus).

Collection: U. S. National Museum.

Superorder GAMOPETALAE.

Order EBENALES.

Family SAPOTACEAE.

Genus MIMUSOPS Linné.

Mimusops claibornensis Berry, n. sp.

Plate XXII, figure 6.

Leaves ovate-elliptical in outline, the apex broadly rounded, retuse, or emarginate and the base somewhat narrowed and cuneate. Length about 7.5 centimeters. Maximum width, in the middle part of the leaf, about 3.5 centimeters. Margins entire, irregularly and slightly undulate. Texture very coriaceous. Petiole missing, obviously stout. Midrib very stout and prominent all the way to the apical sinus, more or less curved. Secondaries very stout and prominent, about ten opposite to alternate pairs; they diverge from the midrib at angles that range from 45° to 70°, curve gradually upward until they are close to the margin, where they curve abruptly upward parallel with and close to the margins, and each joins the adjacent superior secondary in a camptodrome manner. Tertiaries mostly obsolete, percurrent.

These characteristic leaves as a rule are somewhat inequilateral and are readily recog-

nized by their stout prominent secondaries of scarcely diminished caliber almost to their distal terminations. They greatly resemble those of several existing species of *Mimusops* and *Sideroxylon*. They are also much like those of the American tropical monotypic genus *Bucida* Linné.

The present species is very close to and undoubtedly a descendant of the Wilcox species *Mimusops eolignitica* Berry,[51] from which it differs in its relatively shorter length, more robust form, and stouter secondaries.

Occurrence: Yegua formation, at Cherry Valley, Cross County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus EOACHRAS Berry.

Eoachras eocenica Berry.

Plate XXII, Figures 7–9.

Eoachras eocenica Berry, Am. Jour. Sci., 4th ser., vol. 39, pp. 208–213, pl. 1, figs. 1–3, 1915.

Seed of large size, compressed laterally, obliquely elliptical in outline when viewed from the side, proximal end more broadly rounded than the distal end. Length about 3.6 centimeters. Maximum height from dorsal to ventral margin about 2.2 centimeters. Maximum thickness about 1.5 centimeters. The seed has been subjected to pressure after burial by sediments, and this has destroyed the symmetry between the lateral surfaces. Dorsal margin broadly rounded, sigmoid in outline, and a restricted but pronounced sinus toward the distal end. Ventral margin thickened, considerably deformed, curved in outline; the umbilical sinus open, extending the whole length of the seed.

This seed differs from those of *Achras zapote* in its slightly larger size and in its more open umbilicus, which also extends the whole length of the seed. As I have interpreted the orientation of the fossil its smaller end is distal and not proximal as in *Achras*, but this is a negligible feature. The seeds of *Calocarpum* as a rule are much larger, fusiform, and not compressed; the umbilicus occupies the whole inner face. The seeds of *Lucuma* are also very similar to the fossil. A fact of interest is the presence in the upper Eocene of Texas (Fayette sandstone, of Jackson age) of leaves that agree almost exactly with those of the existing *Calocarpus viride* Pittier.

It is not possible to suggest the character of the foliage in *Eoachras*. *Achras* has a dense cover of smooth, thin-veined coriaceous evergreen leaves. *Calocarpum*, on the other hand, has very large ovate-lanceolate coarse deciduous leaves. Remains of leaves are associated with the seed of *Eoachras*, but none of these remains can be definitely correlated with the seed, and none are comparable with those of *Achras*. There are fragments of large leaves, which are tentatively referred to the genus *Terminalia*, that might possibly represent *Calocarpum*-like leaves.

The fossil seed, though it has the general characters of the seeds of the large-fruited genera *Achras*, *Vitellaria*, *Lucuma*, and *Calocarpum* of the Sapotaceae, is not exactly like any of them. In size and form it is perhaps most like the seeds of *Achras*, but in the *Achras* the umbilical area is narrow and shortened, whereas in the fossil this area attains the full length of the seed and is as wide as it is in the genus *Calocarpum*. The real difficulty lies not so much in any uncertainty with regard to its relationship to still existing forms, but in the purely taxonomic tangle that involves these forms and the lack of knowledge regarding the relationship of these among themselves and their true generic limits.

For example, *Achras* in the existing flora is a genus that was artificially distributed in prehistoric times and is now cultivated in all tropical countries. Pittier has recently described two new species of it, but the single species previously known has served as the type of at least two genera—*Achras* Linné (1753) and *Sapota* Miller (1759). Miller's genus *Sapota* gives its name to the family Sapotaceae. Moreover, *Achras* differs in the extent of its umbilical area from the fossil. The genus *Achras* obviously has had a geologic history, though it is as yet unknown, and it is quite possible that the umbilical character of the seeds may have differed in the unknown fossil ancestors of the existing form. At the same time it does not seem proper to amplify what is one of the diagnostic characters of the recent genus to include hypothetic fossil species.

[51] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 339, pl. 99, fig. 3, 1916.

The fossil agrees with the seeds of *Calocarpum* in the character of the umbilicus but is smaller in size and more compressed. There are only two known species of *Calocarpum;* one was described as recently as 1914, and the other, which has been known since 1762, has been placed successively in the genera *Sideroxylum* (by Jacquin in 1762), *Achras* (by Linné in 1782), *Lucuma* (by Gaertner in 1805), *Vitellaria* (by Radlkofer in 1882), *Calospermum* (by Pierre in 1890), *Achradelpha* (by Cook in 1913), and still more recently, in 1914, Pittier has taken up the generic name *Calocarpum,* which was first proposed by Pierre in 1904. It will be seen that the paleobotanist can readily use a generic name for the present fossil seed that will bring up in the mind of each botanist, according to his taxonomic taste, either a different concept of the plant that bore it or else no concept whatever. Moreover it is the acme of improbability to suppose that the existing genera *Achras, Calocarpum, Lucuma, Vitellaria, Sideroxylum,* and *Chrysophyllum* were all fully differentiated as early as the middle Eocene and that they have maintained their existing limits since that time.

The modern *Calocarpum* is an upland form, whereas *Achras* is not. *Eoachras* was probably a coastal form, and it may be considered to represent the ancestral line that probably gave rise to more than one of the existing large-fruited forms. These forms are well described in a recent paper by Pittier.[52]

Occurrence: Lisbon formation, near Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Family EBENACEAE.

Genus DIOSPYROS Linné.

Diospyros brachysepala Alexander Braun.[53]

Diospyros brachysepala Alexander Braun, Neues Jahrb., 1845, p. 170.

Heer, Flora tertiaria Helvetiae, vol. 3, pp. 11, 191, pl. 102, figs. 1–14, 1859; Flora fossilis arctica, vol. 1, p. 117, pl. 15, figs. 10–12, 1868; idem, vol. 7, p. 109, pl. 79, figs. 1–8, pl. 92, fig. 10; pl. 94, fig. 6, 1883.

Lesquereux, The Tertiary flora, p. 232, pl. 40, figs. 7–10; pl. 63, fig. 6, 1878; The Cretaceous and Tertiary floras, p. 174; pl. 34, figs. 1, 2, 1883; U. S. Nat. Mus. Proc., vol. 10, p. 41, 1887.

Ward, Synopsis of the flora of the Laramie group, p. 556, pl. 60, figs. 4, 5, 1886; Types of the Laramie flora, p. 104, pl. 49, figs. 1, 2, 1887.

Andromeda dubia Lesquereux, Am. Jour. Sci., 2d ser. vol. 27, p. 364, 1859; in Safford, 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, Kentucky Geol. Survey, 1888.

This polymorphous species has been recorded from a very large number of localities and horizons and probably represents several similar species, although no criteria other than stratigraphic are available for their separation, and the stratigraphic method is not dependable. The type material came from both the earliest and latest plant beds of the Swiss Miocene (Aquitanian to Tortonian), and other European records include all horizons of the Tertiary. The species is also abundant in the Arctic Tertiary. In America it has been recorded from horizons as old as the later Upper Cretaceous and from different Tertiary outcrops. Remains that present no differential characters occur in the Wilcox deposits of the Mississippi embayment region, and similar remains are sparingly represented in the upper Claiborne of Mississippi and the Jackson of Texas. The occurrences in Texas are based upon rather small leaves that agree closely with the smaller figures of the Swiss types.

Occurrence: Yegua formation, 1 mile below the mouth of Rabb Creek, Colorado River, Fayette County, Tex. (collected by Alexander Deussen). Lisbon formation, at Lexington, Holmes County, Miss. (collected by A. F. Crider).

Collection: U. S. National Museum.

Order GENTIANALES.

Family APOCYNACEAE.

Genus APOCYNOPHYLLUM Unger.

Apocynophyllum texensis Berry, n. sp.

Plate XXII, Figures 12, 13.

Leaves of medium to large size, narrowly lanceolate and elongate in form, the tip gradually narrowed and acuminate and the base similar but somewhat less extended. Length

[52] Pittier, Henry, New or noteworthy plants from Colombia and Central America: Contr. U. S. Nat. Herbarium, vol. 18, pt. 2, pp. 76–86, 1914.

[53] A fairly complete list of citations of this species is given in U. S. Geol. Survey Prof. Paper 91, p. 333, 1916.

ranges from 12 to 14 centimeters. Maximum width, at or slightly below the middle, 1.4 to 3.0 centimeters. Margins entire, as a rule slightly undulate and the two halves of the lamina not entirely equilateral. Texture coriaceous. Petiole not preserved but apparently short and stout. Midrib narrow but relatively very prominent on the lower surface of the leaf, curved in some specimens. Secondaries thin, numerous, abruptly camptodrome, prominent on the lower surface of the leaf; they diverge from the midrib at somewhat irregular intervals at angles that average about 65° or 70°. Tertiaries immersed in the substance of the leaf.

This species appears to be new. Fragments that were collected several years ago from the Lisbon formation of Mississippi have remained unidentified until better material was discovered recently in the Jackson of the Texas area. The species is clearly distinct from the numerous and prevailingly larger species of *Apocynophyllum* of the Wilcox group. It may be compared with several recent forms of Apocynaceae of the American Tropics, and it is also somewhat suggestive of the narrower forms of *Ficus* and of some of the Lauraceae. The venation, however, is more nearly that of numerous recent and fossil forms of Apocynaceae. It is very close to if not identical with some of the leaves from the Green River beds of Wyoming which Lesquereux referred to the European Miocene species *Salix angusta* Alexander Braun.[54] It is not uncommon in beds of Jackson age in the Texas area.

Occurrence: Lisbon formation, Lexington, Holmes County, Miss. (collected by A. F. Crider). Yegua formation, 1 mile below head of Cedar Creek, Nevils Prairie, Houston County, Tex. (collected by C. L. Baker). Mount Selman formation, a small leaf that appears to be this species from Palestine, Anderson County, Tex. (collected by O. C. Funderbunk).

Collection: U. S. National Museum.

Apocynophyllum grevilleafolium Berry, n. sp.

Plate XXIII, Figures 4 and 5.

Leaves linear-lanceolate in outline, gradually narrowed to the similarly acuminate apex and base. Length about 10 centimeters. Maximum width, in the middle part of the leaf, about 9 millimeters or less. Margins entire, distinctly revolute in the specimens preserved in the Mount Selman clay. Texture coriaceous. Petiole much abbreviated, stout and enlarged, 5 to 6 millimeters in length. Midrib very stout and prominent on the lower surface of the leaf, channeled on the upper surface. Secondaries thin, numerous, subparallel, camptodrome, diverging from the midrib at angles that average about 45°, largely immersed in the substance of the leaf. Tertiaries obsolete by immersion.

Narrowly linear leaves like those of this species have little distinctive individuality and are liable to be confused with several genera. In some respects they resemble some of the narrower forms that have been referred to *Sapindus*. For example, they are somewhat similar to the leaflets of *Sapindus georgianus* Berry, of the upper Claiborne and Jackson, but lack the falcate form of that species and are both actually and relatively more elongated. They also resemble rather closely the leaflets of the Wilcox species *Sapindus linearifolius* Berry but differ decidely in venation.

In some respects the present form suggests the family Proteaceae, especially the genera *Grevillea*, *Conospermum*, and *Protea*, but this resemblance is not conclusive, and as authentic representatives of this family are absent from the Claiborne and are limited to a single species of *Banksia* in the Jackson and a species of *Embothrites* in the Catahoula no reliance can be placed on this resemblance. Several genera in the Santalaceae and Anacardiaceae have linear-lanceolate leaves of this aspect, as do several fossil and existing species of Apocynaceae.

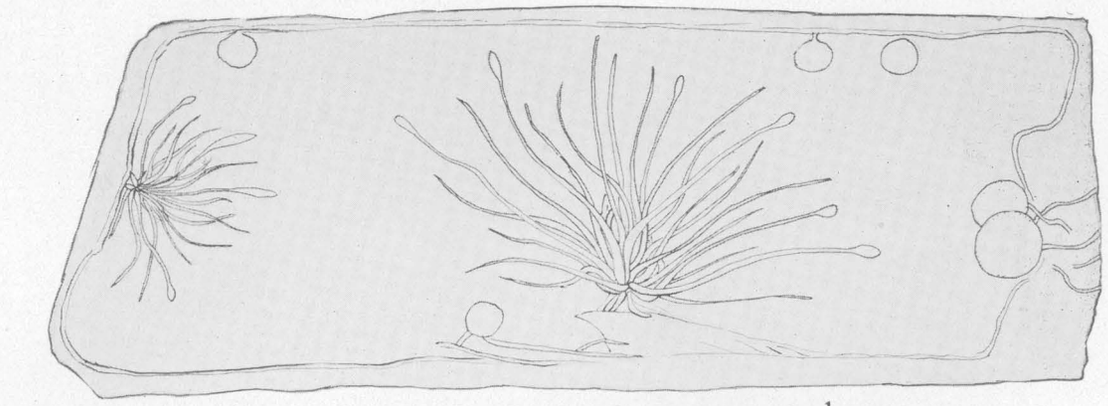
The species has a considerable range. It is common in the small collection from the clays of the Mount Selman formation at Palestine and is also present in the Fayette sandstone of Louisiana and Texas near the top of the Eocene.

Occurrence: Mount Selman formation, 1 mile south of Palestine, Anderson County, Tex. (collected by O. C. Funderbunk); 1¼ miles north of Palafox, Webb County, Tex. (collected by A. C. Trowbridge, L. W. Stephenson, and E. W. Berry).

Collection: U. S. National Museum.

[54] Lesquereux, Leo, The Tertiary flora, pl. 22, figs. 4, 5, 1878.

PLATES II-XXIII.



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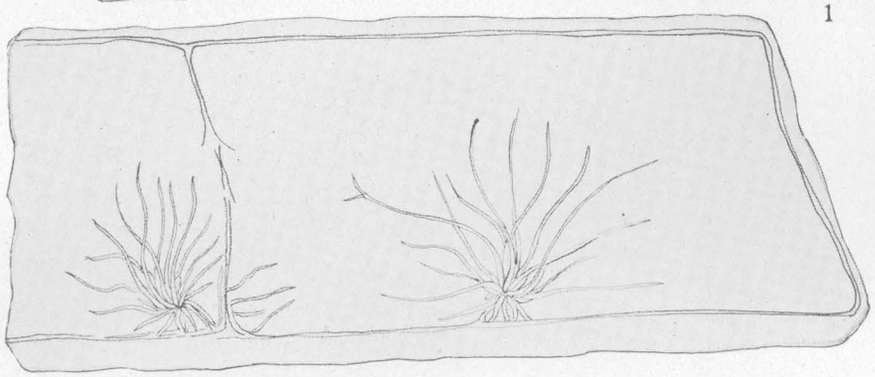

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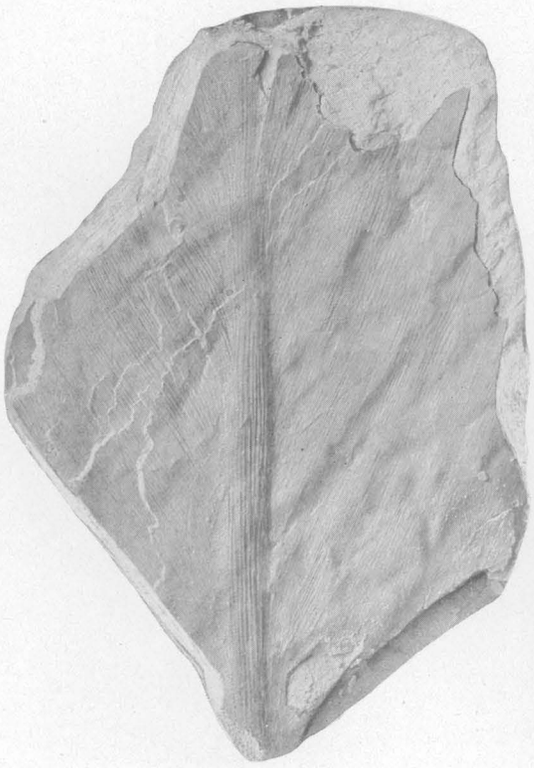

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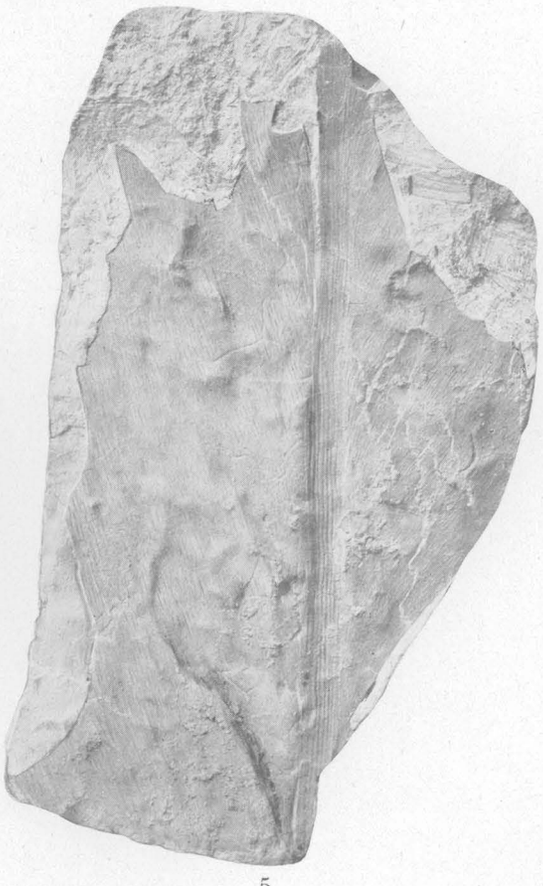

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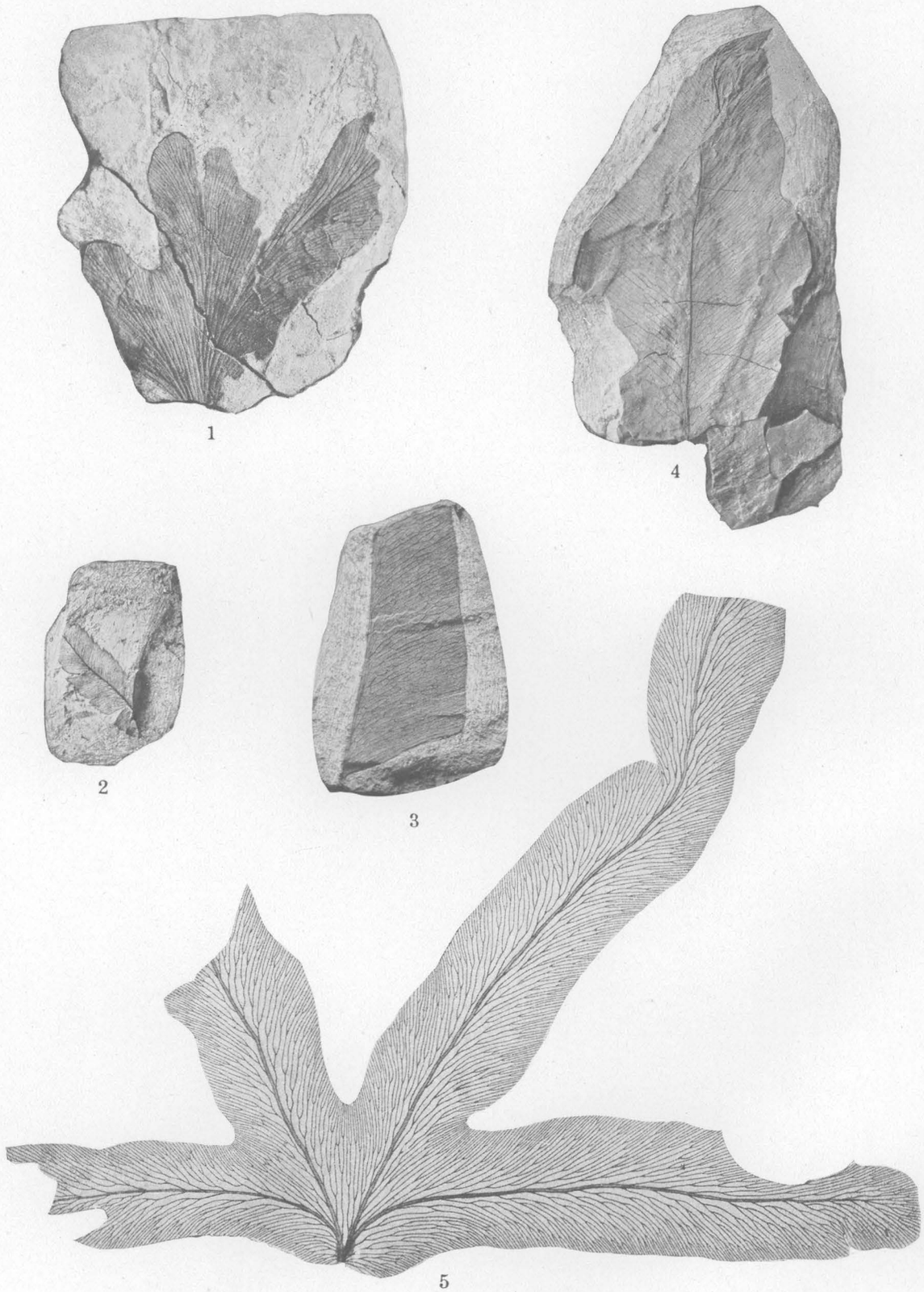
FOSSIL PLANTS FROM CLAIBORNE GROUP.

1, 2. Mycelia and conidia of *Cladosporites fasciculatus* Berry in vessels of *Laurinoxylon bakeri*, Westmoreland Bluff, Houston County, Tex., × 400; p. 39.

3. *Athrotaxis* sp., Cherry Valley, Cross County, Ark.; p. 46.

4, 5. *Canna flaccidafolia* Berry, n. sp., Columbia, La.; p. 50.

All from Yegua formation.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Lygodium kaulfussi* Heer, Gosport sand, Claiborne Landing, Monroe County, Ala.; p. 39.
2. *Pteris inquirenda* Berry, n. sp., Lisbon formation, near Newton, Miss.; p. 46.
3, 4. *Acrostichum hesperium* Newberry, Yegua formation, Columbia, La.; p. 43.
5. *Lygodium kaulfussi* Heer, Eocene rocks, Barrel Springs, Wyo. Introduced for comparison.

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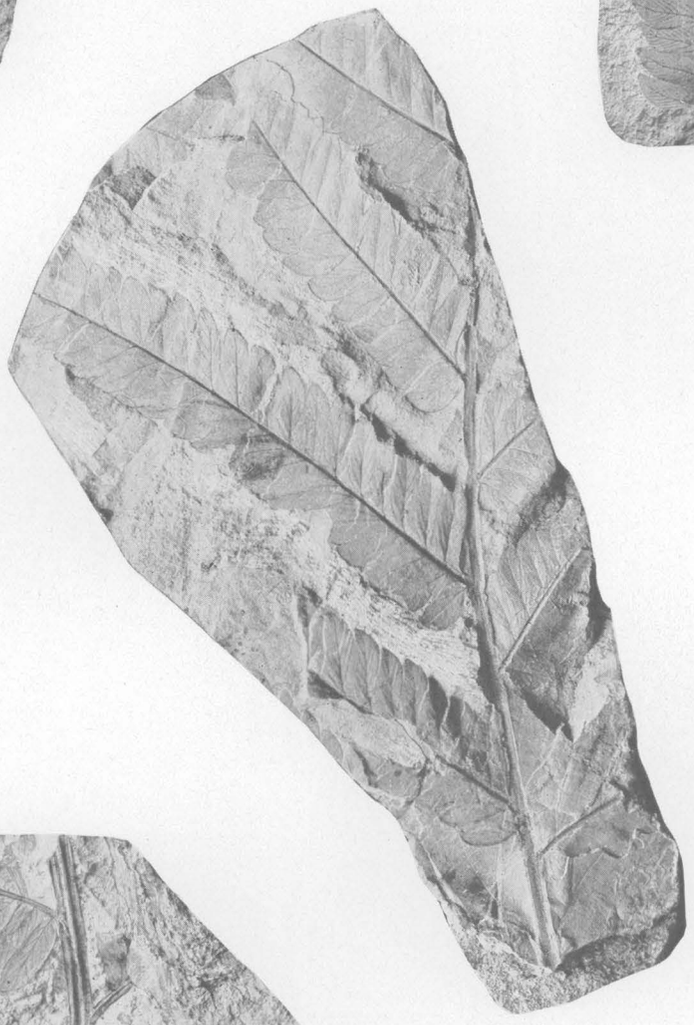

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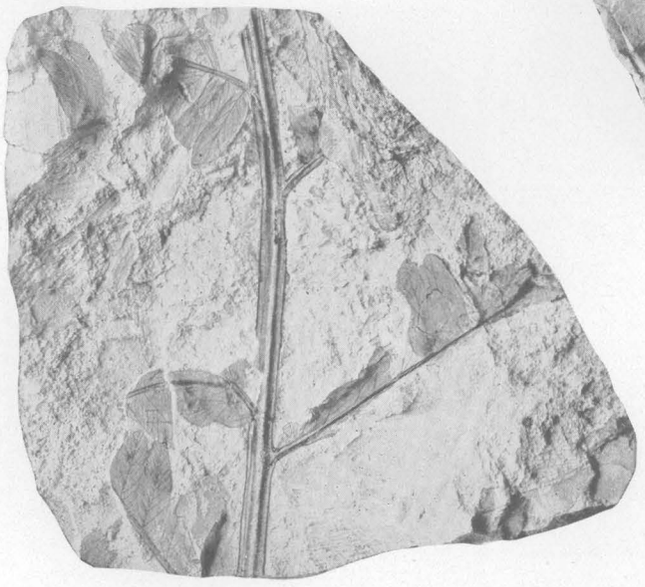

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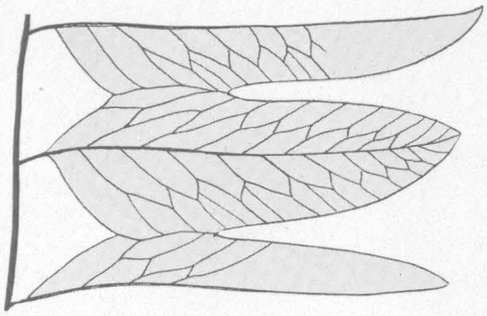
5

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Goniopteris claiborniana Berry, Yegua formation, Columbia, La.; p. 44. **1–3,** Fragments of pinnae; **4,** the alate rachis; **5,** detail of venation, × 4.



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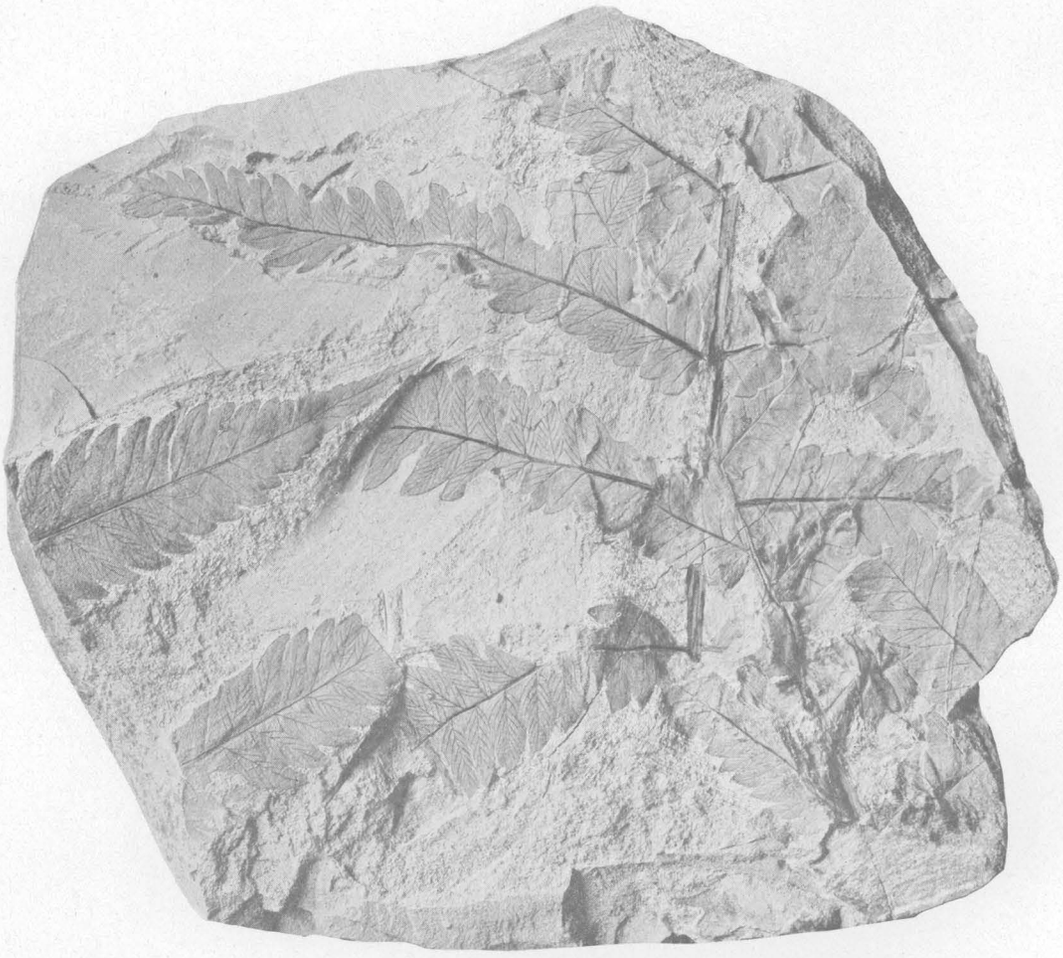

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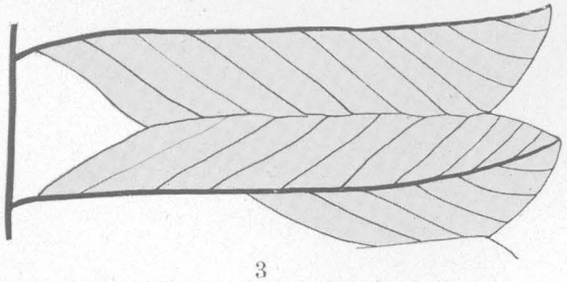
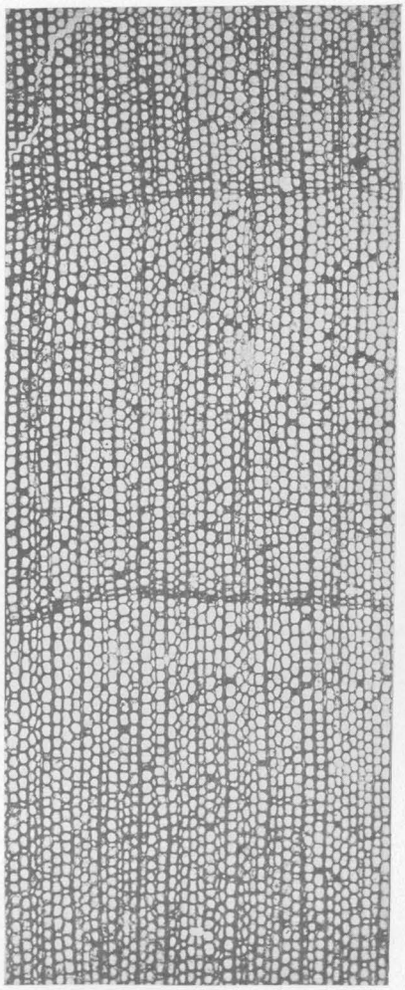


3

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Goniopteris claiborniana Berry, Yegua formation, Columbia, La.; p. 44. **1,** Detail of venation, × 4; **2,** fragments of pinnae; **3,** detail of venation, × 4.



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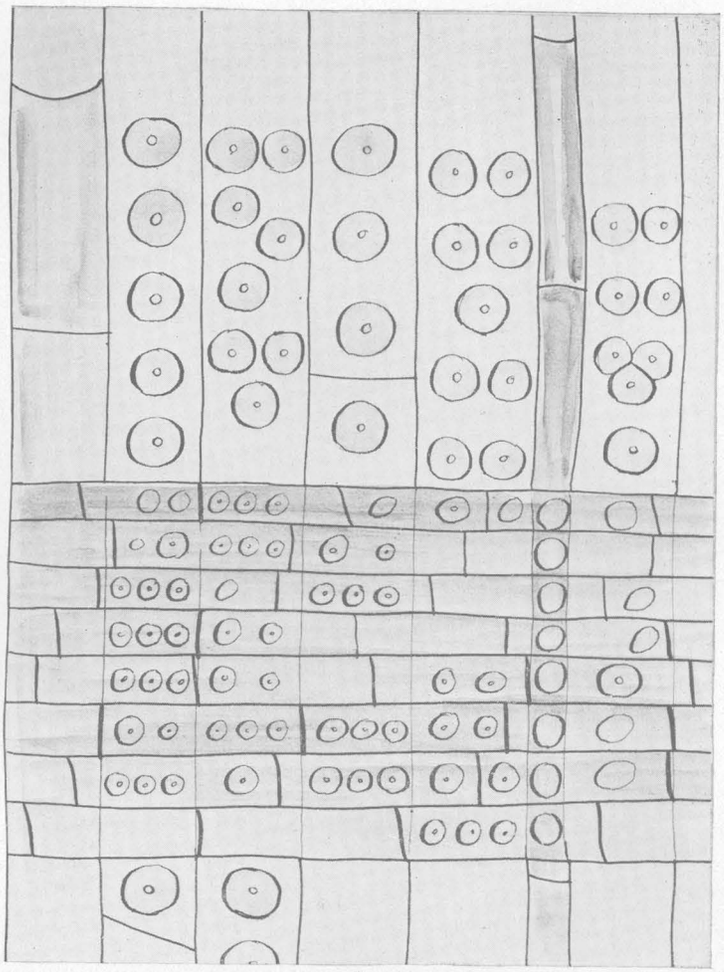

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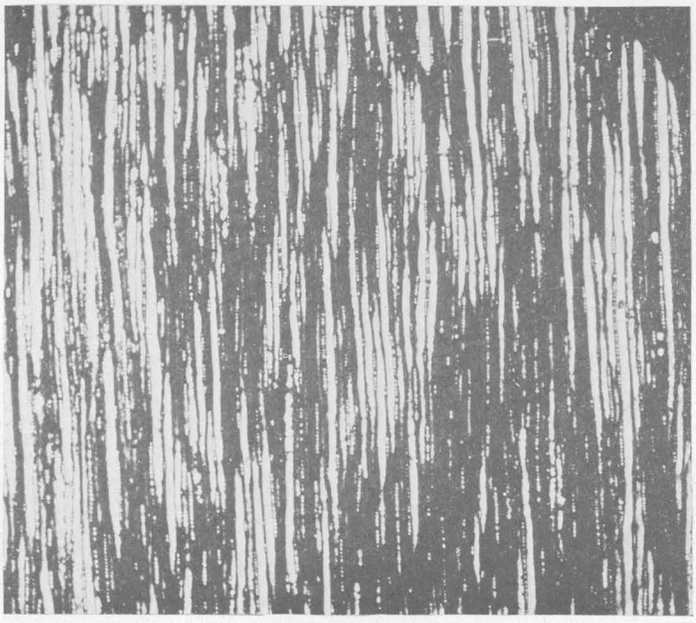
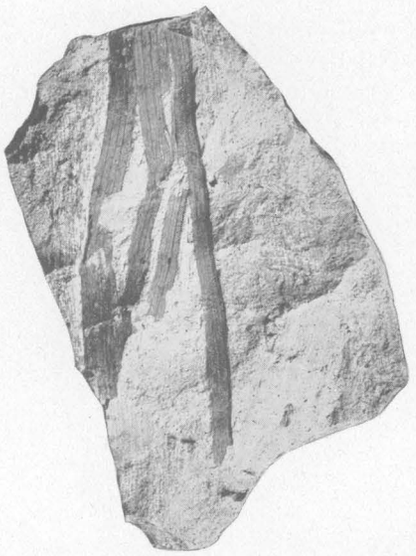


2

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Cupressinoxylon dawsoni Penhallow, Yegua formation, along International & Great Northern Railway in Houston County, Tex.; p. 48.
1, Transverse section, × 25; **2,** tangential section, × 25; **3,** radial section, × about 300.



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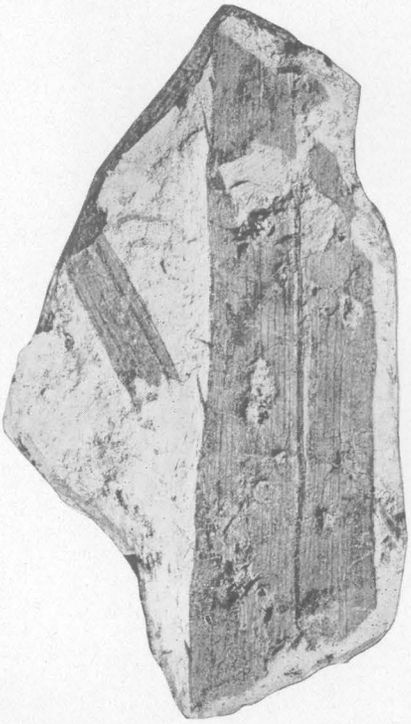

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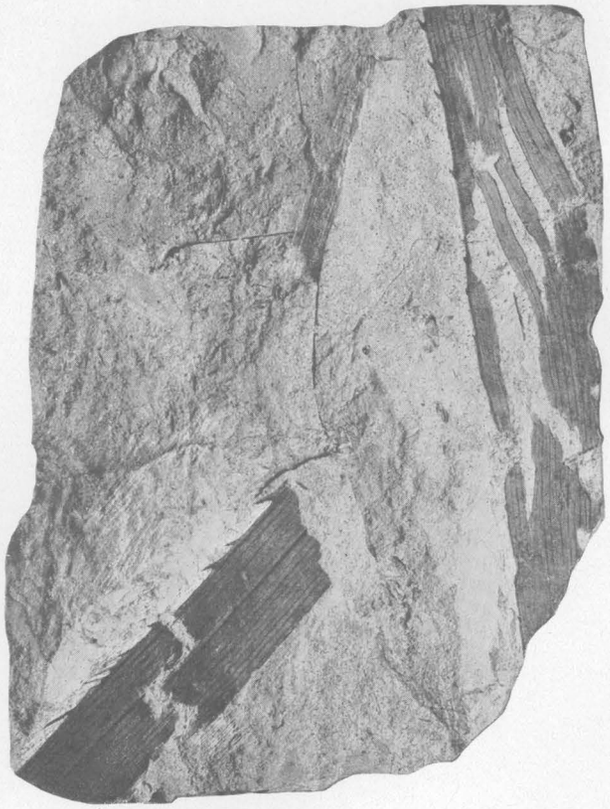
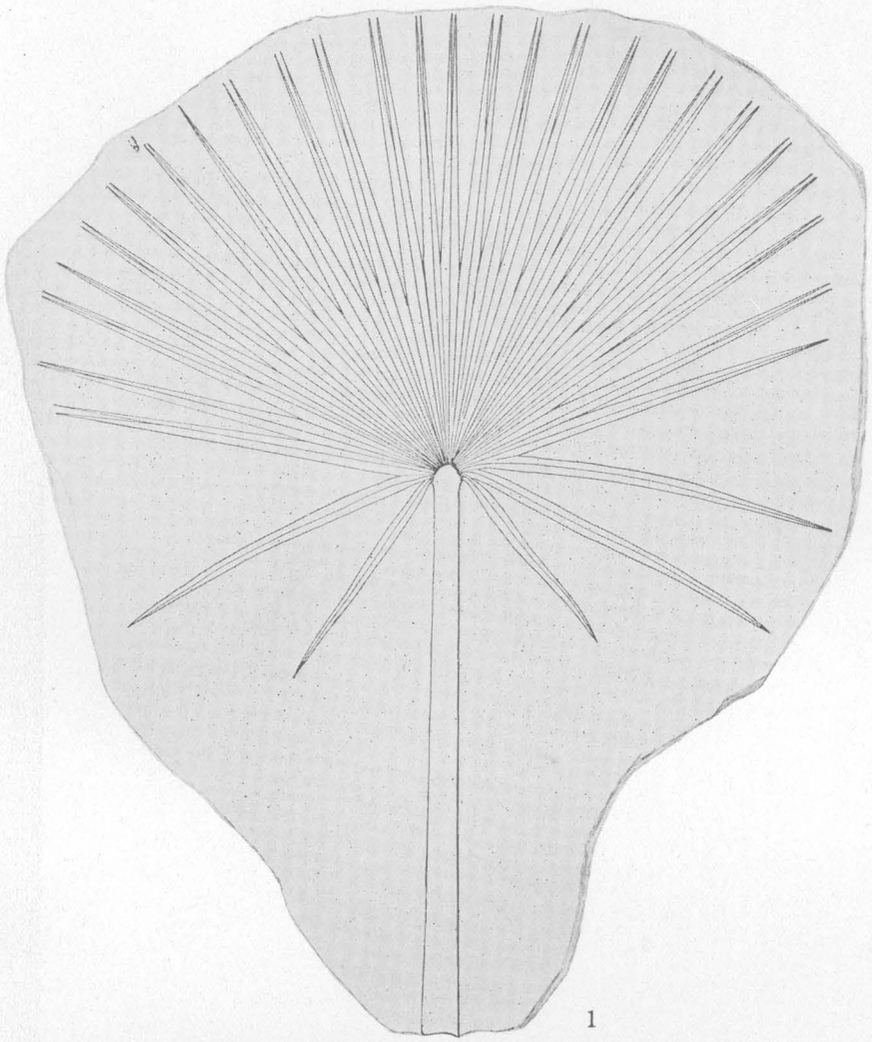


4

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Bactrites pandanifoliolus Berry, n. sp., Lisbon formation, Newton, Miss.; p. 52. **1–4,** Manner of preservation; **5, 6,** range of variation of the marginal spines (fig. **5,** × 3; fig. **6,** length of spines, × 7; spacing of spines, × 2).

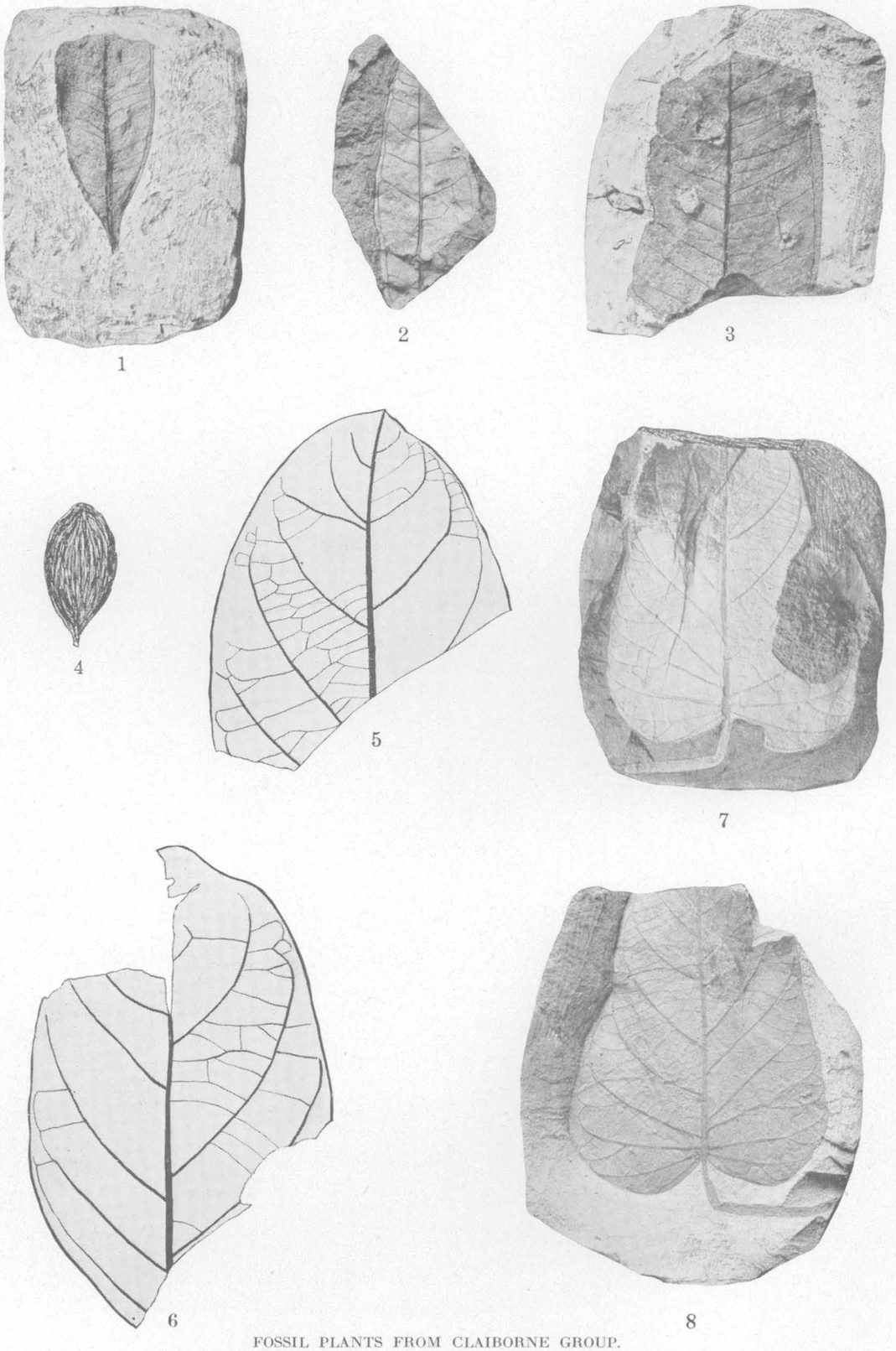


1

2

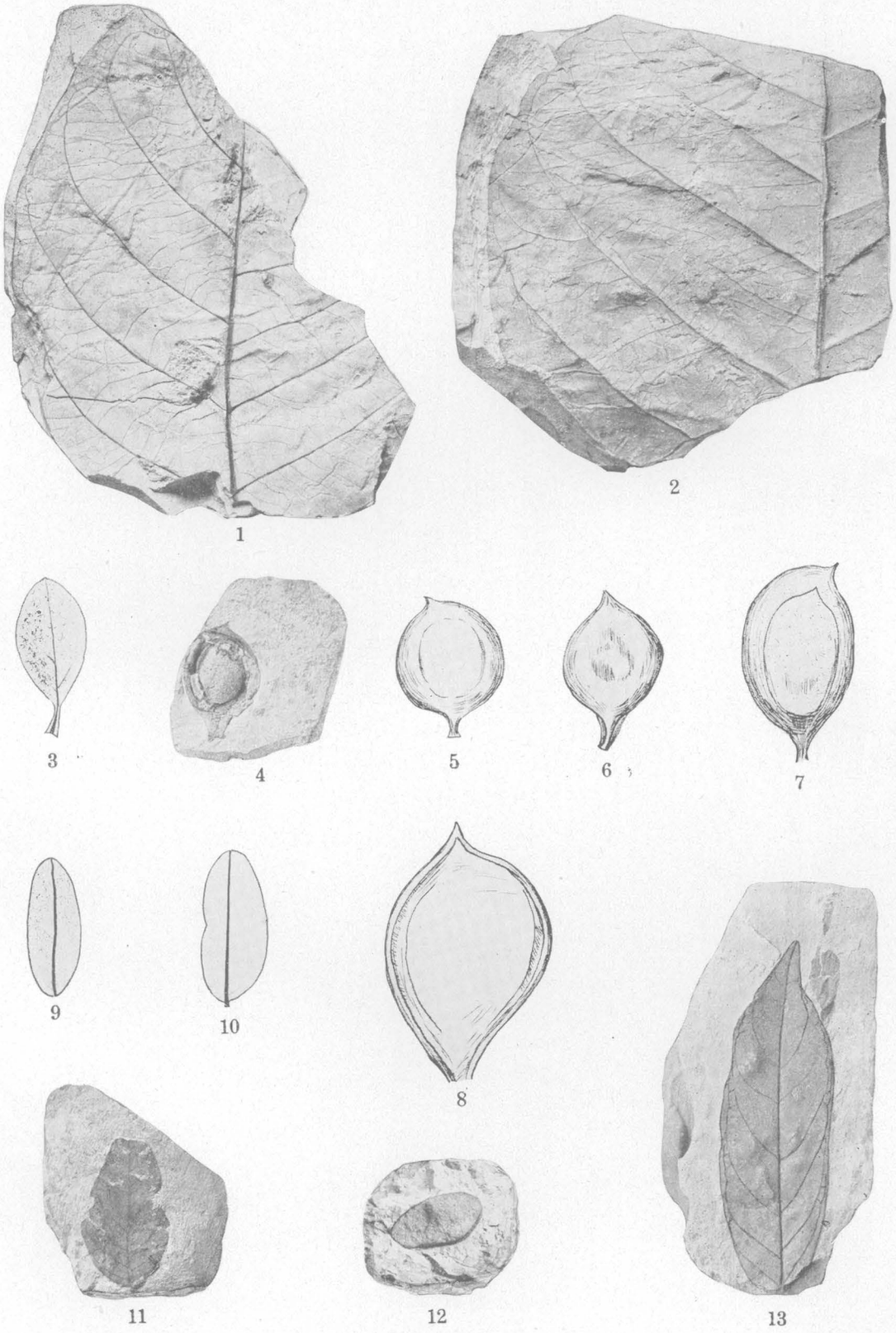
FOSSIL PLANTS FROM CLAIBORNE GROUP.

Thrinax eocenica Berry; p. 51. **1,** Restoration of leaf, × about 1/16; **2,** specimen from Yegua formation, Columbia, La.



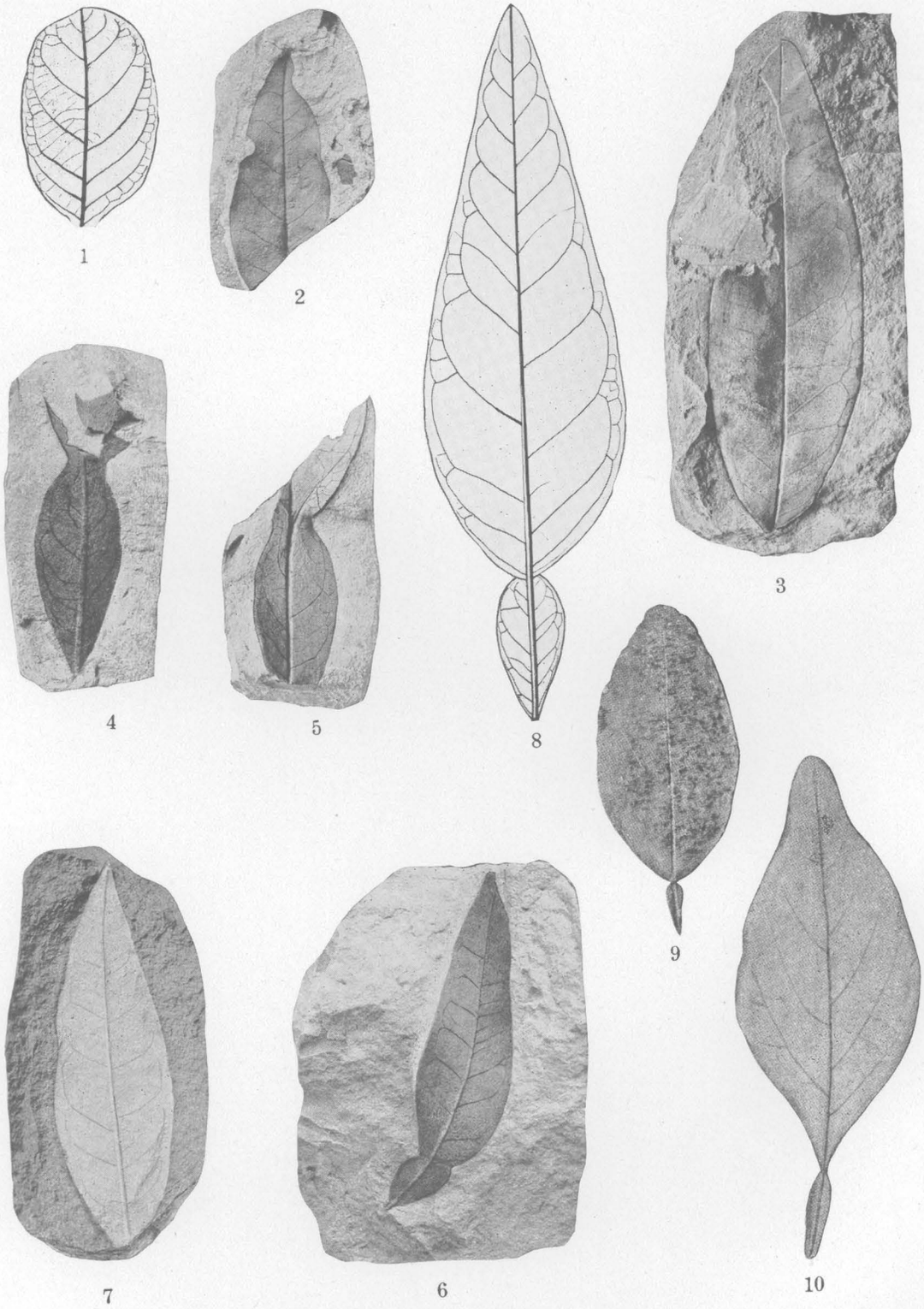
FOSSIL PLANTS FROM CLAIBORNE GROUP.

1-3. *Ficus newtonensis* Berry, n. sp., Lisbon formation, Newton, Miss.; p. 58.
4. *Ficus* sp., Yegua formation, near Rabb Creek, Fayette County, Tex.; p. 58.
5, 6. *Coccolobis claibornensis* Berry, n. sp., Lisbon formation, Lexington, Miss.; p. 59.
7, 8. *Aristolochia claiborniana* Berry, n. sp., Yegua formation, Columbia, La.; p. 59.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

1, 2. *Coccolobis columbianus* Berry, n. sp., Yegua formation, Columbia, La.; p. 60.
3. *Pisonia claiborniana* Berry, Yegua formation, Columbia, La.; p. 61.
4. *Copaifera yeguana* Berry, Yegua formation, Cedar Creek, Angelina County, Tex.; p. 63.
5. *Copaifera langsdorfii* Desfontaines, Brazil. Introduced for comparison.
6. *Copaifera radobojana* Unger, middle Miocene, Croatia. Introduced for comparison.
7. *Copaifera kymeana* Unger, upper Oligocene, Kumi. Introduced for comparison.
8. *Copaifera armissanensis* Saporta, lower Miocene, France. Introduced for comparison.
9, 10. *Sophora claiborniana* Berry, n. sp., Lisbon formation, Newton, Miss.; p. 64.
11. *Sophora wilcoxiana* Berry, Yegua formation, Nevils Prairie, Tex.; p. 65.
12. *Cassia cockfieldensis* Berry, n. sp., Yegua formation, Columbia, La.; p. 63.
13. *Inga arkansensis* Berry, n. sp., Yegua formation, Cherry Valley, Ark.; p. 62.

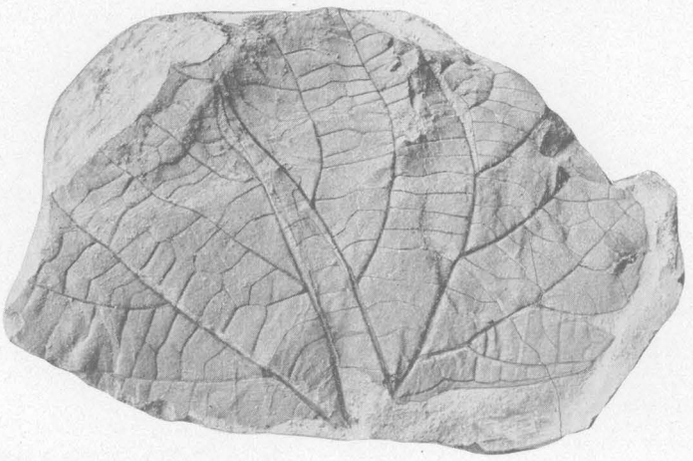


FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Fagara claibornensis* Berry, n. sp., Lisbon formation, Lexington, Miss.; p. 66.
2–8. *Citrophyllum eocenicum* Berry, n. sp.; p. 66. **2,** Gosport sand, Claiborne Landing, Ala.; **3–6,** Yegua formation, Cherry Valley Ark.; **7,** Yegua formation, 1 mile south of Climax siding, Houston County, Tex.; **8,** restoration of a large leaf.
9. *Citrus limonum* Risso, a recent leaf introduced for comparison.
10. *Citrophyllum aligerum* (Lesquereux) Berry, an Upper Cretaceous leaf introduced for comparison.

FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Carapa xylocarpoides* Berry, Claiborne beds near Fort Gaines, Ga.; p. 67.
2. *Xylocarpus* (*Carapa*) *obovatus* (Blume), after Schimper, an existing form introduced for comparison with *Carapa xylocarpoides*.
3. *Celastrophyllum gymindoides* Berry, n. sp., Lisbon formation, Newton, Miss.; p. 68.
4. *Celastrophyllum columbianum* Berry, n. sp., Yegua formation, Columbia, La.; p. 69.
5. *Cupanites parvulis* Berry, n. sp., Yegua formation, Columbia, La.; p. 70.
6. *Sapindus yeguanus* Berry (?), n. sp., Yegua formation, Nevils Prairie, Tex.; p. 73.
7. *Dodonaea viscosoides* Berry, Yegua formation, Columbia, La.; p. 70.
8. *Sapindus affinis* Newberry, Lisbon formation, Lexington, Miss.; p. 72.
9. *Sapindus dentoni* Lesquereux, Lisbon formation, Lexington, Miss.; p. 73.
10, 11. *Zizyphus claibornensis* Berry, n. sp., Yegua formation, Columbia, La.; p. 74.



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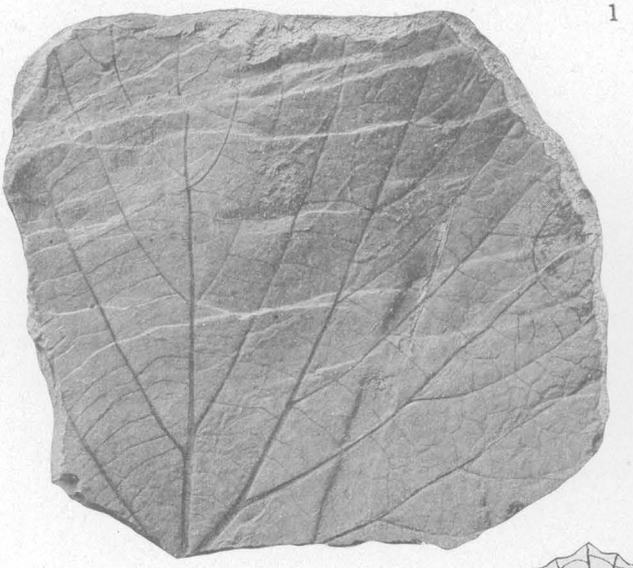

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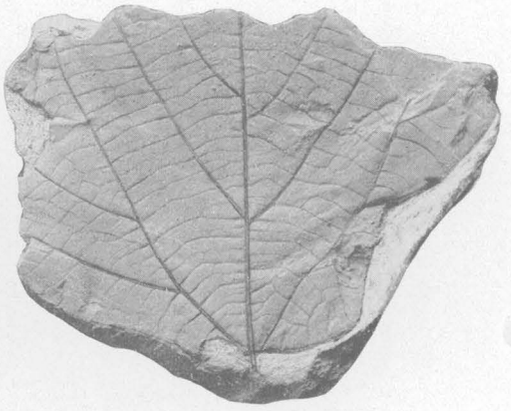

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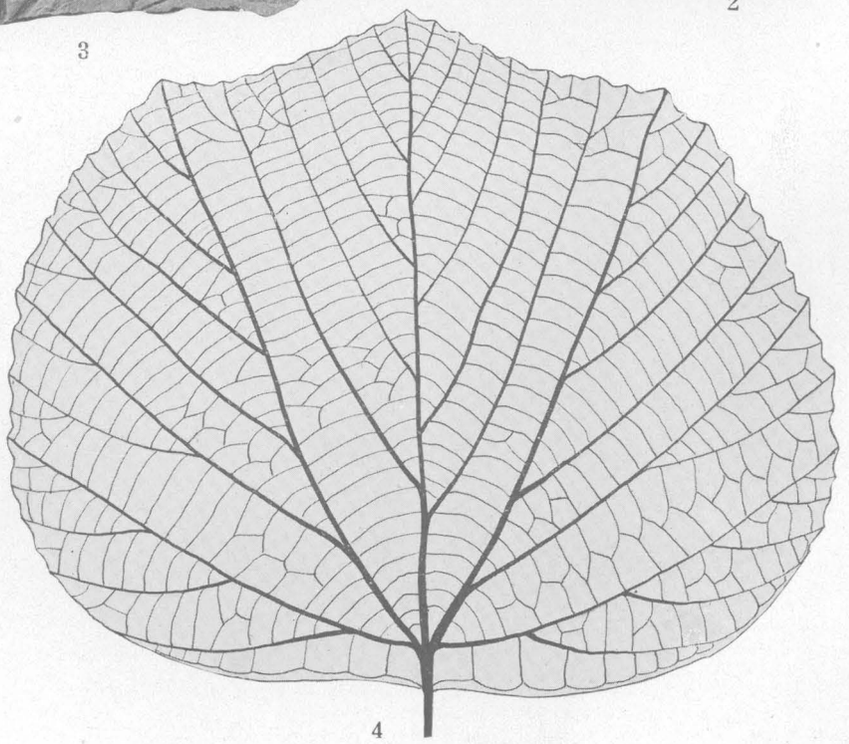
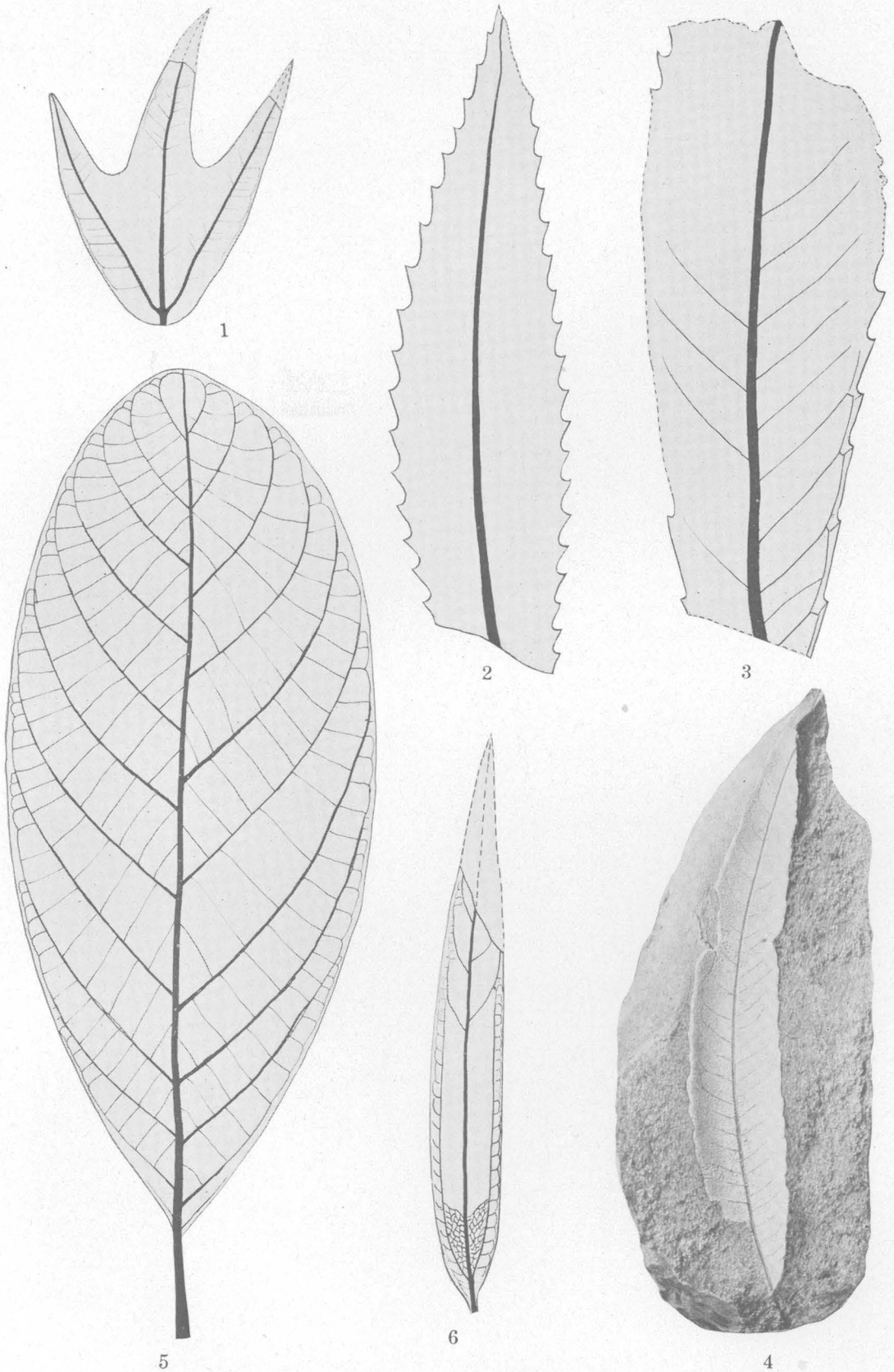


4

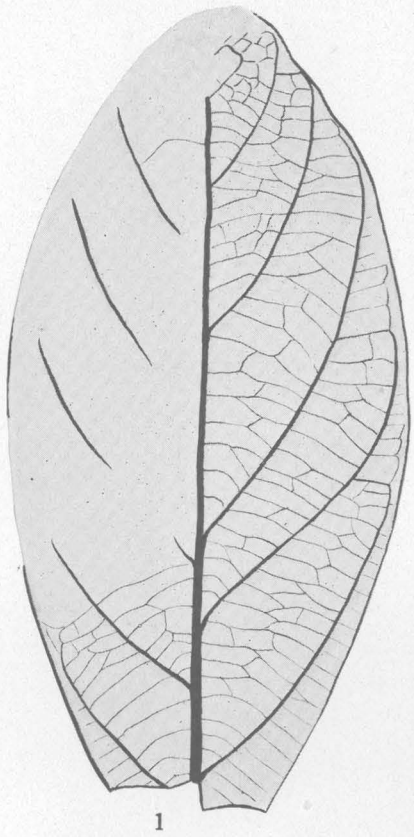
FOSSIL PLANTS FROM CLAIBORNE GROUP.

Grewiopsis claiborniana Berry, n. sp.; p. 75. **1–3,** Specimen from Yegua foramtion, Columbia, La.; **4,** restoration of specimen shown in Figures 1-3.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Sterculia labruscoides* Berry, n. sp., Lisbon formation, Newton, Miss.; p. 76.
2, 3. *Ternstroemites crowleyensis* Berry, n. sp., Yegua formation, Cherry Valley, Ark.; p. 77.
4. *Ternstroemites claibornensis* Berry, n. sp., Yegua formation, Cherry Valley, Ark.; p. 78.
5. *Persea gratissimifolia* Berry, n. sp., Yegua formation, Cherry Valley, Ark.; p. 79.
6. *Cinnamomum angustum* Berry, n. sp., Lisbon formation, Newton, Miss.; p. 78.



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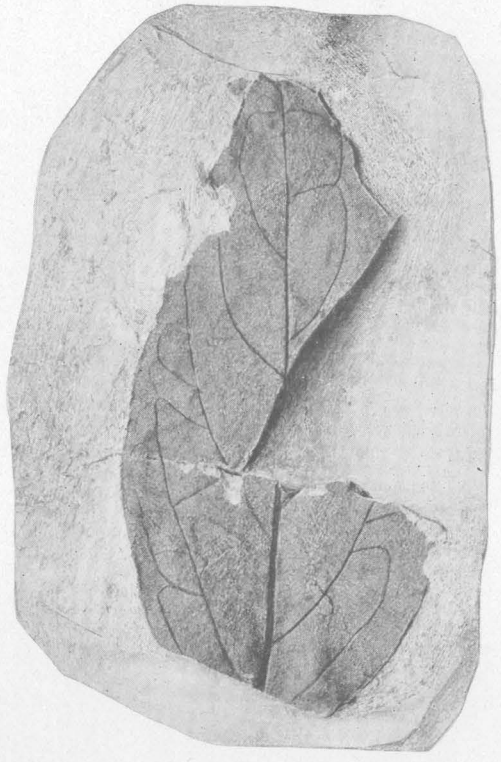

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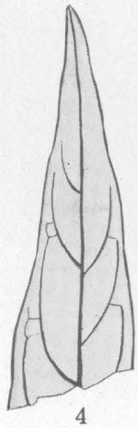

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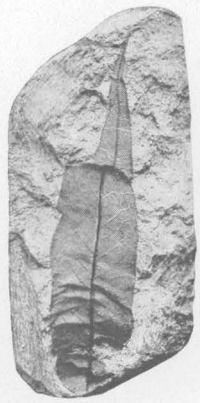
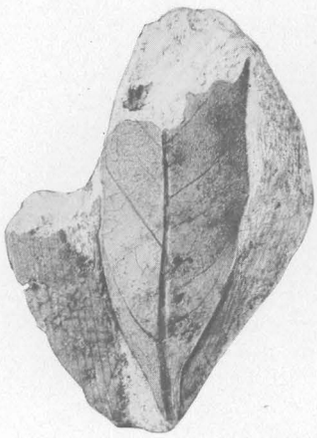


6

7

FOSSIL PLANTS FROM CLAIBORNE GROUP.

1, 2. *Persea lexingtonensis* Berry, n. sp.; p. 79. **1,** Lisbon formation, Lexington, Miss.; **2,** Yegua formation, Nevils Prairie, Tex.
3–5. *Mespilodaphne columbiana* Berry, n. sp.; p. 81. **3, 4,** Lisbon formation, Lexington, Miss.; **5,** Yegua formation, Columbia, La.
6, 7. *Mespilodaphne caudata* Berry, n. sp.; p. 81. **6,** Yegua formation, Columbia, La.; **7,** Yegua formation, Nevils Prairie, Tex.



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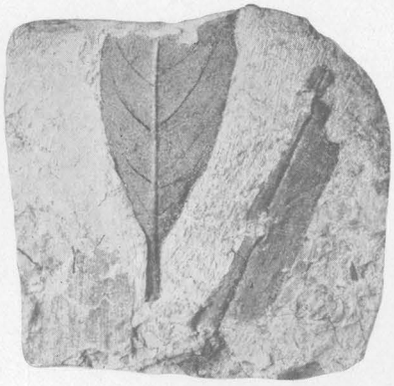

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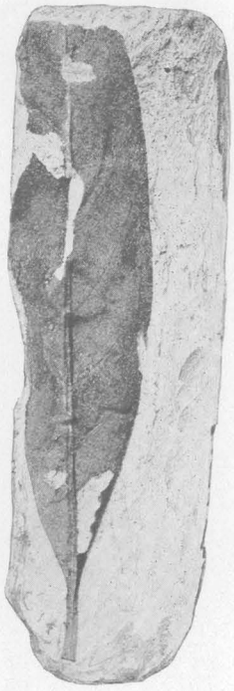

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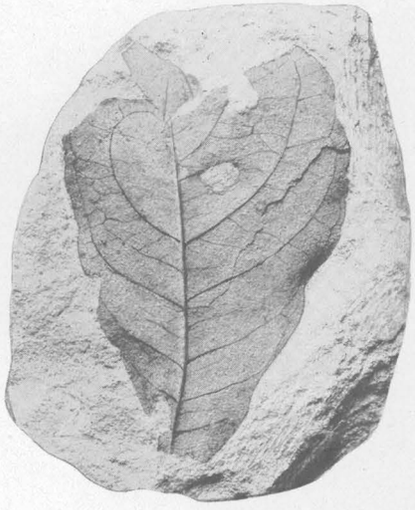

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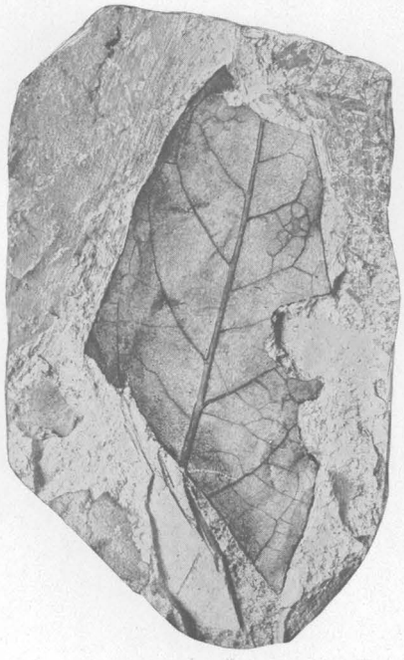
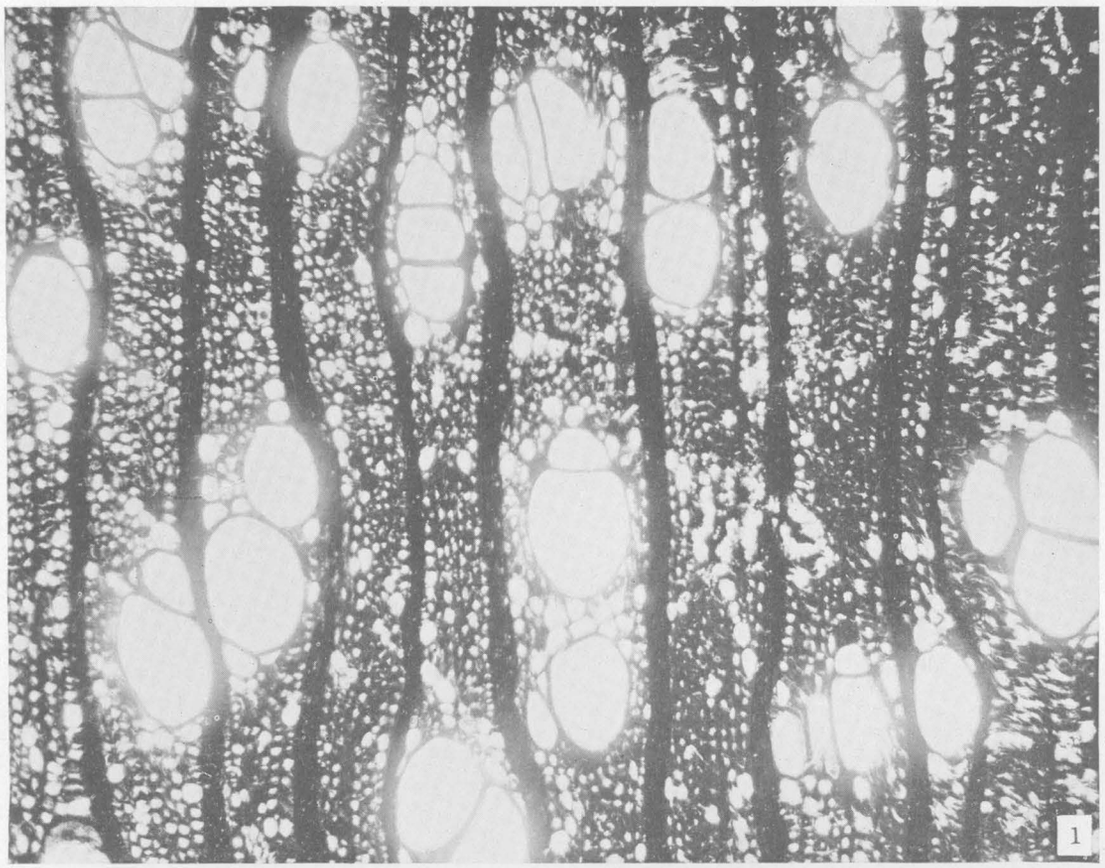


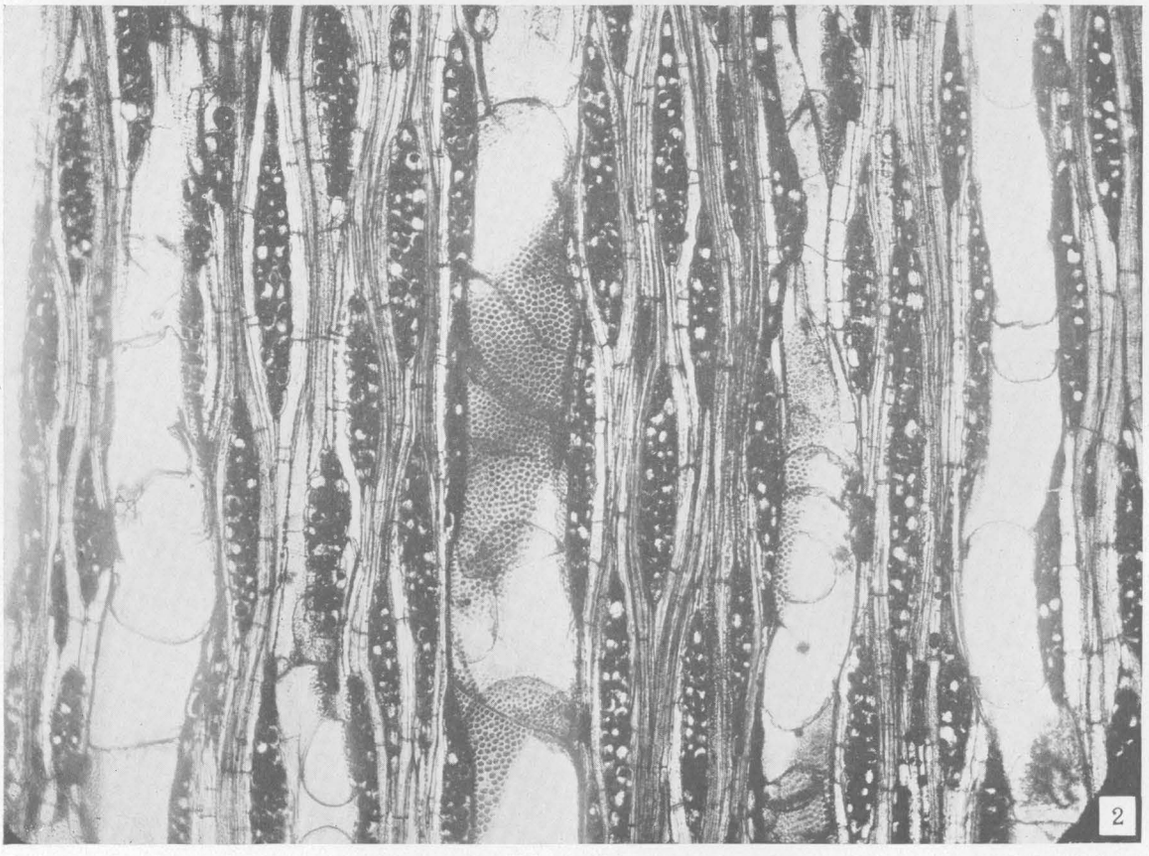
4

6

FOSSIL PLANTS FROM CLAIBORNE GROUP.

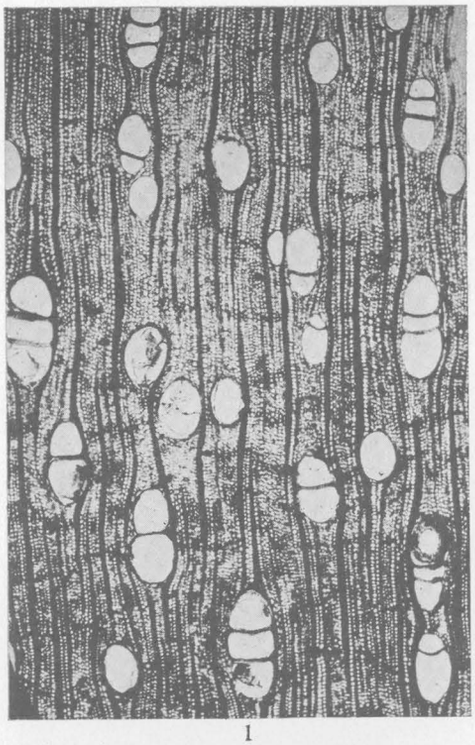
1–3. *Nectandra gosportensis* Berry, n. sp.; p. 82. **1, 2,** Lisbon formation, Newton, Miss.; **3,** Gosport sand, Claiborne Landing, Ala.
4–6. *Oreodaphne inequilateralis* Berry, n. sp.; p. 80. **4,** Gosport sand, Claiborne Landing, Ala.; **5, 6,** Yegua formation, Columbia, La.





FOSSIL PLANTS FROM CLAIBORNE GROUP.

Laurinoxylon bakeri Berry, n. sp., Yegua formation, Westmoreland Bluff, Tex.; p. 83. **1,** Transverse section (No. 230), × 100; **2,** tangential section (No. 230), × 100.



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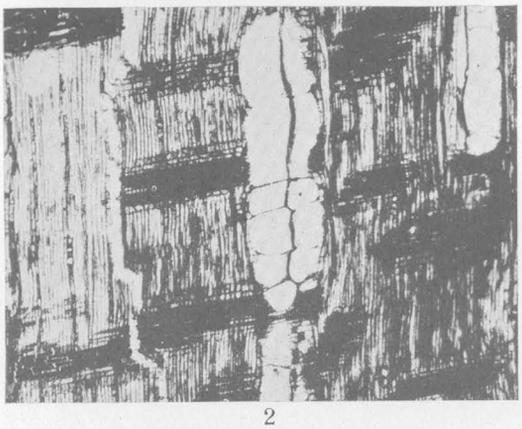

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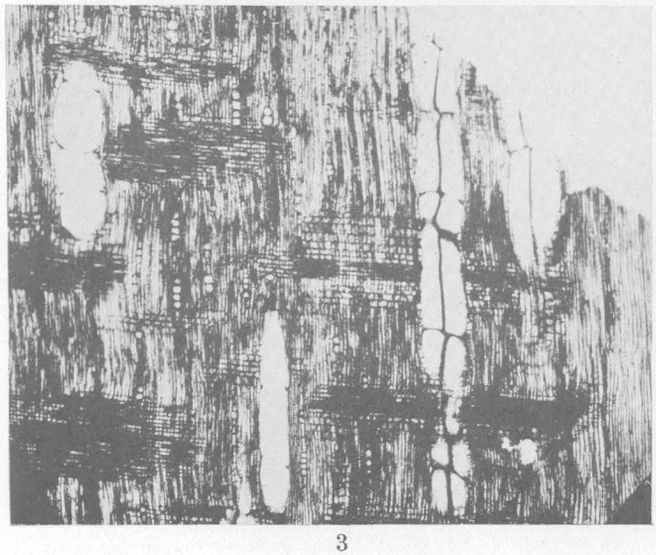

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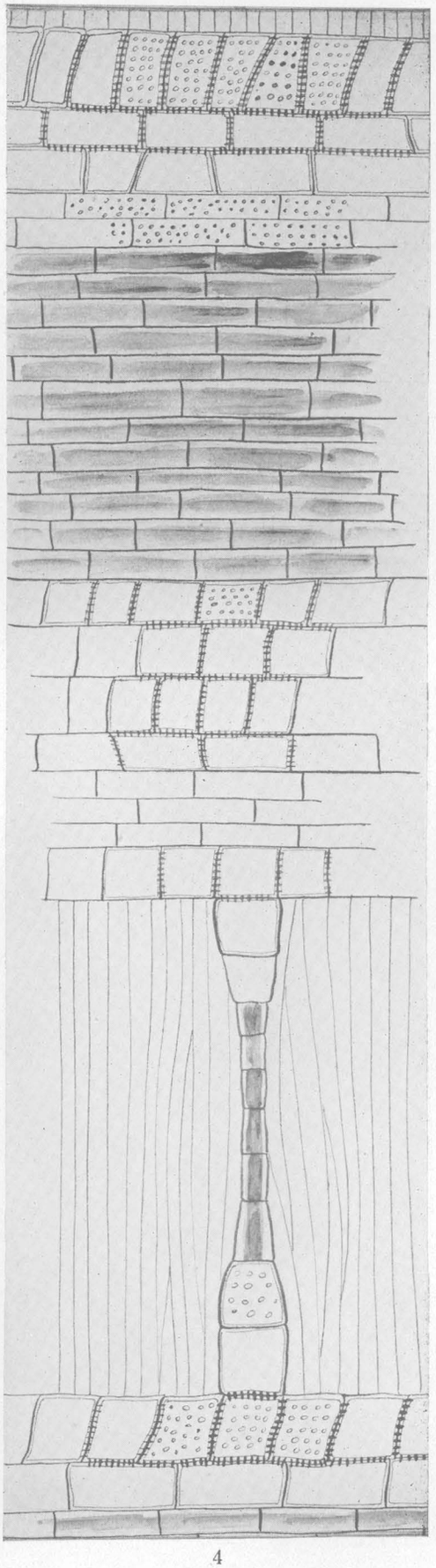
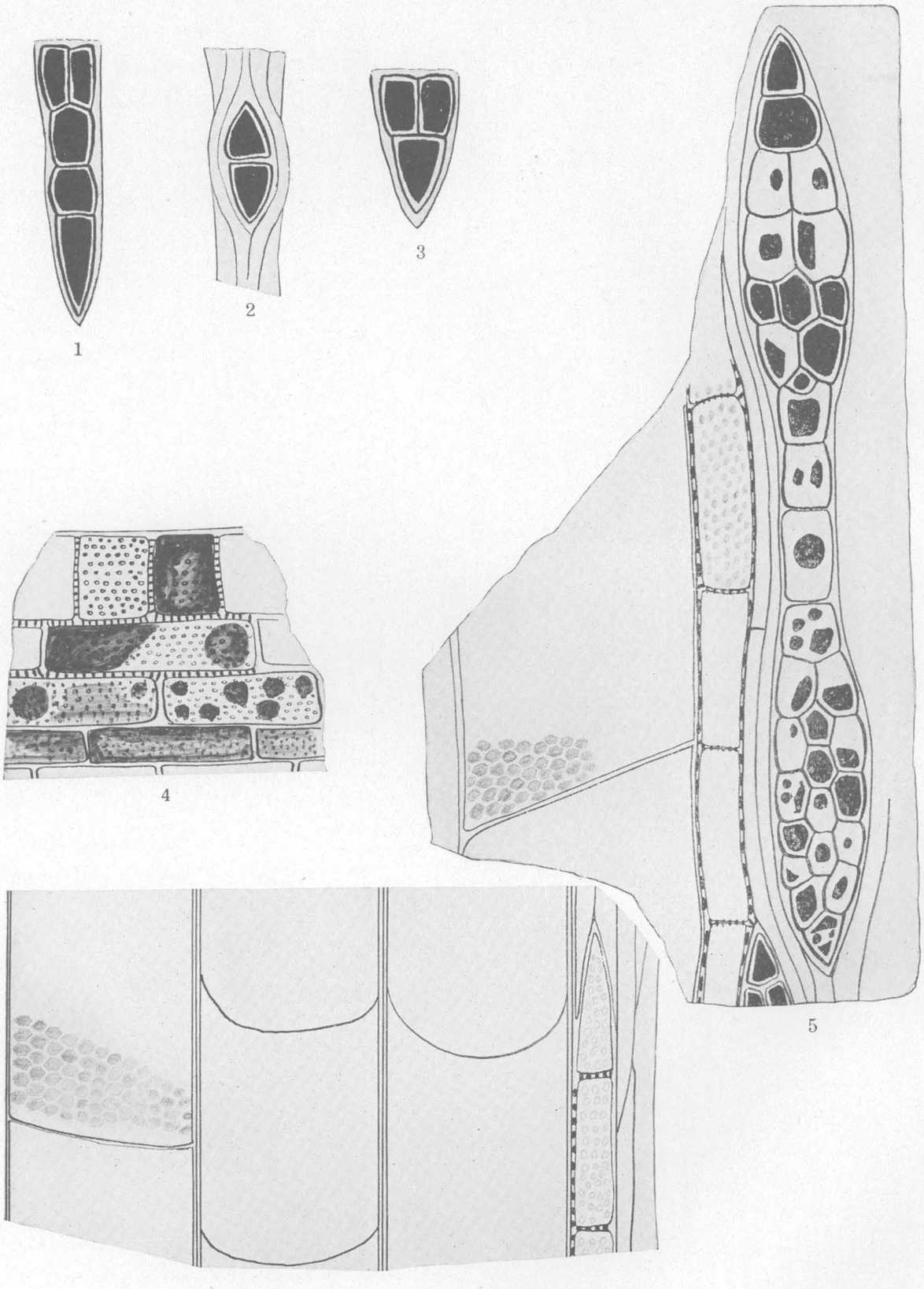


4

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Laurinoxylon bakeri Berry, n. sp., Yegua formation, cut on International & Great Northern Railway at milepost 44, Houston County, Tex.; p. 83. **1,** Transverse section (No. 217), × 25; **2, 3,** radial sections (No. 217), × 25; **4,** drawing of radial section showing character and pitting of ray cells and longitudinal connections between rays, × about 300.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

Laurinoxylon bakeri Berry, n. sp. (No. 230), Yegua formation, Westmoreland Bluff, Tex.; p. 83. **1,** Marginal ray cells in tangential view; **2,** a short ray in tangential view; **3,** marginal ray cells in tangential view; **4,** marginal ray cells in radial view; **5,** vessel, xylem parenchyma, and double ray in tangential view; **6,** vessels, xylem parenchyma, and prosenchyma. All × about 300.

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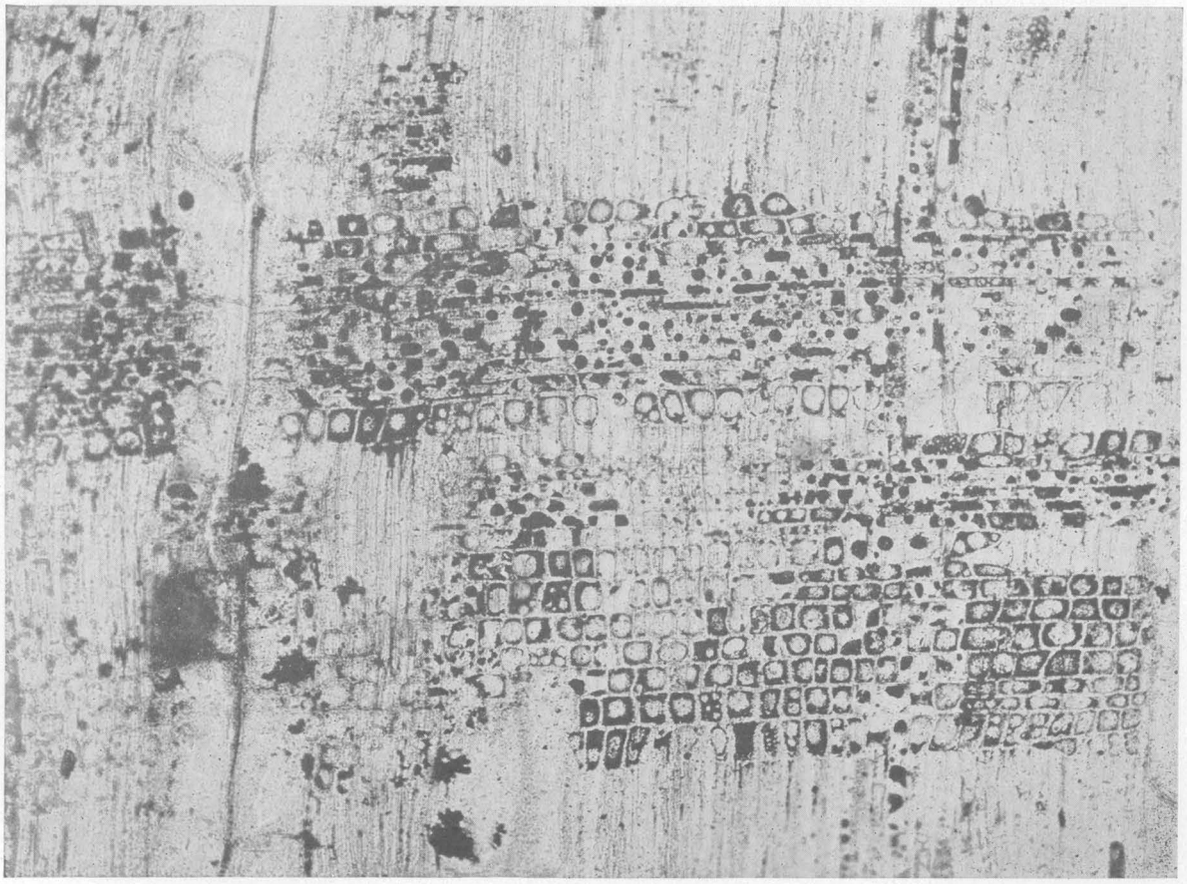
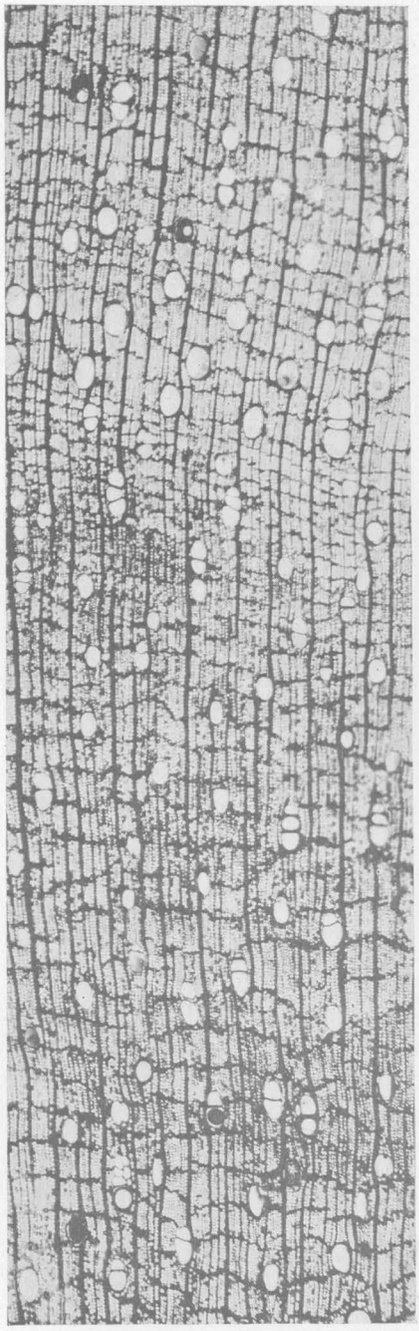


2

FOSSIL PLANTS FROM CLAIBORNE GROUP.

Laurinoxylon bakeri Berry, n. sp., Yegua formation, Westmoreland Bluff, Tex.; p. 83. **1,** Radial section (No. 230), × 10; **2,** radial section (No. 230), × 100.



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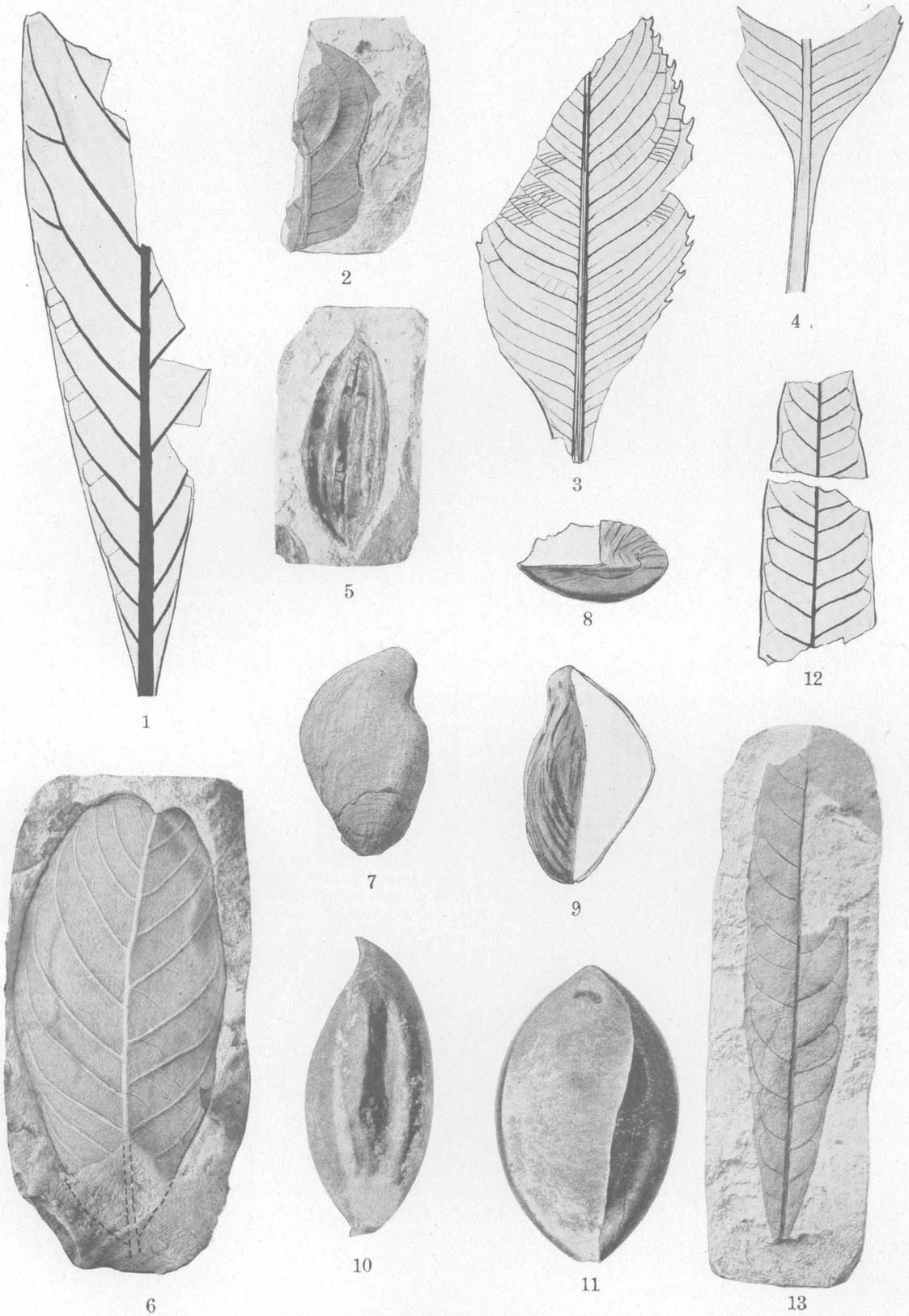
2

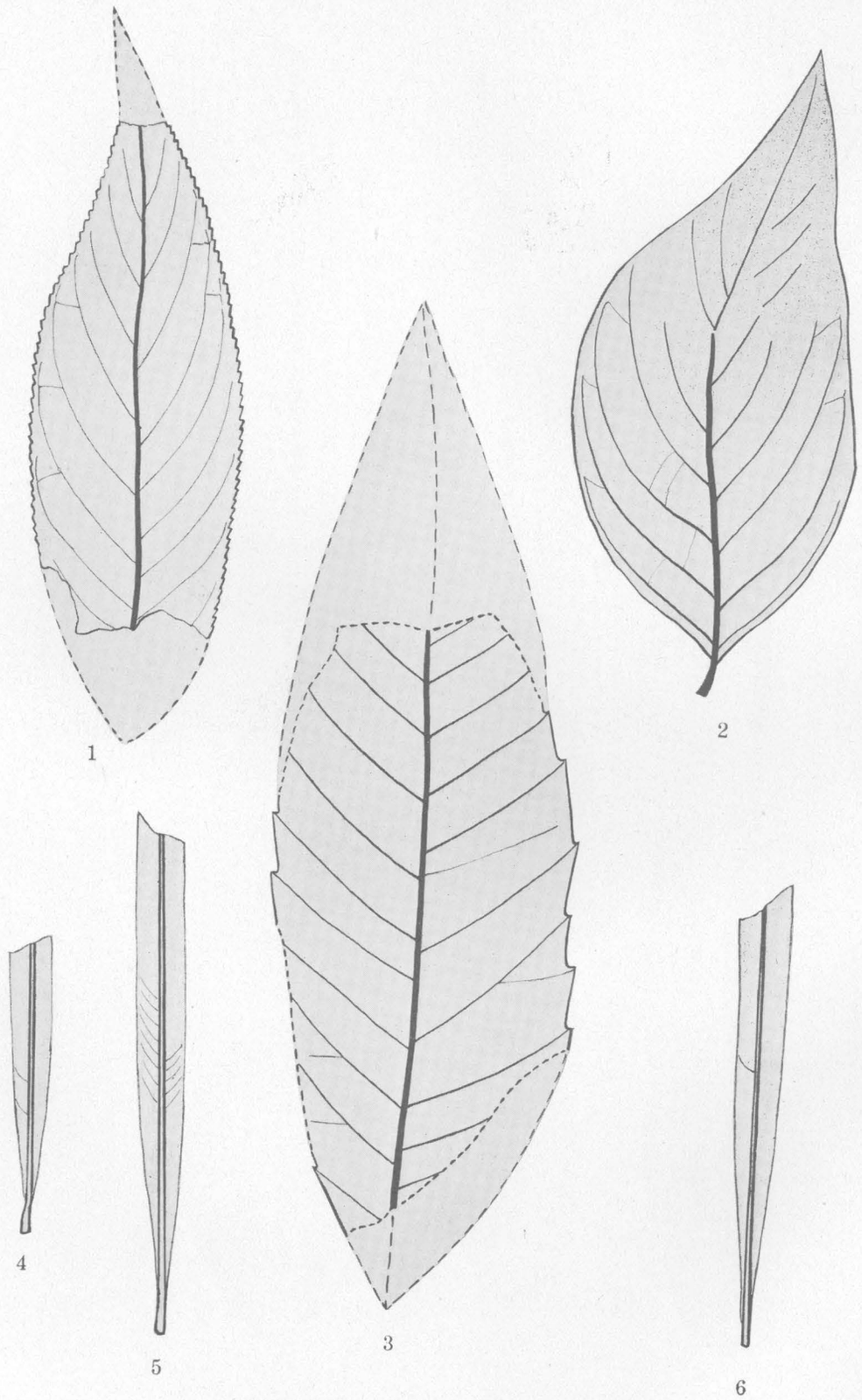
FOSSIL PLANTS FROM CLAIBORNE GROUP.

Laurinoxylon branneri Knowlton, Yegua formation, Westmoreland Bluff, Tex.; p. 84. **1,** Transverse section (No. 231), × 20; **2,** tangential section (No. 231), × 50.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Terminalia claibornensis* Berry, n. sp., Lisbon formation, Lexington, Miss.: p. 86.
2. *Laguncularia claiborniana* Berry, n. sp., Gosport sand, Claiborne Landing, Ala.; p. 87.
3, 4. *Oreopanax mississippiensis* Berry, n. sp., Lisbon formation, Lexington, Miss.; p. 88.
5. *Nyssa texana* Berry, n. sp., Yegua formation, Cedar Creek, Tex.; p. 88.
6. *Mimusops claibornensis* Berry, n. sp., Yegua formation, Cherry Valley, Ark.; p. 89.
7–9. *Eoachras eocenica* Berry, Lisbon formation, Lexington, Miss.; p. 90. **7,** Side view; **8,** distal view; **9,** view showing umbilical area.
10. *Lucuma salicifolia* Humboldt, Bonpland, and Kunth (after Pittier), a living species introduced for comparison.
11. *Calocarpum viride* Pittier (after Pittier), a living species introduced for comparison.
12, 13. *Apocynophyllum texensis* Berry, n. sp.; p. 91. **12,** Lisbon formation, Lexington, Miss.; **13,** Yegua formation, Nevils Prairie, Tex.



FOSSIL PLANTS FROM CLAIBORNE GROUP.

1. *Euonymus santatomasensis* Berry, n. sp., locality 1045, Santo Tomas, Tex.; p. 69.
2. *Rhamnus* sp., locality 1045, Santo Tomas, Tex.; p. 75.
3. *Dryophyllum brevipetiolatum* Berry, n. sp., sandstone on hill above Santo Tomas coal seam, Santo Tomas, Tex.; p. 56.
4–6. *Apocynophyllum grevilleafolium* Berry, n. sp.; pp. 92, 196. **4, 5,** Mount Selman formation, Palestine, Tex.; **6,** Fayette sandstone, Hornbeck, La.

THE UPPER EOCENE OR JACKSON FLORA.

PREVIOUS STUDIES.

The history of the study of the deposits which are referred to the Jackson is not within the scope of this report, for the fossil plants of this age were not collected or studied prior to the work that forms the basis of the following pages. Lignite, petrified wood, and leaves have often been mentioned by field students, but no collections were made or determinations attempted.

In 1914 I described 17 species of plants from beds of lower Jackson age in Georgia,[1] which were at that time referred to the upper Claiborne.[2] The same year I described [3] the fruits of a date palm from deposits of this age in Texas, and two years later the fruits of a nutmeg from the same locality.[4] Meanwhile a petrified fungus was recorded [5] from these beds, and the following Jackson plants were included [6] in an account of the flora of the Catahoula sandstone: *Palmoxylon lacunosum, Anona texana, Fagara catahoulensis, Fagara orbiculata,* and *Fagara elongata.* With these exceptions the flora described in this report from beds of Jackson age is here published for the first time.

CHARACTER, SUCCESSION, AND DISTRIBUTION OF THE DEPOSITS.

The deposits of Jackson age constitute one of the most difficult of our southeastern Tertiary divisions adequately to interpret and subdivide. In their eastern representation in North Carolina they consist of a well-marked impure marine limestone (the Castle Hayne limestone) and a formation composed largely of marls (the Trent marl), which may not be even Eocene in age. In Georgia the initial deposits of Jackson time, which are partly estuarine in origin, transgress widely over earlier formations, completely burying the earlier Eocene and all the Upper Cretaceous in the region east of Ocmulgee River and resting on the Lower (?) Cretaceous in the area between Ocmulgee River and eastward throughout the drainage basin of Savannah River.

In western Georgia and southward in Florida as well as westward across Alabama, the sediments of Jackson age comprise alternating beds of shallow, soft-bottom materials that contain remains of *Zeuglodon,* and limestones of different degrees of impurity, which are distinguishable with difficulty from the overlying limestones of Vicksburg age. In Alabama these argillaceous limestones of Jackson and Vicksburg age are of great lithologic diversity and between 200 and 300 feet thick. They have been termed the "St. Stephens limestone" but have recently been differentiated by Cooke into several formations,[7] and the name "St. Stephens limestone" has been abandoned by the United States Geological Survey.

The type locality of the Jackson [8] is in and near the city of Jackson, Miss., where the richly fossiliferous beds of the formation are well exposed. The Jackson deposits of Mississippi are now separated, on the basis of their lithology, into the following members: [9]

Generalized section of the Jackson formation of Mississippi.

	Feet.
Yazoo clay (upper member):	
Drab or yellowish calcareous clays, with dark lignitic clay toward base and thin beds of lignite in places, probably at least	300
Moody's Branch marls (lower member):	
Calcareous, glauconitic, sandy marls, passing downward into lignitic clays having nodular lime concretions	150±

[1] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, 1914.

[2] Cooke, C. W., and Shearer, H. K., Deposits of Claiborne and Jackson age in Georgia: U. S. Geol. Survey Prof. Paper 120, pp. 41–81, 1919.

[3] Berry, E. W., Fruits of a date palm in the Tertiary deposits of eastern Texas: Am. Jour. Sci., 4th ser., vol. 37, pp. 403–406, 1914.

[4] Berry, E. W., A fossil nutmeg from the Tertiary of Texas: Am. Jour. Sci., 4th ser., vol. 42, pp. 241–245, 1916.

[5] Berry, E. W., Remarkable fossil fungi: Mycologia, vol. 8, pp. 7?-1916.

[6] Berry, E. W., The flora of the Catahoula sandstone: U. S. Geo Survey Prof. Paper 98, pp. 227–251, 1917.

[7] Cooke, C. W., Correlation of Jackson and Vicksburg deposits in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, pp. 186–198, 1918.

[8] Conrad, T. A., Observations on the Eocene deposit of Jackson, Miss., with descriptions of thirty-four new species of shells and corals: Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 257, 1856.

[9] Lowe, E. N., Mississippi, its geology, geography, soil, and mineral resources: Mississippi Geol. Survey Bull. 14, pp. 80–89, 1919. See also Cooke, C. W., Washington Acad. Sci. Jour., vol. 8, pp. 186, 198, 1918.

Toward the center of the embayment, in the region around Vicksburg, Miss., well records show enormous thicknesses of both the Claiborne and the overlying Jackson, indicating a much longer period of sedimentation in that region or a very much faster accumulation of these sediments, or both.

The only deposit of Jackson age in Tennessee is the small belt of lignitic sands and clays in western Shelby, Tipton, and Lauderdale counties and possibly Obion County, which is mostly covered by loess or surficial deposits and is exposed only in stream channels, as at Raleigh, and in some of the Chickasaw bluffs, as at Randolph. These deposits are unfossiliferous, except for lignite and scattered impressions of leaves. Beds containing fossil plants tentatively regarded as of upper Jackson age are present in southwestern Kentucky.

In Arkansas the Jackson is cut out by the flood plain of Mississippi River but reappears west of the river along Crowleys Ridge from the northern part of St. Francis County southward. Lithologically it comprises massive or cross-bedded sands, which are interstratified with massive or laminated, more or less lignitic clays and shallow-water marine fossiliferous marls, that represent the marked northerly transgression of the lower Jackson. Similar fossiliferous calcareous clays and sands are present in a belt that extends from western Jefferson County through Cleveland, Lincoln, and Drew counties into northern Ashley County. Southwest of this area and farther south, in northern Louisiana, they are represented by lignitic sands and clays without fossils.

In Louisiana fossiliferous Jackson again appears in Caldwell and Catahoula parishes, whence it extends southwestward in a narrowing belt between the Yegua formation of the Claiborne group below and the Fayette sandstone above and crosses Red River at Montgomery and Sabine River just below Robinsons Ferry, in Sabine County.

The materials and stratigraphic relations that have just been described continue across east Texas, but west of Brazos River the Jackson marls are absent and the Fayette rests directly on the Yegua. In confirmation of the obvious interpretation of these relations the Fayette, whose thickness in Louisiana and east Texas is nowhere more thn 200 feet, thickens westward until on Brazos, Colorado, and Nueces rivers it ranges from 600 to 800 feet in thickness.

The Fayette sandstone was named by Penrose [10] in 1890 from Fayette County, Tex. He included in it deposits that ranged in age from Claiborne to Miocene or later. Two years later Dumble [11] segregated the Yegua formation, or the Claiborne portion, and in 1903 he differentiated the Oakville sandstone, or Miocene portion.[12] The name Fayette has now been officially restricted to beds of Jackson age, which, as described by Deussen, comprise massive or flaggy gray sandstones and mostly coarse sands, brown and chocolate-colored lignitic clays and lignites, and some small beds of volcanic ash. The Fayette contains a great abundance of silicified and opalized wood and but few remains of plant foliage and these usually in a poor state of preservation, although under favorable conditions, as at the localities in Brazos County, Tex., a fairly abundant and well-preserved flora is found.

In southeastern Texas and western Louisiana the Fayette was formerly confused with the overlying Catahoula sandstone, but the stratigraphic work in that region by Deussen and Matson and the presence of a small marine fauna in the western extension of the formation, together with the evidence of the plants, have led to the reference of the Fayette to the Jackson epoch.[13]

LOCAL DISTRIBUTION OF THE FLORA.

THE PLANT-BEARING OUTCROPS.

Fossil plants have been found in the deposits of Jackson age at 40 localities. These localities are very unequal in their yield of material and range from outcrops that have furnished a single species of petrified wood to others like those around Grovetown, Ga., that have furnished 20 species, or those in the kaolinite of Brazos County, Tex., from one of which 25 species have been recorded. Outcrops that contain representatives of a diversified flora, such as are so common in the Wilcox, are

[10] Penrose, R. A. F., jr., A preliminary report on the geology of the Gulf Tertiaries of Texas from Red River to the Rio Grande: Texas Geol. Survey First Ann. Rept., pp. 47–58, 1890.

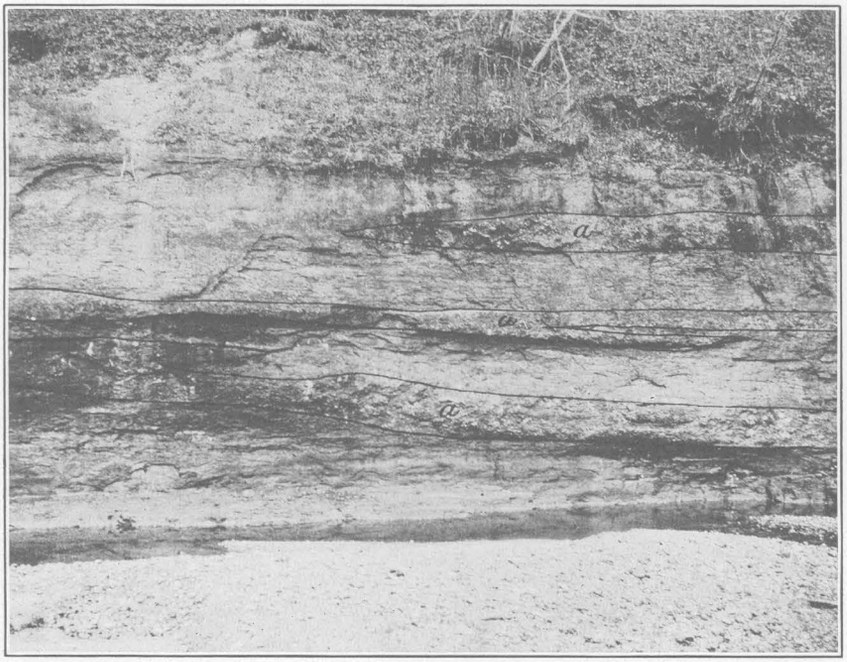
[11] Dumble, E. T., Report on the brown coal and lignite of Texas, p. 148, Texas Geol. Survey, 1892.

[12] Dumble, E. T., Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, p. 957, 1903.

[13] Matson, G. C., The Pliocene Citronelle formation of the Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 98, pp. 167–192, 1917; The Catahoula sandstone: Idem, pp. 209–226.

A. GROVE OF EXISTING DATE PALMS, FOR COMPARISON WITH THE JACKSON SPECIES.

From U. S. Dept. Agr. Bull. 271, pl. 9, fig. 1, 1915.



B. SUCCESSION OF OYSTER BEDS IN THE LOWER PART OF THE JACKSON FORMATION ON LITTLE CROW CREEK, ARK.

The successive positions of oyster beds (a) as deposition continued are indicated by the black lines. Photograph by L. W. Stephenson.

A. STRATA OF LOWER JACKSON AGE ALONG WOLF RIVER NEAR MEMPHIS, TENN.

Photograph by L. W. Stephenson.

B. NEAR VIEW OF STRATA SHOWN IN *A*, TO SHOW ALTERNATING BEDS OF SAND AND LIGNITIC CLAY.

Photograph by L. W. Stephenson.

entirely absent from the Jackson. In this respect the Jackson is even poorer than the Claiborne, so that the present discussion, which is based on the Jackson plants thus far discovered, must be considered entirely preliminary in character.

One of the most prolific areas, as well as the most easterly known, is the area in the immediate vicinity of Grovetown, Ga., where there are a number of local outcrops that have been grouped together in the table of distribution for convenience of treatment.

Grovetown is in Columbia County, about 15 miles west of Augusta. The deposits of Jackson age in this area consist of laminated clays that contain fine sand partings and local lignitic layers, one of which reaches a thickness of 10 feet about 3½ miles south of Grovetown. These laminated clays, which belong to the Twiggs clay member of the Barnwell formation, contain scattered impressions of leaves together with casts of *Modiolus* and other pelecypods. Throughout eastern Georgia the sediments of lower Jackson time have transgressed the earlier Eocene and rest with marked unconformity upon the Cretaceous; in places they extend westward beyond the Cretaceous and rest on the crystalline rocks of the Piedmont Plateau. Grovetown is situated on what appears to have been a pre-Jackson or early Jackson estuary, 2 or 3 miles wide and about 18 miles long, whose strand was lined with *Acrostichum* swamps and mangrove plants. (See Pl. XXVII.) The following 20 species have been identified from this early Jackson estuary and river valley coastal flora:

Sphaerites claibornensis.
Pestalozzites minor.
Acrostichum georgianum.
Potamogeton megaphyllus.
Pistia claibornensis.
Arundo pseudogoepperti.
Thrinax eocenica.
Castanea claibornensis.
Momisia americana.
Ficus claibornensis.
Pisonia claiborniana.
Mimosites georgianus.
Sophora claiborniana.
Leguminosites sp. (pods).
Dodonaea viscosoides.
Sapindus georgianus.
Cinnamomum angustum.
Rhizophora eocenica.
Terminalia phaeocarpoides.
Conocarpus eocenicus.

Besides the two fungi, which are parasitic forms, the list includes one marsh fern, two aquatic monocotyledons, a marsh grass, a strand palm, and 13 dicotyledons, of which two are mangrove plants that grow in muddy tidal waters and at least six are typically strand plants that grow in the jungle of sandy beaches behind beach ridges in a subtropical climate. The most abundant forms are the *Acrostichum* and the *Dodonaea*, and almost as plentiful are the leaves of the *Ficus*, *Conocarpus*, and the thatch palm (*Thrinax*).

The remaining localities in Georgia where Jackson plants have been found show exposures of material similar to that around Grovetown—that is, massive to laminated clay which is locally known as fuller's earth. These outcrops are scattered from east to west as far as the locality 10 miles south of Macon, which is near Ocmulgee River, on the border of Bibb and Twiggs counties. At this locality, which is one of the most prolific in the Jackson, the following 13 species have been obtained from the Twiggs clay member of the Barnwell formation:

Sphaerites claibornensis.
Acrostichum georgianum.
Pteris inquirenda.
Potamogeton sp.
Ficus claibornensis.
Pisonia claiborniana.
Mimosites georgianus.
Cupanites nigricans.
Dodonaea viscosoides.
Malapoenna sp.
Rhizophora eocenica.
Conocarpus eocenicus.
Carpolithus najasoides.

These plants include two or three forms that are not found at the other localities, but the general facies of the flora is exactly the same, and the beds are undoubtedly of the same age. No palms have been collected from this locality, but otherwise there are the same plants of the beach jungle and the *Acrostichum* and mangrove swamps that have been already mentioned in connection with the Grovetown localities. An additional *Potamogeton* occurs here, as well as seeds of a *Najas*-like plant, so that undoubtedly here also we are dealing with the flora which lived along the shores of an estuary. No fossil plants have yet been discovered in the deposits of Jackson age in Alabama, which are prevailingly marine and more or less calcareous.

There are two localities in Mississippi where fossil plants have been collected, both of them in the vicinity of Jackson. The locality 8 miles south of Jackson has furnished only petrified wood, but the other, 10 miles north of Jackson, furnishes a small but interesting florule. This florule is found in the Forest Hill sand, which lies between the marine fossiliferous Jackson and the marine Vicksburg and which recent students place in the Vicksburg group.[14] The following section, given by Hopkins,[15] well illustrates the character of the materials:

Section of Forest Hill sand at Rocky Hill Church, 10 miles north of Jackson, Miss.

	Ft.	in.
Mariana (?) limestone:		
Hard and soft layers of limestone	25	
Forest Hill sand:		
Massive yellow sand	4	
Brown carbonaceous gypsiferous clay	1	
Micaceous sand with clay laminae	12	
Sand and some clay	4	
Micaceous sand with clay laminae	7	4
Sand alternating with thin clay beds	19	6
Hard yellow sand with little clay	8	3
Argillaceous sand, becoming dominantly clayey below	16	1
Jackson (?) formation:		
Clay, slightly sandy above, grading downward to plastic gray clay of Jackson type	27	6
	123	5

The following plants have been recognized from this outcrop of Forest Hill sand:

Lygodium kaulfussi.
Ficus unionensis.
Banksia jacksonensis.
Pisonia jacksoniana.
Mimosites mississippiensis.
Oreopanax mississippiensis.
Apocynophyllum texensis.

It is possible and even probable that the Forest Hill sand may be partly Vicksburg in age, but there can be little doubt that this florule belongs in the Jackson. These sands undoubtedly represent littoral and continental deposits that mark the oscillation of the strand in this area between Jackson and Vicksburg time, and the thin bed of lignite, which usually intervenes between them and the marine Vicksburg, confirms the floral evidence that these sands are of Jackson age.

Three localities in western Tennessee, which are more or less doubtfully referred to the Jackson epoch, are Randolph Bluff and Slip in Hill, in Tipton County, and Cane Creek, in Obion County. Though the plants are few in number and poorly preserved, they are of the utmost importance, for they furnish the clue to the interpretation of the bluish lignitic clays of Shelby and Tipton counties. Unfortunately the precise age of these outcrops has not been conclusively established.

In connection with the extended study of the underground waters during the development of the public water supply for Memphis, bluish clays from 150 to 200 feet in thickness were reported by Glenn [16] at the top of the Lagrange formation. He speaks of them as the clay member of the Lagrange formation. These beds are almost entirely covered by the so-called "Lafayette" and loess or are cut out in the Mississippi bottom, so that exposures are very scarce, and the data from well records are unreliable. The beds outcrop toward the eastern boundary of Shelby County and extend northward beyond Randolph in Tipton County. They reappear west of the Mississippi bottom in Crowleys Ridge in Arkansas. The section exposed in ravines at the bridge across Wolf River about 1 mile north of Raleigh and 10 miles northeast of Memphis shows the following sequence:

Section on Wolf River near Raleigh, Tenn.

	Feet.
Loess:	
1. Brownish massive loam which becomes somewhat coarsely sandy toward the base, about	33
"Lafayette" formation:	
2. Gravel bed composed of angular flint and more rounded and scattered quartz pebbles, the largest of which are 3 inches in diameter, about	2
3. Coarse ferruginous massive or in places stratified and cross-bedded loose to case-hardened sand, which contains scattered pebbles and local ledges of iron sandstone or conglomerate toward the base, about	20

[14] Cooke, C. W., Correlation of the deposits of Jackson and Vicksburg ages in Mississippi and Alabama: Washington Acad. Sci. Jour., vol. 8, pp. 186–198, 1918. Lowe, E. N., Mississippi, its geology, geography, soil, and mineral resources: Mississippi Geol. Survey Bull. 14, p. 89, 1919.

[15] Hopkins, O. B., Structure of the Vicksburg-Jackson area, Miss., with special reference to oil and gas: U. S. Geol. Survey Bull. 641, p. 100, 1916.

[16] 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. 34, 1906.

Lagrange formation:	Feet.
4. Lignite or black carbonaceous clay	2–3
5. Massive fine loose sand	3–4
6. Laminated bluish-gray sand and clay that contain thin lignitic laminae and some yellowish and brownish layers	6
7. Laminated bluish arenaceous clay that contains carbonaceous films and poorly preserved fragmentary impressions of leaves of lower Jackson (?) age; exposed	4

The leaves preserved in bed No. 7 are in the form of much broken lignitic films of very little value for purposes of correlation and not certainly identifiable. Sections were prepared of the lignites, but these were found to be too decayed for determination.

Although I was unable to determine positively any of these leaf remains, because of their fragmentary condition, I believe that the lower part of this section is of Jackson age and is equivalent to the beds of lower Jackson age as developed at Randolph, Tenn., and in northeastern Arkansas. This determination of the age rests on the geographic and topographic position of the beds, their lithologic similarity to beds of similar position and known age in Crowleys Ridge, and the condition of preservation of the contained plant remains. (See Pl. XXV.)

The old Chickasaw Bluff at Randolph is now about a mile from Mississippi River, except during high-water stages, and about 2 miles below Randolph Landing. As active cutting is a thing of the past the bluff is now much covered with vegetation. My section agrees substantially with that given by Safford [17] at a time when the exposure was much better, so that I quote his section:

Section exposed at Randolph Bluff, Tenn.

	Feet
Bluff loam [loess]	68
Bluff gravel	24
Bluff lignite:	
A mass of dark-grayish laminated micaceous sand with lignitic woody fragments, leaves, etc. [of Jackson (?) age]. Laminae of sand alternate with other laminae containing more or less clay. Interstratified with these are two beds of lignite; the upper one 6 feet from the top and from 6 inches to 2 feet thick; the other, 12 feet lower and about 8 inches thick. Some thin laminae of lignite occur below this bed. This portion in all	48
Laminated sand like that above	42

[17] Safford, J. M., Geology of Tennessee, p. 429, 1869.

Mr. L. C. Glenn has furnished me with the following section, which was measured 3 miles below Randolph Landing:

Section measured 3 miles below Randolph Landing, Tenn.

	Feet.
Loess	65–70
Gravel	20–25
Pinkish clay	8
Fairly massive lignitic clay	8–12
Lignite	¾
Underclay	2½–3
Laminated sandy clay	35–40

The lignite is not compact, and considerable carbonaceous matter is scattered through the sands. Fragments of leaves are not uncommon but are poorly preserved and for the most part indeterminable. The state of preservation of the material is the same as that of the material at Raleigh, Tenn., and the lithology of the beds is also very similar to that at Raleigh. The following three species have been identified from Randolph:

Cupressites sudworthi.
Mespilodaphne caudata.
Mespilodaphne texana.

The bluffs on Mississippi River in western Kentucky near Hickman, in Fulton County, and Columbus, in Hickman County, are conspicuous landmarks. They were visited by Sir Charles Lyell, David Dale Owen, and Leo Lesquereux. Owen and Lesquereux discovered fossil plants at the Columbus bluff, and these were described by Lesquereux,[18] who referred them to the Pleistocene. Loughridge[19] subsequently described the outcrops in detail, naming them the "Hickman group," which he regarded as the oldest Eocene in the embayment region. Glenn[20] has also described these deposits. He discovered fossil plants near Hickman, and these were discussed by Knowlton, who referred them to the Pliocene. I visited the bluffs in 1913 and made collections which I referred to the Pleistocene.[21]

Most of the forms discovered were referred to the existing species which they most closely

[18] Lesquereux, Leo, On some fossil plants of recent formations: Am. Jour. Sci., 2d ser., vol. 27, pp. 364–365, 1859.

[19] Loughridge, R. H., Report on the geological and economic features of the Jackson's Purchase region, Kentucky Geol. Survey, 1888.

[20] 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. 38, 1906.

[21] Berry, E. W., The Mississippi River bluffs at Columbus and Hickman, Ky., and their fossil flora: U. S. Nat. Mus. Proc., vol. 48, pp. 293–303, pls. 12, 13, 1915.

resembled, although the matrix was coarse and the preservation not especially good. The uncritical character of some of these determinations would not have been realized had it not been for the field work of Bruce Wade, who studied this region in some detail during 1919 and made large collections of plants from the earlier known locality near Hickman and from several new localities extending southward into western Tennessee. At some of these localities the plants were more abundant and better preserved than those at the two localities that I visited. In particular certain arenaceous lenses stratigraphically above the plant-bearing horizon in the Hickman bluff contain a variety of strange fruits that have proved to be very puzzling. I recognized at once the improbability that these plants were young as Pleistocene, and this led to a more careful comparison of the previously identified forms with their existing relatives. In all the forms slight differences are apparent. A further fact that has simplified their study is our present knowledge of over a hundred species of plants from deposits of Jackson age, described in this paper, which were unknown at the time of my work on the plants from Hickman and Columbus.

The present study shows that Lesquereux, Knowlton, and particularly I myself were in error in referring this flora to the late Tertiary or Pleistocene. It is obviously considerably older. It can not be older than lower Jackson and may be considerably younger. It appears to have more in common with the Jackson flora than with any other flora known at the present time, and an account of it is therefore included in this paper. It is tentatively considered to be of upper Jackson age, although it may be somewhat younger, for the collection contains several types not known from the Jackson or Catahoula and apparently out of place in the environment that has been deduced for those times. I allude to forms like the *Planera*, *Liquidambar*, and *Hicoria*, which suggest a Miocene age, unless it is admitted, as many have thought, that these genera are of southern origin.

The sea has not been present in western Kentucky and Tennessee since early Jackson time. That the enormous interval of time between the upper Eocene and the present should be represented by continental deposits at some localities in the upper part of the Mississippi embayment is a reasonable assumption, and the two most promising places to expect such deposits are in the erosion remnants represented by Crowleys Ridge west of the present Mississippi River and the Chickasaw bluffs east of the river.

Much farther south well-defined continental deposits have been recognized in the Oligocene Catahoula sandstone and the overlying Miocene Hattiesburg clay. The Miocene Pascagoula clay is only part marine, and the Pliocene Citronelle formation is entirely nonmarine. It has not been possible to recognize any probable equivalents of these formations outside the region where the succession, attitude, and lithologic continuity of their sediments have not been destroyed.

It would be perfectly easy to detect far-removed remnants of contemporaneous beds by their fossil plants if a standard section were available, but unfortunately our knowledge of the Oligocene and Miocene floras of southeastern North America is extremely limited. A small flora of but 24 species has been described from the Catahoula sandstone,[22] and a still smaller flora of 13 species has been described from the Hattiesburg clay and Alum Bluff formation.[23] The Pliocene Citronelle formation has furnished 18 species of fossil plants.[24] None are known from the Pascagoula formation. These florules are much too small to furnish conclusive data for detailed comparison; nevertheless they show certain general features which can not be overlooked in an attempt to picture the evolution of floras in southeastern North America during the Oligocene and later Cenozoic. The florules of the Catahoula and its equivalents approach the tropical in character. The florule of the Alum Bluff and Hattiesburg shows a mixture of tropical and temperate forms, and that of the Citronelle is decidedly modern in its facies.

These considerations would seem to limit the age of the deposits under consideration to some horizon in the upper Oligocene or lower Miocene, and I would be disposed to so consider them were it not for a certain number of

[22] Berry, E. W., The flora of the Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98, pp. 227–251, pls. 55–60, 1917.

[23] Berry, E. W., The physical conditions indicated by the flora of the Calvert formation: Idem, pp. 41–59, pls. 7–10.

[24] Berry, E. W., The flora of the Citronelle formation: Idem, pp. 193–208, pls. 44–47.

forms that are common to the Jackson. This last consideration leads me to include them in the Jackson tentatively, for it is desirable to correct my former error at as early a date as possible, although, as I have indicated above, future work may show these deposits to be of Oligocene or early Miocene age, as they exhibit the same mingling of older warmer types with younger temperate types that is seen in the very small flora from the Alum Bluff sands and Hattiesburg clays.

The localities are seven in all, five in southwestern Kentucky and two in western Tennessee, one of which is in Tipton County and the other and the more important of the two in Obion County. Collectively these localities have furnished 30 identifiable forms, in addition to which there are a number that for one reason or another can not be identified at the present time. Of the 30 named species the following 14 are not known from localities outside this immediate area:

Bauhinia wadii.
Bignoniaceous fruit.
Cassia obionana.
Grewiopsis wadii.
Hicoria rostrataformis.
Lauraceous fruit.
Liquidambar sp.
Lonchocarpus anceps.
Menispermites carolinaformis.
Planera hickmanensis.
Rhamnites krugiodendroides.
Capparidocarpus sphericus.
Tecoma preradicans.
Ternstroemites variabilis.

Most of these are indicative of the older Tertiary in this latitude, but the *Menispermites*, *Planera*, and *Rhamnites* and, to a less degree, the *Tecoma* and *Hicoria* suggest younger Tertiary. The forms found in these deposits that have an outside distribution, embracing more than half the total number of species known from this region, are all forms that range throughout the Jackson (*Cedrela jacksoniana*, *Mespilodaphne texana*, *Pisonia jacksoniana*), or that are confined to the Fayette sandstone (*Burserites fayettensis*, *Hicoria jacksoniana*, *Palmocarpon* sp., *Papilionites erythrinaformis*), or that range from the part of the Catahoula sandstone which I consider to be of upper Jackson age into that part of it which is of Vicksburg age.

The distribution of the foregoing species would indicate that this flora lies near the boundary between the Jackson and the Vicksburg, or that it is late Jackson in age, but the considerable element of peculiar forms (14 species) introduces an uncertainty which it seems to me is insoluble at the present time. The two coniferophytes, *Glyptostrobus europaeus* and *Taxodium dubium*, are both probably polymorphic, and both have been recorded throughout the Tertiary in some regions. *Taxodium dubium* is not distinguishable with certainty from the existing *Taxodium* of this same region, and *Glyptostrobus europaeus* is unknown in either the Jackson or Vicksburg deposits. The distribution of this whole florule is shown in the accompanying table.

Five plant localities of Jackson age are known from Arkansas, including Crow Creek, on Crowleys Ridge, from which only a single species of *Laurinoxylon* has been described, and Red Bluff, on Arkansas River, from which a second poorly preserved *Laurinoxylon* is recorded.

White Bluff, on the south bank of Arkansas River, in Jefferson County, Ark., was visited by Owen,[25] who referred its lower portion to the Eocene and mentions the presence of *Cardita*, *Fusus*, *Corbula*, and other fossils. Sections were given by Call [26] in 1891 and by Harris [27] in 1894. Harris recorded fossil leaves from the upper part of the section and considered the shell marl at the base to be uppermost Claiborne or transitional between Claiborne and Jackson. I visited this outcrop in the summer of 1913. The materials show considerable lateral variation, and I attach no importance to the differences which appear between the following section and that given by previous observers. The section as it appeared in 1913 is shown in the accompanying diagram (fig. 5).

[25] Owen, D. D., Second report of a geological reconnaissance of Arkansas, p. 35, 1860.
[26] Call, R. E., The geology of Crowley's Ridge, Ark.: Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 7, 1891.
[27] Harris, G. D., The Tertiary geology of southern Arkansas: Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, pp. 87–91, fig. 16, 1894.

Flora doubtfully of Jackson age from western Kentucky and Tennessee.

	Kentucky.					Tennessee.		Distribution in other areas.
	Columbus.	One-half mile above Hickman.	Hickman, lower.	Hickman, upper.	Five miles south of Hickman.	Cane Creek.	Slip in Hill.	
Banksia jacksonensis		×				×		Forest Hill sand.
Bauhinia wadii			×					
Bignoniaceous fruit					×			
Burserites fayettensis		×						Fayette sandstone.
Carpolithus bumeliaformis				×	×			Vicksburg group.
Cassia obionana						×		
Cedrela jacksoniana						×		Throughout the Jackson.
Fagara catahoulensis coriacea		×		×				Vicksburg group.
Fagara catahoulensis elongata		×			×	×		Jackson and Vicksburg.
Fagara catahoulensis major				×				Do.
Glyptostrobus europaeus (?)						×		Throughout the Tertiary.
Grewiopsis wadii		×		×				
Hicoria jacksoniana	×		×		×			Fayette sandstone.
Hicoria rostrataformis		×		×		×		
Lauraceous fruit						×		
Liquidambar sp		×		×		×		
Lonchocarpus anceps				×		×		
Menispermites carolinaformis	×		×					
Mespilodaphne texana							×	Throughout the Jackson.
Paliurus catahoulensis					×	×		Vicksburg group.
Palm rays				×			×	
Palmocarpon sp				×		×		Fayette sandstone.
Papilionites erythrinaformis			×					Do.
Pisonia jacksoniana						×	×	Throughout the Jackson.
Planera hickmanensis		×	×	×	×	×		
Rhamnites krugiodendroides			×	×				
Solanocarpus sphericus				×				
Taxodium dubium		×				×		Throughout the Tertiary.
Tecoma preradicans	×		×					
Ternstroemites variabilis						×		

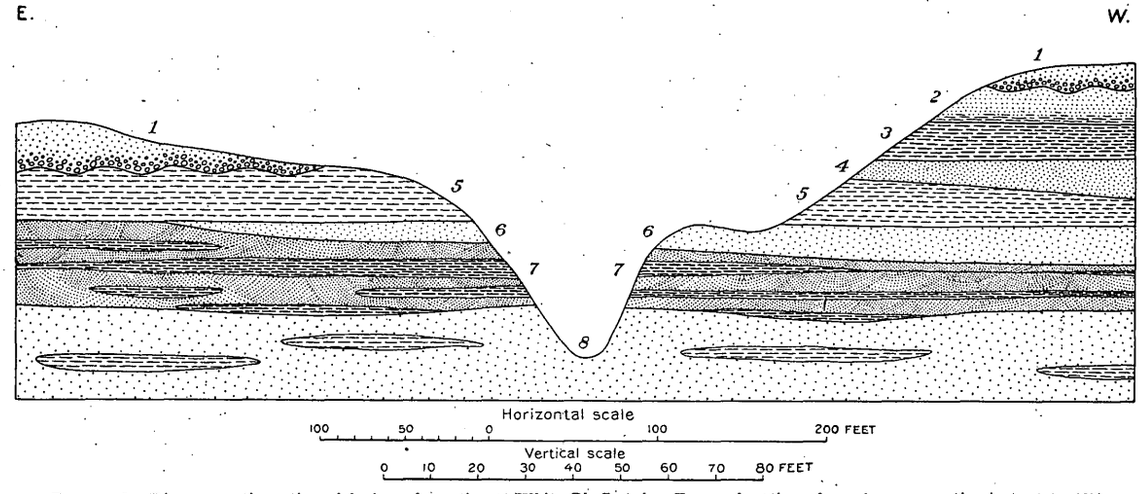


FIGURE 5.—Diagrammatic section of Jackson formation at White Bluff, Ark. For explanation of numbers see section in text (p. 103).

Section at White Bluff, Ark., somewhat generalized.

	Feet.
Pleistocene:	
1. Yellow sand with heavy gravel at base	5–10
Jackson formation:	
2. Sand grading downward into bed 3	8
3. Brownish laminated leaf-bearing clay	8
4. Lens of gray compact sand; maximum thickness	9
5. Brownish laminated clay that contains beds of loose earthy lignite and broken leaves	5–10
6. Gray compact sand; maximum thickness	8
7. Fine compact cross-bedded greenish sand interbedded with laminated lignitic leaf-bearing clay	10
8. Sparingly fossiliferous argillaceous, glauconitic, slightly lignitic, calcareous, ferruginous sand, more or less cross-bedded in the upper part	18–20

From a locality 2 miles south of New Edinburgh in Cleveland County, not visited by me, G. D. Harris collected the following plants:

Taxodium dubium.
Thrinax eocenica.
Ficus unionensis.
Cinnamomum spectabile.
Nectandra antillanafolia.
Myrcia sp.

In the summer of 1911 I made a considerable collection from a cut on the St. Louis, Iron Mountain & Southern Railway at McMurrains Crossing, 3.3 miles north of El Dorado, in Union County. The section, which has been described by Harris,[28] shows the sequence of materials that is illustrated in Figure 6. This section is apparently at the extreme base of the Jackson of this locality, as it shows continental

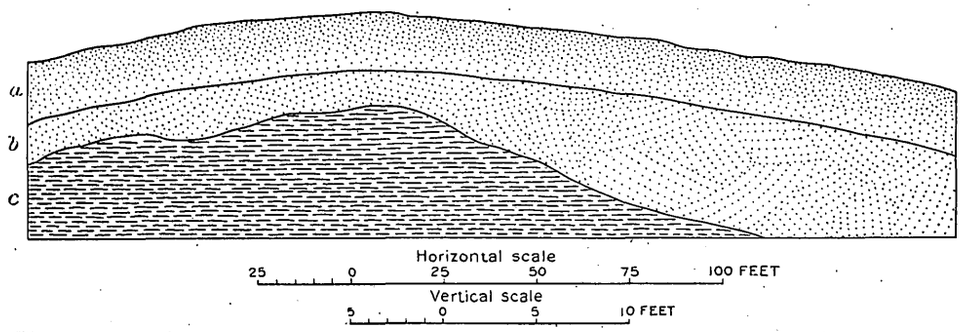


FIGURE 6.—Diagrammatic section of Jackson formation at McMurrains Crossing, Ark. *a*, Yellowish loamy sand, passing gradually into the underlying member, of which it is the weathered portion, 3 to 6 feet; *b*, fine gray to greenish cross-bedded, finely micaceous sand with clay laminae and pellets, 2 to 6 feet; *c*, more or less thinly laminated brownish sandy clay with gray sand films, more or less ferruginous, toward the top, carrying *Unio*, *Vivipara*, and numerous poorly preserved plants, maximum thickness 7 feet.

The identifiable leaves, few in number and poorly preserved, come from bed No. 7. Those in bed No. 3 that were noticed by Harris were all unidentifiable. There are also fragmentary remains of leaves in bed No. 5, especially toward the eastern end of the bluff. Beds Nos. 4, 5, and 6 are obviously lenses, for they thicken and thin along the face of the bluff. The unconformity noted by Harris is merely the result of the littoral character of the sediments, and I am convinced that the entire section is of Jackson age with the exception of bed No. 1, which is of Pleistocene age and is markedly unconformable on the underlying materials.

The following plants have been determined from this outcrop:

Pisonia jacksoniana.
Cedrela jacksoniana.
Mespilodaphne texana.

deposits transgressed by littoral sands at the beginning of the lower Jackson marine invasion of this region.

The following plants have been determined:

Equisetum sp.
Arundo pseudogoepperti.
Engelhardtia jacksonensis.
Myrica zachariensis.
Ficus unionensis.
Coccolobis claibornensis.
Mimosites spatulatus.
Cassia jacksoniana.
Dodonaea viscosoides.
Nectandra arkansana.
Cypselites jacksonensis.

There are five plant localities in the deposits of Jackson age in Louisiana, all of which are in beds referred to the Fayette sandstone by Deussen and Matson and contain but few plant remains that are determinable.

[28] Harris, G. D., op. cit., p. 140.

There are eleven plant localities in the deposits of Jackson age in Texas. Four of these localities have furnished but a single species, and the only prolific localities are one near Miraflores, in Webb County, from which 14 species of plants were collected by G. C. Matson and 5 additional species were collected by A. C. Trowbridge in 1920, and several localities in Brazos County, from which extensive collections have been sent to me by O. M. Ball. As I have been unable to visit any of these outcrops I can give only the following sections, which were furnished by Alexander Deussen, who made most of the collections studied by me.

Section on Colorado River 1 mile west of Plum, Fayette County, Tex.

	Feet.
Pleistocene terrace No. 3.	
Fayette sandstone (of Jackson age):	
Hard blue semiquartzitic sandstone	5–6
Lenses of white clay with *Pisonia jacksoniana*	2
Brown clay	15

Section exposed on W. F. Hamilton league about 3 miles southeast of West Point, Fayette County, Tex.

	Feet.
Pleistocene terrace materials	2
Fayette sandstone:	
Soft white massive volcanic ash that carries fossil leaves	3
Brown shale	10

The fossil plants identified from the Fayette sandstone at this outcrop are *Sabalites vicksburgensis*, *Calocarpum viridiformis*, and *Apocynophyllum texensis*.

Section on branch of Yegua Creek about 1½ miles northwest of Somerville and one-fourth mile west of the Gulf, Colorado & Santa Fe Railway in Burleson County, Tex.

	Feet.
Quaternary:	
Brown loam soil that contains small pebbles of quartz and jasper	1½
Fayette sandstone:	
Lens of laminated shale interbedded with thin sand beds; maximum thickness	5⅛
Massive brown shale that contains flakes of gypsum and leaves of *Bombacites jacksonensis*	13⅛

This outcrop, which is on the Paul Taylor place, has furnished two or three fragments of what appears to be very promising material. The only determinable form is the *Bombacites*, which occurs elsewhere near Christie, La., and near Miraflores, in Webb County, Tex.

The following plants were collected by O. M. Ball from Alum Creek, in the S. W. Robertson League, about 3 miles east of Wellborn, Brazos County, Tex.:

Apocynophyllum grevilleafolium.
Apocynophyllum texensis.
Bombacites jacksonensis.
Burserites fayettensis.
Conocarpus eocenicus.
Cedrela jacksoniana.
Dodonaea viscosoides.
Dryophyllum brevipetiolatum.
Ficus claibornensis.
Inga jacksoniana.
Mespilodaphne caudata major.
Mespilodaphne texana.
Nectandra antillanafolia.
Pisonia balli.
Pisonia jacksoniana.
Sophora claiborniana.

The two species of *Apocynophyllum*, *Inga jacksoniana*, *Pisonia jacksoniana*, and *Sophora claiborniana* are the most abundant forms. This florule is of especial interest, as it comprises 16 species and comes from the region where the "Wellborn formation" (Fayette sandstone) was originally described. The beds are of Jackson age.

An extensive lens of fine white clay, locally known as kaolinite, 15 feet in maximum thickness, occurs in the Fayette sandstone at several openings from 1½ to 3 miles east of Wellborn, Brazos County, Tex.

The horizon is probably about the same as that from which the flora listed from Alum Creek was collected. Around the borders of this clay lens fossil plants, beautifully preserved, are not uncommon. The following species were collected from this locality by O. M. Ball:

Apocynophyllum grevilleafolium.
Apocynophyllum texensis.
Canna jacksoniana.
Cinnamomum spectabile?
Combretum petraflumense.
Diospyros mirafloriana.
Fagara catahoulensis major.
Ficus mississippiensis (Lesquereux).
Inga jacksoniana.
Mespilodaphne caudata major.
Nectandra antillanafolia.
Sabalites vicksburgensis.

This is a typical mesophytic plant association and includes novelties in a beautiful new *Canna* and a form of *Ficus* not heretofore known at horizons younger than the Wilcox in the embayment region. It also includes abundant remains of a fan palm, some of the leaves of which are complete and stand upright in the clay. The most abundant form at this locality is the *Nectandra* in all sizes, and this, together with the palm and *Apocynophyllum grevilleafolium*, are the most abundant species.

At a locality in the Barrera League, about 3 miles northeast of Millican, in Brazos County, the following plants have been collected by O. M. Ball:

Anacardites balli.
Ardisia sp.
Buettneria jacksoniana.
Ceanothus jacksonensis.
Cedrela jacksoniana.
Coccolobis columbianus.
Combretum petraflumense.
Euonymus santotomasensis.
Ficus brazosensis.
Ficus sp.
Mespilodaphne jacksonensis.
Mespilodaphne texana.
Myrcia catahoulensis.
Oreodaphne brazosensis.
Palmocarpon sessile.
Phoenicites sp.
Pteris inquirenda.
Sapotacites millicanensis.
Smilax fayettensis.

This florule of 19 forms has the same significance as the others found in these kaolinite beds in the Fayette but contains a number of species not found at the other outcrops, especially the palm fruits, leaves of *Smilax*, and large leaves of *Buettneria*.

Another prolific locality in the kaolinite lenses of the Fayette is at Mossy Creek, 3 miles southwest of Wellborn, in Brazos County. The following species have been collected from this outcrop by O. M. Ball:

Antholithes balli.
Ardisia sp.
Buettneria jacksoniana.
Bumelia balli.
Caenomyces jacksonensis.
Cedrela jacksoniana.
Chrysophyllum preoliviforme.
Citharexylon brazosense.
Combretum petraflumense.
Conocarpus eocenicus?
Dodonaea viscosoides.
Ficus brazosensis.
Marchantites stephensoni.
Mespilodaphne texana.
Mimosites georgianus.
Myrcia ambiguaformis.
Nectandra antillanafolia.
Nipadites burtini umbonatus.
Nyssa jacksoniana.
Papilionites erythrinaformis?
Phoenicites sp.
Rhamnites krugiodendroides.
Sapotacites millicanensis.
Tilia jacksoniana.

This locality is remarkable for the diversity of its flora and for the abundance of the very variable leaves of *Combretum*, which must have been growing in the immediate vicinity in large numbers during this part of the Jackson. It contains a fine example of the rare *Marchantites stephensoni* and a characteristic new species of *Tilia*, the first representative of this genus that has been found in the Tertiary of the Atlantic Coastal Plain. Notable is the presence at this locality of the fruits of the Eocene littoral palm *Nipadites*, whose discovery here makes the range of this genus in the Mississippi embayment from Wilcox to Jackson, thus paralleling its range in the Old World.

A small florule from a locality at Piedmont, Grimes County, collected by O. M. Ball, contains the following species:

Anacardites balli.
Calocarpum viridiformis.
Carpolithus piedmontensis.
Dryophyllum brevipetiolatum.
Fagara catahoulensis var.

Collections made at a locality on Mill Creek, Brazos County, by O. M. Ball contain undeterminable fragments of dicotyledonous leaves and those of *Cedrela jacksoniana*.

The total flora found in the kaolinite lenses of the Fayette sandstone in Brazos and adjoining counties, a knowledge of which we owe almost entirely to the energy and cooperation of Prof. O. M. Ball, of the Agricultural and Mechanical College of Texas, consists of the following 53 species:

Anacardites balli.
Antholithes balli.
Apocynophyllum grevilleafolium.
Apocynophyllum texensis.
Ardisia sp.
Bombacites jacksonensis.
Buettneria jacksoniana.
Bumelia balli.
Burserites fayettensis.
Caenomyces jacksonensis.
Calocarpum viridiformis.

Canna jacksoniana.
Carpolithus piedmontensis.
Cedrela jacksoniana.
Chrysophyllum preoliviforme.
Cinnamomum spectabile?
Citharexylon brazosensis.
Coccolobis columbiana.
Combretum petraflumense.
Conocarpus eocenicus.
Diospyros miraflorianus.
Dodonaea viscosoides.
Dryophyllum brevipetiolatum.
Euonymus santotomasensis.
Fagara catahoulensis major.
Fagara catahoulensis var.
Ficus claibornensis.
Ficus brazosensis.
Ficus mississippiensis.
Ficus sp.
Inga jacksoniana.
Marchantites stephensoni.
Mespilodaphne caudata major.
Mespilodaphne jacksonensis.
Mespilodaphne texana.
Mimosites georgianus.
Myrcia ambiguaformis.
Myrcia catahoulensis.
Nectandra antillanafolia.
Nipadites burtinii umbonatus.
Nyssa jacksoniana.
Palmocarpon sessile.
Papilionites erythrinaformis.
Phoenicites sp.
Pisonia balli.
Pisonia jacksoniana.
Pteris inquirenda.
Rhamnites krugiodendroides.
Sabalites vicksburgensis.
Sapotacites millicanensis.
Smilax fayettensis.
Sophora claiborniana.
Tilia jacksoniana.

The foregoing list presents the largest florule as yet known from deposits of Jackson age, and it contains representatives of many species not found at any other localities. It is distinctly coastal in its general facies and contains many Claiborne elements as well as forms prenuncial of the Oligocene. The question of the origin of these lenses of relatively pure kaolinite in an essentially sandy littoral formation, like that of the origin of the sedimentary kaolins in the Cretaceous of South Carolina and Georgia, is a phase of environmental interpretation that is decidedly uncertain at the present time, but it is hoped that the fossil plants may help toward a solution of the problem.

At a locality about 45 miles southeast of Laredo and about 4 miles north of Miraflores ranch house, in Webb County, Tex., a light volcanic ash contains well-preserved leaves that are somewhat sparingly represented. A considerable collection was made by G. C. Matson and A. C. Trowbridge. The following species are represented:

Apocynophyllum grevilleafolium.
Apocynophyllum texensis.
Bombacites jacksonensis.
Cinnamomum sp.
Coccolobis claibornensis?
Conocarpus eocenicus.
Diospyros mirafloriana.
Inga jacksoniana?
Mespilodaphne texana.
Myristica catahoulensis?
Nectandra antillanafolia.
Papilionites erythrinaformis.
Pisonia jacksoniana.
Sabalites vicksburgensis.
Sapindus dentoni.
Sapotacites miraflorianus.
Sophora claiborniana.
Terminalia phaeocarpoides.
Ternstroemites claibornensis?

Only two of the foregoing species, namely, the *Papilionites* and *Sapotacites*, are peculiar to this outcrop. The age indicated is either middle or upper Jackson.

LOCAL DISTRIBUTION OF THE SPECIES.

The following table shows the localities at which the different species of the Jackson flora have been found and also gives the occurrence of the species in the Wilcox, Claiborne, and Vicksburg deposits.

Distribution of the Jackson flora.

	Georgia.						Mississippi.		Tennessee.			Kentucky.				Arkansas.					Louisiana.					Texas.													
	Grovetown.	Phinizy Gully.	2 miles east of Gibson.	¼ mile southwest of Forrest Station.	10 miles south of Macon.	13½ miles west of Sandersville.	8 miles south of Jackson.	11 miles north of Jackson.	Cane Creek, Obion County.	Slip in Hill, Tipton County.	Randolph Bluff, Tipton County.	Columbus, Hickman County.	Hickman, Fulton County.	¼ mile north of Hickman, Fulton County.	5 miles south of Hickman, Fulton County.	Crow Creek. St. Francis County.	White Bluff, Jefferson County.	Red Bluff, Jefferson County.	McMurrain's Crossing, Union County.	2 miles south of New Edinburgh, Cleveland County.	North of Pollock, Grant Parish.	1 mile east of Gailbreath, Rapides Parish.	1½ miles northeast of Christie.	3 miles north of Hornbeck, Sabine Parish.	4 miles northeast of Hornbeck, Sabine Parish.	1 mile northeast of Pennington, Trinity County.	Caney and White Rock creeks, Trinity County.	International & Great Northern Ry. cut, Trinity County.	Alum Creek, Brazos County.	Near Wellborn, Brazos County.	Stryker, Polk County.	Hamilton League, Fayette County.	Near Riverside, Walker County.	Near Somerville, Burleson County.	Near Miraflores, Webb County.	Hibbensville-Zapato road, Webb County.	Wilcox group.	Claiborne group.	Vicksburg group.
Sphaerites clàibornensis	×				×																																		
Pestalozzites minor	×																																						×
Caenomyces jacksonensis																														×									
Cladosporites fasciculatus							×																			×												×	
Marchantites stephensoni																														×							×		
Equisetum sp																				×																			
Lygodium kaulfussi								×																														×	
Lygodium mississippiensis																											×												×
Acrostichum georgianum		×	×		×																																	×	
Pteris inquirenda					×																																	×	
Cupressites sudworthi											×																												×
Taxodium dubium									×					×						×																	×		
Glyptostrobus europaeus									×																												×	×	
Potamogeton megaphyllus		×																																					
Potamogeton sp					×																																		
Pistia claibornensis	×																																						
Arundo pseudogoepperti		×		×															×																			×	
Smilax fayettensis																														×									
Canna jacksoniana																														×									
Thrinax eocenica	×	×																		×																		×	
Phoenicites occidentalis																												×											
Phoenicites sp																														×									
Sabalites vicksburgensis																											×				×	×			×	×			×
Palmoxylon lacunosum																					×	×																	×
Palmocarpon sessile																														×									
Palmocarpon sp									×				×																								?	×	?

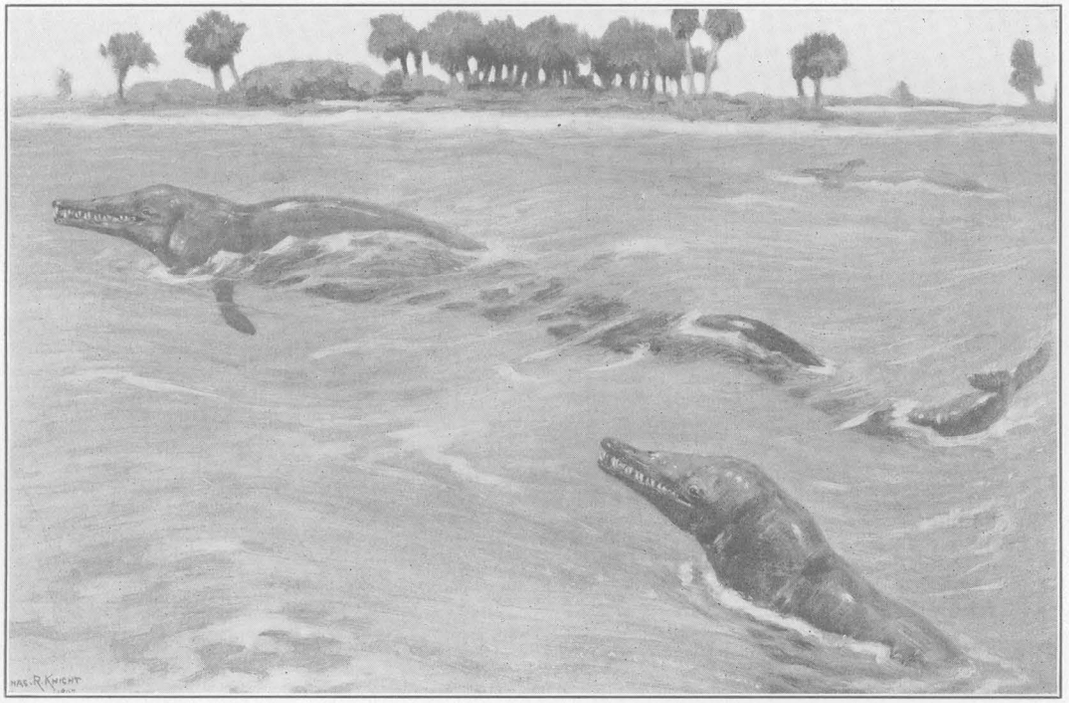
Distribution of the Jackson flora—Continued.

	Georgia.						Mississippi.		Tennessee.			Kentucky.				Arkansas.					Louisiana.					Texas.													
	Grovetown.	Painizy Gully.	2 miles east of Gibson.	¼ mile southwest of Forrest Station.	10 miles south of Macon.	13½ miles west of Sandersville.	8 miles south of Jackson.	11 miles north of Jackson.	Cane Creek, Obion County.	Slip in Hill, Tipton County.	Randolph Bluff, Tipton County.	Columbus, Hickman County.	Hickman, Fulton County.	½ mile north of Hickman, Fulton County.	5 miles south of Hickman, Fulton County.	Crow Creek, St. Francis County.	White Bluff, Jefferson County.	Red Bluff, Jefferson County.	McMurrain's Crossing, Union County.	2 miles south of New Edinburgh, Cleveland County.	North of Pollock, Grant Parish.	1 mile east of Gaillbreath, Rapides Parish.	1½ miles northeast of Christie.	3 miles north of Hornbeck, Sabine Parish.	4 miles northeast of Hornbeck, Sabine Parish.	1 mile northeast of Pennington, Trinity County.	Caney and White Rock creeks, Trinity County.	International & Great Northern Ry. cut, Trinity County.	Alum Creek, Brazos County.	Near Wellborn, Brazos County.	Stryker, Polk County.	Hamilton League, Fayette County.	Near Riverside, Walker County.	Near Somerville, Burleson County.	Near Miraflores, Webb County.	Hibbensville-Zapato road, Webb County.	Wilcox group.	Claiborne group.	Vicksburg group.
Nipadites burtini umbonatus																														×							×		
Palm rays										×			×																										
Engelhardtia jacksonensis																			×																				
Hicoria jacksoniana												×	×		×																							×	
Hicoria rostrataformis									×				×	×																									
Myrica zachariensis																			×																				
Castanea claibornensis	×																																						
Dryophyllum brevipetiolatum																									×		×	×										×	
Momisia americana		×																																				×	
Planera hickmanensis									×				×	×	×																								
Ficus unionensis								×											×	×																		×	
Ficus mississippiensis																														×							×		
Ficus claibornensis	×			×	×																																		
Ficus brazosensis																														×									
Ficus newtonensis				×																																		×	
Ficus sp																														×									
Banksia jacksonensis								×	×					×																									
Coccolobis claibornensis																			×																×			×	
Coccolobis columbianus																														×								×	
Pisonia jacksoniana								×	×	×							×																		×				
Pisonia balli																													×										
Pisonia claiborniana		×			×																																	×	
Myristica catahoulensis																											×								×				
Anona texana																										×													
Menispermites carolinaformis												×	×																										

Capparidocarpus sphericus													X																	X									
Inga jacksoniana																													X						X				
Mimosites spatulatus																			X																				
Mimosites georgianus	X	X			X																																		X	
Mimosites mississippiensis								X																															
Cassia georgiana			X																																				
Cassia jacksoniana																			X																				
Cassia obionana									X																													
Bauhinia wadii													X																									
Sophora claiborniana		X	X																															X			X	
Sophora wilcoxiana			X																																	X		
Papilionites erythrinaformis													X																					X				
Lonchocarpus anceps									X				X																									
Liquidambar sp									X				X	X																								
Fagara catahoulensis orbiculata																															X								X
Fagara catahoulensis elongata														X	X																X								X
Fagara catahoulensis major													X																	X									X
Fagara catahoulensis coriacea													X	X																									X
Cedrela jacksoniana									X								X								X													X	
Banisteria texana																															X								
Burserites fayettensis														X											X						X		X						
Anacardites balli																														X									
Cupanites nigricans					X																																	
Dodonaea viscosoides	X	X		X	X														X																		X	
Sapindus dentoni																																			X			X	
Sapindus georgianus		X																																			X	
Ceanothus jacksonensis																														X									
Paliurus catahoulensis									X						X																								X
Euonymus santatomasensis																														X								X	
Rhamnites krugiodendroides													X																									
Grewiopsis wadii													X	X																								
Tilia jacksoniana																														X									
Bombacites jacksonensis																							X											X	X				
Dombeyoxylon jacksonensis																								X														
Buettneria jacksoniana																														X								?	
Sterculia cf. S. labruscoides																															X								
Ternstroemites claibornensis																																			X			X	
Ternstroemites variabilis									X																													
Cinnamomum angustum		X																																			X	
Cinnamomum spectabile																				X																		
Cinnamomum sp																																			X				
Mespilodaphne caudata											X																										X	
Mespilodaphne caudata major																													X									
Mespilodaphne columbiana																				X																		X	
Mespilodaphne jacksonensis																														X									
Mespilodaphne texana										X	X						X											X							X				
Oreodaphne brazosensis																														X									
Nectandra arkansana																			X																			X	
Nectandra antillanafolia																												X	X						X			X	
Nectandra gosportensis jacksonensis																												X										
Malapoenna sp					X																																	
Laurinoxylon branneri																X																						
Laurinoxylon (?) sp																		X																				
Lauraceous fruit									X																													
Rhizophora eocenica		X		X	X	X																																

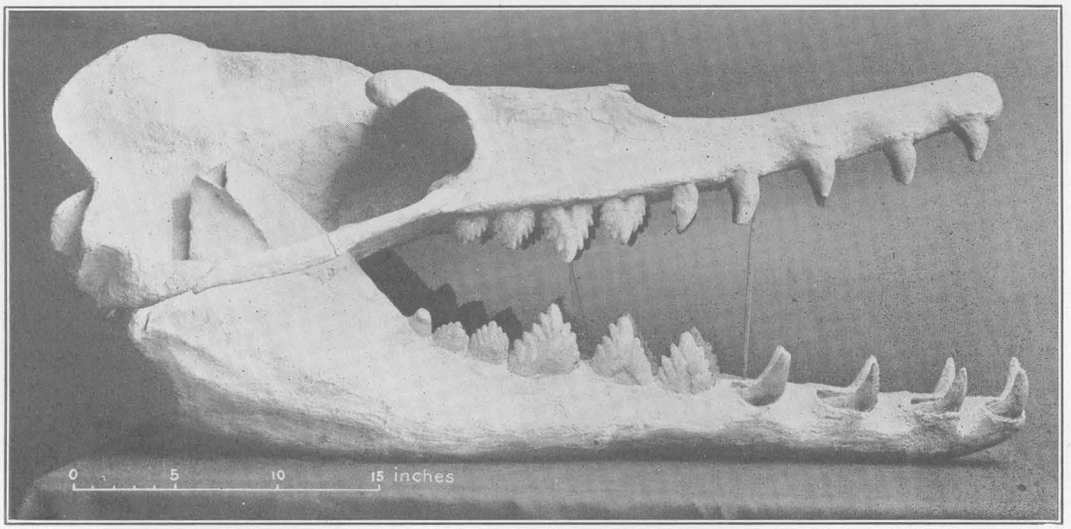
Distribution of the Jackson flora—Continued.

	Georgia.						Mississippi.		Tennessee.			Kentucky.				Arkansas.					Louisiana.					Texas.													
	Grovetown.	Phinizy Gully.	2 miles east of Gibson.	½ mile southwest of Forrest Station.	10 miles south of Macon.	13½ miles west of Sandersville.	8 miles south of Jackson.	11 miles north of Jackson.	Cane Creek, Obion County.	Slip in Hill, Tipton County.	Randolph Bluff, Tipton County.	Columbus, Hickman County.	Hickman, Fulton County.	½ mile north of Hickman, Fulton County.	5 miles south of Hickman, Fulton County.	Crow Creek, St. Francis County.	White Bluff, Jefferson County.	Red Bluff, Jefferson County.	McMurrain's Crossing, Union County.	2 miles south of New Edinburgh, Cleveland County.	North of Pollock, Grant Parish.	1 mile east of Gailbreath, Rapides Parish.	1½ miles northeast of Christie.	3 miles north of Hornbeck, Sabine Parish.	4 miles northeast of Hornbeck, Sabine Parish.	1 mile northeast of Pennington, Trinity County.	Caney and White Rock creeks, Trinity County.	International & Great Northern Ry. cut, Trinity County.	Alum Creek, Brazos County.	Near Wellborn, Brazos County.	Stryker, Polk County.	Hamilton League, Fayette County.	Near Riverside, Walker County.	Near Somerville, Burleson County.	Near Miraflores, Webb County.	Hibbensville-Zapato road, Webb County.	Wilcox group.	Claiborne group.	Vicksburg group.
Terminalia phaecarpoides	×																						×						×						×			×	
Conocarpus eocenicus	×	×		×	×																		×												×			×	
Combretum petraflumense																														×								×	
Myrcia bentonensis																				×										×							×		
Myrcia ambiguaformis																														×									
Myrcia catahoulensis																											×												×
Oreopanax mississippiensis								×																														×	
Ardisia sp																														×									
Nyssa texana																												×										×	
Nyssa jacksoniana																														×									
Calocarpum viridiformis																									×							×							
Chrysophyllum oliviforme																														×									
Sapotacites miraflorianus																																			×				
Sapotacites millicanensis																														×									
Bumelia balli																														×									
Diospyros mirafloriana																																			×				
Apocynophyllum texensis								×																			×					×			×			×	
Apocynophyllum grevilleafolium																									×				×						×			×	
Tecoma preradicans												×	×																										
Citharexylon brazosensis																														×									
Carpolithus callitriformis																												×											
Carpolithus najasoides					×																																		
Carpolithus bumeliaformis									×				×																										×
Carpolithus balli																														×									
Cypselites jacksonensis																			×																				
Leguminosites sp		×																																					
Antholithes balli																														×									



A. RESTORATION OF THE JACKSON COAST OF ALABAMA.

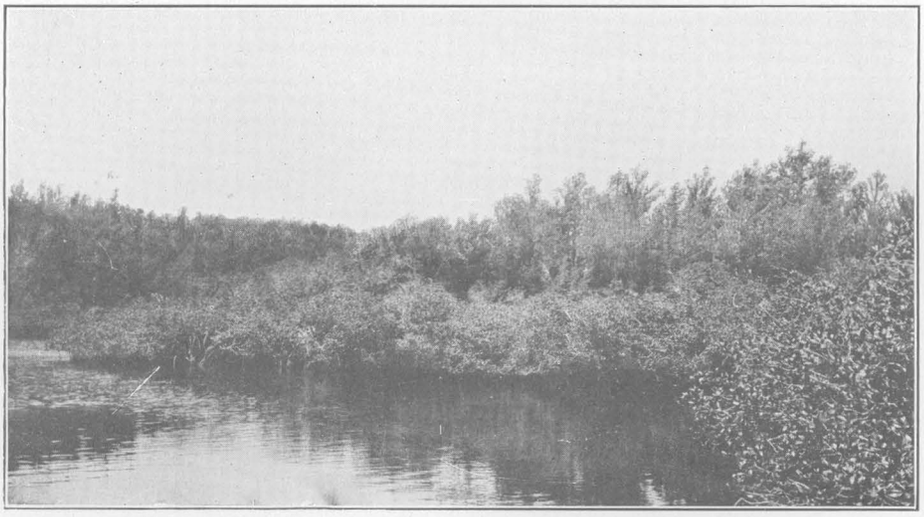
Zeuglodon in the foreground. Reproduced by courtesy of the American Museum of Natural History.



B. RESTORATION OF A SKULL OF ZEUGLODON.

A. ACROSTICHUM AUREUM ALONG CALOOSAHATCHEE RIVER, FLA.

Photograph by John W. Harshberger.



B. MANGROVES IN BERMUDA, SHOWING THE CHARACTER OF THE VEGETATION IN EARLY JACKSON TIME IN THE ESTUARY AT GROVETOWN, GA.

Photograph by Harvey Bassler.

THE JACKSON FAUNAS.

The richly fossiliferous marine beds of certain localities in the Jackson have been favorite collecting grounds for students of marine invertebrates for many decades, and a large number of species have been recorded. The fauna as a whole has never received monographic treatment, although parts of it have been revised by C. W. Cooke, so that very many new species await the consideration of systematists. Mr. Cooke informs me in a letter dated May 3, 1915, that there are in the National Museum collections 214 named species of mollusks and corals from Jackson, Miss. About 50 of these species, or nearly 23 per cent, are common to the Claiborne, and the genera of the Jackson are prevailingly the same as the genera of the Claiborne, so that the facies of the invertebrate fauna of the Jackson sea was not markedly different from that of the Claiborne sea. The most spectacular element in the Jackson fauna is *Zeuglodon*, a great marine mammal or ancestral cetacean (Pl. XXVI), which reached a length of 60 or 70 feet but was slender in form and a powerful swimmer and diver. These Zeuglodons must have been present in large numbers in the ancient Gulf of Mexico during Jackson time, possibly as migrants from the Mediterranean Sea of the Old World, for their bones are found from North Carolina and Florida to Arkansas and Louisiana. Teeth of several species of shark are common in the Jackson, and a small cetacean (*Dorudon serratus* Gibbs), a large aquatic snake (*Pterosphemus schucherti* Lucas), and a fresh-water turtle (*Hadrianus schucherti* Hay) are associated with the two species of *Zeuglodon* or *Basilosaurus*, as it is more properly called, but no traces of terrestrial vertebrates have been discovered.

The terrestrial faunas nearest the age of the Jackson are those of the top of the Bridger formation in southwestern and southern central Wyoming and of the Uinta formation and underlying late Eocene deposits of northern Utah.

Although these faunas are geographically remote from the area of Jackson sedimentation they are interesting in that they show very slight changes when compared with the middle Eocene faunas of the same region and also in their indications of a well-watered country of interspersed savannas and forests in what subsequently became a semiarid region. The Rocky Mountain types of Jackson time include several genera of camelids, large amblypods (*Eobasileus*), rhinoceroses (*Amynodon*), several genera of titanotheres (*Dolichorhinus, Diplacodon, Manteoceras*), giant pigs (*Achaenodon*), horses (*Epihippus*), tapirs (*Isectolophus*), and primitive carnivores or creodonts.

BOTANIC CHARACTER OF THE JACKSON FLORA.

The Jackson flora, although it has been found at 40 localities scattered from a point near Savannah River in Georgia westward to a point within a few miles of the Rio Grande in southwestern Texas, is unfortunately small and numbers but 133 species. In this respect it is somewhat larger than the Claiborne flora and about one-fourth the size of the Wilcox flora. This meagerness of the known Jackson flora can not be ascribed to any actual diminution in the flora that grew along the coasts of southeastern North America throughout the Tertiary period but must be explained by the character of the Jackson sediments, which are largely either coarse sands or marine marls and limestones throughout the greater part of their outcrop. The lack of exploration also is a cause of the meagerness of the flora, for not only is the actual amount of field work less than usual, but I have not had any opportunities of collecting from more than one-third of the known localities. Though the Jackson flora will probably never be as thoroughly known as that of the Wilcox, it may receive many additions as the different areas from Georgia to Mexico are studied in detail.

The Jackson flora, as described in this preliminary report, consists of 133 species, as compared with 90 in the Claiborne or middle Eocene and 353 in the Wilcox or lower Eocene. This is an extremely small basis for any discussion of floral facies, physical conditions, or correlation, and hence the conclusions derived from it are only tentative in character.

These 133 species comprise 4 fungi, a *Marchantites*, 4 ferns, an equisetum, 2 or possibly 3 gymnosperms, 15 monocotyledons, and 106 dictyledons. They represent 89 genera in 52

families and 32 orders. The orders with more than two species are the following:

Fungi, 4.	Geraniales, 7.
Filicales, 4.	Sapindales, 5.
Coniferales, 3.	Rhamnales, 4.
Arecales, 8.	Malvales, 6.
Juglandales, 3.	Thymeleales, 16.
Urticales, 8.	Myrtales, 7.
Chenopodiales, 3.	Umbellales, 3.
Ranales, 3.	Ebenales, 6.
Rosales, 13.	

This list shows that the two most abundantly represented orders are the Rosales, with 13 species, almost entirely belonging to the leguminous alliance, and the Thymeleales, with 16 species, all of which belong to the family Lauraceae.

The families with 3 or more species are the following:

Arecaceae, 8.	Rutaceae, 4.
Juglandaceae, 3.	Sapindaceae, 4.
Moraceae, 6.	Rhamnaceae, 4.
Nyctaginaceae, 3.	Lauraceae, 16.
Mimosaceae, 4.	Combretaceae, 3.
Caesalpiniaceae, 4.	Myrtaceae, 3.
Papilionaceae, 4.	Sapotaceae, 5.

All but the last of these belong to the more primitive choripetalous group of families. There are 86 species of Choripetalae, or more than 85 per cent of the dicotyledons represented, and but 12 species, or less than 15 per cent, belong to the later and more specialized Gamopetalae.

Among the relics of former vegetation that carry the record back many millions of years the remains of fungi are so rarely found that their presence is always exceptional, although it is obvious that many times during the long history of the earth the environment has offered optimum conditions for their abundant development. To mention but one such period, the formation of the coal measures must have witnessed an exceedingly abundant mycologic flora. That these plants were present thus early is indicated by the abundance of hyphae and other traces of fungal activity, such as butyric fermentation, in the tissues of Carboniferous vascular plants, and the scarcity of described forms must be attributed to the perishable nature of most fungal tissues and to the lack of systematic work by experienced mycologists on the more or less obscure material available. To be sure, a considerable number of fossil forms referred to fungi have been recorded from different geologic horizons, but the vast majority of these are leaf-spot types that are based upon real or fancied resemblances and are found on impression of foliage and lack definite botanic characters. Some undoubtedly represent fungal ravages, others are due to insects, some are glandular, and others are purely imaginary.[29]

Sometimes the traces of fungi preserved in petrified plant tissues are fortunately disclosed in sections, and a number of well-authenticated forms are known, principally from the Carboniferous, their discovery being due almost entirely to the relatively large amount of histologic work that has been expended on the Carboniferous flora. The exceptional conditions of preservation afforded by the accumulations of amber at a time long subsequent to the Carboniferous have given us a glimpse of some few fungal types of the older Tertiary.

In studying the numerous specimens of petrified wood, which are especially abundant in the more sandy beds of both the Claiborne and the Jackson, I have frequently noted the ravages of parasitic fungi as well as branching mycelia of both septate and nonseptate hyphae. Most of these forms are too indefinite for incorporation in the record, but it may be safely concluded that fungi were as abundant then as now, and among the remains discovered several are exceptionally well preserved. Among these fungi is *Cladosporites fasciculatus*, an intracellular *Cladosporium*-like form that ranges from the Claiborne to the Forest Hill sand, the latter regarded by me as largely of Jackson age. Two additional species of fungi are recorded from the Jackson. Both these species are leaf-spot types of doubtful identity. One, which is commonly found on the leaves of *Ficus*, is referred to the genus *Sphaerites;* the other, which infests palm rays, is referred to *Pestalozzites*. The indefiniteness in the identifications of previously described fossil leaf-spot fungi makes any summary of the occurrence of similar types in other regions and at different geologic horizons a useless proceeding.

Thus far no traces of bryophytes or moss plants except a well-marked *Marchantites* have been discovered in the Jackson, a feature that conforms to usual experience. Arthrophytes are represented solely by a single fragmentary specimen on an *Equisetum*.

The pteridophyte phylum is represented in the Jackson by four ferns. Thus the Jackson

[29] For a rather complete illustrated list of all these forms down to the year 1900 the student is referred to Meschinelli, A., Fungorum fossilium omnium iconographia, 144 pp., 31 pls., 1902.

ferns are only about half as numerous as those of the Wilcox and Claiborne, each of which has furnished six or seven species. The Jackson ferns comprise two species of *Lygodium* of the family Schizaeaceae and two species of the family Polypodiaceae, which represent the genera *Pteris* and *Acrostichum*. One *Lygodium* survives into the Jackson from the Claiborne, and the other originates in the Jackson and survives into the Catahoula. *Lygodium* is a scandent type from coastal thickets and is represented in the Wilcox by an allied form. The genus *Pteris* is present in both the Wilcox and Claiborne and is a genus that has many fossil and recent species of wide range and great variety of climatic and edaphic requirements and therefore of unknown significance in the present connection. The *Acrostichum* belongs to a genus of large swamp ferns that makes its appearance in the Claiborne, or possibly in the Wilcox, of this region and at about the same time in Europe. Its modern species, particularly *Acrostichum aureum* (Pl. XXVII, *A*), are widespread on tropical shores in brackish swamps, as for example along the Central American coasts, where extensive tracts are covered almost exclusively with this fern, whose fronds are 6 to 10 feet tall.

Ferns are abundant in most tropical countries---for example, there are about 800 species in the Recent flora of the Philippines. In Porto Rico the Polypodiaceae is the largest family among the higher plants and has 182 species (Urban, 1912). Jamaica is similarly noted for its variety of fern life. It might seem, then, that four ferns under the favorable conditions of Jackson time is entirely disproportionate, but it is obviously not so when it is is recalled that the known Jackson flora is very largely a strand flora, and the great variety of ferns that are recorded from Porto Rico, Jamaica, and other tropical lands are not members of the strand flora but of the upland rain-forest valleys, as in the mountains of Porto Rico, Blue Mountain in Jamaica, the highlands of the Malay Peninsula and East Indies, New Zealand, and the montaña zone of the Andes. The Jackson ferns are in agreement with the balance of the Jackson flora, as *Lygodium* is a form of coastal thickets; *Acrostichum*, one of coastal brackish swamps; and *Pteris*, of the coastal sandy strand. It would be a matter for surprise if upland and epiphytic types were encountered in abundance in an assemblage of plants of the sea margin and especially of a shallow sandy shifting sea margin, as was the area now occupied by the Jackson deposits, and it may confidently be assumed that other and unknown Jackson ferns dwelt inland, although these could not have been as varied as the present fern flora of the Tropics, for the Jackson land was prevailingly low and without elevated mountains or conspicuously great humidity or rainfall.

The Jackson *Equisetum* is a fragment that has no special significance. The genus has been in existence since the dawn of the Mesozoic era or earlier, and the 25 existing species for the most part have a wide range. The genus is common in Tertiary floras where the sandy or marshy habitats of *Equisetum* become overwhelmed with river or lake deposits. The Jackson species was of large size, as compared with our modern temperate species, and but slightly smaller than some recent tropical forms. It may have inhabited the wet areas back of the *Acrostichum* swamps or sandy depressions behind beach ridges or coastal dunes. It is of about the same size as existing specimens of *Equisetum giganteum* that were seen in irrigation ditches in Peru, and if similar in its requirements to the existing larger Equisetums it indicates a wet substratum.

As is usual in Tertiary floras the seed plants constitute the great bulk of the collections. The gymnosperms thus far found in the Jackson are very sparingly represented both in species and in individuals. The relative unimportance of this class of plants in the Cenozoic as compared with the Mesozoic is thus emphasized and also further emphasizes the fact that the nature of the habitat and the climate were not favorable for most gymnospermous genera. An exception to this statement is furnished by the cycads, of which two species that belong to the genus *Zamia* have been discovered in the Wilcox. *Zamia* is a genus that contains about 30 existing species, which are confined to the tropical and subtropical regions of America, and was undoubtedly present in this region throughout the Eocene and Oligocene epochs, although no traces of it have been discovered in either the Claiborne or the Jackson. Among the Coniferales the genus *Podocarpus* might be expected to have invaded southeastern North America at some time during the Tertiary period. Eocene species occur in Europe northward as far as southern England, and in the existing flora a species is found as far north as Costa Rica.

None have been found in the region here considered, however, and the three known Jackson conifers are represented by poorly preserved cones that are referred to the genus *Cupressites* and by a few leaf-bearing twigs identified as *Glyptostrobus europaeus* and *Taxodium dubium*. The *Taxodium* has a wide geologic and geographic range and is probably polymorphous. It is found in North America from the base of the Eocene to the Chesapeake group of the Miocene, and from the Pliocene of the Gulf coast it passes insensibly into the Pleistocene and still existing bald cypress, from which even the older remains are not certainly distinguishable. *Taxodium* is a mesophytic type, and this Jackson representative probably lived in a habitat like that of the well-known bald cypress of our Southern States—that is, in the coastal or river swamps.

The genus *Athrotaxis*, which is doubtfully determined, is recorded from both the Wilcox and the Claiborne; *Glyptostrobus* has been recorded from the Wilcox and Claiborne; and *Sequoia* from the Claiborne; but the first and last of these have not been discovered in the Jackson.

Possibly a third coniferous type is represented in the Jackson by the object described as *Carpolithus callitriformis*, which appears to represent the valvular cone of *Callitris*, a genus of Cupressinae which is common throughout the European Tertiary deposits and which has a single existing species in northern Africa. The genus has never been recognized in North America, and the Jackson remains are too meager to substantiate its presence in the Jackson. Similar and larger remains in beds of supposed upper Jackson age in the Lagrange formation of western Kentucky and Tennessee have not been described in this paper but await further study.

Among the monocotyledonous angiosperms only the families Naiadaceae, Araceae, Poaceae, Cannaceae, Smilacaceae, and Arecaceae are represented in the Jackson. The family Naiadaceae, or Potamogetonaceae as it is sometimes called, is represented by two species of *Potamogeton*. Between 30 and 40 fossil species have been referred to this genus, none of which appear to be identical with the forms from Georgia. They range in age from the Arctic Senonian through the Eocene, Oligocene, Miocene, and Pliocene to the Pleistocene epoch, and several still-existing species are recorded from Pleistocene beds, both in this country and abroad. Well-defined forms are present in the Upper Cretaceous of the Atlantic Coastal Plain.

The modern species, all of which are aquatic to a greater or less degree, number more than 60 and occur both in the Tropics and in the Temperate Zone, though the larger representation is in the Temperate Zone. Most of the species have a wide and many a cosmopolitan range, and a single species commonly extends over many degrees of latitude—for example, *Potamogeton perfoliatus* Linné extends over more than 20° of latitude in America, from Newfoundland and British Columbia to Florida and California, and also occurs in Europe and Asia. It is an interesting fact that all the wide-ranging species extend into both comparatively high and low latitudes, whereas species of more restricted range, such as *Potamogeton floridanus* Small and *Potamogeton curtissii* Morong, of Florida, are commonly confined to warmer regions.

This condition may indicate either that species confined to low latitudes in the existing flora, or their immediate ancestors in more ancient floras, had originally a much wider range than now, or that the modern wide-ranging species have greatly extended their range in recent times. I incline to accept the latter supposition, although the majority of aquatic organisms, both animal and plant, are little influenced even by rather wide differences in latitude.

A fossil species of about the same size as the larger Jackson species but with a more open venation has been described by Heer from the Tertiary of Spitzbergen as *Potamogeton nordenskiöldi*. Both this species and the Georgia species probably represent floating, not emerged or submerged leaves. Their significance, as indicative of sluggish rivers discharging into Jackson estuaries, is obvious.

The order Arales (Spathiflorae 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 Araceae. The kindred family Lemnaceae, which consists of smaller forms, all aquatic, comprises but few species, which, however, have a very wide distribution. The distinctive features of the plants that comprise these allied groups are the differentiation of the leaves into

stalk and blade, the netted venation of the blade, certain anatomical differences, and the aggregation of the flowers into a spadix. The floral structure is varied, ranging from bimerous to tetramerous, pentacyclic, syncarpous forms, such as *Calamus*, with its bractlike spathe, to the more abundant bisporangiate forms that have an obsolete perianth and a much developed petaloid spathe that is specialized for entomophily.

The Araceae are cosmopolitan, but most of the forms are found in the Tropics and are 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 and is especially common in the southern Atlantic Coastal Plain. 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 beds of lower Jackson age in Georgia. All the modern species are floating plants, and their presence in the Jackson points to the same conclusions as the presence of *Potamogeton* in these deposits.

The order Poales and the family Poaceae (Gramineae) are represented by a large reedlike grass in the Jackson, which is referred to *Arundo* and which is also common in the underlying Claiborne. Its generic relationship is regarded as uncertain.

That the grasses are not primitive is suggested by their obviously hydrophytic origin and specialized floral bracts. It is the one group of monocotyledons that has become thoroughly established on dry land, and both in individual abundance and number of species it ranks as one of the great angiospermous alliances, for it contains over 350 genera and over 5,000 species. The group is cosmopolitan, and its range extends to the polar regions and to the snow line of high mountains. The largest number of species are present in the Tropics, but the largest number of individuals grow in temperate regions of uniform rainfall. Grasses also predominate in steppes and savannas, and in the savannas they are commonly tall and reedlike. The bamboos form a prominent part of tropical forests, especially in regions of monsoon climates, and shrubby species in the arid region of southeastern Bolivia and northwestern Argentina form an entirely closed cover.

Many species of grass have become artificially cosmopolitan. Others are naturally present in both hemispheres. Still others of the wooded regions of the North Temperate Zone reappear in similar situations in the South Temperate Zone (*Deschampsia*, *Festuca*, *Poa*), and others that have a similar range, such as *Phleum alpinum* Linné, are also found in isolated localities on high tropical mountains, thus indicating an interesting geologic history. At least 90 genera are common to the Old and New worlds. No one tribe is confined to one hemisphere and no large genus to a single floral region. The Paniceae and Andropogoneae are prominent in the Tropics, and the Festuceae, Aveneae, and Hordeae in the Temperate and Frigid zones.

The wooded region of eastern North America has preserved many more types than Europe, but I suspect that the little-known area of west China probably rivals it in this respect.

Grasses lack a perianth and are anemophilous. The place of a perianth is taken by specialized bracts, but these ensheath individual flowers, and not flower clusters as in the Pandanales and Helobiales. Some morphologists regard the lodicules and certain hairs and bracts as the reduced remnants of a true perianth, although there is much diversity of opinion on this point, which will become of slight importance when systematists cease to regard the Monocotyledonae as a genetic series and look to something beside floral structures as a key to relationships.

Though many fossil species have been recorded, the vast majority are based upon fragments of linear parallel-veined leaves which have been referred to as *Poacites*, *Phragmites*, *Arundo*, and other genera and are of slight botanic interest. Occasionally more definite material has been discovered, and there is no doubt that grasses were in existence during the Upper Cretaceous and probably in the later part of the Lower Cretaceous. Their degree of differentiation or individual abundance is entirely unknown. Nor is the Tertiary record much better, although the great expansion of grazing animals and the dental evolution of the Mammalia in the early Tertiary give clear evidence of the abundance of grasses at that time.

The order Arecales, which includes the palms, was already well differentiated in pre-Jackson time, for no less than 22 species, which repre-

sent the genera *Nipa, Oenocarpus, Areca, Iriartea, Livistona, Sabal, Chamaerops, Thrinax, Asterocaryum,* and *Elaeis,* have been recorded from the lower Eocene (Ypresian) of Sheppey, England. The genera *Sabalites, Chamaedorea,* and *Nipadites* are common in the Wilcox of southeastern North America, and *Thrinax, Bactrites, Geonomites, Sabalites,* and *Palmocarpon* occur in the Claiborne of this region. The Jackson species of palms number eight, including petrified wood that is referred to *Palmoxylon.* The five genera that are based upon foliage or fruit are *Sabalites, Thrinax, Nipadites, Phoenicites,* and *Palmocarpon. Sabalites* is a genus of fan palms that appears in southeastern North America continuously from the Upper Cretaceous to the present and range through northern Africa and southern Asia, the majority being Asiatic. (See fig. 7.) They are all confined to hot climates, and two or three of the species are small coastal forms.

The Jackson contains two types of palm fruits, that described as *Palmocarpon sessile* being a remarkable example of fossil palm inflorescence with numerous small sessile nutlets. The presence of the fruits of *Nipadites,* which are not uncommon at one locality in the Fayette sandstone, is of exceptional interest, as it is indicative of tidal conditions. *Nipadites* is the earlier Tertiary representative of the modern oriental nipa palm. Its fruits have long been known throughout the older Tertiary of the Old World. Typical specimens were discovered some years ago in the Wilcox, and what is

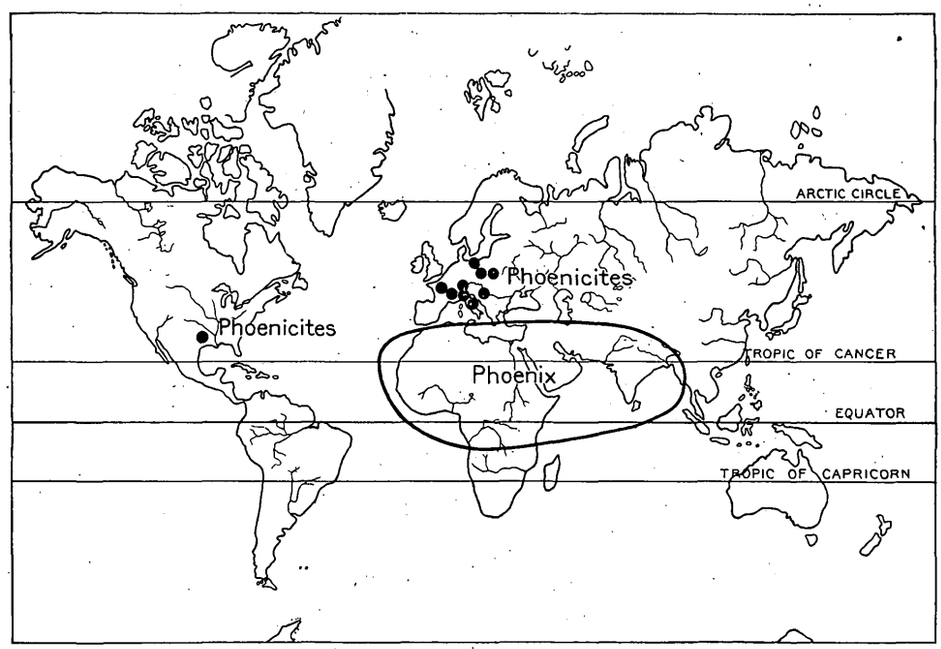


FIGURE 7.—Sketch map showing area of distribution of existing species of *Phoenix* and the Tertiary occurrences of *Phoenicites.*

is now represented by several species of *Sabal,* all of which are prevailingly coastal types.

The genus *Thrinax,* represented by the modern thatch palms of the Florida Keys and the Antilles, appears in the Claiborne, and a single species survives into the Jackson. It represents a small fan palm of sandy-beach habitat.

Feather palms are represented by *Phoenicites,* the genus to which the ancestors of the existing genus *Phoenix* or date palms are referred. The genus appears in the European Eocene, and several species have been described, this being the first record of an American form, which is represented by characteristic fruits and foliage. The modern date palms (Pl. XXIV, *A*) number about 12 species and apparently the same species extends upward into the Jackson, thus approximately paralleling its range in the Old World.

The order Scitaminales is represented by a splendid and characteristic species of *Canna,* a genus which appears in the geologic record in the Wilcox and is also represented in the Claiborne by closely related and apparently affiliated species. It is a strictly hygrophilous type of river and estuary swamps and moist valley bottoms. It is confined to the warmer parts of America in the existing flora and has undoubtedly been present in this general region throughout the Cenozoic era.

The order Liliales, which is large and diversified in modern floras, is represented in the upper

Eocene by the family Smilaceae, with a single species of *Smilax*, the first found in the Eocene of the Atlantic Coastal Plain. Many fossil species have been described from other regions in beds ranging in age from Upper Cretaceous to the Pliocene. The genus has about 200 existing and widely distributed species, mostly aggressive climbing shrubs of mesophytic environments. It is most abundantly represented at the present time in tropical Asia and America.

The Dicotyledonae, which are the predominating plants in the Jackson flora, number 98 species, of which the majority, as might be expected, are choripetalous forms. The following orders are unrepresented in the Jackson: Casuarinales, Piperales, Aristolochiales, Papaverales, Salicales, Balanopsidales, Leitneriales, Santalales, Sarraceniales, and Opuntiales. The absence of the Balanopsidales, Sarraceniales, and Opuntiales is to be expected, for they are all specialized types of rather modern evolution. The presence of the primitive Casuarinales and Piperales might be expected, as also some members of the Salicales, for the Piperales and Salicales were both present in this region during the Upper Cretaceous. The Aristolochiales are present in both the Wilcox and Claiborne, and their absence in the Jackson may be due to the accidents of preservation and discovery, for they are never abundant in fossil floras and have but a single species in the Wilcox and Claiborne. The same reason probably accounts for the absence of the Papaverales, which have a single species in the Wilcox but none in the Claiborne.

The order Juglandales, which contributes eight species to the Wilcox and two species to the Claiborne, is represented in the Jackson by three species—a single species of *Engelhardtia* and two species of *Hicoria*. The genus *Engelhardtia*, which has about ten recent species in the southeastern Asiatic region and one in Central America, has a number of extinct species. It appears in the Wilcox of southeastern North America together with more primitive forms of the same stock, which are regarded as ancestral and referred to the genus *Paraengelhardtia*, but is first found in Europe in the lower Oligocene. Its history has been somewhat fully described elsewhere [30] and need not be repeated here. The hickories (*Hicoria*) are represented by both leaves and characteristic fruits in the Jackson. They represent a type which is not certainly known from earlier horizons but which has existed in America from the middle Eocene to the present, and their former range covered most of the Northern Hemisphere. In so far as I know, this is the earliest record of undoubted fruits of this genus. Its present range and geologic history have been discussed by me in other papers, to which the reader is referred for fuller information regarding this most interesting genus.[31]

The order Myricales has a single species of *Myrica* in the Jackson. *Myrica* is a very old generic type and has a large number of fossil species, which range from the middle Cretaceous to the present and is especially well represented in the Ripley formation of this region. 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 [32] in 1906. *Myrica* is much less abundant in our Eocene than in the European Tertiary, although it was present in the embayment area throughout the Upper Cretaceous. Its meager representation in Eocene time may possibly be due to the more tropical climate or may simply represent accidents of preservation and discovery. The modern Myricas are temperate and subtropical, and a number of the species are coastal forms of either swamps or sand dunes. *Myrica zachariensis* of the Jackson was evidently a coastal form and very similar to the existing *Myrica cerifera*, which ranges from New Jersey to Texas and is also found in 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 also be compared with that of *Myrica wilcoxensis* of the earlier Eocene in this region, which seems to be the ancestral stock of the species that occur along the Eocene coast of the embayment.

The order Fagales, which includes many well-known timber trees of the Temperate

[30] Berry, E. W., An *Engelhardtia* from the American Eocene: Am. Jour. Sci., 4th ser., vol. 31, pp. 491–496, 1911; Notes on the geological history of the walnuts and hickories: Plant World, vol. 15, pp. 234–238, 1912; The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 78–80, 1916.

[31] Berry, E. W., Notes on the geological history of the walnuts and hickories: Plant World, vol. 15, pp. 225–240, figs. 1–4, 1912; Smithsonian Inst. Ann. Rept. for 1913, pp. 319–331, 1914.

[32] Berry, E. W., Living and fossil species of *Comptonia*: Am. Naturalist, vol. 40, pp. 485–520, pls. 1–4, 1906.

Zone and a very large number of fossil forms, comprises the two families Betulaceae and Fagaceae. These families together contain about 450 existing species, about three-fourths of which belong to the Fagaceae. Although the Betulaceae are characteristically developed in the Upper Cretaceous of North America, they are unrepresented in the Eocene flora of southeastern North America, probably because the climate was too warm, and this probability may also account for the absence of true oaks, the Fagaceae being represented in the Wilcox, Claiborne, and Jackson floras by the genus *Dryophyllum*, which includes six rather widespread and locally common species.

The genus *Dryophyllum* is of world-wide distribution and shows consistently uniform characters throughout a wide vertical range in the late Cretaceous and early Eocene deposits from the Senonian to the Bartonian 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 Jackson species, which survives from the Claiborne, apparently was a strand type, as were also the many species from the sandy shores of the Upper Cretaceous sea of Rhenish Prussia which have been enumerated by Debey, the describer of the genus. *Dryophyllum* is abundant in the Montian of Belgium and in the littoral sands of the French Eocene. A species of *Castanea* is recorded from the Jackson, but it is quite possible that it may represent a second species of *Dryophyllum*.

The Urticales include the families Ulmaceae, Moraceae, and Urticaceae, which together contain about 1,600 existing species. The Urticaceae are largely herbaceous forms and are not represented in the Eocene of southeastern North America.

The Ulmaceae, which are partly extratropical, comprise 13 genera and about 140 existing species that are widely distributed in temperate and tropical regions. A single species of *Momisia*, which survives from the Claiborne, is present in the Jackson, and a species of *Planera* occurs in those beds which are doubtfully referred to the upper Jackson.

Momisia, which is not known elsewhere as a fossil, has about 20 existing species, which are confined to tropical America, and it is sometimes made a subgenus of *Celtis*, as by Engler. The present species is similar to *Momisia aculeata*, a widespread form of tropical America and the Antilles, which reaches its northern limits in the valley of the Rio Grande and on the Florida Keys. *Planera*, a monotypic genus in the existing flora, where it is confined to the warmer and wetter part of southeastern North America, has been present in this region ever since Upper Cretaceous time.

The Moraceae, which is by far the largest family of the order Urticales and the only one abundantly represented in the Jackson flora, contains between 900 and 1,000 existing species, which are 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 Moraceae 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 23 species of Moraceae in the Wilcox flora, which represent the genera *Artocarpus*, *Artocarpidium*, *Pseudolmedia*, and *Ficus*, but *Ficus* is the only genus of the family that has been discovered in the Claiborne or the Jackson. *Ficus* has about 600 existing and 300 fossil species and has nearly a score of species in the Wilcox, four species in the Claiborne, and six species in the Jackson, two of which originated in the Claiborne. As *Ficus* is such a large genus and as its numerous species have such a variety of habitats, the Jackson species do not afford definite evidence of their environment, but I assume from the associated flora that they were coastal forms, as are so many of the existing species, and grew in the beach jungle, where they were distributed by fruit-eating birds, so that they are thus comparable with the bowers of wild figs that have been recorded by Seeman [33] in his description of the existing flora of the coast of the Isthmus of Panama.

The order Proteales includes the single family Proteaceae, which has about 1,000 existing species. They include the prominent arborescent forms of the Choripetalae in the Southern

[33] Seeman, B. C., Flora panamensis, Botany of H. M. S. *Herald*, pp. 57-346, 1852-1857.

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 four 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 Proteaceae 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 there are six species in the Wilcox, which represent the genera *Palaeodendron, Banksia, Proteoides,* and *Knightiophyllum,* no members of the family have yet been found in the Claiborne, and but a single species of *Banksia* appears in the Jackson. *Banksia* is confined to the Australian region in the existing flora and contains about 50 species, which have a variety of habitats. The fossil species are found throughout the Northern Hemisphere from the Upper Cretaceous and later deposits. The Jackson species was probably a sand-dune and beach-ridge type, as are several of the existing species.

The order Polygonales includes the single family Polygonaceae, which has about 800 existing species that are 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 choripetalous alliances enumerated above 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 Jackson by the single genus *Coccolobis,* with two species, which are survivors from the Claiborne. There are two species in the Wilcox and two additional in the Claiborne, which represent the Eocene prototypes of the only two existing arborescent species of Polygonaceae that reach the United States (the sea grape and the pigeon plum). The genus *Coccolobis* contains about 120 existing species, all confined to the warmer regions of America, 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 ancestral Eocene forms, 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 Eocene forms had a similar range and an identical habitat.

The Chenopodiales (Centrospermae of Engler) include 10 familes, which culminate in the Caryophyllaceae and contain about 3,500 existing species. They appear to be illy assorted and show a wide range in floral and other morphologic characters. Perhaps a majority are modern types. The single family Nyctaginaceae represents this order in the Jackson.

The Nyctaginaceae, which include about 150 existing species, are predominantly American. They occur within the limits of the southern United States on the north to Chile and Argentina on the south. The genus *Pisonia* Plumier, the only genus thus far found in the Jackson flora, is represented by three especially well-marked species. It comprises about 40 existing species, which live chiefly in the American Tropics, and includes the only existing arborescent form of the family found within the United States. It has an extended geologic history, for well-marked forms are found in the European and American Upper Cretaceous. The Jackson 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 other genera, exactly as it was during the Wilcox, Claiborne, and Jackson. Species of *Pisonia* occur in the Upper Cretaceous of the Atlantic Coastal Plain (Black Creek formation), as well as in the lower (Wilcox), middle (Claiborne), and upper (Jackson) Eocene.

The order Ranales, a highly unnatural assemblage, is represented by three families in the Jackson. The families Magnoliaceae and Nymphaeaceae, which were present in this region in the Upper Cretaceous and lower Eocene, have not been found in the Jackson. The Anonaceae, which were abundantly represented in the Wilcox, have a single Jackson species, and the family Myristicaceae appears for the first time in the record at this time, being represented by the fruits of a species of *Myristica*. *Myristica*, to which the commercial nutmeg belongs, contains more than 100 existing species, which are widely distributed in the Tropics of both hemispheres. About 25 species are American—mainly South American—although the sections (often considered genera) *Virola* and *Compsoneura* both occur in Central America. They are small trees, commonly insular in their range, and indicate a strictly tropical climate. Four species are recorded by Schimper in his Indo-Malayan strand flora, so that the Jackson species is not out of place among the representatives of an upper Eocene strand flora (beach jungle). The Jackson *Anona* belongs to a family, the Anonaceae, whose 700 existing species are almost exclusively confined to the Tropics.

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, and there are four well-marked species in the Wilcox. I assume that the Jackson form had habits similar to those of most of the existing species, as exemplified by *Anona glabra* Linné, the pond apple of Florida, which grows in shallow fresh-water swamps, low shady hammocks, or along 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. From the prevalent habit among the existing species, the growth in wet shaded soils is evidently an old characteristic, and as the Jackson *Anona* is associated with a strand flora, the assumption that it grew on the inner beaches or the shaded and swampy edges of lagoons possesses every degree of probability.

The third family of Ranales, the Menispermaceae, is represented by a single form referred to the genus *Menispermites*, a type abundantly represented in the Upper Cretaceous and still present in this region.

The order Rosales includes about 18 families and more than 1,400 existing species. The largest modern families are the Mimosaceae, Caesalpiniaceae, Papilionaceae, Rosaceae, Saxifragaceae, and Crassulaceae. The first three, which belong to the alliance or superfamily Leguminosae, are represented in the Jackson. The Mimosaceae of the Jackson comprise three species of *Mimosites* and one of *Inga*. The Jackson forms are plants of the strand. I would expect to find *Pithecolobium* in the Jackson flora, for it is present in the Wilcox, and it may eventually be discovered. The Caesalpiniaceae is represented in the Jackson by three species of Cassia, which are also coastal tropical types, and one species of *Bauhinia*. There are five genera and 26 species of Caesalpiniaceae in the Wilcox and two genera and three species in the Claiborne, so that the Jackson material is evidently not especially representative.

The genus *Bauhinia* has many existing species of trees or climbing shrubs with characteristic leaves. They inhabit the equatorial regions and the warmer parts of the Temperate Zone. *Bauhinia* appears in the geologic record as early as the Upper Cretaceous in this general region (from New Jersey to Alabama and Tennessee), characteristic species having been found in the Raritan, Magothy, Tuscaloosa, Eutaw, and Ripley formations. This is, however, the first recorded occurrence of the genus in the Tertiary of southeastern North America.

The Papilionaceae, the most highly evolved florally and also the most modern types of Leguminosae, are represented in the Jackson by two species of *Sophora*, one of *Lonchocarpus*, and one of *Papilionites*. The genus *Sophora* contains about 25 existing species of shrubs and small trees, 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 epoch. Though few species have been described, the genus is widely distributed in the European Miocene deposits, where *Sophora europaea* Unger was a common coastal form of the Mediterranean region

throughout the Miocene and into the Pliocene epoch. There are seven species in the Wilcox and three in the Claiborne, and two of the Claiborne species survive into the Jackson. They are very similar to the existing *Sophora tomentosa*, a cosmopolitan tropical beach plant. I would expect to find *Dalbergia* and *Canavalia* in the Jackson, for both are abundant in the lower Eocene of southeastern North America, but neither has yet been discovered.

The genus *Lonchocarpus*, which belongs to the tribe Dalbergieae, is found in the deposits which are tentatively referred to the upper Jackson, where it is present in the form of numerous characteristic pods. The many existing species are mainly tropical and largely American. The only fossil occurrences of *Lonchocarpus* outside of the South American Tertiary are the present species and another, also based on pods, found in the Cohansey sand of southern New Jersey, of late Tertiary age.

A fourth Jackson family of Rosales is the Hamamelidaceae, which is represented by numerous fruits of *Liquidambar* in the deposits that are here tentatively referred to the upper Jackson. No traces of leaves have been found, but the fruits are characteristic. The genus has four existing species, much alike but having a very disconnected range in the Northern Hemisphere. Several Tertiary species, which serve to bridge the gaps in the distribution of the existing species, are known. The modern species are not tropical but are mesophytic forms of warm temperate regions, or upland types of tropical regions.[34]

The order Geraniales includes 21 families and more than 10,000 existing species, of which nearly half belong to the family Euphorbiaceae. The other large families in the order of their size are the Rutaceae, Meliaceae, Malpighiaceae, and Polygalaceae, each of which contains more than 500 existing species. The Rutaceae, Meliaceae, Malpighiaceae, and Burseraceae are sparingly represented in the Jackson flora. Only the first two occur in the Claiborne, but there are representatives of six families in the Wilcox—the Rutaceae, Meliaceae, Simarubaceae, Humiriaceae, Malpighiaceae, and Euphorbiaceae, the last of which has five species. It is surprising that the genera *Crotonophyllum* and *Drypetes* of the Euphorbiaceae, which appear in the Wilcox of this area, have not been detected in either the Claiborne or the Jackson.

The Rutaceae of the Jackson comprise four forms of *Fagara* which are common to the overlying Vicksburg. 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 are two additional 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. These forms make their first appearance in the Jackson. Still another form is found in the Alum Bluff formation of Florida.

The family Meliaceae is represented in the Jackson by an abundant species of *Cedrela*, although the genus *Carapa* occurs in both the Wilcox and Claiborne. The genus *Cedrela*, which is sometimes made the type of an independent family, the Cedrelaceae, is represented in southeastern North America by four Wilcox and one Claiborne and Jackson species, which are the Eocene prototypes of the existing American species. This genus, which includes nine or ten existing species, is confined to America at the present time and is known outside this area only in two species from the Miocene deposits of Croatia, which Unger referred to *Cedrela*, and an undescribed *Cedrela*, which is recorded by Ettingshausen from the Ypresian of the south of England.

The family Malpighiaceae, 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

[34] Berry, E. W., The geological history of the sweet gum and witch hazel: Plant World, vol. 22, pp. 345–354, figs. 2, 1919.

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 Jackson representative of the family is a single species of *Banisteria*, a descendant of one of the four species of this genus that is represented by both foliage and fruit in the antecedent Wilcox.

The family Burseraceae includes about 16 genera and over 300 existing species. Ten of the genera and about 210 species are confined to the Eastern Hemisphere, mostly in Asia and Africa; four genera and about 90 species are confined to the Western Hemisphere; and the genera *Protium* and *Pachylobus* are common to the two hemispheres. The family is made up of resinous trees or shrubs that bear alternate exstipulate, pinnate leaves and drupaceous fruits. The Jackson form represents either the modern *Bursera* or *Protium*, both of which are largely developed in the American Tropics.

The order Sapindales, which is sometimes called the Celastrales, includes adout 20 families and about 3,200 existing species. The largest families in number of species are the Sapindaceae, which contain more than twice as many species as any of the others; the Celastraceae, Anacardiaceae, Balsaminaceae, and Ilicaceae. The only families represented in the Jackson are the Sapindaceae and Anacardiaceae, although the Celastraceae is found in the Claiborne and the Ilicaceae occurs in the Wilcox.

The family Sapindaceae 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 27 of the genera, or about 23 per cent, and 345 of the species, or 34 per cent, are confined to America. As in both the Wilcox and Claiborne, the Jackson representatives of this family comprise the genera *Cupanites*, *Dodonaea*, and *Sapindus*. The modern Cupanieae 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 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 about a dozen 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 and a fourth in the Jackson. The oldest European form comes from the late Oligocene of Styria. Miocene species are recorded from Germany, Bohemia, Austria, Croatia, and Hungary.

The genus *Dodonaea* Linné, which is often made the type of a distinct family, the Dodonaeaceae, includes about 50 existing species, four-fifths of which are Australian. *Dodonaea 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 *Dodonaeites*) 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 stage of the south of England and the two contemporaneous species in the Wilcox, which are represented by both leaves and characteristic fruits. The Claiborne species, which survives into the Jackson, is very similar to the existing strand plant *Dodonaea viscosa*, and this same species is exceedingly abundant in the

lower Jackson. The genus *Sapindus* includes a large number of fossil species and is abundant and widespread from the dawn of the Upper Cretaceous epoch to the present. There are two well-marked species in the Tuscaloosa formation of the eastern Gulf area and one in the Bingen and Woodbine formations of the western Gulf area. Nine species are abundantly represented in the Wilcox, five occur in the Claiborne, and two occur in the Jackson. The Jackson species has survived from the Claiborne. They are similar in character and identical in habitat with the existing *Sapindus saponaria*, a prominent member of the strand flora of the American Tropics, which is dispersed largely by means of ocean currents.

The order Rhamnales, which comprises the two families Rhamnaceae and Vitaceae, is usually represented in fossil floras of the Upper Cretaceous and Tertiary by at least a few species of *Rhamnus*. Thus *Rhamnus* and *Zizyphus* were both present in this area during the Upper Cretaceous epoch; *Rhamnus, Rhamnites, Zizyphus, Paliurus,* and *Reynosia* are abundant in the Wilcox; and *Rhamnus, Rhamnacinium, Zizyphus,* and *Reynosia* occur in the Claiborne. The genera *Rhamnites, Euonymus, Ceanothus,* and *Paliurus,* the last representing an early occurrence of an Oligocene (Vicksburg) species, are present in the Jackson; the two last are unknown in the Claiborne.

The order Malvales is represented in the Jackson by the families Tiliaceae, Bombacaceae, and Sterculiaceae. The family Tiliaceae has two species in the Jackson, representing the genera *Grewiopsis* and *Tilia*. The first is an old genus of American origin in Upper Cretaceous time, and the Jackson species is probably a descendant of a Claiborne form. The modern species are referred to the genus *Grewia* and are African and oriental in their distribution, although the genus was present in Europe during the Tertiary. There is an especially well-marked species of *Tilia* in the Fayette sandstone, of Jackson age, representing this familiar and mostly temperate type of tree.

The second family, the Bombacaceae, 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 America. There is a single species in Africa, about six in southern Asia, and one 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. There are three species in the Ypresian stage of southern England and two well-marked forms in the Wilcox, from one of the last of which the Jackson species is probably a direct descendant. Five or six Oligocene species are recorded from 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 seven Miocene species from Bohemia, Croatia, Styria, and Australia, and others in the Miocene of South America.

The family Sterculiaceae 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. 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. It is represented in both the Wilcox and Claiborne of this area but is represented in the Jackson at but a single locality. Large and characteristic leaves of a species of *Buettneria* are found in the Fayette sandstone. The other member of this family from beds of Jackson age is based upon petrified wood that is referred to the genus *Dombeyoxylon* and that is supposed to be related to the genus *Dombeya,* which is an African genus in the existing flora but which has ancestral forms, known as *Dombeyopsis,* in both North America and Europe.

The order Parietales includes 30 families and more than 4,000 existing species. The largest families are the Guttiferae (775 species), Flacourtiaceae (530 species), Begoniaceae (425 species), Violaceae (400 species), and Dipterocarpaceae (330 species). None of these families are found in the Jackson, where the order is represented by the family Ternstroemiaceae, which is also present in the Tuscaloosa, Ripley, Wilcox, and Claiborne floras of this region.

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The family Ternstroemiaceae (Theaceae) contains about 16 genera and 175 existing species, which are mostly tropical, though they extend into the North Temperate Zone in both North America and eastern Asia (*Thea, Gordonia,* and *Stewartia*). The remarkable pairing between North America and Asia indicates an extended geologic history, which is unfortunately for the most part entirely unknown. The genus *Ternstroemia* Nuttall (antedated by *Taonabo* Aublet) includes several fossil species, the oldest of which (*Ternstroemiphyllum*) comes from the Perucer beds (Cenomanian) of Bohemia. It is represented by two 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 four well-marked species of *Ternstroemites* from the Wilcox group, two from the Claiborne group, and two in the Jackson, one of the Jackson species surviving from the Claiborne.

The order Thymeleales, to which I refer the Lauraceae, has 31 Wilcox species, 12 Claiborne species, and 16 Jackson species. The Lauraceae, which includes more than 1,000 existing species in about 50 genera, is often placed near the Anonaceae in the Ranalian plexus. It is abundantly represented in all the Tropics, and some of the ancient genera like *Sassafras* have penetrated long distances into the Temperate Zone. The Lauraceae are abundant in all Upper Cretaceous and Tertiary floras, particularly in areas adjoining the equatorial zone, as in southeastern North America. The largest tribe of Lauraceae, the Cinnamomeae, includes more than 500 species, which are endemic on all the continents but Europe, though chiefly the Asiatic and American. The four genera *Persea, Phoebe, Notaphoebe,* and *Mespilodaphne* (all large genera except *Mespilodaphne*) are found in both hemispheres; *Cinnamomum* and *Machilus* are Oriental; and *Oreodaphne, Strychnodaphne,* and *Nectandra* and the monotypic genera *Pleurothyrium, Umbellularia, Dicypellium,* and *Synandrodaphne* are Occidental.

There are two species of *Cinnamomum* in the Jackson—one a new type confined to the Claiborne and Jackson and the second a widely distributed form. 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 the range during Upper Cretaceous and Tertiary time, like that of many other plant groups, is surprisingly extensive. 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 central Europe, Greenland, North America, 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 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. 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.

The genus *Persea,* which was present in both the Wilcox and Claiborne, has not been discovered in the Jackson. There are five species of *Mespilodaphne* in the Jackson, as compared with two in the Claiborne and four in the Wilcox. 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 the form genus *Laurus.* The genus *Oreodaphne,* which is represented by characteristic forms in the Upper Cretaceous of this region, has seven Wilcox and two Claiborne species but is represented by a single species in the Jackson.

Nectandra is represented in the Jackson flora by three species. The geologic history of *Nectandra,* which includes about seventy existing species that are confined to tropical and subtropical America, is probably entangled with that of the fossil forms that are referred to *Laurus.* It occurs in the American Upper Cretaceous and the European and South American Tertiary. There are at least five characteristic Wilcox species, some of which were abundant along the Wilcox coasts and some range from the base to

the top of the deposits of that age. There are three Claiborne species, and one of them continues into the Jackson. Like *Oreodaphne*, this genus appears to have been of American origin, but it became cosmopolitan in the Tertiary period and was restricted to its original home during the Pleistocene epoch. It is still a vigorous and much differentiated type on the American continents.

A doubtfully determined fruit from the Jackson is referred to the genus *Malapoenna*, and two varieties of petrified wood are referred to the form genus *Laurinoxylon*. A second type of fruit is described under the simple category of lauraceous fruit.

The order Myrtales, as developed in the Jackson, contains representatives of three families—the Rhizophoraceae, Combretaceae, and Myrtaceae—seven species in all, as compared with about 7,000 existing Myrtales, 22 in the Wilcox flora, and five in the Claiborne flora.

Among the most interesting Jackson forms is a species of *Rhizophora*. The Rhizophoraceae consists of about 60 species of shrubs and trees, which are segregated into 16 genera. They are all forms that live on tropical coasts, and many of them have become specialized for a tidal habitat, so that they form thickets in the mud of tidal estuaries and are abundant even in regions like the Pacific coast of Central America, where the high tides submerge them more or less completely twice a day. They have also become specialized to an extraordinary degree for distribution by ocean currents. The center of distribution of the modern forms seems to be the Indian Ocean. Most of the species are found from Madagascar to the East Indies, whence they range for greater or less distances through Polynesia to and beyond the north coast of Australia. Little is known of the geologic history of the family, for *Rhizophora* is the only genus represented by fossils and is not certainly known outside the Jackson.

There are three existing species of *Rhizophora*. *Rhizophora mangle* Linné of the American Tropics is found as far north as Mosquito Inlet and Cedar Key in peninsular Florida and at the mouth of the Mississippi; it also extends from the Mexican coast for some distance along the coast of Texas. It occurs throughout the Bahamas and West Indies and very generally throughout Central America and northern South America and in comparatively recent times has extended its range northward through the Bahamas to Bermuda. On the west coast it is found northward to Lower California and southward to the Galapagos Islands. *Rhizophora mucronata* Lamarck ranges from southern Japan to northern Australia and westward to east Africa. *Rhizophora conjugata* Linné is confined to tropical Asia. Doubtless modern systematists will differentiate additional specific forms, but because of the rather uniform habits of these plants such differentiation will be based on minor characters. These and other so-called mangrove plants possess the singular ability to flourish in sea water and in their manner of life and development have become well adapted both structurally and physiologically to their mode of existence, so that they have become widely disseminated and individually abundant; in fact, they are the most remarkably specialized plants for this habitat known, and their specialization was in a measure reached in the Eocene epoch. This specialization includes the development of pneumatophores and prop roots, the tolerance of salt water, the germination of the seeds before shedding (viviparity), and the floating power of the seedling, which is horizontal in sea water of full density but becomes vertical in water of reduced specific gravity, so that the seedlings come to rest in the shallow water of estuaries and similar situations where streams are discharging into the sea. The mangroves do much work as makers of land, as has often been described, and they are especially well developed on low shores around the heads of tropical or subtropical bays and estuaries.

The family Combretaceae (Terminaliaceae) 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, and 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, which in many species is crowned with the accrescent calyx and which contains a solitary seed without endosperm. The existing species

are all tropical or subtropical and range from 34° north latitude to 35° south latitude, and a relatively large number are littoral or strand types.

The geologic history of the family is most incomplete, but it is exceedingly prominent in the Wilcox flora, where it is represented not only by characteristic leaves but by flowers and fruits. The Wilcox genera are *Combretum*, *Combretanthites*, *Terminalia*, *Conocarpus*, and *Laguncularia*. Four of these genera, namely, *Terminalia*, *Combretum*, *Conocarpus*, and *Laguncularia*, are continued through the Claiborne. *Laguncularia* has not been found in the Jackson, but *Terminalia*, *Combretum*, and *Conocarpus* are present, the two last mentioned being represented by the same species as in the Claiborne.

The genus *Conocarpus* is a member of the tropical mangrove association, very close to the modern form of the American Tropics. Fruits of *Conocarpus* have also been described recently from the Aquitanian of Rhenish Prussia. *Terminalia* is a large genus in the existing flora and contains more than 100 species that are almost equally divided between America, Asia, Africa, and Australia; several of the species are very wide-ranging littoral types. In southeastern North America one species has been obtained from the Midway (?), three from the Wilcox, represented by both leaves and fruit, one from the Claiborne, and another from the Jackson. *Combretum* has about 130 existing species in all tropical lands except Australia and Polynesia. There are three species in the Wilcox and one in the Claiborne.

The family Myrtaceae includes over 3,100 existing species, which are separated by taxonomists into two subfamilies. The first of these subfamilies, the Myrtoideae, comprises 32 genera and about 2,400 species, which are mostly tropical forms, and more than 75 per cent of them are confined to the Western Hemisphere. There are more than 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 three monotypic genera in the subfamily, as well as large and greatly differentiated genera like *Myrcia*, which has more than 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 of the species in the genus *Myrtus* and more than 65 per cent of those in the genus *Eugenia*. The second subfamily, the Leptospermoideae, comprises the Leptospermae, which contain 28 genera and about 700 species, and the Chamaelaucieae, which contain 12 genera and about 165 species. Both these tribes are even more strikingly Australian than the Myrtoideae are American. The Chamaelaucieae are entirely Australian and are mainly confined to western Australia. The Leptospermae include a single monotypic genus in Chile, and the distribution of the other members of this tribe suggests that it should be placed in some other alliance, for with the exception of *Metrosideros*, which is represented in Africa, and *Baeckea*, which reaches the Asiatic mainland, all the genera are confined to Australia or the surrounding islands southeast of Asia.

The genus *Myrcia* probably goes back to the Upper Cretaceous. It is abundant in the Wilcox and is sparingly represented in the Claiborne and Jackson, as well as in the later Vicksburg. A great many of the existing species are tropical and subtropical strand plants.[35] It is singular that the allied large and typically American family Melastomataceae is not represented in either the Claiborne or Jackson. It has two characteristic species in the Wilcox, and there are about 2,500 existing species in the American Tropics, where several fossil forms have also been found.

The order Umbellales (Umbelliflorae of Engler) includes only three families—the Araliaceae, Umbelliferae, and Cornaceae—but more than 3,000 existing species, of which more than two-thirds belong to the Umbelliferae. 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 Umbelliferae, some members of the alliance can be traced back as far as undoubted dicotyledons have been found, and this fact is one of the strongest arguments for considering the relationships of the Umbelliferae to the

[35] Berry, E. W., The origin and distribution of the Myrtaceae: Bot. Gazette, vol. 59, pp. 484–490, 1915.

Gamopetalae to be less close than some botanists have suggested, a suggestion that is based primarily on a consideration of the floral structures apart from the morphologic features of the whole plants.

The family Araliaceae contains about 52 genera and 500 existing species, which are 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, and no less than 33 genera are confined to Asia, Malaysia, Australia, or Polynesia. 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 Araliaceae, 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, and they are abundant at this time in southeastern North America. The Araliaceae of the Wilcox include three species of *Aralia* and two of *Oreopanax*. There is a species of *Oreopanax* in the Claiborne which survives into the Jackson and is the sole representative of the family in the Jackson deposit. This genus contains about 80 existing species, which are divided into simple, lobate, and digitate leafed sections, and is confined to tropical America, though its fossil forms occur in the Paleocene, Tongrian, and Aquitanian of France.

The Cornaceae is a relatively small family and is mostly confined to the Temperate Zone in the Recent epoch but has lived under very different climatic conditions during its geologic history. The genera *Cornus* and *Nyssa* are represented in both the Upper Cretaceous and Wilcox of southeastern North America, and *Nyssa* occurs in both the Claiborne and Jackson. The genus *Nyssa* Linné (including also *Nyssidium* Heer and *Nyssites* Geyler and Kinkelin) comprises about seven 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 characteristic costate stones of the fruit and found from the Upper Cretaceous onward. The genus is apparently of occidental origin.

No family of the Choripetalae has succeeded in maintaining a world-wide distribution, as have several families of Monocotyledonae and Gamopetalae. No distinctly boreal group has been developed, as among the Gamopetalae (Ericales). Certain great families characterize the north temperate region, and these are all herbaceous forms and are believed to be of relatively recent origin, such as Polygonaceae, Caryophyllaceae, Cruciferae, Saxifragaceae, Onagraceae, and a majority of the Umbelliferae. Though aquatic forms are common, this habit does not characterize whole families, as among the Monocotyledonae. The Choripetalae predominate in the American Tropics, and many of the families which are represented in the Tertiary deposits of southeastern North America probably originated in that region.

The second grand division of the Dicotyledonae, the Gamopetalae (Sympetalae), constitutes a rather well defined group, which is presumably derived from the Choripetalae and 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 Gamopetalae 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 Choripetalae.

The herbaceous forms of the alliance predominate, and several of the families are distinctly boreal. Though the Compositae, Labiatae, and Plantaginaceae are of world-wide distribution, there are no notable continental pairings such as usually testify to an extended geologic history. These and many other facts suggest that the Gamopetalae 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 orders Ebenales, Gentianales, Polemoniales, Primulales, and Personales are the only ones certainly recognized in the Jackson, and only the first two of these are known in

the Claiborne. On the other hand, six orders have been found in the Wilcox, of which only the Rubiales have not been found in either the Claiborne or Jackson.

The order Ebenales includes the families Sapotaceae, Ebenaceae, Styracaceae, and Symplocaceae, which contain more than 1,000 existing species. The larger families are the Sapotaceae and Ebenaceae, both of which are represented in the Jackson flora.

The family Sapotaceae 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 and is present in all tropical countries. About half of the existing species are American. The Jackson genera are *Bumelia*, *Chrysophyllum*, *Sapotacites*, and *Calocarpum*. *Sapotacites* is a form genus for sapotaceous leaves of uncertain generic affinities that are found from the Upper Cretaceous onward. The genus *Calocarpum* is represented in the existing flora by two species which are natives of Central America and possibly the West Indies and northern South America and which are widely cultivated in all tropical countries. No other fossil occurrences are known.

The family Ebenaceae includes about eight genera and more than 300 existing shrubs and trees, of which more than 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.

Diospyros, which includes about 180 existing species, is cosmopolitan. Between 90 and 100 fossil forms have been described, and the genus was present in the forests of southeastern North America from the dawn of the Upper Cretaceous to the present. There are two Wilcox species, one Claiborne species, and the Jackson representative is a large accrescent calyx of undoubted affinity, associated with leaves.

The order Gentianales (Contortae of Engler) includes six families and between 4,000 and 5,000 existing species. The largest family is the Asclepiadaceae, which contains more than 2,000 species. The only family represented in the Jackson is the Apocynaceae, which has two species of *Apocynophyllum*, both of which survive into the Jackson from the Claiborne. The family Apocynaceae 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 genus *Apocynophyllum* is a form genus for fossil members of the family of uncertain generic affinities. It has five well-marked species in the Wilcox and but two in the Claiborne and Jackson.

The order Personales, as restricted to part of the Tubiflorae of Engler, comprises 16 families and about 12,000 known existing species. They are distinguished from the members of the order Polemoniales, among other features, by the zygomorphism of the flowers. The largest families, in the order of their rank, are the world-wide and mostly herbaceous Labiatae, with over 3,000 existing species, notably developed in the Mediterranean region; the Scrophulariaceae, with 180 genera and about 2,500 existing species, mostly herbaceous and modern, inhabitants of the North Temperate Zone; the Acanthaceae, with about 185 genera and 2,000 existing species, largely developed in tropical South America and Asia; the Solanaceae, with about 70 genera and 1,800 existing species, widely distributed and largely tropical but also temperate, especially in the Western Hemisphere; and the Verbenaceae, with about 75 genera and 1,400 existing species, a largely tropical and subtropical alliance, especially well represented in South America.

The remaining families of this order are much smaller, none having as many as one-half the number of known species of Verbenaceae, and several, such as the Mediterranean families Orobanchaceae and Globulariaceae or the tropical American Martyniaceae, Nolanaceae, and Columelliaceae, are extremely small.

But two families of Personales, the Bignoniaceae and the Verbenaceae, are known from the Jackson, and one of these occurs in those deposits which are here tentatively referred to the upper Jackson. None are known from the Claiborne, but the families Verbenaceae and Solanaceae are present in the Wilcox. The family Bignoniaceae consists of about 102 genera and 600 existing species of climbing shrubs

and trees, of which all but 34 genera with about 120 species are confined to the Western Hemisphere. One-third of these genera are monotypic, and no one of them has as many as a score of species. The main center of development of the family is in tropical South America, and the extreme limits of the few Temperate Zone representatives are 34° south and 40° north.

There are twenty-one monotypic genera in the Western Hemisphere, and there are some anomalies of distribution, such as the genus *Campsis*, which has a single species in eastern North America and a second one in Japan, and the presence of the genus *Tecomaria* in America and Africa, *Catalpa* in America and Asia, and several genera in Madagascar, the Seychelles, and Mascarene islands. The family shows evidence of antiquity, but the fossil record is most incomplete and furnishes little beyond the occurrence of such genera as *Catalpa*, *Jacaranda*, and *Tecoma* in the Tertiary.

The genus *Tecoma*, the sole member of the Bignoniaceae found in the Jackson, has about 80 existing species in the Tropics of both hemispheres, mainly developed in the Amazon Basin and its peripheries. One species—our familiar trumpet creeper—reaches the northern limit of range of the family. There are five fossil species referred to *Tecoma*, of which the upper Jackson (?) form, a lower Miocene form from Chile, and a Miocene form from Colombia are the only ones certainly identified.

Five Jackson species are described under the heading "Forms of uncertain position." These species include three forms referred to *Carpolithus*, which represent seeds or fruits of uncertain botanical affinity that suggest comparisons with *Callitris*, *Najas*, and *Bumelia*, respectively; a species of *Cypselites*, which suggests the Compositae; and a leguminous pod of uncertain affinity, which is referred to *Leguminosites*.

PHYSICAL CONDITIONS INDICATED BY THE JACKSON FLORA.

In an attempt to picture the physical conditions that prevailed along the coast of southeastern North America during Jackson time the reader should remember that this epoch was of long duration, for it seems to correspond to the whole of the upper Eocene (Priabonian) of the European section. Not only was the time interval long, but the physical conditions were not uniform along this great stretch of coast. The sequence of events seems to have been different in Texas from what it was in the central and eastern parts of the embayment—for example, there appears to have been a considerable interval of emergence between the Eocene and the Oligocene in Texas and continuous marine deposition in southern Alabama.

If the floras preserved in the Jackson sediments were more extensive it would be possible to sketch the paleoecology for every part of the region. In the western Gulf region there appears to be a suggestion of local aridity at intervals during Jackson time, but there is no suggestion of diminished rainfall or humidity during lower Jackson time in Georgia. Whether the border lands of the region of deposition of the "St. Stephens limestone" (Jackson and Vicksburg) suffered any diminution in rainfall is practically unknown, for the only plants are petrified trunks of palms, and the only suggestion that the run-off from the land was lessened is the formation of marine limestones that were laid down in very shallow water, but these are generally so impure as to invalidate any definite conclusions. That the climate was at least subtropical is, I think, an obvious conclusion. That the rainfall varied from place to place more than it did during Claiborne time is, I think, a legitimate conclusion. That the precipitation was less in later than in earlier Jackson time seems to be indicated by the less extensive floras as well as by the extensive oxidation of some of the upper Jackson sediments; but of this I am not certain. That the conditions along the Jackson coast were more uniform in earlier than in later Jackson time is indicated by the character of the sediments and by outcrops like that at White Bluff, in Arkansas, where although but few plants are recognizable there is a great abundance of carbonaceous materials, and the few plants that have been identified indicate conditions like those predicated for the earlier part of the Jackson epoch in Georgia.

A very fair idea of early Jackson environment in the eastern Gulf area is furnished by the flora from the Barnwell formation at Grovetown,

Ga. Although but 20 species are identified from this locality, these can be considered as in general representing the commoner types of vegetation of early Jackson time. The two parasitic fungi (*Sphaerites* and *Pestalozzites*), which represent types that are present in all Tertiary floras and whose preservation and identification are more or less fortuitous, can be omitted from further consideration. Ferns are represented by the genus *Acrostichum*, parts of whose fronds are the most abundant fossils in the clays at Grovetown. *Acrostichum* is a large fern whose modern representative is a widespread form in the equatorial regions, and unlike most ferns it is adapted to a marshy habitat that is usually more or less submerged by marine or brackish waters—that is, it is a tidal swamp or marsh species that is never found far from the coast. Four monocotyledons are found here, including the two aquatic genera *Potamogeton* and *Pistia*. *Potamogeton* dwells in very shallow water and is wholly or partly submerged, and *Pistia* is a small floating plant. Both are represented at Grovetown by single specimens, and it seems obvious that both inhabited the lower courses or bayous of a river that emptied into the Grovetown estuary. The other two monocotyledons are *Arundo* and *Thrinax*. *Arundo* is represented by a great abundance of fragments of a large broad-leafed marsh grass or reed. *Thrinax*, which is also very abundant, is a small fan palm whose modern representatives live on the sand strand in the American Tropics and the Florida Keys. There are 12 dicotyledons, three of which—*Castanea*, *Momisia*, and *Cinnamomum*—do not offer certain evidence regarding habitat, although all are mesophytic forest types of warm climates. The remaining nine forms furnish clear evidence on this subject. *Pisonia*, *Mimosites*, *Sophora*, *Dodonaea*, *Sapindus*, and *Terminalia* are all plants of the jungle which clothes the beach ridges and grows behind the coastal lagoons in present-day tropical and subtropical regions. Among the forms enumerated the *Dodonaea* is the most abundant. *Ficus*, which is also abundant at Grovetown, is a genus which has hundreds of living and fossil species, so that it is of no special significance here, although a number of species of figs are strand plants of the beach jungle in both the American and oriental Tropics. The remaining dicotyledons are *Rhizophora* and *Conocarpus*, both of which are characteristic mangrove plants. *Rhizophora*, the true mangrove, invariably inhabits tidal swamps, whereas *Conocarpus* not only frequents the mud flats back of the mangrove swamps but also grows on sandy beaches in warm climates. *Rhizophora* is rare in the Grovetown collections, but *Conocarpus* is exceedingly common.

In the deposits that are exposed near Grovetown there are thick beds of earthy lignite and fine-grained clays or muds laminated with partings of fine sand. These beds occur as a long, narrow tongue of materials, 2 to 3 miles wide, that extends northwesterly a distance of about 18 miles from the main body of the deposits. This tongue seems to represent the filling of a Jackson estuary. It contains *Modiolus* and other estuarine pelecypods and exactly the plant assemblage that would be expected in such a situation—*Acrostichum* and *Arundo*, which live on flats near or slightly below tide level; mangrove plants, which invariably frequent estuaries; an abundant sprinkling of plants that are characteristic of beaches; and two aquatic forms that owe their presence to the discharge from the river. We may picture the early Jackson coast of Georgia as a low coast under a subtropical climate, similar to many spots observable along the present coasts of tropical America. The lagoons and barrier beaches and long, narrow estuaries contained mangrove and *Acrostichum* swamps, and the strand was clothed with a beach jungle of figs, *Terminalia*, Leguminosae like *Mimosites* and *Sophora*, soapberries (*Sapindus*), Pisonias, and Dodonaeas, which to-day abound in similar situations in both the oriental and occidental Tropics and which in the American region reach their northern limits either in the Bahamas and Florida Keys or in the Bermudas.

The two plant localities near Stryker, on the Missouri, Kansas & Texas Railway, and in the cut on the International & Great Northern Railway in Polk County and the adjoining southern part of Trinity County, Tex., respectively, are of especial interest, for Deussen refers these outcrops to the Catahoula sandstone, and the flora seems to be of Jackson age. They acquire additional interest because the lithology of the material from southern Trinity County was exhaustively studied by M. I. Goldman.[37]

[37] Goldman, M. I., Petrographic evidences on the origin of the Catahoula sandstone of Texas: Am. Jour. Sci., 4th ser., vol. 39, pp. 261–287, 1915.

Before quoting the conclusions reached by Goldman as a result of his petrographic study it will be well to consider the floras identified from these two localities, which supplement each other, as they have but one species in common and the combined list numbers 15 species. The first and most important locality, which furnished the material for Goldman's petrographic studies, is a cut on the International & Great Northern Railway. From this outcrop the following species are known:

Phoenicites occidentalis.
Dryophyllum brevipetiolatum.
Myristica catahoulensis.
Cedrela jacksoniana.
Nectandra antillanafolia.
Nectandra gosportensis var. jacksonensis.
Mespilodaphne texana.
Nyssa texana.
Carpolithus callitriformis.

Of the foregoing nine species, the *Nyssa*, which is represented by fruits but no leaves, is by far the most common. Next in abundance are the fruits of *Myristica*, of which no foliage has been found. The *Carpolithus* and *Nectandra gosportensis* var. *jacksonensis* are represented by single specimens, and the remaining species are represented by a few broken specimens. Before considering the climatic character of these forms their condition of preservation demands attention. The matrix is a light-colored, prevailingly brownish quartz sandstone which in most specimens has an irregular binder of opal. In the specimens which do not have this binder the material is very friable and contains numerous clay pellets or "galls." It is without lamination, and the leaves are in places matted in a subparallel manner and were apparently laid down in water. Other specimens show but few leaves, and these are curled and lie at all angles in the sandstone, in a manner that is usually interpreted as indicating burial in a dry state by wind-blown material. This method of deposition is also indicated by the loss of the arils in the nuts of *Myristica*, which must have blown around for a while before burial. This evidence is corroborated by the method of occurrence of the *Nyssa* stones.

These stones occur also in the clays of the Yegua, where they lie parallel with one another and with the bedding of the clays. In the Catahoula sandstone they are massed, so that a single hand specimen, like the one figured, may contain dozens of these stones, and elsewhere the outcrop may not contain a single specimen. Where present they are jumbled together and lie at all angles and manifestly could not have been buried by water-laid materials. Moreover, all the stones have lost their fleshy pericarp and were thoroughly desiccated before burial. Invariably they are represented by casts in the porous sandstones and are lignified in the clays.

Botanically I consider all the forms as coastal forms of the strand except the *Nyssa* and possibly the *Myristica*. In its modern species *Myristica* is commonly an upland rain-forest type, but it also has sandy-strand species in both the oriental and occidental Tropics, so that it is not conclusive either way. *Nyssa*, so far as its existing species are concerned, is not a strand plant, although it is a coastal type. The general habitat is one of river bottoms and mesophytic river and estuary swamps. *Nyssa biflora* and *Nyssa acuminata* and to a greater or less extent all the other existing species are found on a sandy substratum. I would consider the Jackson species as dwelling in small ponds or "bays" near the Jackson coast.

Phoenicites is a sand-inhabiting form. It and its modern allies all require abundant ground water, but if conclusions can be drawn from the large, hard fruits of the fossil and the habitat of the existing species that have similar large and hard fruits, it indicates a very long growing season under a clear sky and in very hot sunshine. It may or may not indicate abundant rainfall, but its roots require an abundant water supply, which is obtained for the cultivated species of the African deserts by artificial irrigation. *Callitris* is a sand plant, and *Dryophyllum*, *Cedrela*, *Nectandra*, and *Mespilodaphne* are strand plants of sandy beaches and dunes. Though *Dryophyllum* is an extinct type, its greatest display is invariably in littoral sands of beaches, as in the Upper Cretaceous sands of Aix-la-Chapelle, which are beach and dune sands; in the lower Eocene "sables d'Ostricourt," which are also beach and dune sands; and in the Wilcox beach sands.

All the identified species that are based upon leaves from this locality have leaves of a coriaceous texture. This indicates one of two alternatives—either an arid climate, which is negatived by the *Phoenicites* and *Nyssa*, or an

open growth on a sandy soil in which the direct and reflected rays of the sun cause reduced transpiration by the development of coriaceous leaf structure. I regard the second alternative as reasonably well established.

The seven plants from the locality near Stryker are identified as follows:

Sabalites vicksburgensis.
Fagara catahoulensis orbiculata.
Fagara catahoulensis elongata.
Cedrela jacksoniana.
Banisteria texana.
Burserites fayettensis.
Sterculia cf. S. labruscoides.

These forms are all coastal or strand plants, and only one, the *Cedrela*, is common to the other locality. All are represented by foliage. The *Sabalites* is a large-leafed fan palm like the modern *Sabal palmetto*. It can not represent the foliage of the form that bore the *Phoenicites* fruits, for they have come from a feather palm. This florule from Stryker, a place so near the locality in southern Trinity County, and from beds that lie at the same horizon as those that contain the other florule, is decidedly more mesophytic and shows that the conditions indicated by the other florule were purely local.

In the study of the petrographic characters of the deposits at this locality, Goldman[38] reaches the following conclusions:

> The picture presented by the combination of these different factors appears somewhat as follows:
>
> A sand flat, either coastal or inland, containing temporary or more permanent but in either case small and quiet bodies of water; the climate arid and perhaps tropical, with strong winds driving the sand about but not accumulating it characteristically in dunes, while near-by rocky hills or mountains crumbling under the effects of temperature changes constantly add fresh angular fragments to the sand.
>
> To review the different characters, in the order given above, for their bearing on this conclusion we have, first, the important feature of sizing supporting the assumption of sorting of the sand by wind and probably by strong wind such as prevails in tropical regions, but the sorting probably not as perfect as would result in a region of well-developed dunes. In the very perfect rounding even of grains as small as 0.035 millimeter there is pretty certain evidence of wind action, while the rather small proportion of rounded grains again indicates that dunes did not prevail here and that new angular material was being constantly added. This conclusion is strongly supported by the abundance of feldspar, which indicates, moreover, that the source of supply of this new material was near by. On the amount of weathering of the feldspars, however, which is one of the most important features for the determination of the climate, the evidence is particularly unsatisfactory. Still I shall accept as a working hypothesis the tentative conclusion, arrived at above, that the feldspars were predominantly fresh when deposited. Then we have in them also evidence of mechanical disintegration—that is, of arid conditions.
>
> As stated above there is no basis, in the condition of the feldspars themselves, for choosing between arid and glacial climate. I reject glacial simply because all our other knowledge about the period, as well as other evidence presented in this paper, especially that from the heavy minerals, precludes such an assumption. How easy it is to be misled by the feldspars is shown by Mackie's paper on the subject, in which he concludes for glacial conditions in formations which are now generally believed to have originated in an arid climate.
>
> The proportion of heavy minerals was seen to lie between that characteristic of normal subaqueous deposits and a desert sand and to be most like that of dune sands. The negligible proportion of micaceous minerals points to wind action; the small amount of epidote and absence of chlorite to absence of chemical conditions of weathering; the scarcity of ferromagnesian minerals to insolation in an arid region; and the predominance of the two resistant minerals magnetite and zircon to strong mechanical wear, such as, under the circumstances, is most likely to have resulted from eolian action. In the seeming porosity of the rock there was some support for the assumption of subaerial deposition. The interpretation of absence of lamination was uncertain, but it seemed likely to be due to rapid deposition, such as might be caused by wind or by emptying of a strong current into a quiet body of water. The arrangement of fossils is of two types, one indicating subaerial burial in blown sand, the other also probably burial by wind but in a quiet body of water. It was shown that clay galls in general are produced in regions of loose sand, arid or at least without vegetation, and where there is occasional flooding or washing by rain. Their concentration with the masses of flat leaves is taken to confirm the assumption that the water was quiet and that the burial was by wind-blown material, though it may also indicate that these bodies of water were intermittent or variable in their extension.

There is thus substantial agreement between the two lines of evidence with respect to this one locality, and similar petrographic studies should be made in connection with a study of the field relations at a large number of outcrops, especially in the region of the outcrop of the Fayette sandstone, which commonly appears to be partly subaerial. Matson[39] implies that the well-rounded sand grains and the unweathered feldspars were the result of weathering under arid conditions in the region east of the Continental Divide and

[38] Goldman, M. I., op. cit., pp. 285–286.

[39] Matson, G. C., The Catahoula sandstone: U. S. Geol. Survey Prof. Paper 98, p. 221, 1917.

were brought down to the coastal region by the rejuvenation of the streams of the Great Plains area by regional uplift in the Rocky Mountain region. This view may, of course, account for the great quantities of sand in the western Gulf area throughout the Tertiary period and the peculiar condition of weathering found by Goldman. If subsequent studies show that these features are common to a large number of localities such an explanation will doubtless be accepted. Until this hypothesis is tested no definite conclusions can be formulated.

Certainly the facies of the Jackson flora as a whole is not that of an arid climate, and I am disposed to consider that such aridity as is indicated in Trinity County is a local condition due to coastal sand flats. There is no reason for supposing that such sand flats, beach ridges, and small dunes can not exist in a moist warm climate. In the Wilcox the flora, though not tropical, is a warm temperate flora of what was clearly a region of heavy rainfall, and yet there were developed very extensive areas of shifting sands and beach dunes interspersed with swamps and beach jungle. In any consideration of climatic conditions the presence of a large and hard-fruited date palm is of great significance. Though there are a dozen existing species of *Phoenix* they are all indigenous in the tropical region of northern Africa and southern Asia, and the uncultivated coastal species have small fruits. Among the cultivated forms the greatest range from north to south is found in Egypt, where date culture of very ancient origin extends from the Nile delta to Khartum, over 16° of latitude, or about 1,100 miles. The extremes have a difference in mean annual temperature of 15° F. Though humidity records are not completely available Mason [40] gives extremes of mean annual humidity from 24 to 74 per cent. Comparisons with trees growing under artificial conditions are unsatisfactory, because much depends upon irrigation.

The ancestral dates seem to have been coastal tropical types, so that the utmost caution is necessary in making comparisons between the conditions in Jackson time and those necessary for the production of cultivated dates. A temperature of 18° C. or 64.4° F. is universally assumed as the zero point of activity of the cultivated date as regards flowering and fruiting, although vegetative growth may go on at considerably lower temperatures, as in the south of France. The growing season from pollination to ripening of fruit is about 7 months, and the hard fruits come from the regions of high temperature and minimum humidity. The Jackson date fruit was large and hard enough to resist decay, and it was covered by the wind-blown sands of upper Jackson time, so that without attaching too great a significance to these facts, it would seem that a high mean annual temperature prevailed at that time. The associated flora does not lend special support to an arid climate, as I have already indicated, nor to the accumulation of sediments at any great distance from the coast.

The net result of these more or less tentative conclusions that have been derived from a study of the Jackson flora are indicative of a subtropical climate and a strictly coastal flora, which in the later Jackson was growing under somewhat more variable conditions of moisture than in the preceding lower Jackson or Claiborne times. This coastal flora lived under the usual variety of habitats found along a coast—that is, on beaches, in moist situations behind beach ridges, in swamps, partly tidal and partly above sea level, in estuaries, and along bayous and lagoons.

The geologic history indicates a more or less extensive withdrawal of the sea, which was slightly reflected in the sediments of southern Alabama but was prominent from Mississippi to Mexico in the littoral, palustrine, and continental deposits of the Yegua formation. Partly contemporaneous with these continental deposits of late Claiborne time there was a marked transgression of the lower Jackson sea from Georgia to Arkansas and a less pronounced transgression in the Texas region, which was indicated by the occasional marine horizons in the Fayette sandstone and Frio clay. In Mississippi the Jackson closes with a deposit of littoral plant-bearing sand, included in the Forest Hill sand, a formation of partly continental origin and apparently contemporaneous in part with the marine Red Bluff marl of the lower Vicksburg. That there was such an oscillation of the strand line between the Jackson and the Vicksburg is indicated by the

[40] Mason, S. C., Dates of Egypt and the Sudan: U. S. Dept. Agr. Bull. 271, p. 5, 1915.

character of the Forest Hill sand, by the palustrine lignites that are commonly present at the base of the Vicksburg, and by the enormous thickness of the Jackson down the dip, as shown by the well borings in western Mississippi and eastern Louisiana in the region around Vicksburg, where prospecting for oil has been active. In the Texas region no such pronounced migrations of the strand line are discernible, but there appears to have been an oscillation that permitted continental deposits to interfinger with shallow marine deposits—an oscillation that was less pronounced but was comparable to the sequence of contemporaneous events in the Paris Basin which resulted in the gypsum deposits of the Ludian stage. This oscillation in Texas was prevailingly negative in character and resulted in the continuation of the continental type of sediments of the Fayette sandstone throughout the greater part of Vicksburg time in that region. These sediments make up the Catahoula sandstone and are distinguished with difficulty from those of the underlying Fayette.

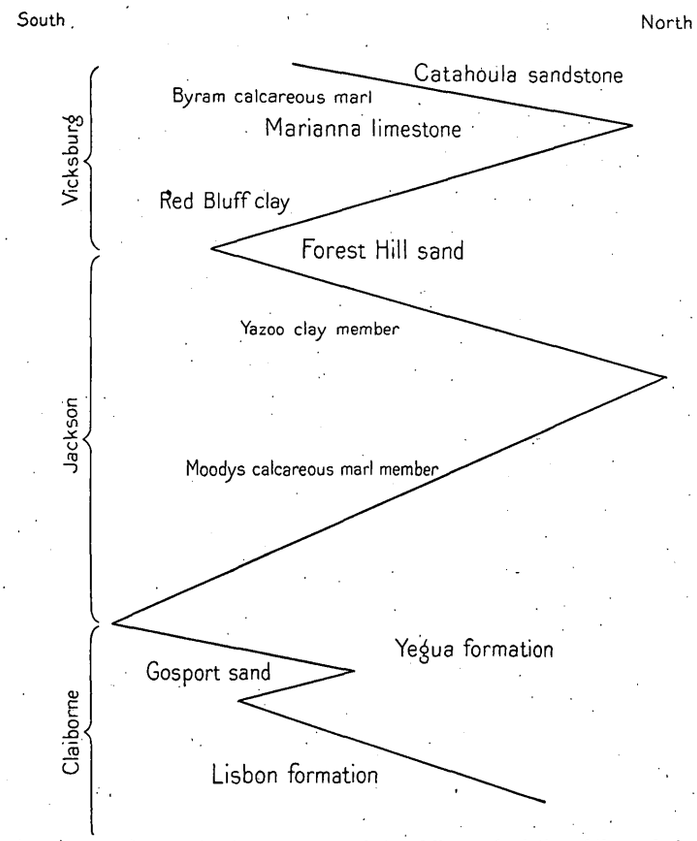

FIGURE 8.—Diagram showing movement of strand line and relation of the geologic formations in the central area of the Mississippi embayment.

This history as thus briefly outlined is graphically summarized in the accompanying diagrams (figs. 8 and 9).

CORRELATION.

CORRELATION OF THE JACKSON PLANT LOCALITIES.

Fossil plants have not been found in sufficient abundance nor widely enough distributed in the deposits of Jackson age for precise correlation of the plant-bearing outcrops with one another. The beds at certain of these outcrops, from their stratigraphic relations and the large number of Claiborne plants that they contain, are definitely referred to lower Jackson time. These include the deposits at localities in Georgia, Tennessee, and Arkansas. The beds at the two localities in Mississippi and those at most of the localities in Louisiana and Texas are referred to upper Jackson time, but the data are insufficient for the precise correlation of the locality on Hamilton League or the Paul Taylor place. The beds of the locality near Miraflores, in southwestern Texas, I have considered probably Jackson, for of the 19 known species from this outcrop 3 are peculiar, 6 are upper Jackson forms, and 10 are lower Jackson and Claiborne forms. From a consideration of the distribution of the species in beds of known age and their general relations to antecedent and subsequent forms, it is possible to distinguish between the earlier and later floras—that is, between the lower and upper Jackson floras—although the differences between the two are not strikingly contrasted and will probably decrease rather than increase as the floras come to be better known.

The following 16 species either have been actually collected from all horizons in the Jackson or are thought to range throughout the Jackson because of their occurrence in beds of earlier or later age or both.

Pestalozzites minor.
Cladosporites fasciculatus.
Lygodium kaulfussi.
Taxodium dubium.
Glyptostrobus europaeus.
Palmocarpon sp.
Dryophyllum brevipetiolatum.

Ficus unionensis.
Ficus mississippiensis.
Coccolobis claibornensis.
Nectandra antillanafolia.
Terminalia phaeocarpoides.
Oreopanax mississippiensis.
Nyssa texana.
Apocynophyllum texensis.
Apocynophyllum grevilleafolium.

Eleven of these species range up into the Jackson from the antecedent Claiborne, and two—the polymorphous *Taxodium* and *Glyptostrobus*—go back as far as the Wilcox. On the other hand, none of these 16 species have been found at horizons as young as the Vicksburg.

The flora that in the present state of our knowledge is confined to the lower or earlier Jackson and that is characteristic of those beds comprises the following 43 species:

Sphaerites claibornensis.
Equisetum sp.
Acrostichum georgianum.
Pteris inquirenda.
Potamogeton megaphyllus.
Potamogeton sp.
Pistia claibornensis.
Arundo pseudogoepperti.
Thrinax eocenica.
Engelhardtia jacksonensis.
Myrica zachariensis.
Castanea claibornensis.
Momisia americana.
Ficus claibornensis.
Ficus newtonensis.
Pisonia claiborniana.
Mimosites spatulatus.
Mimosites georgianus.
Cassia georgiana.
Cassia jacksoniana.
Sophora claiborniana.
Sophora wilcoxiana.
Cupanites nigricans.
Dodonaea viscosoides.
Sapindus dentoni.
Sapindus georgianus.
Ternstroemites claibornensis.
Cinnamomum angustum.
Cinnamomum spectabile.
Mespilodaphne caudata.
Mespilodaphne columbiana.
Nectandra arkansana.
Malapoenna sp.
Laurinoxylon branneri.
Laurinoxylon? sp.
Rhizophora eocenica.
Conocarpus eocenicus.
Myrcia bentonensis.
Sapotacites miraflorianus.
Diospyros miraflorianus.
Carpolithus najasoides.
Cypselites jacksonensis.
Leguminosites sp.

Two of the foregoing 43 species—a *Sophora* and a *Myrcia*—go back to the Wilcox, and 18 are found in the Claiborne, further emphasizing the great distinction between the floras of the Wilcox and the Claiborne and the striking continuity in the floras in passing from the Claiborne into the Jackson.

The flora which in the present state of our knowledge is not found in the earlier Jackson but which makes its appearance in the upper Jackson comprises the following 47 species:

Lygodium mississippiensis.
Cupressites sudworthi.
Canna jacksoniana.
Phoenicites occidentalis.
Sabalites vicksburgensis.
Palmoxylon lacunosum.
Hicoria jacksoniana.
Hicoria rostrataformis.
Planera hickmanensis.

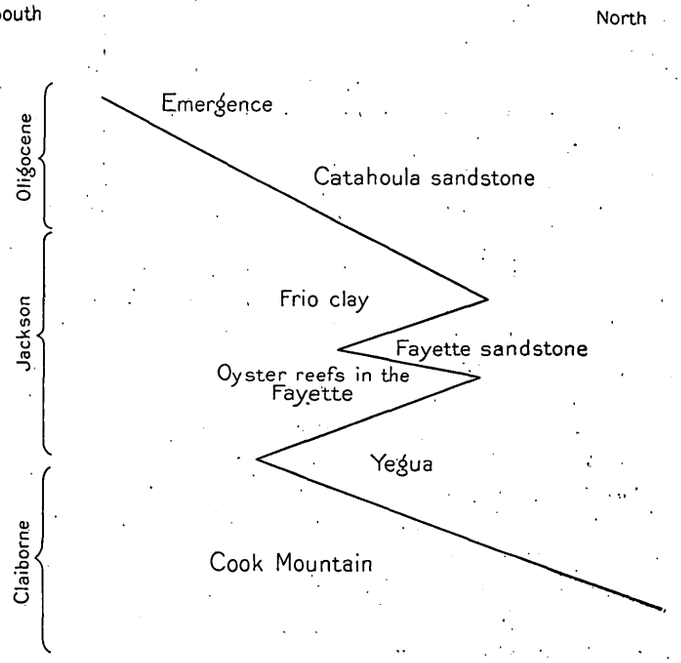

FIGURE 9.—Diagram showing movement of strand line and relation of the geologic formations in the Texas area.

Banksia jacksonensis.
Pisonia balli.
Pisonia jacksoniana.
Myristica catahoulensis.
Anona texana.
Menispermites carolinaformis.
Inga jacksoniana.
Mimosites mississippiensis.
Cassia obionana.
Bauhinia wadii.
Papilionites erythrinaformis.
Lonchocarpus anceps.
Liquidambar sp.

Fagara catahoulensis orbiculata.
Fagara catahoulensis elongata.
Fagara catahoulensis major.
Fagara catahoulensis coriacea.
Cedrela jacksoniana.
Banisteria texana.
Burserites fayettensis.
Paliurus catahoulensis.
Rhamnites krugiodendroides.
Grewiopsis wadii.
Bombacites jacksonensis.
Dombeyoxylon jacksonensis.
Sterculia cf. S. labruscoides.
Ternstroemites variabilis.
Mespilodaphne caudata major.
Mespilodaphne texana.
Nectandra gosportensis jacksonensis.
Lauraceous fruit.
Combretum petraflumense.
Myrcia catahoulensis.
Calocarpum viridiformis.
Tecoma preradicans.
Capparidocarpus sphericus.
Carpolithus callitriformis.
Carpolithus bumeliaformis.

Eleven species, or nearly one-fourth of the foregoing list, continue in deposits in this general region which are of Vicksburg age (Oligocene), and this is a surprisingly large number when it is recalled how very small is the known Oligocene flora of this area.

Although the lower Jackson flora is much like that of the Claiborne, from which it derives 24 of its 56 species, it is sufficiently distinct to be readily recognized when any reasonable representation of it is available for study. The genera present in the Jackson which are not known from the Claiborne number 23 and comprise *Sphaerites, Pestalozzites, Equisetum, Cupressites, Taxodium, Potamogeton, Pistia, Engelhardtia, Castanea, Banksia, Papilionites, Cedrela, Banisteria, Burserites, Cupanites, Paliurus, Rhamnites, Bombacites, Dombeyoxylon, Malapoenna, Rhizophora, Calocarpum, Sapotacites, Tecoma, Carpolithus, Capparidocarpus,* and *Cypselites.*

On the other hand, the following 24 genera, represented in the Claiborne, have not been detected in the Jackson: *Anemia, Goniopteris, Athrotaxis?, Sequoia, Cupressinoxylon, Geonomites, Bactrites, Juglans, Aristolochia, Gleditsiophyllum, Copaifera, Citrophyllum, Carapa, Celastrophyllum, Euonymus, Zizyphus, Rhamnicinium, Reynosia, Rhamnus, Persea, Oreodaphne, Laguncularia, Mimusops,* and *Eoachras.*

One possibility that should not be overlooked in further detailed areal work in the Texas area is the possibility—one might almost say the probability—that some of the deposits now referred to the Yegua formation of the Claiborne group were contemporaneous with a part of the Fayette sandstone, of late Jackson age. This seems to be established for certain localities, as, for example, in Brazos County. It is not certainly established, however, that the lithologic units now recognized as Fayette sandstone and Catahoula sandstone are chronologic units, the first of Jackson and the second of lower Oligocene age. Certain plant-bearing outcrops referred by the field geologists to the Catahoula—those near Stryker and those at the cut on the International & Great Northern Railway—contain a flora which, according to our present knowledge of the floras of this region, is of Jackson age and which is so considered in the present report.

RELATION OF THE JACKSON FLORA TO LATER FLORAS OF SOUTHEASTERN NORTH AMERICA.

Succeeding the Jackson come deposits of Oligocene age which are termed the Catahoula sandstone and Vicksburg group. These deposits may be considered together here, as the florules of each are very small and form a unit and as the lithologic units represented by the formational names are at least partly contemporaneous.

Twelve or thirteen of the Jackson species have been found in the Catahoula or the Vicksburg. These are *Pestalozzites minor, Lygodium mississippiensis, Cupressites sudworthi, Sabalites vicksburgensis, Palmoxylon lacunosum, Palmocarpon* sp.?, *Fagara catahoulensis orbiculata, Fagara catahoulensis major, Fagara catahoulensis coriacea, Fagara catahoulensis elongata, Paliurus catahoulensis, Myrcia catahoulensis,* and *Carpolithus bumeliaformis.* Although the Oligocene floras in this region are very small, still in the clay lenses of the lower Catahoula near Chalk Hills, La., a considerable number of coastal plants have been preserved, the forms discovered amounting to 14 species. The number compares favorably with even the most prolific Jackson plant localities, which are those near Miraflores, Tex., with 14 species, and near Grovetown, Ga., with 19 species. Only 8 of the Chalk Hills plants are common to the Jackson. These are *Pestalozzites minor,*

Cupressites sudworthi, *Sabalites vicksburgensis*, *Fagara catahoulensis* var. *orbiculata*, *major*, *coriacea*, and *elongata*, and *Myrcia catahoulensis*.

Although there are thus considerable specific differences between the Jackson flora and that of the lower Oligocene, the general facies and the generic representation are very similar. Thus both floras have, in addition to the 12 or 13 identical species enumerated above, representatives of the genera *Lygodium*, *Acrostichum*, *Ficus*, *Myrcia*, and *Carpolithus*. The Oligocene flora is small, but as it is a typical subtropical strand flora, and as it is corroborated and amplified by the evidence furnished by the more abundant marine faunas of the Jackson and the Vicksburg, the conclusion is reached that physical conditions, particularly the climatic conditions, did not show much change throughout Jackson, Catahoula, and Vicksburg time, such change as is apparent being a gradual approach to more nearly tropical conditions. The small flora of the "Apalachicola group," as known from the 13 species described from the Alum Bluff formation and the Hattiesburg clay [41] (both of which are now referred to the Miocene), is not especially close to that of the Jackson but appears to represent the somewhat impoverished descendants of the Jackson flora modified by the invasion of a few types from the warm temperate parts of southeastern North America and suggests comparison with the flora from western Kentucky and Tennessee which is tentatively referred to the upper Jackson.

The Miocene flora of the Chesapeake group [42] and that of the Pliocene Citronelle formation [43] are far removed in time and present an entirely different facies.

COMPARISON WITH EOCENE FLORAS OF OTHER AREAS.

In the discussion of the Claiborne flora comparisons were made with the Green River flora of Wyoming and with several little known floras of the Pacific coast region, and the probability that the Green River flora is partly contemporaneous with both the Claiborne and the Jackson was suggested. Four of the Jackson species are found in the Green River formation of Wyoming—*Arundo pseudogoepperti*, *Myrica zachariensis*, *Cupanites nigricans*, and *Sapindus dentoni*. Two of these are also present in the underlying Claiborne, leaving but two species peculiar to the Jackson—*Myrica zachariensis*, which is abundant in the basal Oligocene (Sannoisian) of France, and *Cupanites nigricans*, which is peculiar to the Jackson and Green River. The Green River is probably at least in part contemporaneous with the Jackson, although it contains many inland and upland types of hardwood trees of a distinctly temperate facies as compared with the nearly tropical flora of the Jackson.

The floras of the so-called "Arctic Miocene" have already been discussed in connection with the Claiborne. The actual resemblance between the Jackson and these Arctic floras is very slight, being confined to the single wide-ranging species *Taxodium dubium*. If the temperate floras of the Far North were contemporaneous with the most tropical floras of southeastern North America—the Jackson, Catahoula, and Vicksburg—this lack of specific resemblance is just what should be expected, and these Arctic floras of Jackson or Vicksburg age should contain, as they actually do, a number of types that existed in the Gulf region during lower Eocene time. Moreover, if their greatest extension occurred during Jackson and Vicksburg time they should contain other types that are found subsequently at later horizons in lower latitudes, and in this also they fulfill the requirements, as has already been pointed out by Count Saporta and J. Starkie Gardner.

RELATION TO EUROPEAN FLORAS.

Elsewhere in this paper (p. 37) I have shown that there is satisfactory evidence for correlating the Claiborne flora with the Auversian or lower Barton of the European section. The Jackson flora is then to be compared with that found in the upper Eocene of Europe.

The upper Eocene of Europe, differently denominated in different countries, comprises in the Paris Basin the Bartonian below, named by Mayer Eymar in 1857 from the Barton sand and clay of southeastern England, and the

[41] Berry, E. W., The physical conditions and age indicated by the flora of the Alum Bluff formation: U. S. Geol. Survey Prof. Paper 98, pp. 41–59, 1916.

[42] Berry, E. W., The physical conditions indicated by the flora of the Calvert formation: U. S. Geol. Survey Prof. Paper 98, pp. 61–73, 1916.

[43] Berry, E. W., The flora of the Citronelle formation: U. S. Geol. Survey Prof. Paper 98, pp. 193–208, 1916.

Ludian above (Munier-Chalmas and De Lapparent, 1893). In England the Ludian is represented by the glass sands or Headon series containing a few *Chara* fruits, a *Folliculites*, and an unnamed feather palm. In the Paris Basin the Bartonian marks a slight transgression of the sea, less in extent than that of the preceding Auversian or the subsequent Ludian. The Ludian represents a considerable transgression and then an oscillation of the strand that permitted the formation of the successive gypsum beds for which that region is celebrated. In Belgium the corresponding stages are typically marine and are termed the Wemmelian (in the strict sense) and the Asschian (Rutot, 1882), respectively. In the region of the Alps deposition was continuous, but the Ludian transgresses somewhat beyond the borders of the underlying Eocene. In the Alpine region the upper Eocene is often considered a unit under the term Priabonian, from Priabona, in the Venetian Alps.

The recorded fossil floras from the upper Eocene of Europe are extremely small and fragmentary, so there is little that affords any basis for comparison with the Jackson flora, which, small as it is, is much larger than any contemporaneous European flora. The celebrated lower Oligocene flora (Sannoisian or Stampian) from the gypsiferous shales of Provence, with which the town of Aix is inseparably associated, was considered by Count Saporta, its describer, as of upper Eocene age. It is very extensive and includes several hundred species. There seems to be little doubt but that it is not older than lower Oligocene and may even be upper Oligocene, so that it is conclusively recognized as somewhat younger than the Jackson flora.

There are some upper Eocene floras in northern Italy, but they are poorly described, and as the term Ligurian, to which they are often referred, includes both Eocene and Oligocene horizons they can not be utilized for purposes of precise correlation. There remain for comparison the small flora described by Saporta [44] from Brives, in Velay, and the plants recorded by Crié [45] from the upper Eocene sandstones of Maine and Anjou. The Brives flora is small, comprising but 21 species, and though it contains some of the genera found in the Jackson, such as *Sabalites*, its chief interest is in that it contains a well-marked date palm, which was referred by Saporta to the existing genus *Phoenix*, thus paralleling the Jackson date palm referred to *Phoenicites*. Saporta referred the Brives flora to the Lutetian, but I follow De Lapparent (1906) in considering it Bartonian in age.

The plants described by Crié from the *Sabalites* sandstones of Maine and Anjou, in western France, are of especial interest, as the leaves of the fan palms that are sometimes found in an upright position in these sandstones indicate their burial by wind-blown sands, and the physical conditions appear to have been much the same as those that accompanied the formation of the Fayette sandstone of Texas, where similarly preserved palms are found. This flora numbers 55 species and includes five ferns, five palms, three gymnosperms, and several dicotyledons. Genera common to the Jackson are *Lygodium*, *Sabalites*, *Myrica*, *Ficus*, *Diospyros*, and *Apocynophyllum*.

Since the account of the Jackson flora was written, a monograph describing the flora found in association with the brown coal of Messel, in Hesse, has been published. This flora is regarded as of late Eocene age and more or less transitional to Oligocene in its facies. It is described in a posthumous paper by Engelhardt [45a] and comprises representatives of 66 families, 154 genera, and 346 nominal species. There are no elements exactly identical with those of the Jackson, but the two have a considerable number of closely related species, and a large number of the genera are common to both floras. The Hesse flora differs from that of the Jackson in the large number of forms that it contains that are referred to *Quercus*, in the large number of species of *Ficus*, members of the Proteaceae and Myrtaceae, and in the presence of certain Old World genera such as *Amomum*, *Doliostrobus*, *Laurelia*, *Leptomeria*, *Elaeagnus*, *Ligustrum*, *Notelaea*, *Maesa*, *Cunonia*, *Ceratopetalum*, *Callicoma*, *Knema*, *Coriaria*, *Pomaderris*, *Anaphremum*, *Mangifera*, *Tristania*, *Callistemon*, and *Acmena*.

[44] Saporta, Gaston de, Essai descriptif sur les plantes fossiles des arkoses de Brives près le Puy-en-Velay: Soc. agr., sci., arts et commerce du Puy Annales, vol. 33, pp. 1–72, pl. 1–6, 1878.

[45] Crié, L., Recherches sur la végétation de l'ouest de la France à l'époque tertiaire: Annales sci. géol., vol. 9, pp. 1–72, pls. 8–22, 1877.

[45a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, 1922.

There is thus little evidence for precise intercontinental correlation with the Jackson. It is safe to say that it is Priabonian in age, but whether upper or lower remains inconclusive. Thus, in so far as the paleobotanic evidence is concerned, the Jackson flora may be Bartonian or it may be Ludian in age, or it may cover the time concerned in the deposition of the sediments of both of these stages in Europe.

THE FLORA.

THALLOPHYTA.

Fungi:
- Sphaerites claibornensis.
- Pestalozzites minor.
- Caenomyces jacksonensis.
- Cladosporites fasciculatus.

BRYOPHYTA.

Marchantiales:
- Marchantites stephensoni.

ARTHROPHYTA.

Equisetales:
- Equisetum sp.

PTERIDOPHYTA.

Filicales:
- Lygodium kaulfussi.
- Lygodium mississippiensis.
- Acrostichum georgianum.
- Pteris inquirenda.

SPERMATOPHYTA.

Gymnospermae.
- Coniferales:
  - Cupressites sudworthi.
  - Taxodium dubium (Sternberg).
  - Glyptostrobus europaeus.

ANGIOSPERMAE.

Monocotyledonae:
- Naiadales:
  - Potamogeton megaphyllus.
  - Potamogeton sp.
- Arales:
  - Pistia claibornensis.
- Scitaminales:
  - Canna jacksoniana.
- Liliales:
  - Smilax fayettensis.
- Poales:
  - Arundo pseudogoepperti.
- Arecales:
  - Phoenicites occidentalis.
  - Phoenicites sp.
  - Nipadites burtini umbonatus.
  - Thrinax eocenica.
  - Sabalites vicksburgensis.
  - Palmoxylon lacunosum.
  - Palmocarpon sessile.

Dicotyledonae:
- Choripetalae:
  - Juglandales:
    - Engelhardtia jacksonensis.
    - Hicoria jacksoniana.
    - Hicoria rostrataformis.
  - Myricales:
    - Myrica zachariensis.
  - Fagales:
    - Fagaceae:
      - Castanea claibornensis.
      - Dryophyllum brevipetiolatum.
  - Urticales:
    - Ulmaceae:
      - Momisia americana.
      - Planera hickmanensis.
    - Moraceae:
      - Ficus unionensis.
      - Ficus claibornensis.
      - Ficus newtonensis.
      - Ficus mississippiensis.
      - Ficus brazosensis.
      - Ficus sp.
  - Proteales:
    - Proteaceae:
      - Banksia jacksonensis.
  - Polygonales:
    - Polygonaceae:
      - Coccolobis claibornensis.
      - Coccolobis columbianus.
  - Chenopodiales:
    - Nyctaginaceae:
      - Pisonia jacksoniana.
      - Pisonia claiborniana.
      - Pisonia balli.
  - Ranales:
    - Myristicaceae:
      - Myristica catahoulensis.
    - Anonaceae:
      - Anona texana.
    - Menispermaceae:
      - Menispermites carolinaformis.
  - Papaverales:
    - Capparidaceae:
      - Capparidocarpus sphericus.
  - Rosales:
    - Mimosaceae:
      - Inga jacksoniana.
      - Mimosites spatulatus.
      - Mimosites georgianus.
      - Mimosites mississippiensis.
    - Caesalpiniaceae:
      - Cassia georgiana.
      - Cassia jacksoniana.
      - Cassia obionana.
      - Bauhinia wadii.
    - Papilionaceae:
      - Sophora claiborniana.
      - Sophora wilcoxiana.
      - Papilionites erythrinaformis.
      - Lonchocarpus anceps.

Dicotyledonae—Continued.
Choripetalae—Continued.
Rosales—Continued.
Hamamelidaceae:
Liquidambar incerta.
Geraniales:
Rutaceae:
Fagara catahoulensis orbiculata.
Fagara catahoulensis elongata.
Fagara catahoulensis major.
Fagara catahoulensis coriacea.
Meliaceae:
Cedrela jacksoniana.
Malpighiaceae:
Banisteria texana.
Burseraceae:
Burserites fayettensis.
Sapindales:
Sapindaceae:
Cupanites nigricans.
Dodonaea viscosoides.
Sapindus dentoni.
Sapindus georgianus.
Sapindus georgianus elongatus.
Anacardiaceae:
Anacardites balli.
Rhamnales:
Rhamnaceae:
Paliurus catahoulensis.
Rhamnites krugiodendroides.
Ceanothus jacksonensis.
Malvales:
Tiliaceae:
Grewiopsis wadii.
Tilia jacksoniana.
Bombacaceae:
Bombacites jacksonensis.
Sterculiaceae:
Dombeyoxylon jacksonensis.
Sterculia cf. S. labruscoides.
Buettneria jacksoniana.
Parietales:
Ternstroemiaceae:
Ternstroemites claibornensis.
Ternstroemites variabilis.
Thymeleales:
Lauraceae:
Cinnamomum angustum.
Cinnamomum spectabile.
Cinnamomum sp.
Mespilodaphne caudata.
Mespilodaphne caudata major.
Mespilodaphne columbiana.
Mespilodaphne texana.
Mespilodaphne jacksonensis.
Oreodaphne brazosensis.
Nectandra arkansana.
Nectandra antillanafolia.
Nectandra gosportensis jacksonensis.
Malapoenna sp.
Laurinoxylon branneri.
Laurinoxylon? sp.

Dicotyledonae—Continued.
Choripetalae—Continued.
Myrtales:
Rhizophoraceae:
Rhizophora eocenica.
Combretaceae:
Terminalia phaeocarpoides.
Conocarpus eocenicus.
Combretum petraflumense.
Myrtaceae:
Myrcia bentonensis?
Myrcia catahoulensis?
Myrcia ambiguaformis.
Umbellales:
Araliaceae:
Oreopanax mississippiensis.
Cornaceae:
Nyssa texana.
Nyssa jacksoniana.
Gamopetalae:
Primulales:
Myrsinaceae:
Ardisia sp.
Ebenales:
Sapotaceae:
Calocarpum viridiformis.
Sapotacites miraflorianus.
Sapotacites millicanensis.
Chrysophyllum preoliviforme.
Bumelia balli.
Ebenaceae:
Diospyros mirafloriana.
Gentianales:
Apocynaceae:
Apocynophyllum texensis.
Apocynophyllum grevilleafolium.
Personales:
Bignoniaceae:
Tecoma preradicans.
Verbenaceae:
Citharexylon brazosensis.

FORMS OF UNCERTAIN POSITION.

Carpolithus callitriformis.
Carpolithus najasoides.
Carpolithus balli.
Carpolithus bumeliaformis.
Cypselites jacksonensis.
Leguminosites sp.
Antholithes balli.

Phylum THALLOPHYTA.

Class FUNGI.

Order PYRENOMYCETES.

Genus SPHAERITES Unger.

Sphaerites claibornensis Berry.

Sphaerites claibornensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 132, pl. 24, fig. 6, 1914.

Perithecia small and numerous, arranged in elevated rings, 1 to 1.5 millimeters in diameter, on the upper surface of the leaves of *Ficus*.

Large numbers of fungi of this sort have been described by European paleobotanists, chiefly from Tertiary horizons, and referred to the genera *Sphaeria* Haller or *Sphaerites* Unger. They possess little biologic interest, except in so far as they indicate the presence of this class of plants in bygone floras, and American paleobotanists have usually ignored them entirely.

The present species is similar to *Sphaerites myricae* (Lesquereux) Meschinelli,[46] from the Green River formation of Wyoming, which occurs on leaves of a species of *Myrica*, and to *Sphaerites nervisequus* Fritel,[47] from the Sparnacian of the Paris Basin, which occurs on the leaves of a species of Lauraceae and is somewhat smaller than the Georgia form.

Occurrence: Barnwell formation (Twiggs clay member), Fiske property, Grovetown, Columbia County, and 10 miles south of Macon, Twiggs County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus CAENOMYCES Berry.

Caenomyces jacksonensis Berry, n. sp.

Plate LXV, Figure 8.

Irregularly circular spots of discolored and disorganized leaf tissue with a circular elevated umbilicate fruit mass about 2 millimeters in diameter, evidently representing a spot fungus resembling those of the genus *Phyllisticta* Persoon, which has hundreds of existing species. On leaves of *Combretum petraflumense* Berry.

As the identification of the thousands of existing leaf-spot fungi depends almost entirely upon their methods of reproduction and the morphology of their reproductive parts, the present fossil species is referred to the form genus *Caenomyces*, proposed by me [48] in 1916 for the reception of undeterminable fossil remains of Tertiary age that are undoubtedly fungi and not the result of insect injury.

Occurrence: Fayette sandstone, Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

[46] Lesquereux, Leo, The Tertiary flora, p. 34, pl. 1, fig. 4, 1878.

[47] Fritel, P. H., Étude sur les végétaux fossiles de l'étage sparnacien du bassin de Paris: Soc. géol. France Mém. 40, p. 13, pl. 1, fig. 14, 1910.

[48] Berry E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 162, 1916.

Genus PESTALOZZITES Berry.

Pestalozzites minor Berry.

Pestalozzites minor Berry, U. S. Geol. Survey Prof. Paper 98, p. 230, pl. 55, fig. 2, 1916.

Essential characters unknown. Infests the rays and the rachis of *Thrinax eocenica* Berry and forms relatively small, usually nearly circular spots, which average about 1 millimeter in diameter.

Indistinguishable remains are present in abundance on the rays of *Sabalites vicksburgensis* Berry, a common species in the Jackson and in the succeeding Vicksburg group.

These remains are of trifling value from the viewpoint of either the botanist or the geologist, but they are of considerable interest in the indications which they afford of the existence of this type of plant life in the middle Eocene of southeastern North America.

Occurrence: Barnwell formation (Twiggs clay member), Grovetown, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus CLADOSPORITES Felix.

Cladosporites fasciculatus Berry.

This species is described under the flora of the Claiborne group (p. 39). It is present in the lower Jackson of Texas and in the upper Jackson of Mississippi and was undoubtedly widespread throughout southeastern North America during the middle and upper Eocene.

Occurrence: Fayette sandstone, 1 mile northeast of Pennington, Trinity County, Tex. (No. 223); upper part of Jackson formation, 8 miles south of Jackson, Miss. (No. 281).

Collection: U. S. National Museum.

Phylum BRYOPHYTA.

Class HEPATICAE.

Order MARCHANTIALES.

Genus MARCHANTITES Brongniart.

Marchantites stephensoni Berry.

Plate LXIV, Figure 2.

Marchantites stephensoni Berry, U. S. Geol. Survey Prof. Paper 131, p. 4, pl. 4, fig. 1, 1922.

Plant body thallose, consisting of a linear, repeatedly dichotomously forked thallus, prominently thickened medianly and with very irregularly placed oblique and transverse markings,

which I consider represent appressed rhizoids. The lamina is about 6 millimeters wide, and the margins are very full and waved. The specimen figured has a total length of 11 centimeters and shows three dichotomies, the left branch of the main fork remaining entire for a distance of 5.5 centimeters before forking and the right branch forking at 2 centimeters and again 3 centimeters and 3.5 centimeters farther on. The thallus appears to have been of considerable consistency.

There are no features by which these remains can be separated from the type material of this species, which was described recently from the upper Wilcox of Arkansas. The present material, which is more complete, shows a greater distance between the dichotomies and has a fuller, more undulating margin, in the last feature approximating *Marchantia sezannensis* Brongniart, fruiting specimens of which were described many years ago from the Paleocene of France. The present species is also much like *Marchantia pealei*, described by Knowlton[49] from the Fort Union formation in Montana, which is a somewhat more robust form. Thalloid liverworts are so rarely found fossil that all records of them are noteworthy, and the present form is an exceedingly characteristic representative of this class of fossils. Similar remains have been recorded from several Jurassic and Lower Cretaceous localities, both in this country and abroad, and several Eocene and Oligocene species have also been described.

Occurrence: Fayette sandstone, Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Phylum ARTHROPHYTA.

Order EQUISETALES.

Family EQUISETACEAE.

Genus EQUISETUM Linné.

Equisetum sp.

Plate XLI, Figure 5.

A fragment of what is apparently a rather large species of *Equisetum* with coarse ribs. The material is too incomplete for a proper characterization.

[49] Knowlton, F. H., Description of new fossil liverwort from the Fort Union beds of Montana: U. S. Nat. Mus. Proc., vol. 35, p. 157, pl. 25, 1908.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Phylum PTERIDOPHYTA.

Order FILICALES

Family SCHIZAEACEAE.

Genus LYGODIUM Swartz.

Lygodium kaulfussi Heer.

This species is described under the flora of the Claiborne group (p. 39). It is not uncommon in the Claiborne but is rare and fragmentary in the Jackson, occurring at but a single locality.

Occurrence: Forest Hill sand, 11 miles north of Jackson, Mich. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Lygodium mississippiensis Berry.

Lygodium mississippiensis Berry, U. S. Geol. Survey Prof. Paper 98, p. 231, pl. 55, figs. 3, 4, 1917.

This species was described by me as follows:

Pinnules small and somewhat coriaceous, bilobate. Base rounded. Margins entire, slightly undulate. Lobes narrow, linear, with rounded tips, diverging at an angle of about 90° and separated by a right-angled sinus that approaches within 6 or 7 millimeters of the base. Width of lobes about 7 millimeters; length about 3 centimeters. Venation characteristic of the genus; rather open, considering the small size of the pinnules. At or just above the base the leaf trace of the pinnule forks at an angle of 55° to 60°, the branches curving outward and pursuing a course approximately in the middle of the lobes until they become obsolete by repeated branching. The branches go off at acute angles and curve outward, forking one or more times (usually but once) by a narrow dichotomy and ending in the margin.

The present species was based on very scanty and fragmentary remains found in the Catahoula sandstone of Rankin County, Miss. It is fully recognized that *Lygodium* pinnules are in general variable in size, outline, and lobation and that the foregoing description is inadequate in many respects. At the same time this species represents a characteristic element in a meager flora which is of great interest from the standpoint of the comparative paleobotanist. It is clearly distinct from the Wilcox or Claiborne species of *Lygodium*, the tendency seemingly having been in the direction of a progressive diminution in the size of the pinnules, a feature also noticeable in the records of *Lygodium* in the Tertiary of Europe.

It resembles somewhat but is perfectly distinct from *Lygodium dentoni* Lesquereux,[50] of the Green River formation in the Rocky Mountain region. It also resembles what J. Starkie Gardner terms a "dwarfed barren frond of *Lygodium kaulfussi* Heer" from the Lutetian of southern England.[51] Saporta has described three species from the Ligurian of southern France, a horizon not very different from the present one, which greatly resembles this species. They are *Lygodium parvifolium*,[52] *Lygodium exquisitum*,[53] and *Lygodium distractum*.[54] The first is a small bilobate form very close to the present species; in fact, the two may be identical, but in the present state of our information, both being rare and scantily represented, it is wiser to keep them distinct.

Occurrence: Fayette sandstone, three-fourths of a mile above junction of Caney and White Rock creeks, Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family POLYPODIACEAE.

Genus ACROSTICHUM Linné.

Acrostichum georgianum Berry.

Plate XXVIII, Figure 1.

This species is described under the flora of the Claiborne group (p. 42). It is not uncommon in the middle and upper Claiborne and is exceedingly abundant in deposits of lower Jackson age in Georgia.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry); Marion-Macon road, 10 miles south of Macon, Bibb County, Ga. (collected by C. W. Cooke and H. K. Shearer); 2 miles east of Gibson, Glascock County, Ga. (collected by Cooke and Shearer).

Collection: U. S. National Museum.

[50] Lesquereux, Leo, The Tertiary flora, p. 63, pl. 65, figs. 12, 13, 1878.

[51] Gardner, J. S., and Ettingshausen, C. von, British Eocene flora, vol. 1, p. 67, pl. 13, fig. 8, 1882.

[52] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, suppl. 2, p. 87, pl. 1, fig. 14, 1867; Dernières adjonctions à la flore fossile d'Aix-en-Provence, pl. 2, fig. 6, 1889.

[53] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 3, p. 88, pl. 1, fig. 13, 1867.

[54] Saporta, G. de, Dernières adjonctions à la flore fossile d'Aix-en-Provence, pt. 1, p. 24, pl. 2, fig. 8, 1889.

Genus PTERIS Linné.

Pteris inquirenda Berry.

This species is described under the flora of the Claiborne group (p. 46). The material both from the Claiborne and lower Jackson is very incomplete and scanty.

Occurrence: Barnwell formation (Twiggs clay member), Marion-Macon road, 10 miles south of Macon, Bibb County, Ga. (collected by C. W. Cooke and H. K. Shearer). Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMAE.

Order CONIFERALES.

Family PINACEAE.

Genus CUPRESSITES Bowerbank.

Cupressites sudworthi Berry.

Cupressites sudworthi Berry, U. S. Geol. Survey Prof. Paper 98, p. 232, pl. 55, fig. 1, 1917.

Cones small, subglobose, 1.5 to 2 centimeters in diameter. Cone scales ligneous, decussate, less than ten in number, the exact number not determinable; peltate in form, with a thick axis abruptly dilated to the subangular four or five sided, expanded, and transversely flattened tip, which is thick and radiately wrinkled from the subcentral mucronate umbo.

The present species is based upon poorly preserved and somewhat crushed cones, whose substance is replaced by a friable calcareous deposit. No traces of coniferous foliage have been found in association with them. These cones are very similar to those described by Unger[55] from the lower Oligocene of Haering, in the Tyrol, as *Cupressites taxiformis*, which Gardner,[56] on apparently good grounds, transfers to the genus *Cupressus* and associates with cones from the supposedly earlier horizon of Bournemouth (Middle Bagshot) of the south of England.

The present material is too poorly preserved to show whether the proximal scales are fused or free, or whether sterile scales persist at the

[55] Unger, Franz, Chloris protogaea, p. 18, pl. 8, figs. 1–3; pl. 9, figs. 1–4, 1847.

[56] Gardner, J. S., British Eocene flora, vol. 2, p. 26, pl. 91, figs. 22–26, 28–30, 1883. (Other figures show the characteristic dimorphic foliage.)

base of the cone. As identity with *Cupressus taxiformis* can not be positively established the present remains were described as new, and as they can not be definitely referred to the genus *Cupressus* rather than to *Chamaecyparis*, they were referred to the form genus *Cupressites* of Bowerbank and named in honor of Mr. George B. Sudworth, of the United States Forest Service.

This species was described from the Catahoula sandstone of Louisiana and is represented by lignified material from the deposits of lower Jackson age in western Tennessee. The modern species of *Cupressus* number about 12 forms of comparatively warm climatic requirements, living in southern Eurasia and Pacific North America from California southward to Central America, usually in sandy habitats near the coast. The modern species of *Chamaecyparis* number four or five and are confined to the Atlantic and Pacific coast regions of North America and similar mostly swampy habitats in Japan and Formosa.

Occurrence: Lagrange formation (upper part), Randolph Bluff, Tipton County, Tenn. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus TAXODIUM L. C. Richard.

Taxodium dubium (Sternberg) Heer?

Taxodium dubium (Sternberg) Heer, Flora tertiaria Helvetiae, vol. 1, p. 49, pl. 17, figs. 5, 15, 1855; 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.

Taxodium distichum miocenum Heer, Miocene baltische Flora, p. 18, pl. 2; pl. 3, figs. 6, 7, 1869.

Newberry, U. S. Geol. Survey Mon. 35, p. 22, 1898.

Knowlton, U. S. Geol. Survey Bull. 204, p. 27, 1902.

Berry, Jour. Geology, vol. 17, p. 22, fig. 1, 1909.

This species is abundantly represented at a large number of localities in the Northern Hemisphere during the Tertiary by foliage, cone scales, seeds, catkins, and wood. It is especially common in the lower Eocene of the Rocky Mountain province, the Tertiary of a large number of Arctic localities, and the Aquitanian of Europe. A single fragment of a twig is the only indication of its presence in southeastern North America during Jackson time, and the material is so incomplete that the identification is queried. It is represented by sparing but more characteristic material from a single locality in the antecedent Wilcox group.

The species is much like the modern *Taxodium distichum* in structure and habit. Its rarity in southeastern North America during the Eocene and Oligocene is believed to be due to the warm climate, for it is also absent from the more torrid periods of the European Eocene, as, for example, the Lutetian of France and England, and is abundant in the far north at about this same time.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, 75 feet above river, half a mile north of Hickman, Fulton County, Ky.; E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade). Jackson formation, 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris).

Collection: U. S. National Museum.

Genus GLYPTOSTROBUS Endlicher.

Glyptostrobus europaeus (Brongniart) Heer?

Plate XLIX, Figures 1, 2.

This species is described under the Claiborne flora. It has not been seen in beds of unquestioned Jackson age but occurs in those near the head of the embayment which I have tentatively regarded as upper Jackson and which may be somewhat younger. The remains are of slender twigs with acutely pointed, falcate, decurrent leaves, such as are frequently referred to the genus *Widdringtonia*. In two specimens the leaf bases are very much extended, and the leaves are correspondingly remote. In the absence of cones their reference to *Glyptostrobus* is questionable, but they appear indistinguishable from remains so identified throughout the Tertiary of both North America and Europe.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Class ANGIOSPERMAE.

Subclass MONOCOTYLEDONAE.

Order NAIADALES.

Family NAIADACEAE.

Genus POTAMOGETON Linné.

Potamogeton megaphyllus Berry.

Plate XXVIII, Figure 3.

Potamogeton megaphyllus Berry, U. S. Geol. Survey Prof. Paper 84, p. 135, pl. 27, fig. 2, 1914.

Leaf ovate-lanceolate in outline, 8 or 9 centimeters in length by 3.6 centimeters in greatest width, which is in the basal half of the leaf. Apex not seen, but the margins converge apically to a marked degree, so that it was rather obtusely or acutely pointed. Base rounded. Veins numerous, about 1 millimeter apart, unbranched, acrodrome. Midrib not differentiated. Transverse veinlets not visible. Texture apparently thin and firm.

The present species resembles a number of fossil forms of undetermined botanic affinity, such as *Smilacina rackiana* Pilar,[57] of the later Tertiary of Europe. It comes closest, however, to the leaves from Trocadero, in the Eocene of the Paris Basin (Lutetian), referred by Saporta [58] to the genus *Ottelia* Persoon (Hydrocharitaceae) but described originally as a species of *Potamogeton* by both Brongniart and Watelet [59] and referred by Bureau [60] to the genus *Monochoria* of the Pontederiaceae.

Between thirty and forty fossil species have been referred to this genus, none of which appear to be identical with the Georgia form. They range in age from the Arctic Senonian through Eocene, Oligocene, Miocene, and Pliocene to the Pleistocene, from which a large number of still existing species have been recorded, both in this country and abroad.

The modern species number over sixty, occurring in the Tropics as well as in the Temperate Zone, which has the larger representation. Most of the species have a wide and many a cosmopolitan range, a single species commonly extending over a great many degrees of latitude, as, for example, *Potamogeton perfoliatus* Linné, which extends over more than 20° of latitude in America, from Newfoundland and British Columbia to Florida and California, and which also occurs in Europe and Asia. All the wide-ranging species extend into both comparatively high and low latitudes, whereas species of narrow range are usually confined to warmer regions, as *Potamogeton floridanus* Small and *Potamogeton curtissii* Morong, of Florida.

This distribution may indicate that formerly the species confined to low latitudes in the existing flora or their immediate ancestors in more ancient floras had a much wider range, or that the modern wide-ranging species had greatly extended their former range in recent times. I incline to the latter supposition, although it is well known that the majority of aquatic animals as well as plants are little influenced by latitudinal temperature changes.

A form of similar size but more open venation, *Potamogeton nordenskiöldi*, is described by Heer [61] from the Tertiary of Spitzbergen. Both the Spitzbergen and the Georgia species probably represent floating and not emerged or submerged leaves.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, near Grovetown, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Potamogeton sp.

Plate XXVIII, Figure 2.

Leaves elliptical ovate, with a broadly rounded apex and base, the latter semicircular. Narrowed above the middle. Margins entire, evenly rounded. Leaf substance thin and apparently flaccid. Venation obscured. Length, 3.5 centimeters. Maximum width, in the basal half, 2.1 centimeters.

Based on a single specimen of what is apparently a submerged monocotyledon. Of doubtful botanical affinity but clearly distinct from the known members of the Claiborne flora.

Occurrence: Barnwell formation (Twiggs clay member), Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

[57] Pilar, Georgio, Flora fossilis susedana, p. 13, pl. 3, fig. 8, 1883.

[58] Saporta, G. de, Le monde des plantes avant l'apparition de l'homme, p. 227, fig. 45, 1879.

[59] Brongniart, Adolphe, Tableau des genres de végétaux fossiles, p. 115, 1849. Watelet, A., Description des plantes fossiles du bassin de Paris, p. 86, pl. 23, fig. 1, 1866.

[60] Bureau, E., Compt. Rend., vol. 115, pp. 1335-1337, 1892.

[61] Heer, Oswald, Flora fossilis arctica, vol. 1, p. 157, pl. 130, figs. 1b, 5c, d, 6–8, 1868.

Order ARALES.

Family ARACEAE.

Genus PISTIA Linné.

Pistia claibornensis Berry.

Plate XXVIII, Figure 4.

Pistia claibornensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 137, pl. 26, figs. 1, 2, 1914.

Leaves broadly obovate with a retuse apex, which gives them an obcordate outline, 2.5 centimeters in length by 2.5 centimeters in greatest breadth. Base broadly cuneate, descending to the wide petiole. Apex with a shallow, broadly rounded sinus. Venation indistinct, fasciculate, forming irregular polygonal meshes by repeated cross branching. There are indications in the fossil of intumescence and inflation in the basal half of the leaf exactly comparable to the conditions found in the existing species.

This species was the first to be discovered in the Tertiary, and only three Cretaceous species are known. It is clearly distinct from any previously described fossils but resembles somewhat certain leaves of *Pistia corrugata* Lesquereux, from the Upper Cretaceous Montana group, but it differs from this species in the degree of apical retuseness and from the leaves of the recent species in the same respect, although the older leaves of the recent species tend to a truncate form and many of them are slightly retuse.

In size, outline, and venation this species is not very different from the modern species *Pistia stratiotes* Linné, to which Engler has referred all the living representatives of the genus.[62] The result is certainly a somewhat variable and a most widely distributed species, practically confined to the tropical and subtropical zones of both the Old and the New World. In this country it is found from Florida to Texas. Elsewhere it occurs in the West Indies and southward through Mexico and Central America to Paraguay and Argentina. In Africa it is found from Natal to Senegambia and Nubia, occurring also in Madagascar and the Mascarene Islands. In Asia it occurs throughout the East Indies and northward to the Philippines.

[62] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, Teil 2, Abt. 3, p. 152, 1889.

But few fossil forms have been referred to this genus. Hosius and Von der Marck[63] described in 1880 what they called *Pistites loriformis* from the Lower Senonian of Westphalia, but this is probably cycadean, as Schimper[64] suggested. Lesquereux[65] in 1876 named a remarkably well preserved form from Point of Rocks, Wyo., *Pistia corrugata*. This form was later fully described and illustrated[66] and included leaves of different sizes and rootlets. It comes from beds belonging to the Montana group (Senonian), which are of about the same age as the French beds from which the only other species was known. This latter, *Pistia mazelii*, was mentioned and figured from the lignites of Fuveau (Provence), France, by Saporta and Marion[67] in a popular work and has never been adequately described.

Recently I showed that Heer's *Chondrophyllum nordenskiöldi*, described from the Atane beds of Greenland, was a true *Pistia* and was exceedingly abundant in the Upper Cretaceous Black Creek formation of North Carolina, which is of Colorado (Turonian) age.[68] A well-characterized species occurs in the Wilcox group in Louisiana.[69]

It is significant as showing how imperfect the geologic record really is, even of the European Tertiary, that this widespread modern type ranged over at least two continents during the Upper Cretaceous and presumably had a still wider range in Cenozoic time, and yet not a single specimen has ever before come to light at any of the thousands of localities where plant beds of Cenozoic age have been exploited.

Occurrence: Barnwell formation (Twiggs clay member), Fiske property, Grovetown, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

[63] Hosius, A., and Von der Marck, W., Die Flora der Westfälischen Kreideformation: Palaeontographica, vol. 26, p. 182, pl. 38, figs. 151, 152, 1880.

[64] Schimper, W. P., in Zittel, K. A., Handbuch der Palaeontologie, Abt. 2, Paleophytologie, p. 378, 1890.

[65] Lesquereux, Leo, On the Tertiary flora of the North American lignitic, considered as evidence of the age of the formation: U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 299, 1876.

[66] Lesquereux, Leo, The Tertiary flora, p. 103, pl. 61, figs. 1, 3–7, 9–11, 1883.

[67] Saporta, G. de, and Marion, A. F., L'évolution du règne végétale: Phanérogames, vol. 2, p. 37, figs. 114C, 114D, 1905.

[68] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain; V, North Carolina: Torrey Bot. Club Bull., vol. 37, p. 189, pl. 21, figs. 1–15, 1910.

[69] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 175, pl. 113, fig. 4, 1916.

Order SCITAMINALES.

Family CANNACEAE.

Genus CANNA Linné.

Canna jacksoniana Berry, n. sp.

Plate XLIX, Figures 4–6.

Leaves ovate-lanceolate in outline, of large size. Length estimated from the widest specimen collected to have been between 45 and 55 centimeters. Maximum width about 20 centimeters. Margins entire. Texture subcoriaceous. Midrib stout below, becoming inconspicuous distad, prominent on the lower side of the leaf. Secondaries thin but prominent, evenly spaced at intervals of about 1 to 2 millimeters, parallel; they diverge from the midrib at very acute angles and immediately curve outward, becoming slightly less closely spaced, and then pursue a nearly straight course, curving upward but slightly in the marginal region. Their general angle of divergence is about 55° to 60°. Every fourth or fifth secondary is very slightly more prominent, but there are no intermediate tertiaries parallel with the secondaries. The laterals are connected by thin, very closely spaced percurrent tertiaries, nearly at right angles to the laterals but slightly oblique and visible only on impressions of the under side of the leaf. These are characteristic of this species.

The spacing of the secondaries and the large angle which they form with the midrib suggested comparisons with the genus *Musa* or its commonest existing American relative *Heliconia*, but these were found to show differences in venation, particularly in lacking the percurrent nervilles or anything approaching them, except in the immediate vicinity of the midrib, whereas exactly comparable nervilles have been found in large leaves of the modern *Canna*. This resemblance, coupled with the known presence of species of *Canna* in both the Wilcox and Claiborne, enables this Jackson form to be referred to that genus with considerable confidence.

Canna jacksoniana was a fine large species, which, although closely related to its probable ancestor *Canna flaccidafolia* Berry, of the Claiborne, shows well-marked specific differences. These are the wider spacing of the laterals, their more open angle of divergence, and the well-marked nervilles.

The genus has between thirty and fifty existing species, exclusively American, chiefly hygrophilous and largely confined to tropical and subtropical regions. They constitute a picturesque element in the Tertiary floras of southeastern North America, where they have been represented from the Eocene to the present time. In their natural state they extend northward sparingly along the Atlantic coast as far as about latitude 34°. They are widely cultivated in ornamental plantings, and I have seen tropical forms escaped from cultivation and naturalized in Mississippi, Louisiana, and Texas. Aside from the fossil forms described by me, of which the Wilcox form is the best known and most wide ranging, having been found from northeastern Mississippi to southwestern Texas, the genus is sparingly represented in paleobotanic literature mostly by doubtful or undeterminable material. Although queried by Knowlton, its describer, I regard *Canna magnifolia* Knowlton [70] as an undoubted *Canna*. Its features are especially well marked, and it is of especial interest, as it was collected from the Upper Cretaceous Vermejo formation of southeastern Colorado and is therefore the oldest known undoubted representative of this genus.

Occurrence: Fayette sandstone, 1½ to 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order LILIALES.

Family SMILACEAE.

Genus SMILAX Linné.

Smilax fayettensis Berry, n. sp.

Plate LXI, Figures 1–3.

Leaves of variable size and outline, orbicular, elliptical-ovate or ovate-lanceolate, rounded to pointed apically; slightly decurrent, rounded or broadly cordate at the base. Margins entire, full and rounded, or narrowed in the upper half of the leaf, where it is extended distad. Length 6 to 9 centimeters. Maximum width, at or below the middle, 4 to 7 centimeters. Leaf substance thin, but stiff and not membranous. Petiole short. Midrib stout and prominent. A stout lateral primary

[70] Knowlton, F. H., Geology and paleontology of the Raton Mesa and other regions in Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 101, p. 254, pl. 36, fig. 3, 1917.

on either side diverges from the top of the petiole, forming an angle of about 55° with the midrib; these primaries curve upward, running parallel with the lateral leaf margins, about halfway between the midrib and the margins, becoming attenuated distad, where they are acrodrome. Outside the lateral primaries there is a pair of thin pseudoprimaries, diverging at similar angles from the top of the petiole and parallel with and a short distance within the leaf margins; these are not prominent, and in the middle part of the leaf they commence to arch from tertiary to tertiary but preserve their identity to the apex of the leaf and are acrodrome. Tertiaries thin, in general transverse in direction, commonly inosculating. Areolation prominent, forming transversely elongated, relatively large polygonal meshes, with mostly rounded angles.

The genus *Smilax* has not heretofore been collected in the Eocene of the Coastal Plain, although it has an extended geologic history. There are five species known from the Upper Cretaceous, four of which are American and the fifth European. The European species is of Emscherian age, whereas the American species are Cenomanian or Turonian. There are about eight other Eocene species—five found in the United States, three in the Arctic, one in Europe, and one in Asia. There are at least a score of named forms from the Oligocene, all from European localities; and about twenty-five Miocene forms, also for the most part European. The five or six Pliocene species are also entirely European, but the preponderance of Europe in both Oligocene and Pliocene is largely a result of accidents of preservation. I have seen *Smilax* in the Cohansey sand of New Jersey.

Except that the base in the present species tends to be cordate it much resembles the form from the late Eocene of Hesse that Engelhardt [70a] identifies as *Smilax reticulata* Heer, a European Oligocene species.

The genus has about 200 existing species, widely distributed and most abundant in the tropical parts of America and Asia. Its members are mostly climbing shrubs, and several extend for long distances into the Temperate Zone. The leaves are remarkably variable but generically characteristic. The present fossil species is not unlike *Smilax glauca* Walter or *Smilax walteri* Pursh, of the existing flora of southeastern North America.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

[70a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, p. 27, pl. 1, fig. 4, 1922.

Order POALES.

Family POACEAE.

Genus ARUNDO Linné.

Arundo pseudogoepperti Berry.

Plate XLI, Figure 6.

This species is described under the flora of the Claiborne group (p. 49). It is very common but in an exceedingly fragmentary condition in both the Claiborne and Jackson floras.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry). Barnwell formation (Twiggs clay member), Phinizy Gully (collected by E. W. Berry), and one-fourth mile southwest of Forrest station (collected by C. W. Cooke and H. K. Shearer), Columbia County, Ga.

Collection: U. S. National Museum.

Order ARECALES.

Family ARECACEAE.

Genus PHOENICITES Brongniart.

Phoenicites occidentalis Berry.

Plate XXVIII, Figures 8–10.

Phoenicites occidentalis Berry, Am. Jour. Sci., 4th ser., vol. 37, pp. 403–406, 1914.

Fruit as preserved in a coarse gray sandstone an oblate spheroid about 4 centimeters in length and 1.5 centimeters in maximum diameter. The surface is longitudinally wrinkled, probably as a result of desiccation before fossilization, which may also make the dimensions as given somewhat less than they were in life. The flesh was relatively thin, as compared with that of the cultivated date, and fibrous rather than of the soft and almost fluid character of some of the modern varieties of the date. The seed was relatively as well as actually large—in the specimen mentioned, which shows the exterior of the fruit, it is rounded at both ends,

about 3 centimeters in length, nearly circular in transverse section, and about 1 centimeter in diameter. A smaller specimen shows a length of about 2.5 centimeters and a diameter of 8 millimeters. The larger of these seeds shows the central hilum, the deep longitudinal sinus on the opposite side, the transversely lamellated structure exactly comparable to that of a modern date seed, and the finely corrugated surface coat identical with that of a dried seed of the modern date. The smaller specimen, though not so perfect, shows the general form and sinus and the lamellated structure.

The considerable range of species of *Phoenix*-like palms in the Tertiary of southern Europe has led to the expectation of their discovery in our more tropical southern Tertiary beds when these should have been thoroughly explored.

There can be no doubt that we are dealing with a *Phoenix*-like fruit, and we may confidently expect to discover the foliage eventually—in fact, some of the fragments of palm rays found at this and other horizons in our southern Tertiary may represent this foliage. Petrified wood of several species of palms is exceedingly abundant in these beds, and although the study of palm woods has not progressed to a point where the generic relations of the petrified woods can be made out with certainty, still it is significant that wood of several different species occurs at this horizon.

Although the geologic record is confessedly incomplete, a number of fossil species of *Phoenix*-like forms have been described—in fact, there are more fossil than recent species. These fossil species are usually referred to the genus *Phoenicites* of Brongniart, as I have done here, although some students refer them directly to the genus *Phoenix* of Linné. The previous fossil occurrences are all European and are based on both leaves and inflorescence. In 1886 Conwentz described a flower preserved in perfection in the Baltic amber (Sannoisian),[71] and the staminate inflorescence of another species is associated with splendid leaves in the Eocene of the Paris Basin.[72] The oldest known form comes from the middle or upper Eocene of the Paris Basin, and in the succeeding Oligocene epoch the remains of date palms are abundant in Germany, Bohemia, and especially in northern Italy. They are preserved in the early Miocene of France, Switzerland, and Croatia. A species is recorded from the west coast of the Adriatic in Pliocene time, and a well-marked form which Drude calls *Phoenix dactylifera fossilis*, as it is so much like the existing date, occurs in the Pleistocene deposits of the volcanic island of Santorin, in the Aegean Sea. This occurrence indicates that the date palm was endemic in at least a part of southern Europe until comparatively recent geologic time.

The cultivated date belongs to a group of about a dozen existing species referred to the genus *Phoenix*, all of which are confined to northern Africa and southern Asia, most of the species being indigenous in the Indian region. Two of the African species, *P. spinosa* and *P. reclinata*, are small shrubby forms that bear small fruits, found along the coasts of Senegambia, Sierra Leone, and Natal. The true date of commerce in countless varieties has existed since prehistoric times in the hot dry zone extending from Senegal eastward to the basin of the Indus. (See Pl. XXIV, *A*.)

The cultivated date does not perfect its fruit except in exceedingly hot climates where clouds are not common and where all forms of atmospheric humidity are very low—in fact, no amount of heat or degree of dryness of the air is injurious, provided the roots have access to a sufficient supply of moisture. Although the great caravan routes that traverse the deserts of northern Africa and southwestern Asia mark the areas of date culture, and although the finest varieties grow in the oases and sunken gardens of the Sahara, a consideration of the ecology of the date and of the other existing species of *Phoenix*, at least two of which are coastal types, indicates that the geologic ancestors were not desert types but inhabitants of coasts and stream banks, where the water table approached near enough to the surface to become available for their root system. When corroborated by the facies of the associated flora or fauna they may indicate hot climates accompanied by a scanty rainfall, as they probably do in eastern Texas, and it seems certain that the temperature could not

[71] Conwentz, H., Die Flora des Bernsteins, vol. 2, p. 8, pl. 1, figs. 6-9, 1886.

[72] Saporta, G. de, Essai descriptif sur les plantes fossiles des arkoses de Brives près le Puy-en-Velay, p. 25, pl. 1, 1878.

have gone below 18° C. without having been been fatal to flowering and fruiting.

Occurrence: Catahoula (?) sandstone, in a cut on the International & Great Northern Railway in southern Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Phoenicites? sp.

Plate LXII, Figure 1.

I refer this fragment of a pinnate palm leaf to *Phoenicites* because of the presence of *Phoenix*-like fruits at this horizon, although fully recognizing their inconclusive nature. They might with equal propriety be referred to *Chamaedorea*, *Geonomites*, *Iriartites*, and other palm genera, more or less prominent in the geologic history and recent palm flora of America.

The single specimen figured is the only one of its kind collected. It shows the distal part of a small pinnate leaf, with a slender rachis, the linear-lanceolate rays being contracted and folded at the base and attached to the side of the rachis, as in the existing genera *Phoenix* and *Archontophoenix*. The present material offers little of diagnostic value but differs from previously described forms and is easily recognizable, so that additional and more complete material may subsequently be discovered. Associated with this leaf is the unique specimen of palm fruit described as *Palmocarpon sessile* Berry, and this association renders negligible the argument from the presence of *Phoenix*-like fruits in the Fayette sandstone, which I mentioned above as one of the reasons for considering the leaf a *Phoenicites* rather than a *Geonomites* or *Iriartites*. The method of attachment of the rays, however, seems favorable to my interpretation, as these other genera have mostly flat and commonly undivided rays. A fragment subsequently collected has a stipe 5 millimeters in diameter, showing that these leaves were fairly large.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, and on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus NIPADITES Bowerbank.

Nipadites burtini umbonatus Bowerbank.

Plate LXIV, Figure 6.

Nipadites umbonatus Bowerbank, A history of the fossil fruits and seeds of the London clay, p. 9, pl. 1, 1840.

Nipadites burtini Brongniart var. *umbonatus* Bowerbank. Ettingshausen, Roy. Soc. London Proc., vol. 29, p. 393, 1879.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 176, pl. 112, figs. 13, 14, 1916.

Drupelike fruits of different sizes, from 4 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 species was recognized in the Wilcox of the Mississippi embayment region in 1916, and several specimens of similar remains in the Jackson are referred to the same species, thus bringing the range in America more into accord with the range of this interesting genus in the Old World.

This material consists of compressed, rather poorly preserved but perfectly characteristic fruits of a *Nipa*-like palm found in the kaolinite of Brazos County, Tex. 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 to their condition of preservation. It is quite possible to match these Eocene fruits from Mississippi and Texas with one or more of Bowerbank's types, but in the main they are most closely allied to his species *umbonatus*.

The fossil species of *Nipadites* and the existing genus *Nipa* were rather fully discussed in the account of the Wilcox occurrence, to which the reader is referred.

Occurrence: Fayette sandstone, Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus THRINAX Linné.

Thrinax eocenica Berry.

Plate XXX.

This species is described under the flora of the Claiborne group (p. 51).

Occurrence: Barnwell formation (Twiggs clay member), Fiske property and Phinizy Gully, Columbia County, Ga. (collected by S. W. McCallie and by E. W. Berry). Jackson formation, 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris).

Collection: U. S. National Museum.

Genus SABALITES Saporta.

Sabalites vicksburgensis Berry.

Plate XXIX.

Sabalites vicksburgensis Berry, U. S. Geol. Survey Prof. Paper 98, p. 233, 1917.

Leaves of variable size, flabellate, the maximum diameter estimated from collected material at about 120 centimeters. Rachis relatively slender, unarmed, not enlarged at the base of the leaf, continued upward as a long, slender, gradually narrowed acumen. Whether or not the two surfaces of the leaf differ as they do in *Sabalites grayanus* Lesquereux of the Wilcox and *Sabalites apalachicolensis* Berry of the so-called "Apalachicola group" can not be determined from the available material. Fragmentary counterparts of the base of a leaf indicate that the acumen is practically the same on both leaf surfaces. Rays carinate, about forty in number; basal ones becoming smaller, narrower, and closer as well as more curved proximad. All are extended, linear-lanceolate, and acuminate, becoming free distad for greater or less distances, generally from one-third to one-half their total length. Maximum observed width of rays, near the middle, is 3.6 centimeters. Midrib of rays stout. Lateral veins parallel with midrib, stout, about thirty on each side, one or two at irregular intervals on each side more prominent than their fellows, connected by fine transverse veinlets at right angles to the main parallel venation. Leaf substance relatively thin but stiff.

This species is close to previously described forms of *Sabalites*, the specific relations of all of which are not certainly assured. It differs from *Sabalites apalachicolensis* Berry[73] in its more slender rachis, longer acumen, thinner leaf, and more prominent venation. It may be distinguished from the widespread Wilcox form, *Sabalites grayanus* Lesquereux,[74] by its more slender rachis, lack of enlargement at the base of the leaf, and thinner texture.

Sabalites vicksburgensis was a form that resembled in its habitat *Sabalites apalachicolensis* as well as the modern *Sabal palmetto* Roemer and Schultes—that is, it probably never flourished far from the coast.

This species was described from the Catahoula sandstone of western Louisiana, which is considered to be of lower Vicksburg age at that outcrop. It is represented by little first-class material, although the abundance of fragments of rays shows that it must have been abundant along the coast of the Mississippi Gulf during lower Vicksburg time. It is more common in the Jackson than in the Vicksburg but is commonly poorly preserved, largely because of the large size and thin texture of the leaves. It differs from *Thrinax eocenica* Berry,[75] a fan palm that ranges up into the Jackson from the Claiborne, in its much larger size, relatively narrower rays, less prominent veins, and more extended acumen, which appears to have been equally developed on both surfaces of the leaf.

The present species greatly resembles the European Oligocene forms of the large fan palm *Sabal major* Unger, a species that is common throughout the European Oligocene and into the Miocene, if the identifications from a large number of localities can be trusted.

Occurrence: Catahoula (?) sandstone, Stryker, Polk County, and three-fourths of a mile above junction of Caney and White Rock creeks, Trinity County (collected by C. L. Baker); and Hamilton League, Fayette County, Tex. (collected by Alexander Deussen). Fayette sandstone, 1.2 miles southwest of crossing of Solomaneno Creek by Hubbensville-Zapata road, Webb County, Tex. (collected by A. C. Trowbridge).

Collection: U. S. National Museum.

[73] Berry, E. W., The physical conditions and age indicated by the flora of the Alum Bluff formation: U. S. Geol. Survey Prof. Paper 98, p. 46, pl. 8, fig. 3; pl. 9, fig. 9, 1916.

[74] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 177, pl. 12, figs. 1–3; pl. 14, fig. 1, 1916.

[75] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, p. 136, pls. 25, 26, 1914.

Genus PALMOXYLON Schenk.

Palmoxylon lacunosum (Unger) Felix.

Fasciculites lacunosus Unger, in Martius, Genera et species palmarum, p. 58, 16, tab. geol. 1, fig. 1; 2, fig. 8; 3, fig. 1, 1845; Synopsis plantarum fossilium, p. 186, 1845; Chloris protogaea, p. 71, 1845; Genera et species plantarum fossilium, p. 335, 1850.

Palmoxylon lacunosum (Unger) Felix, Die fossilen Hölzer Westindiens, p. 23, pl. 5, fig. 3, 1883. (*Palmoxylon lacunosum* Felix, Studien über fossilen Hölzer, p. 78, Inaug. Diss., Leipzig, 1882, is referred to *Palmoxylon anomalum* (Unger) by Stenzel, Fossile Palmenhölzer, p. 81 (187), pl. 8 (6), figs. 64–66, 1904.)

Schenk, in Zittel, Handbuch der Palaeontologie, Abt. 2, p. 889, fig. 430, 1890.

Berry, U. S. Geol. Survey Prof. Paper 98, p. 236, pl. 57, fig. 1; pl. 58, 1916.

Fibrovascular bundles not crowded, especially in the interior of the stem; sclerenchyma portion ovate or reniform in transverse section. Vascular portion orbicular. Auxiliary sclerenchyma bundles numerous, thin, without modified encircling cells. Groundmass with intercellular spaces, which are greatly developed in the peripheral part of the stem.

Stenzel [76] refers to this species the form *Fasciculites anomalus* Unger in Martius.[77] This if correct would according to the laws of priority involve a change in the name of this well-known form. *Palmacites axonensis*,[78] from the valley of the Aisne (Quincy-sous-le-Mont), is also referred to this species by Stenzel.

The species is close to *Palmoxylon texense* and also to *P. antiguense*. The original locality is unknown, although it is often referred to the Island of Antigua, as by Schenk.[79] My material is abundant but not especially well preserved. A form that appears to be *Palmoxylon lacunosum*, or that at least differs from it in only minor particulars, occurs near the boundary between the Tallahatta and Lisbon formations of the Claiborne group in southern Alabama.

Occurrence: Jackson formation, Texas & Pacific Railway, 1 mile east of Gailbreath, northwest border of Rapides Parish; south bank of creek just north of Pollock, Grant Parish, La.

Collection: U. S. National Museum.

[76] Stenzel, K. G., Fossile Palmenhölzer, p. 81 (187), 1904.

[77] Martius, C. F. P., Genera et species palmarum, p. 57, pl. 2, fig. 0, pl. 3, fig. 2, 1845.

[78] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 103, pl. 30, fig. 3, 1866.

[79] Schenk, A., in Zittel, K. A., Handbuch der Palaeontologie, Abt. 2, Palaeophytologie, p. 889, 1890.

Genus PALMOCARPON Lesquereux.

Palmocarpon sp.

Forms that appear to be nuts of some species of palm occur at a number of localities in beds of Jackson age or of supposed Jackson age. They present few characters of a specific nature, and their generic relationship is unknown. The larger forms are an inch and a half in diameter, and only this size occurs at the locality in Texas. The smaller forms are about one-half inch in diameter, and both large and small forms occur in western Tennessee.

Occurrence: Yegua formation (in beds regarded by me as of Jackson age), Rock Creek, William Dunn League, Brazos County, Tex. (collected by O. M. Ball). Lagrange formation, in beds of upper Jackson (?) age, Hickman, upper part of bluff, in cove just north of city water tower, Fulton County, Ky.; E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Palmocarpon sessile Berry, n. sp.

Plate LXI, Figure 5.

This species is unique. The specimen consists of parts of several slender axes of the inflorescence of a palm with numerous pendent axes and small nutlike fruits. The axes are somewhat flattened, undulating, about 3 millimeters in diameter, enlarging at intervals of about a centimeter, where they bear small spherical nutlike objects about 3 millimeters in diameter. The longest fragments are 10 centimeters in length without any change in character throughout this length.

I at first thought that the specimen represented a flower cluster, but the nutlike objects show no traces of floral parts and appear to have been hard spherical fruits, for they have not been flattened as have the stipes or as they would be if they were flowers. Subsequently I entertained the tentative opinion that these enlargements represented the points of attachment of more normal-sized palm nuts that had been shed before fossilization, for the nutlike objects are unusually

small for palm fruits. This last interpretation may be the true one, but for the present I lean toward the conclusion that the specimens represent the fruits, perhaps unusually small through abortion, although some palms have tiny fruits. There can be no question but that the specimen represents part of a palm inflorescence; in fact, objects somewhat similar but lacking fruits have been described by Saporta[80] under the names *Palaeorachis* and *Leptomeria* from the Tertiary of southeastern France. I have four specimens, and probably additional material will be forthcoming at some future time, as longer fragments are seen on the backs of other specimens in the collection, where they have been more or less destroyed by trimming the specimens. All are alike, tending to confirm the interpretation of functional fruits.

Among recent palms a considerable number have this type of inflorescence. Two genera, both represented by foliage in the Eocene of southeastern North America, appear to be most similar to the fossil in fruit characters. These are the genera *Chamaedorea* and *Geonoma*, both ancient and both still common, varied, and wide-ranging. The fossil is particularly like certain existing species of *Geonoma*, as, for example, *Geonoma orbigniana*, which has small spherical nuts not much larger than those of the fossil.

This makes seven different palm types known from the Jackson, emphasizing the abundance of this type in the middle and upper Eocene of southeastern North America and fully in consonance with the abundance of petrified palm wood in the late Eocene and early Oligocene of this region.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Palm rays.

Palm rays of undetermined generic affinity were found in collections from the following two localities. They are of interest in indicating the pre-Pleistocene age of these recent-looking deposits, which are here tentatively referred to the upper Jackson.

[80] Saporta, G. de, Les inflorescences des palmiers fossils: Rev. gén. botanique, vol. 1, pp. 229-243, pls. 2, 3, 1889.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, at Hickman, upper part of bluff in cove just north of city water tower, Fulton County, Ky.; slip in hill, near Corona, Tipton County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Subclass DICOTYLEDONAE.

Superorder CHORIPETALAE.

Order JUGLANDALES.

Family JUGLANDACEAE.

Genus ENGELHARDTIA Leschen.

[In Blume, Bydragen tot de Flora van Nederlandsch Indie, p. 528, 1825.]

Engelhardtia jacksonensis Berry, n. sp.

Plate XXVIII, Figure 5.

Involucre of medium size, trilobate, somewhat reflexed. Alae of approximately equal size, spreading but slightly narrowed below, the angle between the median and lateral wings about 70°. Sinuses correspondingly openly rounded, 1.5 centimeters from base of specimen and 6 millimeters from the margin of the fruit. Median wing slightly longer than the lateral wings, ovate-lanceolate in outline; 7 millimeters wide below and 10 millimeters in maximum width, about two-thirds of the distance to the tip, which is broadly pointed; margin full and rounded above, incurved below; total length, 3.4 centimeters. Lateral wings of approximately the same size and shape as the median wing, slightly inequilateral. Each wing is provided with a median vein, that of the median wing being stoutest. Midveins of the lateral wings thin and curved, their points of origin nearer the outer than the inner margin. Enlarged secondaries of about the same caliber as the primaries radiate from the fruit at regular intervals and run approximately parallel with each other and with the primaries for a greater or lesser distance, sending off short inosculating branches that become thin distad and eventually merge with the secondary system. There are three of these veins between the median and lateral primaries on one side and four on the other, and there are one or two on each side outside the lateral primaries. Normal secondaries

thin, diverging at a wide angle, curving upward in a short full arc, camptodrome, becoming thin distad and merging with the scarcely visible tertiary system. Essential portion of the fruit poorly preserved; it is, however, preserved and is indicated by a large, nearly circular, thick-margined ring of coriaceous tissue, the apex being crushed almost flat, as is well shown in the figured specimen.

The present species is very close to the existing species of *Engelhardtia*. Among previously described fossil species it is closest to *Engelhardtia mississippiensis*, described by me[81] from the Wilcox group of Mississippi. It differs from *Engelhardtia mississippiensis* in its smaller size, relatively larger and more prominent fruit, in the fuller and relatively wider wings and more delicate primaries, in their somewhat smaller angle of divergence, and in the basal venation surrounding the cupule and in the basal part of the wings. A less robust species, *Engelhardtia puryearensis* Berry, is also known from the Wilcox group.

Among the several Tertiary species of Europe *Engelhardtia jacksonensis* stands closest to *Engelhardtia abscondita*, described by Saporta[82] from the Aquitanian of Armissan, in southeastern France. Saporta's species, however, is much smaller, with wider and more rounded wings, and is clearly distinct from the present species.

The genus *Engelhardtia*, which was described by Leschen in 1825, contains about ten species of the southeastern Asiatic region ranging from the northwestern Himalayas 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. This is much more restricted in its range than its kin beyond the Pacific. *Oreomunnea* is very close to *Engelhardtia*, and for the purposes of the paleobotanist the two may be considered identical, for they represent but slightly modified descendants of a common ancestry that was of cosmopolitan distribution during the early Tertiary. The present isolation of *Oreomunnea* furnishes a striking illustration of the enormous changes which have taken place in the flora of the world in the relatively short time, geologically speaking, that has elapsed since the close of the Cretaceous.

The principle has frequently been enunciated that when closely related forms in the existing flora of the world are restricted in range and isolated from their nearest relatives, or when the existing genera are monotypic, an interesting and extended geologic history is probable. *Engelhardtia* proves to be another 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* (Betulaceae). With the botanical exploration of distant lands in the early part of the 19th century, specimens of *Engelhardtia* began to be represented in the larger European herbaria, and Baron Ettingshausen,[83] that most sagacious of paleobotanists, as long ago as 1851 pointed out that certain supposed species of *Carpinus* really represented 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 existence of a living species of *Engelhardtia* in Central America.[84]

Since Ettingshausen's announcement a dozen or more fossil species have been described. With the exception of the present form and the Wilcox form recently described, the oldest known form occurs in the upper Eocene or lower Oligocene (Ligurian) 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 stating that the slabs from the leaf beds at Armissan, in southeastern France, are thickly strewn with their peculiar fruits. Fossil forms continue in Europe

[81] Berry, E. W., An *Engelhardtia* from the American Eocene: Am. Jour. Sci., 4th ser., vol. 31, p. 494, fig. 2, 1911.

[82] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 345, pl. 12, fig. 3, 1866.

[83] Ettingshausen, C. von, Fossile Flora von Wien: K.-k. geol. Reichsanstalt Abh., Band 2, Abt. 3, p. 12, 1851.

[84] Ettinghausen, C. von, Beiträge zur Kenntniss der fossilen Flora von Sotzka: K. Akad. Wiss. Wien Sitzungsber., Band 28, p. 12 ,pl. 4, fig. 4; pl. 5, figs. 1–3, 1858.

throughout the Miocene and Pliocene, and specimens of late Miocene or early Pliocene age are recorded from Spain, France, Italy, Croatia, and Hungary.

The fruits of *Engelhardtia jacksonensis* are smaller than those of the Central American *Oreomunnea*, according to a single specimen of this form, which is practically unrepresented in all the larger American herbaria, or those of the Asiatic *Engelhardtia chrysolepis* Hance, but all the modern species that I have seen have somewhat smaller fruits (I refer to the essential part of the fruit) and relatively longer and more slender wings.

Occurrence: Jackson formation, in a cut on the Iron Mountain Railway at McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus HICORIA Rafinesque.

Hicoria jacksoniana Berry.

Plate XLIII, Figures 6, 7; Plate L, Figures 1–3.

Carya olivaeformis Nuttall. Lesquereux, Am. Jour. Sci., 2d ser., vol. 27, p. 365, 1859.
Hicoria pecan (Marshall) Britton. Berry, U. S. Nat. Mus. Proc., vol. 48, p. 297, 1915.

This species is also abundant in the sandstones of Brazos County, Tex., in beds which are referred to the Yegua formation but which are in that part of the Yegua which I regard as of Jackson age. These last are all detached, and the matrix is coarse, so that the details of venation are obscure. They are described under the Claiborne flora.

The genus *Hicoria* has generally been regarded as a Temperate Zone type, largely from its range in the existing flora, but several students have pointed out that its ancestry was probably tropical, and, as I have stated on several occasions, the eight to fifteen existing species, which are confined to southeastern North America, may be segregated into two natural groups that appear to have diverged early in the geologic history of the genus—the true hickories and the pecan hickories. The true hickories are slow-growing trees, in general of temperate dry soils and with hard strong wood. They have full buds of overlapping scales; the leaflets number from 3 to 9, and the nuts are generally thick-shelled and thick-husked. The pecan hickories require moisture and warmer climate; they have relatively weak wood, with thin buds without overlapping scales, numerous slender falcate leaflets, and nuts with thin shells and thin husks.

Although confined to southeastern Asia and southeastern North America in the existing flora, the genus during its long geologic history is found nearly throughout the Northern Hemisphere. It is known from the early Eocene onward, reaching its maximum range in the Miocene and continuing common in Europe to the close of the Pliocene.

The present species is very similar to the existing pecan in the foliar characters. The associated nuts, which I have described as *Hicoria rostrataformis*, if they represent the same species, show decided differences from the fruit of the modern species. There is, however, a Pliocene species from southern Alabama which, as regards both fruit and leaves, is very close to the modern pecan.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Columbus, Hickman County, Ky.; 5 miles south of Hickman, old Dickerson farm on Fish Gap road, 4 miles north of State line, Fulton County, Ky.; and Hickman, Fulton County, Ky. (collected by E. W. Berry and Bruce Wade).

Collection: U. S. National Museum.

Hicoria rostrataformis Berry, n. sp.

Plate L, Figures 6–9.

Thick-shelled obtusely angled nuts with small kernels. The nuts are pointed at the apex and rounded at the base. They differ considerably in size, ranging from 1.25 to 1.50 centimeters in length and slightly under these dimensions in transverse diameter. The husk is thick and indehiscent and prominently rostrate.

This species is exceedingly common in the upper part of the bluff at Hickman and is a very characteristic form, unique among existing species of the genus but paralleled by *Hicoria rostrata* Ludwig,[85] from the German Tertiary, which is a still more rostrate form, but as it is said to be very rare in the Salzhausen lignites, it may be a sport or pathological form. It has a more extended beak

[85] Ludwig, Rudolph, Fossile Pflanzer aus der ältesten Abtheilung der Rheinisch-Wetterauer Tertiär-Formation: Palaeontographica, Band 8, p. 136, pl. 55, figs. 1–7, 1860.

and a larger kernel than the American form, and the *Hicoria* leaves associated with the two species are entirely unlike, so that there can be no doubt as to the distinctness of the two forms.

There are at least two types of leaves associated with these nuts—the long, narrow leaves formerly confused with the existing *Hicoria pecan* (Marshall) Britton and subsequently described as *Hicoria jacksoniana* Berry, and the larger leaves formerly confused with the existing *Hicoria glabra* (Miller) Britton. These nuts may belong to one or the other of these foliar forms, but at any rate they are entirely distinct from the fruits of any of our existing hickories.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, Fulton County, Ky.; upper part of bluff, half a mile north of Hickman, 15 feet above river, in Fulton County, Ky.; E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Order MYRICALES.

Family MYRICACEAE.

Genus MYRICA Linné.

Myrica zachariensis Lesquereux.

Plate XXVIII, Figures 6, 7.

Myrica zachariensis Lesquereux, The Cretaceous and Tertiary floras, p. 146, pl. 25, fig. 5; pl. 45A, figs. 6–9, 1883 (probably not of Saporta).

Leaves nearly sessile, alternate, oblong-lanceolate in general outline, widest below the middle and gradually narrowing upward to the acute apex. Base bluntly cuneate, more generally broadly rounded and slightly inequilateral. Length about 8 centimeters. Maximum width, in the basal third of the leaf, about 1.6 centimeters. Margins entire in the rounded base; above this point they are beset with somewhat irregularly spaced, not prominent, serrate teeth. Texture subcoriaceous, punctate. Petiole practically obsolete, wanting in the Jackson material, about 1.5 millimeters long in one rather doubtfully determined specimen from Wyoming that Lesquereux figured as belonging to this species. Midrib stout. Secondaries thin, mostly obsolete by immersion in the Arkansas material but said to be camptodrome in the western material.

The present species is doubtfully related to Saporta's French material. *Myrica zachariensis* was identified by Lesquereux from the Green River formation of Wyoming and adds an element to the Jackson flora that is prominent in most Eocene floras but that has heretofore been sparingly represented in the Eocene floras of southeastern North America. *Myrica* is represented by very numerous fossil species from the Upper Cretaceous to the present. Two species are known from the antecedent Wilcox flora. In the existing flora there are about two score species widely distributed in the temperate and tropical zones of both the Eastern and the Western Hemisphere.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by R. E. Call and by E. W. Berry).

Collection: U. S. National Museum.

Order FAGALES.

Family FAGACEAE.

Genus CASTANEA Adanson.

Castanea claibornensis Berry.

Castanea claibornensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 138, pl. 28, figs. 1, 2, 1914.

Leaves oblong-lanceolate in outline, of a thin, firm texture, about 18 or 19 centimeters in length by 4.5 centimeters in greatest width, which is about halfway between the apex and the base. Apex acuminate (?). Base cuneate, acute. Margin coarsely serrate, with sharp ascending teeth, becoming less marked proximad, the margin finally entire toward the base of the leaf. Petiole and midrib stout. Secondaries of medium size, numerous, regular, parallel and alternate, craspedodrome; they branch from the midrib at angles of about 40° and curve slightly upward, terminating in the marginal teeth. Tertiary venation consisting of numerous close-set and nearly transverse veins, which constitute about the only feature in which these leaves differ from those of our modern American chestnut *Castanea dentata* (Marshall) Borkhausen.

The genus *Castanea* is represented by a large number of fossil species, one doubtful form occurring as early as the Senonian of Europe. In addition the genus *Dryophyllum*

Debey, often and properly considered as in part ancestral to *Castanea* and forming a link between the *Castanea* and *Quercus*, has a number of species in the Upper Cretaceous and Paleozoic.

Species of *Castanea* are found in the Eocene beds of Montana, Oregon, Canada, Alaska, Greenland, France, Italy, and England. There are a number of species in the European Oligocene and in the Miocene of Japan, Europe, and America, including records in New Jersey on the east coast and Oregon on the west coast. No less than eight species have been described from the European Pliocene, all of which are very similar and are variously combined and segregated by different authors. They at least indicate the abundance of the chestnut in southern Eurasia during preglacial time.

The common modern chestnut of Europe (*Castanea vulgaris*) is recorded from interglacial beds in northern Italy and France, and the modern chinquapin (*Castanea pumila*) is recorded from the American Pleistocene in Kentucky and West Virginia.

Starkie Gardner comments on the incongruity of the presence of *Castanea* in the warm temperate or subtropical Eocene flora and expresses the belief that these supposed chestnuts are really referable to the tropical genus *Godoya* Ruiz and Pavon (Ochnaceae). After a careful comparison of the fossil species with the foliage of this modern genus I am strongly of the opinion that Gardner's comparison has no actual basis. On reviewing the possible evidence bearing on the supposed incongruity of *Castanea* in association with various tropical and subtropical genera we find that the modern species of chestnut number four or five—*Castanea vulgaris* Lamarck of southern Europe, another species in eastern Asia, and three species in America. Of the American species *Castanea nana* Muehlenberg is found in the sand hills and barrens of Georgia and Florida to Louisiana; *Castanea dentata* (Marshall) Borkhausen is found on rich, noncalcareous soils from Maine and Ontario to Michigan, Tennessee, Georgia, and Alabama. In Alabama it occurs as far south as Tuscaloosa County, where the mean annual temperature is about 65° F., as against 42° for Maine and about the same for Ontario, Canada, indicating a very wide actual range of temperature.

We find that the allied genus *Castanopsis* Spach, which Prantl[86] makes a section of *Castanea*, although it appears to be a little nearer *Quercus* than *Castanea*, has about 35 species, mostly of southeastern Asia and tropical India, with one western American species, which ranges from southwestern Washington to southern California. The closely allied genus *Quercus*, although primarily a temperate type, has a large number of strictly tropical species. These considerations effectually disarm any criticism of the presence of *Castanea* in association with *Thrinax*, *Acrostichum*, *Pisonia*, and similar forms in the Claiborne of Georgia.

Occurrence: Barnwell formation (Twiggs clay member), Grovetown, Columbia County, Ga. (collected by S. W. McCallie).

Collection: U. S. National Museum.

Genus DRYOPHYLLUM Debey.

Dryophyllum brevipetiolatum Berry, n. sp.

Plate XXVIII, Figure 11; Plate XXXI.

Leaves of variable proportions, lanceolate in general outline, ranging from linear-lanceolate to broadly lanceloate in form, gradually narrowed and about equally acuminate both distad and proximad. Length ranges from 12 to 17 centimeters. Maximum width, about midway between the apex and the base, ranges from 1.5 to 3.25 centimeters. Margins entire proximad, their distal two-thirds beset with approximately uniformly spaced, serrate teeth, separated by inequilaterally rounded sinuses. The teeth are not produced, and they increase in accentuation distad. There is considerable variation in their prominence on different leaves, and this variation is well shown in the specimens figured. Texture coriaceous. Petiole short and stout, tumid proximad. Midrib stout, prominent on the lower surface of the leaf. Secondaries numerous and stout, most of them regularly spaced, although there is a departure from this arrangement in some of the larger leaves. There are from twelve to fifteen opposite to alternate pairs of secondaries diverging from the midrib at angles of about 50° and promptly curving upward in regular subparallel curves; the lower three or four pairs are camptodrome close to the margins, but the

[86] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, Theil 3, 1894.

succeeding pairs are generally craspedodrome, running to the tips of the marginal teeth. In a few of the larger leaves that have more prominent teeth like the tip figured an intermediate camptodrome secondary is inserted between two adjoining craspedodrome secondaries.

Leaves of the sort last described suggest in both their outline and venation those of the species from the Wilcox group—*Dryophyllum puryearensis* Berry and *Dryophyllum anomalum* Berry. They are, however, obviously the extreme variants of the more abundant and typical leaves with which they are found associated. The coarseness of the matrix renders the tertiary venation very obscure. In places, however, percurrent nervilles can be made out, which show that these leaves are those of *Dryophyllum* and not *Castanea* or *Quercus*.

The present species is clearly unlike the numerous Wilcox species of *Dryophyllum*, the most similar of which have relatively very long petioles. It resembles somewhat some of the European early Eocene species of *Dewalquea* but is readily distinguished by the differences in venation between the two genera. The larger and wider leaves of *Dryophyllum brevipetiolatum* approach very close to the form from the upper Claiborne of the eastern Gulf area, which I have described [87] as *Castanea claibornensis* and which may be a true *Dryophyllum*, not far removed from the present species, or even identical with it, although I do not so consider it, for *Dryophyllum brevipetiolatum* is distinctly more slender, especially in its narrower forms.

The present species may also be compared with a number of previously described European forms, more particularly those from the Sannoisian of Menat, in the Auvergne, which Laurent [88] identifies as *Dryophyllum dewalquei* Saporta and Marion [89] and *Dryophyllum curticellense* Saporta and Marion.[90] The types of these two species were from the basal Eocene of Belgium, and there is a possibility that the basal Oligocene forms from Menat may represent closely similar but distinct species. It is possible that *Dryophyllum brevipetiolatum* may be identical with one or the other of these Sannoisian forms, and if not identical it is certainly closely allied to them.

In the systematic literature of paleobotany the genera *Dryophyllum*, *Quercus*, and *Castanea* are very much confused. Recently both Laurent and Marty [91] have discussed in a most admirable manner the diagnostic foliar characters of these genera, which they find no difficulty in distinguishing when reasonably complete material is available for study.

The present species is exceedingly common in the Fayette sandstone and in the basal beds of the Catahoula sandstone in eastern Texas and is questionably identified from the Claiborne.

Occurrence: Fayette sandstone, three-fourths of a mile above the junction of Caney and White Rock creeks, Trinity County, Tex., and Piedmont, Grimes County, Tex. (collected by C. L. Baker). Catahoula(?) sandstone, in a cut on the International & Great Northern Railway in Trinity County, Tex. (collected by C. L. Baker). Jackson formation, 4 miles northwest of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson).

Collection: U. S. National Museum.

Order URTICALES.

Family ULMACEAE.

Genus MOMISIA F. G. Dietrich.

Momisia? americana Berry.

This species, nowhere abundant, is described under the flora of the Claiborne group (p. 57).

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus PLANERA J. F. Gmelin.

Planera hickmanensis Berry, n. sp.

Plate L, Figures 4, 5.

Planera gmelini Lesquereux (not Michaux), Am. Jour. Sci., 2d ser., vol. 27, p. 365, 1859.

Planera aquatica Berry (not Gmelin), U. S. Nat. Mus. Proc., vol. 48, p. 300, 1915.

Betula nigra Berry (not Linné), idem, p. 298.

[87] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, p. 138, pl. 28, figs. 1, 2, 1914.

[88] Laurent, Louis, Flore fossile des schistes de Menat (Puy-de-Dôme): Mus. hist. nat. Marseille Annales, vol. 14, pp. 93–100, pl. 8, fig. 5b; pl. 9, figs. 2–5; pl. 10, figs. 1, 2, 1912.

[89] Saporta, G. de, and Marion, A. F., Essai sur l'état de la végétation à l'époque des marnes heersiennes de Gelinden, pp. 33–40, pl. 2, fig. 6; pl. 3, figs. 1–4; pl. 4, figs. 1–4, 1873; Revision de la flore heersienne de Gelinden, p. 50, pl. 7, figs. 4, 5; pl. 8, figs. 1–7, 1878.

[90] 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.

[91] Marty, Pierre, Études sur les végétaux fossiles du Trieu de Leval (Hainaut): Mus. roy. hist. nat. Belgique Mém., vol. 5, pp. 15–30, 1907. Laurent, Louis, and Marty, Pierre, Note sur le *Castanea arvernensis* Sap. de Menat: Assoc. franç. avanc. sci. Compt. rend. Congrès de Lille, pp. 607–615, figs. 1–3, 1909. Laurent, Louis, Flore fossile des schistes de Menat (Puy-de-Dôme): Mus. hist. nat. Marseille Annales, vol. 14, pp. 93–100, text figs. 47–50, 1912.

Leaves differing in size and outline because of differences in the relative length and width of the lamina, in general broadly or more narrowly ovate. Tip acute, in some specimens produced into more or less of an acumen and in others short. Base broadly rounded to cordate, in some specimens markedly inequilateral and in others not perceptibly so. Texture subcoriaceous. Length from 2 to 5 centimeters. Maximum width from 1 to 4 centimeters. Average proportions are shown in the specimen figured. Petiole short. Midrib stout, prominent on the under side of the leaf. Secondaries slender but prominent, diverging at angles of more than 45°, regularly spaced, rather straight in their courses, subparallel, seven or eight subopposite to alternate pairs, craspedodrome. One or more prominent branches diverge from the outside of each secondary about two-thirds of the distance above their bases, and these run to the points of the intermediate marginal teeth. Veinlets thin, subpercurrent. Margins with closely spaced rather prominent teeth that range from serrate to dentate in form.

This species, which has heretofore been confused with the single existing species of *Planera* and which it closely resembles in some specimens, is, on the whole, relatively shorter and wider, with shorter petioles, regularly spaced secondaries, regularly curved margins and more uniformly sized teeth, which do not show the tendency for some of the teeth to be enlarged and crenate in form, such as is common in the modern species. The relatively short and broad leaves of *Planera hickmanensis*, such as the one figured, are readily separated from the existing species and suggest comparisons with the genus *Betula*, but this type appears to be connected by a gradating series of forms, which at its other end is distinguishable with extreme difficulty, if at all, from *Planera aquatica*, with which they were formerly confused.

The genus *Planera*, with its single existing species, is now confined to the southeastern United States, where it is not common, except in the vicinity of the coast and in river swamps or bottoms subject to annual inundation. The genus is an old one, with four Upper Cretaceous species that range from western Greenland to North Carolina. There are three or four Eocene species confined to North America and Arctic localities. It is represented in the Miocene of both Europe and North America and in the Pliocene of Europe and Asia. The existing species is not uncommon in the Pleistocene of the southeastern United States, where its range was greater than it is at the present time.

There is a single rare species in the upper Wilcox Grenada formation in Mississippi, but the genus is otherwise unknown in the Eocene of the embayment region. Although a warm temperate type, I am inclined to regard it as of more northern origin. The present fossil species is rather common in the country bordering the Mississippi in southwestern Kentucky.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, Fulton County, Ky. (both upper and lower parts of bluff); half a mile north of Hickman, 75 feet above river; Dickerson farm on Fish Gap road, 5 miles south of Hickman; E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Family MORACEAE.

Genus FICUS Linné.

Ficus claibornensis Berry.

Plate XXXII, Figure 1.

Ficus claibornensis Berry, U. S. Geol. Survey Prof. Paper 84, p. 140, pl. 24, fig. 6; pl. 27, figs. 3, 4, 1914.

Leaves oblong-lanceolate in outline, about 12 centimeters in length by 3.5 centimeters in greatest width, which is about halfway between the apex and the base. Apex acute. Base equally acute and somewhat decurrent on the extremely stout petiole, which is about 3 centimeters in length and fully 3 millimeters in diameter and in one specimen quite curved. Midrib apparently equally stout below, becoming thinner above, not well seen, as all the collected material shows only the upper surface of the leaves; and as the texture was evidently coriaceous, much like that in the leaves of the commonly cultivated rubber plant, the venation is made out with difficulty.

The secondaries are numerous, thin, and parallel, of the character typical in lanceolate fig leaves of the *Ficus elastica* type. The younger leaves are much less elongated, being ovate-lanceolate in outline, 8 centimeters in length by 3 centimeters in greatest width. This fig is the commonest fossil at the locality 10 miles south of Macon, Ga. The species is not uncommon, and some of the leaves are relatively elongated; many of the others are infested with a species of *Sphaerites*.

Among the 600 or more described living species of *Ficus*, which range over the warmer regions of the whole world, and among the more than 300 known fossil species, ranging from the Cretaceous to the Pleistocene, it would be possible to mention many whose foliage greatly resembles the present species, but this is hardly worth while, except to point out that there are a number of modern tropical American species whose foliage is very close to this Eocene form.

There are over a dozen species of *Ficus* in the Wilcox, four in the Claiborne, and six in the Jackson. The genus is also present in considerable variety in the Eocene floras of the western United States and in those of Europe, being especially abundant in the upper Eocene flora of Messel, in Hesse.

Occurrence: Barnwell formation (Twiggs clay member), on Fiske property, Grovetown, Ga., one-fourth of a mile southwest of Forrest Station, Columbia County; Macon-Marion road, 10 miles south of Macon, Twiggs County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Ficus unionensis Berry.

Plate XXXII, Figure 5.

This species is described under the flora of the Claiborne group (p. 57), in which it is sparingly represented.

Occurrence: Lower part of Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry); 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris). Forest Hill sand, 11 miles north of Jackson, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Ficus newtonensis Berry.

This species is described under the flora of the Claiborne group (p. 58). It is sparingly represented in the beds of lower Jackson age in Georgia.

Occurrence: Barnwell formation (Twiggs clay member), one-fourth of a mile southwest of Forrest Station, Columbia County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

Ficus mississippiensis (Lesquereux) Berry.

This common species of the Wilcox and of the lower Eocene of the Rocky Mountain region is represented by a single but very characteristic specimen in the kaolinite lens in the Fayette sandstone of Brazos County, Tex. The species with its varieties was fully discussed in my paper on additions to the Wilcox flora, and the description need not be repeated here.[92]

Occurrence: Fayette sandstone, 1½ to 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Ficus brazosensis Berry, n. sp.

Plate LX, Figure 2.

Leaves of medium size, ovate in general outline, widest at or below the middle, tapering upward to the extended acuminate tip. Base broadly and shallowly cordate. Length about 9 centimeters. Maximum width about 4.5 centimeters. Petiole missing. Margins entire, somewhat irregularly rounded. Texture thin but firm. Midrib stout, prominent. Secondaries stout, five alternate pairs, becoming progressively more widely spaced distad; their angles of divergence from the midrib decreases upward, the basal pair being at right angles and short, the apical pair being at angles of about 25° and sweeping upward in long curves subparallel with the midrib. The tertiaries are percurrent, and the areolation is typical of this genus.

This species, obviously new, adds a distinct type of this genus to its representation during upper Eocene time. It is much like the European *Ficus tiliaefolia* (Alexander Braun) Heer, but more elongated. Heer's species has

[92] Berry, E. W., Additions to the flora of the Wilcox group: U. S. Geol. Survey Prof. Paper 131, p. 9, 1922.

been recorded from both the Eocene and the Miocene of the western United States, but the specific identity between the European and American forms is very doubtful.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican; Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Ficus sp.

Plate LX, Figure 6.

This large leaf is ovate, acuminate, and cordate, with a stout petiole and midrib and entire margins. The single specimen figured of a leaf, about 15 centimeters in length and 8.5 centimeters in maximum width, is the only one collected, and for this reason I have not named it or attempted a detailed description. It may represent a large variant of the associated *Ficus brazosensis* Berry, but this can be determined only from additional collections.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order PROTEALES.

Family PROTEACEAE.

Genus BANKSIA Linné (son).

Banksia jacksonensis Berry, n. sp.

Plate XXXII, Figures 2–4.

Leaves linear-lanceolate and generally falcate in outline, gradually narrowed and about equally acuminate at the apex and base, although the base may be somewhat less produced in the larger leaves. Margins entire for a short distance at the base, above which they have at regular intervals small aquiline or salient serrate teeth. Leaf substance thin but somewhat coriaceous. Estimated length ranges from 8 to 11 centimeters and averages about 9 centimeters. Maximum width, at or below the middle, ranges from 1.6 to 1.3 centimeters and averages about 0.8 centimeter. A petiole is absent in all the material, and I am inclined to think that the leaves were sessile. Midrib rather stout, generally curved, prominent on the lower surface of the leaf. Secondaries thin, nearly obsolete by immersion in the substance of the leaf. Numerous subparallel pairs diverge from the midrib at wide angles at regular intervals; those in the basal part of the leaf are somewhat more ascending and camptodrome, and those in the serrated portion of the leaf are relatively straight in their course and craspedodrome, corresponding in position with the marginal teeth and ending in them. Tertiary system fine, forming a close-meshed polygonal areolation characteristic of the fossil leaves of this genus.

This species is clearly distinct from previously described forms. It conforms in all particulars to the type of leaf usually referred to this genus, to which three well-marked lower Eocene species of the Mississippi embayment area were referred. It is the most abundant fossil at the locality north of Jackson, more than a score of specimens having been collected, but these are all unfortunately incomplete. The two forms that are figured show the known limits of size.

The genus *Banksia,* which is confined to the Australian region in the existing flora, has a recorded geologic range that extends back as far as the Upper Cretaceous and a geographic range that extends to North America and Europe. Although the identifications of some of these fossil forms are questionable, a great many records of this and other genera of Proteaceae from the North Temperate Zone are satisfactory, and there can be little doubt regarding the former cosmopolitan character of this type of plants.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, 75 feet above the river, half a mile above Hickman, Fulton County, Ky.; E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade). Forest Hill sand, 11 miles north of Jackson, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Order POLYGONALES.

Family POLYGONACEAE.

Genus COCCOLOBIS P. Browne.

Coccolobis claibornensis Berry?

This species is described under the flora of the Claiborne group (p. 59). It is represented in the Jackson of Arkansas and in deposits of this age in southwestern Texas by scanty and not certainly determined material.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union

County, Ark. (collected by E. W. Berry). Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Coccolobis columbianus Berry?

This species is described under the Claiborne flora (p. 60).

Occurrence: Fayette sandstone, Barrera League, 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Order CHENOPODIALES.

Family NYCTAGINACEAE.

Genus PISONIA Plumier.

Pisonia jacksoniana Berry, n. sp.

Plate XXXII, Figures 6, 7; Plate XLIX, Figure 3.

Leaves of small to medium size, somewhat variable in general outline, ranging from broadly lanceolate and slightly falcate to almost orbicular, all of them, however, longer than broad and preserving the pointed apex and base. The two extremes of variation are well shown in the specimens figured. Apex and base equally but shortly pointed in the narrower leaves; the base somewhat less narrowed than the apex in the wider leaves. The length ranges from 2.5 to 6 centimeters. The maximum width, midway between the apex and the base, ranges from 0.9 centimeter to 4.25 centimeters. Margins strictly entire, full and rather evenly rounded, the conspicuously undulatory appearance in the larger specimen figured being due to the curvature of the specimen away from the direction of the camera. Texture very coriaceous, the leaf substance being represented by a thick sheet of lignite. The epidermal cells are small and thick walled, but microscopic preparations fail to show any details of structure. Petiole short and stout. Midrib stout and prominent, generally somewhat curved. Secondaries as well as the tertiaries obsolete by immersion in the thick substance of the leaf. A few thin ascending secondaries are seen.

The present species is very characteristic and entirely distinct from previously described forms. It is surprisingly like the leaves of the existing *Pisonia aculeata* Linné. It is also very close to some of the European Tertiary specimens that have been referred to *Pisonia eocenica* Ettingshausen, although it is not so similar to the type material of that species, which came from the Sannoisian of the Tyrol.

The genus *Pisonia*, which has about 40 existing species, mostly tropical and American, is sparingly represented by small coastal trees from the Upper Cretaceous onward. There are three well-marked species in the Wilcox group, one of which, *Pisonia chlorophylloides* Berry, is not unlike the present species. The genus is also represented by a small-leafed form in the upper Claiborne, so that its history in the Atlantic Coastal Plain extends from the Upper Cretaceous (Black Creek formation) through the entire Eocene (Wilcox, Claiborne, and Jackson).

Occurrence: Lagrange formation, in beds of upper Jackson(?) age, Slip in Hill, near Corona, Tipton County, Tenn.; E. H. Russell place, 8 miles west of Union City, Obion County, Tenn. (collected by Bruce Wade). Jackson formation, White Bluff, Jefferson County, Ark. (collected by E. W. Berry). Forest Hill sand, 11 miles north of Jackson, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Pisonia claiborniana Berry.

This species is described under the flora of the Claiborne group (p. 61). It is not abundant in either the Claiborne or the Jackson.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County; Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Pisonia balli Berry, n. sp.

Plate XLII, Figure 4.

Leaves obovate in general outline, widest in the middle, with a broadly rounded tip and narrowed slightly decurrent base. Margins entire. Texture coriaceous. Length about 3 centimeters. Maximum width about 1.5 centimeters. Petiole short and stout, scarcely developed, about 2 millimeters in length. Midrib stout and wide to the extreme tip, prominent on the lower surface of the leaf. Secondaries very thin and immersed in the leaf substance, ascending, camptodrome.

Named for the collector, Prof. O. M. Ball, of College Station, Tex.

This species may simply represent large leaves of the Claiborne and lower Jackson species *Pisonia claiborniana* Berry. It is

similar to that species but is about twice as large, with less ascending secondaries. It is entirely different from the third Jackson species, *Pisonia jacksoniana* Berry, with which it is associated. It is identical with some of the variable leaves of *Pisonia eocenica* Ettingshausen,[93] a common European species. It is much smaller than the Alum Bluff *Pisonia apalachicolensis* Berry[94] and is similar to but entirely distinct from the three species of *Pisonia* that have been described from the Wilcox.[95]

It is very similar to a number of existing species of *Pisonia*, as, for example, *Pisonia ovalifolia* De Candolle, *Pisonia longifolia* Sargent, which ranges northward as far as the Florida Keys, and the Central American *Pisonia macranthocarpa* Donnell Smith.

Occurrence: Fayette sandstone, Alum Creek, S. W. Robertson League, about 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order RANALES.

Family MYRISTICACEAE.

Genus MYRISTICA.

Myristica catahoulensis Berry.

Plate XXXII, Figures 8–13.

Myristica catahoulensis Berry, Am. Jour. Sci., 4th ser., vol. 42, p. 241, figs. 1–6, 1916.

Pericarp broadly ovate, slightly longer than wide, approximately circular in cross section, thick, two-valved, about 5 centimeters in length and 3.75 centimeters in diameter, inclosing a single large seed. The aril either decayed before fossilization or became separated from the seed and was not preserved in the same deposit, and the perisperm is likewise missing. The seed is large, circular in cross section, evenly rounded proximad, and shows a distinct hilum. It is slightly narrowed and bluntly pointed distad. The surface is ornamented by numerous irregular longitudinal corrugations, marking the ruminating endosperm. These markings are in faint relief and much less prominent than the corresponding markings of the cultivated nutmeg, due in a measure to the fact that the fossils are all casts in a somewhat porous sandstone. Similar artificial casts of the strongly marked cultivated nuts can scarcely be distinguished from the fossil casts. The nuts, of which several have been found, are about 3 centimeters in length by 1.7 centimeters in maximum diameter, which is midway between the apex and the base.

The species is based on the single valve of the pericarp and on the remains of several nuts, only one of which is perfect. The nuts were apparently relatively abundant, but as they were discovered only in the weathered sandstone there are few that are reasonably complete, although several show parts of the sides or ends, some of them half complete.

All the plant remains at this locality are in the form of casts, and the nuts must have been buried by wind-blown sand, for they lie in the sand at all angles. The eolian character of the sandstone at this outcrop is of the greatest importance in explaining the absence of both aril and perisperm and is therefore deserving of comment. The evidence for this conclusion is derived from several sources. Many of the leaf specimens are curled and not flat, as they would almost invariably be if laid down in water. These and other associated nuts (*Nyssa texana*) are jumbled in a confused mass at all angles. Violent currents could form such a jumble, but the nuts would not be heavy enough to be deposited under such conditions; instead they would be carried away by water action strong enough to stand them on end, nor would waterlogging in more quiet waters explain their varying positions. Associated with the nutmegs are much more numerous large-ribbed nuts of *Nyssa texana*. These nuts lie at all angles in the sandstone but occur elsewhere in clays, where they invariably lie on their sides. The conclusions of Goldman, based on a petrographic study of the matrix, including the proportion of different sizes of grains present, their rounding, the ratio of feldspar to quartz, the degree of weathering, absence of clay, proportion of heavy minerals, and other features, point to strong eolian action in a hot arid climate.

The nuts are fully matured and evidently were shed naturally and at no great distance

[93] Ettingshausen, C. von, Die Tertiärflora von Haering in Tirol, p. 43, pl. 11, figs. 1–22, 1853.

[94] Berry, E. W., The physical conditions and age indicated by the flora of the Alum Bluff formation: U. S. Geol. Survey Prof. Paper 98 p. 49, pl. 10, fig. 1, 1917.

[95] Berry, E. W., The lower Eocene flora of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 213–214, pl. 37, fig. 1; pl. 38, figs. 5–7; pl. 42, fig. 1, 1916.

from the sand flats where they subsequently became entombed. The sediments do not, according to Goldman, show characters of dune sands, and I infer that the winds which rounded and sorted the sand grains were not constant enough in direction to form dunes of any size. Under such conditions of blowing about, the arils would soon be lost, but the perisperm could not be so readily dissipated, although I know of no other method to account for its absence. As less than a dozen nuts are known, and as much of the sand from near-by outcrops appears to have been blown into pools of standing water, where the accompanying leaves were fossilized in a normal flat condition, the small percentage of nutmegs preserved in the wind-blown sands may thus be exceptional, and there is a possibility that large numbers were fossilized in a normal way, with the perisperm intact.

That the fossils are unmistakably those of a species of *Myristica*, I think no botanist will dispute. No leaves that I can identify as those of *Myristica* have yet been determined, but the leaf material is scanty, and I have not enough recent material of this genus for intelligent comparison of the foliar organs. The recent species of this family, which number about 90 forms, are variously treated. De Candolle [96] referred them all to the single genus *Myristica*, which he segregated into 13 sections, and this is the method followed by Prantl.[97] Other authors raise a number of these sections to generic rank—quite rightly so, it seems to me. I have, however, preferred to refer the fossil to *Myristica*, as comparative recent material for closer discrimination is lacking. The nutmeg of commerce belongs to the section *Eumyristica*, which has about 15 existing species of the Asiatic Tropics. It is a small tree, endemic in the Moluccas, and has long been under cultivation, as is indicated both by the numerous varieties extant and by the historical records, for Europe has been receiving nutmegs from this region beginning with the trade through the Arabs in the sixth century. It has been introduced into other East Indian islands, as well as in Bourbon, Mauritius, and Madagascar and in tropical America, usually with indifferent success. Although the Texas fossil is much like the commercial nutmeg in size and characters, it is also similar to existing American species, of which there are about twenty-five. These species are mainly South American, but the sections or genera *Virola* Aublet and *Compsoneura* De Candolle both are represented also in Central America. The fossil nuts are remarkably like those of *Myristica* (*Compsoneura*) *costaricensis* Warburg, but the pericarp is much larger and more massive.

Beyond the fact that they are tropical, I know little regarding the habitat of the recent species. Many are certainly insular and coastal forms, their range in the Pacific extending eastward to the Fiji, Tonga, and Samoan islands, the Fiji Islands having four or five species. Schimper records four species in his Indo-Malayan strand flora. *Myristica subcordata* Blume of New Guinea and *M. littoralis* Miquel of Java are both members of the *Barringtonia* or beach jungle association. Both Gaudichaud and Guppy record unopened fruits of *Myristica* in the Pacific sea drift, although their floating powers are not great and they are normally dispersed by fruit pigeons, according to Moseley, Hemsley, and Guppy.

Referring to the foliage it may be noted that, contrary to the opinion of Hooker and Thomson, De Candolle found that the flowers and fruits were much alike throughout the family and that the leaves furnish the most useful characters for differentiation, especially in their venation, and this opinion was also shared by Miquel. It would seem that the lack of comparative material has hitherto prevented the recognition of fossil foliage of *Myristica*. Certainly no definite evidence of extinct species has heretofore been published, although the distribution of the existing species in tropical Asia, Africa, and America is convincing enough evidence that the group had an extensive even if unknown Tertiary history. The only previously known fossil records are based on a very few and indifferently characterized leaf impressions from the Miocene of Labuan (Borneo), described by Geyler [98] as *Myristicophyllum majus* and *M. minus*, and by equally unconvincing leaf fragments described by Engelhardt as *Myristica fossilis*,[99] which come from

[96] De Candolle, A., Note sur la famille des Myristicacées: Annales sci. nat. (Botanique), 3d ser., vol. 4, pp. 20–31, 1855.

[97] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, Teil 3, Abt. 2, 1891.

[98] Geyler, H. T., Ueber fossile Pflanzen von Labuan: Vega-Expeditionens, Vetenskapliga Jakttagelser, Band 4, p. 498, pl. 33, figs. 3–6, 1887.

[99] Engelhardt, Hermann, Ueber Tertiärpflanzen von Chile: Senckenberg. naturf. Gesell. Abh., Band 16, Heft 4, p. 663, pl. 5, fig. 9; pl. 7, fig. 1, 1891; Ueber neue Tertiärpflanzen Süd Amerikas: Idem, Band 19, p. 13, pl. 1, fig. 21, 1895.

beds in Ecuador and Chile considered to be of Miocene age.

Occurrence: Catahoula (?) sandstone (not regarded as Catahoula by me, but older and of Jackson age), in a cut on the International & Great Northern Railway at spur to Government Lock, in southern Trinity County, Tex. (collected by A. C. Trowbridge).

Collection: U. S. National Museum.

Family ANONACEAE.

Genus ANONA Linné.

Anona texana Berry.

Plate XXXIII, Figure 7.

Anona texana Berry, U. S. Geol. Survey Prof. Paper 98, p. 239, pl. 60, fig. 9, 1917.

Leaves large, broadly ovate in outline, with a pointed apex and a rounded base. Length about 15 or 16 centimeters. Maximum width about 5.25 centimeters, in the lower half of the leaf. From the region of maximum width the leaf narrows upward, but the tip is not produced. Margins entire but slightly undulate. Texture presumably coriaceous, but as these leaves are preserved as impresions in sandstone this is not certain. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf. Secondaries of considerable size but relatively thin, eight to ten pairs, irregularly spaced and usually remote; they diverge from the midrib at varying angles, which range from 60° to 70°, are either regularly curved or relatively straight and are camptodrome in the marginal region. A few transversely percurrent tertiaries are visible, but most of the tertiary venation is obsolete.

This is a well-marked species of *Anona*, somewhat resembling but entirely distinct from the *Anona* leaves so common toward the close of the middle Wilcox. It is also very similar to several existing species in this genus.

Occurrence: Fayette sandstone, three-fourths of a mile above the junction of Caney and White Rock creeks, Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family MENISPERMACEAE.

Genus MENISPERMITES Lesquereux (in broad sense).

Menispermites carolinaformis Berry, n. sp.

Plate L, Figures 10, 11; Plate LI, Figure 1.

Menispermum canadense Knowlton (not Linné), in Glenn, L. C., U. S. Geol. Survey Water-Supply Paper 164, p. 38, 1906.

Cebatha carolina Berry (not Britton), U. S. Nat. Mus. Proc., vol. 48, p. 300, 1915.

Leaves of variable size, cordate in outline, the tip bluntly pointed, the base broad, more or less deeply embayed. Margins entire, somewhat irregular. Leaf substance of considerable consistency but scarcely meriting the term coriaceous. Length in the collected material ranges from 3.5 to 7 centimeters. Maximum width, which is below the middle, from 3.25 to 6.5 centimeters. Petiole stout, its length unknown, preserved for about a centimeter in one specimen; other specimens suggest that the leaves normally abscised at the distal end of the petiole. Primaries stout, five to seven in number, diverging at acute angles from the extreme base of the leaf. The midrib and the two main lateral primaries are the stoutest and longest. All are generally camptodrome, but the leaves have a tendency to become somewhat irregularly sublobate, as shown in the smallest and largest specimens figured, and any one of the primaries may then change from camptodrome to craspedodrome. Secondaries thin, camptodrome. Tertiaries thin but well marked, inosculating in the middle regions. Areolation of very fine, mostly quadrangular meshes.

This species is similar to the existing *Cebatha carolina* (Linné) Britton, with which it was formerly confused. *Cebatha carolina* is a slender vine of stream banks and woodland borders, ranging from Virginia to Illinois and Kansas and southward to Florida and Texas. As generic identifications of fossil leaves of this family are beset with difficulties, it seems best to transfer the present fossil species to the form genus *Menispermites*, proposed by Lesquereux for fossil leaves belonging to this family.

Menispermites contains numerous fossil species, especially in rocks of Upper Cretaceous age, at which time it is known from both Europe and America, as well as the Arctic. There are two species in the Wilcox of the embayment region, but none have heretofore been known from later horizons in this region. The family Menispermaceae has about 60 genera and 350 existing species in the warmer parts of all the continents, and that it is an old one is indicated, aside from the known fossil record, by its present distribution, no subfamily being confined to a single continental region.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Columbus, Hickman County, Ky., and Hickman, Fulton County, Ky. (collected by L. C. Glenn, E. W. Berry, and Bruce Wade).

Collection: U. S. National Museum.

Order PAPAVERALES.

Family CAPPARIDACEAE?

Genus CAPPARIDOCARPUS Berry, n. gen.

The generic term *Capparidocarpus* is proposed for fruits of uncertain botanic affinity which are thought to belong to the family Capparidaceae.

Capparidocarpus sphericus Berry, n. sp.

Plate LV, Figures 4–9.

Spherical fruits, rather large; whether an indehiscent capsule, a berry-like fruit with a more or less lignified outer coat, or a gourd-like fruit it is impossible to determine. In form they are a slightly prolate spheroid, slightly flatter at the distal than at the proximal end; ranging from 2.75 to 4 centimeters in diameter. Equatorial section circular. The wall is thick, from 4 to 8 millimeters in thickness. The interior is filled with what is probably best interpreted as placental tissue, and in this are embedded, somewhat irregularly, the numerous small seeds. These seeds are pointed at both ends, falcate fusiform in shape, somewhat variable as a result of mutual compression; the hilum appears to have been at one end, but of this I am not absolutely certain. They are about 7 to 8 millimeters in length and about 2 to 3 millimeters in diameter.

These fruits are not uncommon in the upper part of the section at Hickman. They are ordinarily preserved in a partly lithified argillaceous sand, in which the whole fruit seems to have been replaced by colloidal clay that was rendered permanent by more or less infiltration of ferruginous solutions; rarely they are partly lignitic. In no specimens are the details of structure preserved. In external appearance they might be taken for ferruginous concretions, but they are unquestionably definitely organized fruits, which can be broken open, disclosing the supposed placental mass full of seeds. These seeds, which are somewhat harder than the rest of the interior, can be readily separated out. Many specimens have been collected. They are uniform in size, within the narrow limits indicated, and the contained seeds are similarly uniform in size and shape.

These curious fruits, which are abundant, have been compared with a number of existing genera without conclusive results. They are not related to the Cucurbitaceae, Menispermaceae, or Passifloraceae, nor are they comparable with such fruits as those of the genus *Clusia* of the Guttiferae. As regards form they might be compared with small fruits of *Crescentia* (Bignoniaceae), but the seeds are quite different. The seeds alone are not unlike those figured from the Aquitanian stage of Germany and referred by Heer to the Old World genus *Gardenia* (Rubiaceae). The form is also like that of some of the existing species of *Brugmansia* or the tree daturas, belonging to the family Solanaceae, as are the seeds, but these forms usually have thin capsules, and the walls of the fossil are relatively extraordinarily thick. There are a number of genera of this largely American family, the Solanaceae, whose fruits are organized like that of the fossil, as for example those of the tropical American genus *Cyphomandra*.

Among previously described fossil fruits the only one that shows close similarities is one described by Müller many years ago from the auriferous Tertiary drifts of New South Wales as *Plesiocapparis leptocelyphus*[1] and considered to represent some member of the Capparidaceae. This same author described two other species of probably similar age but not certainly congeneric, and more recently Johnston

[1] Müller, F. von, Descriptive note on the Tertiary flora of New South Wales: New South Wales Dept. Mines Ann. Rept. for 1878, appendix D, p. 171, pl. 4, fig. 5, 1879.

has described [2] a fourth from beds of similar age in Tasmania. The last three descriptions I have not seen.

Obviously the American form does not represent the same genus as these Australian fossils, if indeed the Australian fossils represent a single genus, which is doubtful. Their remoteness geographically and their great difference in geologic age militate against such a conclusion. These fossil forms are mentioned in this connection, as they seem to corroborate the supposed family reference of these curious fruits. *Plesiocapparis leptocelyphus*, although it has a similar morphology, is smaller and has a very much thinner test. The seeds, however, are much like those of the Tennessee fossil.

I feel justified in referring these fossils to the family Capparidaceae and to the tribe Capparideae, although this reference is made tentatively. Among the few fruits of this tribe that I have seen the genus *Morisonia*, with four or five arborescent species in the Antilles and tropical South America, is most like the fossil. Until much more carpologic material is available for comparison the exact botanic position of this interesting fossil must remain uncertain. Its peculiar character and the well-marked seeds will undoubtedly enable some future student to correct the mistake if their botanic affinity has been misunderstood. No fossils exactly like them have ever been described, so far as I can discover.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, Fulton County, Ky., in upper part of the section (collected by Bruce Wade).

Collection: U. S. National Museum.

Order ROSALES.

Family MIMOSACEAE.

Genus INGA Willdenow.

Inga jacksoniana Berry, n. sp.

Plate XLII, Figures 5, 6.

Leaflets variable in size, petiolulate, markedly inequilateral and falcate-lanceolate in outline, widest medianly and tapering upward to the narrowly extended, ultimately bluntly pointed tip. Base markedly inequilateral, the inner (upper) half of the lamina narrowing gradually proximad and decurring on the petiolule about 5 millimeters above the point where the margin of the outer (lower) half of the lamina diverges from the petiole. The outer (lower) margin is more rounded than the inner and continues full until it rounds markedly inward to join the petiole. In the smaller leaflet figured the outer lamina is already 3 millimeters wide at the point where the inner lamina has entirely disappeared. The margins are entire and in places faintly undulate. The texture is subcoriaceous. The length ranges from 7 to 12 centimeters. Maximum width ranges from 1.1 to 2.7 centimeters. Most of the material is near the maximum dimensions just given. The petiolule is stout and expanded at the base; it is absent in most of the material but is 8 millimeters long in the small specimen figured. Midrib stout, curved, prominent on the lower surface of the leaf. Secondaries thin, camptodrome, diverging from the midrib at wide angles. Tertiaries obsolete.

This species is an exceedingly well-marked form, which is present in considerable abundance in the Texas region. It is larger and markedly distinct from the only known Claiborne species, *Inga arkansensis* Berry, which comes from the Yegua formation of eastern Texas and Arkansas. There are four species of Inga in the Wilcox, and one of these, *Inga laurinafolia* Berry,[3] presents many points of similarity to the present species. The general form is the same, but *Inga laurinafolia* is less elongate. Both are extremely like the existing *Inga laurina* Willdenow, of the Antillean and Central American Tropics.

Occurrence: Fayette sandstone, on Alum Creek, S. W. Robertson League, about 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball); Miraflores, Webb County, Tex. (collected by A. C. Trowbridge).

Collection: U. S. National Museum.

Genus MIMOSITES Bowerbank.

Mimosites spatulatus Berry, n. sp.

Plate XXXIII, Figure 1.

Leaflets small and sessile, nearly equilateral, with a broadly rounded apex and a narrowed

[2] Johnston, R. M., Notes on the discovery of a new fossil fruit from the deep-lead tin drifts at Derby, Tasmania: Roy. Soc. Tasmania Papers and Proc. 1918, pp. 9–10, 1919.

[3] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 224, pl. 48, fig. 8, 1916.

but eventually bluntly pointed base. Length about 1.8 centimeters. Maximum width, which is at or above the middle, 5 millimeters. Margins entire. Texture thinner than in associated species of *Mimosites*. Midrib relatively slender. Secondaries thin but distinct, seven or eight subparallel pairs, branching from the midrib at angles of about 45° and curving upward, eventually camptodrome.

The present species, although clearly congeneric, is perfectly distinct from the numerous Wilcox species of *Mimosites*. It is unfortunately based on very incomplete material from the very sandy clays of southern Arkansas, the most complete specimen collected being the one figured. It is shorter and wider with a more prominent venation than *Mimosites georgianus*, which is so common in the Georgia Claiborne.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Mimosites mississippiensis Berry, n. sp.

Plate XXXIII, Figures 2–5.

Leaflets of small size, oblong-obovate in outline, with a broadly rounded nearly equilateral apex and a pointed markedly inequilateral base. Margins entire. Length about 1.7 centimeters. Maximum width, in the middle part of the leaflet, about 4 millimeters. Petiolule short and broad, about 1 millimeter in length. Midrib straight and fairly stout, flush with the upper surface and prominent on the under surface of the leaflets. Secondaries not differentiated, forming a part of the areolation, which is nearly immersed in the leaf substance and consists of numerous subparallel laterals diverging from the midrib at wide angles of about 60°, forking and anastomosing in a dictyodrome manner.

This species resembles a number of previously described American species of *Mimosites*, as well as several existing American tropical species of Mimosaceae. Among the lower Eocene species it is most similar to *Mimosites inaequilateralis* Berry,[4] of the Wilcox group. It is also much like the upper Eocene species *Mimosites georgianus* Berry.[5] It differs from both of these species in the character of its venation and from *Mimosites georgianus* in its short petiolule, markedly inequilateral base, and uniformly rounded apex.

This species and the associated species of *Mimosites* represent forms usually 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 Mimosaceae. In other words, they represent forms which are referable to this family with great certainty but whose exact generic alinement is more or less uncertain.

Both *Acacia* and *Mimosa* are very large genera in the existing flora, the former having more than 400 and the latter more than 300 species. *Acacia* is largely African and Australian but is present through Oceanica, South and Central America, and the West Indies. *Mimosa*, on the other hand, is mostly confined to tropical and subtropical America, with but a few species in Asia, Africa, and Australia. As the Tertiary flora of southeastern North America is made up to so large an extent of ancient types still chiefly American it would seem that *Mimosites* as used in the present connection indicates a more probable affinity with *Mimosa* than with *Acacia*.

Occurrence: Forest Hill sand, 11 miles north of Jackson, sec. 16, T. 7 N., R 1 E., Hinds County, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Mimosites georgianus Berry.

This species is described under the flora of the Claiborne group (p. 62).

Occurrence: Fayette sandstone, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball). Barnwell formation (Twiggs clay member), Phinizy Gully and Grovetown, Columbia County, Ga.; Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by E. W. Berry); 2 miles east of Gibson, Glascock County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

[4] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 226, pl. 45, fig. 12, 1916.

[5] Berry, E. W., The Upper Cretaceous and Eocene floras of South Carolina and Georgia: U. S. Geol. Survey Prof. Paper 84, p. 142, pl. 27, figs. 5–9, 1914.

Family CAESALPINIACEAE.

Genus CASSIA Linné.

Cassia jacksoniana Berry, n. sp.

Plate XXXIII, Figure 6.

Elongated, slender, flat pods, more than 2.5 centimeters in length and about 6 millimeters in width, with somewhat irregular, straight sides and rounded ends, several seeded, with pronounced transverse veins between the seeds. Texture subcoriaceous.

This species is unfortunately represented by the single specimen figured, which is referred to *Cassia* with considerable hesitation, for it lacks real differential specific characters. As it is, however, a well recognizable element in this most interesting and too little known flora of the upper Eocene, it deserves a name and a place in any discussion of that flora.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Cassia georgiana Berry, n. sp.

Plate XXXIII, Figure 8.

Leaflets ovate in outline, broadest below the middle, with obtusely rounded inequilateral tip and somewhat inequilateral base. Length about 4 centimeters. Maximum width about 1.8 centimeters. Petiolule short and stout, about 2 millimeters in length. Midrib broad but not prominent. Secondaries apparently not different from the thin tertiary areolation.

This is a rather poorly preserved and ill defined form, apparently related to *Cassia* and not especially close to any of the numerous Wilcox species of that genus.

Occurrence: Barnwell formation (Twiggs clay member), 2 miles east of Gibson, Glascock County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

Cassia obionana Berry, n. sp.

Plate LI, Figure 2.

Leaflets relatively small, lanceolate in outline, widest in the middle and tapering equally distad and proximad to the obtusely pointed apex and cuneate base. Slightly falcate and inequilateral, the lamina on one side of the midrib being about 1 millimeter wider than that on the other side. Texture coriaceous. Margins entire, evenly curved. Length about 4.5 centimeters. Maximum width about 1.6 centimeters. Petiolule missing. Midrib rather stout, curved. Secondaries largely immersed, particularly in their upper courses; numerous, subparallel, equally spaced; they diverge from the midrib at angles of about 55°, are rather straight, and are camptodrome close to the margins. Tertiaries obsolete.

This species is represented by scanty material. It is well marked, however, and is clearly a leguminous leaflet, although its reference to *Cassia* is not conclusive. It represents a type of leaflet which is very abundant in the Eocene of southeastern North America and of which there are several well-defined forms in the Wilcox flora that I have referred to *Cassia*. The present fossil is very similar to *Cassia fayettensis* Berry,[6] of the middle and upper Wilcox, and if the leaves can be considered evidence of filiation I would say that this later form was descended from that Wilcox species. It differs from the Wilcox form in its less rounded outline, more cuneate base, and more numerous secondaries.

Cassia is so extensive a genus, both in fossil and existing floras, that comparisons with other species in either are generally without significance.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Genus BAUHINIA Linné.

Bauhinia wadii Berry, n. sp.

Plate LI, Figure 3.

Leaves bifoliate. Leaflets inequilateral, falcate-ovate, widest above the middle, with a rather broadly rounded tip and a gradually narrowed acute sessile base. Margins entire, full and evenly rounded on the outside, rounded above and slightly excavated proximad on the inside. Texture coriaceous. Length about 5.75 centimeters. Maximum width 1.5 centimeters. Veins thin but very prominent on the

[6] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 232, pl. 49, figs. 5–8, 1916.

lower surface of the leaflet. Several primaries, of which the innermost is the stoutest, diverge from the base of the leaflet at very acute angles and pursue a subparallel upward course, forking at intervals and connected by cross veinlets to form narrow elongate meshes, ultimate loops camptodrome.

This striking new species is unfortunately represented by a single leaflet. Its specific characters are particularly well marked, but its generic characters are not so clear, although limited in my opinion to either *Cassia* or *Bauhinia* of the family Caesalpiniaceae. There is a certain resemblance to the leaflets of some existing species of *Acacia* and *Calliandra* of the family Mimosaceae. No fossil species are similar except *Bauhinia potosiana* Berry,[7] from the Pliocene of Bolivia. Among the great many existing and fossil species of *Cassia*, the only bifoliate fossil species that I recall is *Cassia cultrifoliaformis* Berry,[8] likewise from the Pliocene of Bolivia. The existing Cassias generally have pinnate leaves of several pairs of leaflets, the most striking exception being *Cassia cultrifolia* Humboldt, Bonpland, and Kunth, of the Orinoco basin. This form is much like the present fossil species but is somewhat smaller, with the base on the outer side more or less auriculate, with the primaries all of the same size, and with their branches giving the venation a flabellate appearance. In the present fossil species the innermost primary is stouter than the others and appears to me to represent the branch of the midrib, which constitutes so well-marked a feature in the majority of *Bauhinia* leaves in which the two halves are not completely separate. The venation is therefore considered to be more typical of *Bauhinia*, to which I have referred it, naming it after the collector Bruce Wade.

There are more than 200 existing species referred to *Bauhinia*. These are trees or high climbing shrubs, and they are practically confined to the Tropics of both hemispheres, although a few range into the warmer parts of the Temperate Zone, as, for example, *Bauhinia lunaroides* Gray, which reaches Texas from the Mexican region. The existing forms are massed in the southeastern Asiatic region and in South America, although Africa has numerous species. About 40 per cent of the existing species are American, ranging from the West Indies and Mexico to southern Brazil.

The geologic history of the genus is remarkable. It is probably represented in the Cenomanian of Bohemia [9] but is otherwise unknown in Europe before the Tertiary. It is doubtfully recorded by Kryshtofovich[10] from the Upper Cretaceous of Russian Sakhalin but is otherwise unknown in Asiatic deposits earlier than the late Tertiary. The most complete and conclusive Upper Cretaceous occurrences are those of the Atlantic Coastal Plain. The oldest of these are in the middle part of the Raritan formation, where two large species are represented,[11] and New Jersey constitutes the known northern limit of the Cretaceous range of the genus. One of the New Jersey forms ranges southward to Alabama, and there is a fine small-leafed species in the Magothy formation of Maryland that also ranges southward to Alabama.[12] A fine large butterfly-like species is abundant in the basal beds of the Eutaw formation in Alabama,[13] and a fifth species is found in the Ripley formation in Alabama and Tennessee.[14] No species have heretofore been known from the Tertiary of North America except a somewhat doubtful form which is described by Cockerell [15] from the Miocene lake basin at Florissant, Colo.

Aside from the possible Cenomanian occurrence already mentioned, four species, based upon both leaves and pods, have been described from the Miocene of the southern and southeastern parts of Europe. A species is known from the Pliocene of Bolivia and another from the late Tertiary of Indo-China.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, lower part of bluff, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

[7] Berry, E. W., Fossil plants from Bolivia and their bearing upon the age of uplift of the eastern Andes: U. S. Nat. Mus. Proc., vol. 54, p. 144, pl. 17, figs. 1, 2, 1917.

[8] Idem, p. 139, pl. 16, fig. 9.

[9] Velenovsky, Josef, Die Flora der böhmischen Kreideformation, pt. 4, p. 12, pl. 6, fig. 4, 1885.

[10] Kryshtofovich, A., On the Cretaceous flora of Russian Sakhalin: Tokyo Imp. Univ. Coll. Sci. Jour., vol. 40, art. 8, p. 53, fig. 10, 1918.

[11] Newberry, J. S., Flora of the Amboy clays: U. S. Geol. Survey Mon. 26, p. 91, pl. 20, fig. 1; pl. 43, figs. 1–4; pl. 44, figs. 1–3, 1896.

[12] Berry, E. W., A new Cretaceous *Bauhinia*: Torreya, vol. 8, p. 218, 1908.

[13] Berry, E. W., A new Cretaceous *Bauhinia* from Alabama: Am. Jour. Sci., 4th ser., vol. 29, p. 256, fig. 1, 1910.

[14] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain, XI, Tennessee: Torrey Bot. Club Bull., vol. 43, p. 294, pl. 16, fig. 1, 1916.

[15] Cockerell, T. D. A., Two new fossil plants from Florissant, Colo.: Torreya, vol. 9, p. 184, 1909.

Family PAPILIONACEAE.

Genus PAPILIONITES Berry, n. gen.

Papilionites erythrinaformis Berry, n. sp.

Plate XXXIII, Figure 9.

Leaflets of medium size, ovate in general outline, petiolulate, bluntly pointed at the apex, and with a broad base that is straight on one side and widely rounded on the other (inequilateral). Margins entire. Texture subcoriaceous. Length about 6.5 centimeters. Maximum width, at or slightly below the middle of the leaflet, about 2.8 centimeters. Petiolule short and stout, not thickened, about 2 millimeters in length. Midrib stout and rather prominent, becoming thin distad. Secondaries well marked, about six opposite to subopposite pairs; they diverge from the midrib at angles of about 60° and are regularly curved, subparallel, and camptodrome. Tertiaries thin, both percurrent and intersecondarial, forming open, isodiametric meshes. Areolation obsolete. The basal secondary on the straight side of the lamina is straight and parallel with the lower margin and is also more ascending than its regularly curved fellow on the opposite side.

This species is unfortunately based upon scanty material. It seems impossible to decide to which genus of the Papilionaceae it should be referred, and I have therefore proposed the form genus *Papilionites* for its reception. The existing genus to which I was most inclined to refer it is *Erythrina* Linné, a genus of about thirty species of trifoliate shrubs and trees found in all tropical countries. Among the few known fossil species of this genus, *Erythrina ungeri*, described by Ettingshausen [16] from Sagor, in Carniola, is much like the present species, as is also *Dalbergia hecastophyllina*, described by Saporta [17] from the upper Oligocene of southeastern France.

Occurrence: Fayette sandstone, Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball); 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson). Lagrange formation in beds of upper Jackson (?) age, Hickman, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

[16] Ettingshausen, C. von, Die fossile Flora von Sagor in Krain, Theil 2, p. 46, pl. 19, figs. 2–5, 1877.

[17] Saporta, G. de, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 367, pl. 13, fig. 10, 1866.

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Genus SOPHORA Linné.

Sophora claiborniana Berry.

Plate XXXIV, Figures 1–3.

This species is described under the flora of the Claiborne group (p. 64). It is represented in the Jackson by considerable material.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry); 2 miles east of Gibson, Glascock County, Ga. (collected by C. W. Cooke and H. K. Shearer). Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Sophora wilcoxiana Berry.

This species is described under the flora of the Claiborne group (p. 65). It is sparingly and somewhat doubtfully represented in the Jackson.

Occurrence: Barnwell formation (Twiggs clay member), 2 miles east of Gibson, Glascock County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

Subfamily DALBERGIEAE.

Genus LONCHOCARPUS Kunth.[18]

Lonchocarpus anceps Berry, n. sp.

Plate LI, Figures 4–7.

Pods conspicuously stipitate, compressed, elliptical in outline, with a broadly rounded to slightly retuse apex, indehiscent, prominently margined all around, coriaceous in texture, faintly reticulate veined, with three or four seeds, which are elliptical in outline and lenticular in form, their greatest length less than one-half the diameter of the pod. Pods range in length from 4 to 6 centimeters. Maximum width 1.75 to 3 centimeters.

These pods are exceedingly common in a lignified condition in the carbonaceous clays. Their botanic affinity is not absolutely settled, but their features are so like those of *Lonchocarpus* that I feel justified in referring them to that genus, which has very similar indehiscent stipitate and few-seeded pods. The only other possibility is to consider them related to *Gleditsia*, which has indehiscent pods, and in

[18] For a recent discussion of this genus see Pittier, Henry, The middle American species of *Lonchocarpus:* Contr. U. S. Nat. Herbarium, vol. 20, pt. 2, 1917.

the modern species *G. aquatica* these are reduced in size and have but one or two seeds. The distribution of *Gleditsia* would lead to the expectation of finding it in the embayment Tertiary, but the modern species are more distinctly temperate types than should occur in this fossil assemblage, and their pods are less ligneous than the fossil form.

Lonchocarpus is a mainly tropical genus in the existing flora, largely American, having two score species in Mexico and Central America and many more in tropical South America. It is found also in tropical and southern Africa, one species being common to America and West Africa. It also has a few representatives in Madagascar and Australia. Many of the North American species have a very narrow range in the semiarid parts of Central America, and I would be inclined to regard them as recent derivatives of an ancestral rain-forest stock, which have evolved as specializations to a more arid habitat.

The fossil record of *Lonchocarpus* is exceedingly meager. Leaflets, so identified, are known from the Miocene of Ecuador and the Pliocene of Bolivia. By far the most interesting fossil remains are the numerous pods found in the Cohansey sand of southern New Jersey and described by Hollick [19] as *Lonchocarpus novae-caesareae*. This horizon has never been precisely determined but is late Tertiary and either upper Miocene or Pliocene, and the occurrence of this genus so far from any other occurrences and associated with a few exotic and numerous endemic types is unique.

The present species from Tennessee shows very considerable similarities to several existing species of *Lonchocarpus* of tropical America and to the pods of the Central American species formerly referred to *Derris*.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn.; cove just north of city water tower, in upper part of bluff at Hickman, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

[19] Hollick, Arthur, New species of leguminous pods from the Yellow gravel at Bridgeton, N. J.: Torrey Bot. Club Bull., vol. 23, p. 49, pl. 259 figs. 6–8, 1896.

Family HAMAMELIDACEAE.

Genus LIQUIDAMBAR Linné.

Liquidambar incerta Berry, n. sp.

Plate LI, Figures 8, 9.

Fruits preserved as ferruginous mud casts of the capsular cavities, with the beaks in most specimens entirely worn away. They range in size from 1.75 to 2.5 centimeters and are indistinguishable from similar remains described from several geologic horizons. No traces of leaves of this genus are associated with the fruits, but this lack is readily understood when it is considered that the leaves rot readily in water and are less successfully transported by water than those of any other species of tree that I have observed in the rivers of southeastern North America.

Indistinguishable fruits from the European Miocene are referred to *Liquidambar europaeum* Alexander Braun, and similar fruits from the European Pliocene have been referred to the existing *Liquidambar styraciflua* Linné. Similar fruits from the Miocene of Bridge Creek, Oreg., were referred to *Liquidambar europaeum* by Newberry.[20] Most of the present fossils are somewhat smaller than those of the existing American species, but some are as large, and it should be remembered that the fossils represent casts of the aggregation of capsular cavities with the beaks eroded away, thus reducing the diameter when compared with our familiar gum balls by between one-third and one-fourth.

The genus has a most interesting geologic history, which has been discussed by me [21] and also by Laurent.[22] Fruits similar to those in the Jackson occur in the Miocene of southern Mexico.

The existing species number four and are botanically very similar although geographically remote, being segregated in the southeastern United States (1 species), in the mountains of Central America as near sea level as 800 meters (1 species), in southeastern Asia (1 species), and in Asia Minor (1 species).

[20] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 100, pl. 47, fig. 3, 1898.

[21] Berry, E. W., The geological history of the sweet gum and witch hazel: Plant World, vol. 22, pp. 345-352, 1919.

[22] Laurent, Louis, Les Liquidambars: Mus. hist. nat. Marseille Annales, vol. 17, pp. 9-27, 1919.

Such a modern distribution indicates an extended geologic history, and in conformity with this we find at least a score of species ranging throughout the Tertiary and covering the whole Northern Hemisphere.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, upper part of bluff, half a mile north of Hickman, Fulton County, Ky.; on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Order GERANIALES.

Family RUTACEAE.

Genus FAGARA Linné.

Fagara catahoulensis orbiculata Berry.

Fagara catahoulensis orbiculata Berry, U. S. Geol. Survey Prof. Paper 98, p. 240, pl. 59, figs. 1–3, 1917.

This species I have described as follows:

Leaflets glandular punctate, of medium size for this genus, orbicular or elliptical in general outline, equally rounded at the apex and base. Length from 2.5 to 4 centimeters; maximum width, midway between the apex and the base, from 1.8 to 3.3 centimeters. Margins entire. Texture coriaceous. Petiolule short, stout, grooved, curved, about 3 millmeters in length. Midrib stout, curved, or flexuous, prominent on the lower surface of the leaflet. Secondaries stout, prominent on the lower surface of the leaflet, four or five subopposite to alternate pairs, diverging from the midrib at angles ranging from 65° in the lower part of the orbicular leaflets to 35° in the upper part of some of the orbicular leaflets and in the elliptical leaflets; all camptodrome, usually at a considerable distance from the margin. Tertiaries thin but well marked, especially on the lower surface of the leaflets, forming open irregular meshes that are well shown in the small elliptical leaflet figured. Areolation of thin but distinct veinlets forming minute quadrangular or polygonal meshes.

This form shows considerable variation and was based on well-preserved material from the Catahoula sandstone of the Chalk Hills in central Louisiana. The remains found in the basal beds that have been assigned to this sandstone in Polk County, Tex., which I consider of Jackson age, are scanty.

Occurrence: Catahoula (?) sandstone (not regarded as Catahoula sandstone by me, but as of Jackson age), Stryker, Polk County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Fagara catahoulensis elongata Berry.

Fagara catahoulensis elongata Berry, U. S. Geol. Survey Paper 98, p. 241, pl. 59, figs. 11–15, 1917.

This species I have described as follows:

Leaflets glandular punctate, averaging of rather small size, narrowly ovate and inequilateral in general outline, nearly equally pointed at the apex and base, the apex sometimes slightly more pointed than the base. Length from 1.6 to 4.25 centimeters, averaging about 2.75 centimeters. Maximum width, midway between the apex and the base, from 1 to 2 centimeters, averaging about 1.4 centimeters. Margins entire, slightly revolute. Texture coriaceous. Petiolule stout, grooved, curved, enlarged proximad, 3 to 4 millimeters in length. Midrib stout, usually curved, prominent on the lower surface of the leaflet. Secondaries stout, six or seven subopposite to alternate pairs, diverging from the midrib at angles of about 40°, subparallel, camptodrome in the marginal region. Tertiaries immersed in the leaf substance.

This form is more abundant than the varieties *orbiculata* and *coriacea* but is not so abundant as *Fagara catahoulensis major*. It resembles some of the forms of *orbiculata*, as well as some of the variants of *major*, but differs from both of these in its proportions. It was described from the Catahoula sandstone of Chalk Hills, in central Louisiana, in beds of Vicksburg age, where it is well preserved and abundant. It is sparingly represented in Polk County, Tex., in beds which have been referred to the base of the Catahoula sandstone but which I regard as older than the Catahoula and of late Jackson age.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, half a mile north of Hickman and 5 miles south of Hickman, Fulton County, Ky.; Cane Creek, Obion County, Tenn. (collected by Bruce Wade). Catahoula (?) sandstone, Stryker, Polk County, Tex. (collected by C. L. Baker).

Collections: U. S. National Museum, New York Botanical Garden.

Fagara catahoulensis major Berry.

Plate LI, Figures 11, 12.

Fagara catahoulensis major Berry, U. S. Geol. Survey Prof. Paper 98, p. 241, pl. 59, figs. 4–7, 1917.

This species I have described as follows from specimens in the Catahoula sandstone of Louisiana, of Vicksburg age:

Leaflets glandular punctate, averaging of relatively large size, ovate-lanceolate and slightly inequilateral in outline, with an acutely pointed apex and a rounded

or broadly pointed base. Length from 2.2 to 4.5 centimeters, averaging about 3.5 centimeters; maximum width, at or slightly below the middle, from 1.5 to 2.75 centimeters, averaging about 2.5 centimeters. Margins entire. Texture coriaceous. Petiolule stout, grooved, about 4.5 millimeters in length, in some specimens showing evidence of narrow, straight lateral wings. Midrib stout, prominent on the lower surface of the leaflet. Secondaries stout and prominent, about six pairs, subopposite below and usually alternate above; they diverge from the midrib at angles of about 45°, although there is considerable variation in this feature; they are for the most part regularly curved upward and subparallel and are camptodrome in the marginal region. Tertiaries mostly immersed in the leaf substance; a few percurrent ones visible.

A single specimen is contained in the collections from the kaolinite lens in the Fayette sandstone. It is characteristic of *Fagara* and like the present variety, except for its larger size, being 5.5 centimeters in length by 3.5 centimeters in maximum width. The base is slightly more acute, thus approaching the variety *elongata*. Evidently *Fagara catahoulensis* was exceedingly variable, and I prefer not to further multiply its described varieties.

Occurrence: Fayette sandstone, near Wellborn, Brazos County, Tex. (collected by O. M. Ball). Lagrange formation, in beds of upper Jackson (?) age, in upper part of bluff in cove just north of city water tower at Hickman, Fulton County, Ky. (collected by Bruce Wade); a doubtfully determined specimen from Piedmont, Grimes County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Fagara catahoulensis coriacea Berry.

Plate LI, Figure 10.

Fagara catahoulensis coriacea Berry, U. S. Geol. Survey Prof. Paper 98, p. 241, pl. 59, figs. 8–10, 1917.

This species I have described as follows from specimens in the Catahoula sandstone of Louisiana, of Vicksburg age:

Leaflets glandular punctate, of small size, ovate-lanceolate and slightly inequilateral in general outline, with a bluntly pointed apex and a broadly rounded base. Length from 1.75 to 2.75 centimeters, averaging about 2 centimeters; maximum width, below the middle of the leaflet, from 1.2 to 2 centimeters, averaging about 1.4 centimeters. Margins entire, slightly revolute in some specimens. Texture coriaceous. Petiolule very stout, grooved, curved, 3.5 millimeters in length. Midrib stout and curved, prominent on the lower surface of the leaflet. Secondaries stout and prominent, four or five mostly subopposite pairs; they diverge from the midrib at somewhat irregular intervals at angles ranging from 35° to 60° and pursue a straight course halfway to the margins, where they curve upward; camptodrome in the marginal region. Tertiaries immersed in the leaf substance.

This well-marked form is less abundant in the collections than *elongata* or *major* but more abundant than *orbiculata*. It is much like *major* in general outline but is broader nearer the base, has fewer secondaries, and averages much smaller in size.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, at Hickman, in upper part of bluff; half a mile north of Hickman, 75 feet above river, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

Family MELIACEAE.

Genus CEDRELA Linné.

Cedrela jacksoniana Berry, n. sp.

Plate XXXIV, Figures 4, 5; Plate XLIV, Figures 1–5.

Leaflets of medium or small size, narrowly ovate-lanceolate and somewhat falcate in general outline, widest toward the base and tapering upward to the extended acuminate tip. Base cuneate, inequilateral. Length about 8.5 centimeters. Maximum width about 1.9 centimeters. Margin entire. Texture coriaceous. Petiolule wanting or not preserved. Midrib stout, prominent, and somewhat flexuous. Secondaries and tertiaries obsolete by immersion in the thick substance of the leaf.

This form is a type of fossil leaf that is ordinarily referred to the genus *Sapindus*, and it shows considerable resemblance to some of the Wilcox species with small leaflets which have been referred to that genus. After having handled a large amount of both living and fossil material I am more inclined to refer the present form to the genus *Cedrela*, a genus which is abundantly represented in the Wilcox flora. The present species, however, is entirely distinct from any previously described form and seems to have been common along the Jackson coast, for it appears to be very abundant in the sandy clays at White Bluff. The specimens are, however, in general fragmentary and poorly preserved and are therefore not identified with certainty. It is also present in the Catahoula sandstone of eastern Texas and western Louisiana.

It occurs in the Yegua formation of Brazos County, Tex., where it is abundant and variable in size, many of the leaflets being much

smaller than those preserved in beds at higher horizons.

Occurrence: Jackson formation, White Bluff, Jefferson County, Ark. (collected by E. W. Berry). Fayette sandstone, 4 miles north of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson). Catahoula (?) sandstone, in a cut on the International & Great Northern Railway, Trinity County, Tex. (collected by C. L. Baker). Lagrange formation, in beds of upper Jackson (?) age, on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade). Fayette sandstone, Barrera League, about 3 miles northeast of Millican; Mill Creek, 3 miles southeast of Millican; and Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Family MALPIGHIACEAE.

Genus BANISTERIA Linné.

Banisteria texana Berry, n. sp.

Plate XXXIV, Figure 6.

Leaves relatively small, oblong-ovate in general outline, with a short rounded base and a gradually narrowed abruptly acuminate tip. Length about 9 centimeters. Maximum width, below the middle, about 3.5 centimeters. Margins entire, full, and rounded. Texture coriaceous. Petiole not preserved. Midrib narrow, prominent on the lower surface of the leaf. Secondaries thin; about ten alternate pairs diverge from the midrib at angles of about 65° to 75°, curving slightly and camptodrome. Tertiaries obsolete.

This species is represented by very scanty material. However, it is clearly comparable with the leaves of the existing species in this genus, as, for example, *Banisteria argentea* Sprengel, of tropical South America (Brazil). Among fossil species it shows a generic likeness to the species of *Banisteria* found in the Wilcox, of which four have been described, three based on leaves and one on characteristic fruits. Among previously described fossil forms it is smaller but otherwise very close to *Banisteria vasseuri*, described by Laurent [23] from the Tongrian of southern France.

[23] Laurent, Louis, Flore des calcaires de Célas, p. 124, pl. 13, figs. 3, 4, 1899

The genus *Banisteria* contains about eighty existing species, exclusively American and massed in tropical South America.

Occurrence: Catahoula (?) sandstone (not regarded as Catahoula sandstone by me, but older and of Jackson age), Stryker, Polk County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Family BURSERACEAE.

Genus BURSERITES Berry, n. gen.

This name is proposed for a form genus to include the fossil remains referable to the family Burseraceae but of undeterminable generic relationship.

Burserites fayettensis Berry, n. sp.

Plate XLI, Figures 7, 8.

Leaflets of medium size, petiolulate, ovate in general outline, equilateral, with a gradually narrowed, somewhat extended acuminate tip and a broadly rounded base that is inclined to be slightly cordate. Margins entire, full enough to appear flexuous or repand. Texture subcoriaceous. Length from 5.5 to 7 centimeters. Maximum width, at or slightly below the middle of the leaflets, from 2.25 to 3 centimeters. Petiolule short, relatively very stout, about 4 or 5 millimeters in length. Midrib thin but prominent. Secondaries numerous, thin, somewhat unevenly spaced, subparallel; seven or eight subopposite to alternate pairs diverge from the midrib at wide angles, ranging from about 45° in the upper part of the leaflets to about 70° in the lower part; ultimately camptodrome. Tertiaries obsolete.

This species may be compared with several existing species of the genus *Bursera* Jacquin, a genus that has about two score species confined to the American Tropics, ranging from Mexico through the West Indies to northern South America. The second genus with which the fossil may be properly compared is *Protium*, which has about fifty existing species, four-fifths of them confined to tropical America and the balance scattered in India, Java, Madagascar, and Mauritius. *Burserites fayettensis* is particularly close to *Protium heptaphyllum* (Aublet) March, a tree that ranges from Venezuela and Guiana to Paraguay. *Burserites fayettensis* probably represents the genus *Protium*, but as several species of *Bursera* have such

similar foliage it seems best to refer the fossil to the family and to establish for it the noncommital form genus *Burserites*.

The family Burseraceae, except for a recently described Pliocene species from Bolivia,[24] has not been recorded in the fossil state, although the existing distribution of such genera as *Protium* and *Pachylobus* is a clear indication of a considerable geologic history. Fruits described from the Wilcox group as *Carpolithus pilocarpoides* were compared with and possibly indicate a species of *Protium* in the lower Eocene of the United States. The family contains ten oriental genera, four occidental genera, and two that are common to the two hemispheres. Of the 300 existing species 210 are oriental and largely confined to Asia and Africa.

Occurrence: Fayette sandstone, 4 miles north of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson). Catahoula(?) sandstone, Hermons Creek, 250 yards above the Riverside-Smithers farm road in northern Walker County; and Missouri, Kansas & Texas Railway at Stryker, Polk County, Tex. (collected by C. L. Baker). Lagrange formation, in beds of upper Jackson (?) age, half a mile above Hickman, 75 feet above river, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

Order SAPINDALES.

Family SAPINDACEAE.

Genus CUPANITES Schimper.

Cupanites nigricans (Lesquereux) Berry.

Plate XXXIV, Figure 7.

Myrica nigricans Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 6, 1872; The Tertiary flora, p. 132, pl. 17, figs. 9–12, 1878.

Leaflets small, borne irregularly on a stout rachis, ovate-lanceolate in general outline, with a broad, markedly inequilateral base and a gradually narrowed, pointed tip. Margins entire for a short distance proximad, medianly with conspicuous evenly spaced dentate teeth. Leaf substance thin. Length from 4.5 to 7.5 centimeters. Maximum width, slightly below the middle, from 1.1 to 1.8 centimeters. Petiolule stout, curved, ranging from 1 to 3 millimeters in length. Midrib stout but not prominent, generally curved. Secondaries rather stout but not prominent, numerous and subparallel; they diverge from the midrib at angles of 50° to 60°, abruptly ascending about two-thirds of their way out, and each enters a marginal tooth. Tertiaries fine, obsolete in the Claiborne material, numerous and percurrent in the Green River material from Wyoming.

This well-marked species was described by Lesquereux from the Green River shales of Wyoming and was referred to the genus *Myrica*. Features which distinguish it from the members of that genus and ally it with *Cupanites* are the compound nature of the leaves, which is indicated in the type material, the markedly inequilateral form, and the character of the venation.

The genus *Cupanites* was proposed by Schimper from its resemblance to the existing genus *Cupania* Linné, and to it have been referred about a dozen large-leafed species, based on both foliage and characteristic fruits, chiefly from the European Tertiary. Two well-marked species have been described from the Wilcox group in the Mississippi embayment area,[25] and the genus was apparently very common in the Ypresian of southern England, no less than six species of leaves and eight species of fruits having been recorded by Ettingshausen from these beds. The existing genus *Cupania* contains more than thirty species of the Tropics and subtropics of America. It is common in the West Indies but is no longer represented on the Florida mainland.

Occurrence: Barnwell formation (Twiggs clay member), Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

Genus DODONAEA Linné.

Dodonaea viscosoides Berry.

Plate XXXIV, Figures 11–13; Plate XLII, Figure 1.

This species is described under the flora of the Claiborne group (p. 70). It is exceedingly common in the Jackson.

[24] Berry, E. W., Johns Hopkins Univ. Studies in Geology, No. 4, p. 177, 1922.

[25] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 269, pl. 64, figs. 8, 9; pl. 65, figs. 1–4, 1916.

Occurrence: Fayette sandstone, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball). Barnwell formation (Twiggs clay member), Phinizy Gully, Fiske property at Grovetown, Ga.; one-fourth of a mile southwest of Forrest Station, Columbia County, Ga.; Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by E. W. Berry). Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus SAPINDUS Linné.

Sapindus dentoni Lesquereux.

This species is described under the flora of the Claiborne group (p. 73). Characteristic remains are sparingly represented in the Jackson of southwestern Texas.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Sapindus georgianus Berry.

Plate XXXIV, Figures 8–9.

This species is described under the flora of the Claiborne group (p. 71).

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Family ANACARDIACEAE.

Genus ANACARDITES Saporta.

Anacardites balli Berry, n. sp.

Plate LXII, Figure 7.

Leaves fairly large but smaller than those of the most closely related existing form, somewhat inequilaterally obovate, widest above the middle, with a broadly rounded apex and a cuneate, slightly decurrent base. Margins entire, somewhat unsymmetrical. Texture coriaceous. Apparently sessile. Length about 6.5 centimeters. Maximum width about 4 centimeters. Midrib stout, prominent, approximately straight, conspicuously thinning distad. Secondaries about five irregularly spaced and developed pairs, camptodrome close to the margins. Tertiaries immersed in the leaf substance, obsolete in the material examined.

This species, obviously new, is named for the collector. It is sparingly represented in the kaolinite beds and shows resemblances to several exotic species of *Rhus* and to several tropical species of the family Anacardiaceae, Among these it is extremely close to and, I believe, stands in an ancestral relationship to the genus *Anacardium*, which has eight to ten existing species that are confined to the American Tropics.

The genus *Anacardites* is a convenient form genus for members of this family whose true generic identity is not conclusively demonstrable. It is conspicuously represented in the Oligocene of Mediterranean Europe, and to it I have referred seven species from the Wilcox. None of the latter, which probably represent more than one botanic genus, are close to the present Jackson species.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex.; Piedmont, Grimes County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order RHAMNALES.

Family RHAMNACEAE.

Genus PALIURUS Jussieu.

Paliurus catahoulensis Berry.

Plate LIV, Figures 8, 9.

Paliurus catahoulensis Berry, U. S. Geol. Survey Prof. Paper 98, p. 242, pl. 60, figs. 1–4, 1917.

This species I have described as follows from specimens in the Catahoula sandstone of Louisiana, of Vicksburg age:

Leaves of small size, ovate to oblong-lanceolate in general outline, with a narrowed and acutely or bluntly pointed tip and a broadly rounded, somewhat inequilateral base. Length from 2.5 to 5 centimeters, averaging about 3 centimeters; maximum width, in the lower half of the leaf, from 7 millimeters to 2 centimeters. Margins entire. Leaf substance thin but apparently of considerable consistency. Petiole short, stout, and curved, about 2 millimeters in length. Midrib slender, somewhat flexuous. Lateral primaries thin, one on each side, diverging from the top of the petiole and forming an angle of 35° with the midrib curving upward parallel with the lateral leaf margin and becoming parallel with the midrib, extending above the middle of the leaf, terminating by joining a secondary. Secondaries thin, three or four subopposite to alternate pairs in the upper half of the leaf, diverging from the midrib at angles of about 50°, curved regularly upward, camptodrome in the marginal region.

Tertiaries forming open camptodrome arches from the outside of the lateral primaries in the marginal region; internally they are thin, numerous, transverse in direction, nearly straight or inosculating.

This well-marked species has smaller leaves than the majority of described fossil species, but it may be matched by several existing forms in this and the allied genus *Zizyphus*.

In the existing flora *Paliurus* is represented by two species, one confined to China and Japan and the other extending westward into southern Europe. About 30 fossil species based on both leaves and the characteristic fruits are known, some of which extend back in time to the middle Cretaceous. *Zizyphus*, which in the absence of fruiting specimens is not distinguishable with certainty from *Paliurus*, has about forty existing species confined largely to the Indo-Malayan Tropics, only a single species occurring in the American Tropics. It has numerous fossil species. Both genera are well represented in the Eocene floras of the Mississippi embayment.

At the type locality in Louisiana flexuous thorny stems were tentatively referred to the same species as the leaves. In western Kentucky both leaves and similar thorny stems are associated, which tends to confirm their relationship. In western Tennessee a great many thorns have been found without any clue to their relationship. Two of these, representing the extremes of variation, are figured, and these are tentatively referred to this species.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, on the old Dickerson farm, 5 miles south of Hickman, on Fish Gap road, and 4 miles north of State line, Fulton County, Ky.; on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Genus RHAMNITES Forbes.

Rhamnites krugiodendroides Berry, n. sp.

Plate LII, Figure 2.

Xolisma ligustrina Berry (not Britton), U. S. Nat. Mus. Proc., vol. 48, p. 301, pl. 12, fig. 1, 1915.

Additional material and more careful comparison with the leaves of the existing *Xolisma ligustrina* (Linné) Britton have demonstrated that these fossils are not congeneric with *Xolisma*, the most obvious difference being in the character of the secondary venation. After an extended comparison with recent forms they appear to approach most closely the leaves of the genus *Krugiodendron*, especially the larger leaves of the single existing species that is referred to that genus. I hesitate to refer them to *Krugiodendron* in the absence of more conclusive evidence and have therefore referred them to the form genus *Rhamnites*, emphasizing their resemblance to the genus *Krugiodendron* in the specific name *krugiodendroides*. Their description follows:

Leaves small, ovate in general outline, widest near the middle and about equally pointed at the apex and base. Margins entire. Texture coriaceous. Petiole short and stout. Midrib stout. Secondaries thin, somewhat irregularly spaced, and here and there one will be branched; they diverge from the midrib at angles of about 55°, curve upward, and are camptodrome. Length from 4.25 to 5.5 centimeters. Maximum width from 2.25 to 3 centimeters.

Krugiodendron in the existing flora is a monotypic genus of the Rhamnaceae, its single species being a coastal shrub or small tree of the Antilles and Bahamas, which reaches its northern limit of distribution on the Florida Keys. This fossil species, which is compared with it, is sparsely represented in the collections and appears to be unlike any previously described Tertiary forms from southeastern North America.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, at Hickman, Fulton County, in both lower and upper parts of the section (collected by E. W. Berry and Bruce Wade). Fayette sandstone, on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus CEANOTHUS Linné.

Ceanothus jacksonensis Berry, n. sp.

Plate LX, Figures 3, 4.

Leaves ovate, widest below the middle, tapering upward to a more or less extended acuminate tip. Base broadly rounded. Length 7 to 9 centimeters. Maximum width 3 to 4 centimeters. Margins have close-set conspicuous crenate teeth. Texture thin but firm. Petiole stout, not preserved for any great length. Midrib stout and prominent. Lateral primaries thin, one on either side of the midrib, diverging at the top of the petiole and forming angles of about 35° to 40° with the midrib; they curve upward and form a

camptodrome connection with a branch from the lowest secondary about halfway between the apex and the base of the leaf. There are about four pairs of secondaries from the midrib, from which they diverge at angles of about 45°, curving upward, and with camptodrome endings. About four camptodrome secondaries diverge from the outside of the lateral primaries, and a fifth basal one, somewhat longer than the others, diverges on the outside from the top of the petiole, paralleling the basal leaf margins, and camptodrome to the lowest outside secondary from the lateral primaries. The tertiaries are thin but well marked, percurrent internally, forming arches along the margins, and sending well-marked curved branches to the marginal teeth.

This is a well-marked type, new to the Eocene of the Coastal Plain. All its characters are those of the Rhamnaceae, and it shows points of resemblance to the genera *Zizyphus*, *Gouiana*, and *Colubrina*—the last a modern American type and the others found in all Tropics. The fossil, however, is distinctly referable to the genus *Ceanothus*, a genus that has about two score existing American species. Among these the Jackson species is very similar to *Ceanothus azureus* Desfontaines, a Mexican form.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus EUONYMUS Linné.

Euonymus santotomasensis Berry.

Plate LXII, Figures 2–5.

This species is described under the Claiborne flora and was based upon scanty material from Webb County, Tex. A collection from the kaolinite deposits of Brazos County, Tex., recently made by O. M. Ball, contains 32 specimens of this species, the majority excellently preserved. These specimens show that these leaves had long, stout petioles and that they varied in form from the long ovate-lanceolate extreme, such as was shown by the older material, to broadly ovate-acuminate leaves that can not be distinguished with certainty from the Wilcox *Euonymus splendens* Berry. Every gradation from cuneate to rounded bases, from narrow to broad outlines, and from slight to markedly ascending secondaries is represented.

All these forms probably represent a single botanic species, and if so the range would extend from about middle Wilcox time through the Jackson, which is considerably greater than the majority of the Eocene forms of this general region.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order MALVALES.

Family TILIACEAE.

Genus GREWIOPSIS Saporta.

Grewiopsis wadii Berry, n. sp.

Plate LII, Figure 1.

This species is based upon rather abundant material (9 specimens), which is, however, all rather fragmentary. It indicates a leaf which when mature was about 8 centimeters in length by about the same in maximum width, distinctly trilobate in aspect, although there are no pronounced sinuses between the lobes terminated by the lateral primaries and the lobe terminated by the midrib. Texture subcoriaceous. Margin has shallow, broad dentate teeth, each with a craspedodrome vein. Venation stout and prominent on the under side of the leaf. Primaries three, subbasal. The lateral primaries give off several secondaries on the outside and at least one about halfway above the base on the inside. The tertiaries are prominent and prevailingly percurrent. The young leaves are elliptical or cordate in outline, relatively more elongate, and with smaller or obsolete teeth.

This species is closely related to *Grewiopsis claiborniana* Berry, a Claiborne form, and undoubtedly should be regarded as a descendant of that form. It differs from the Claiborne species in outline, having a more extended tip, which gives it a rhombic instead of an orbicular outline, and in its less ascending lateral primaries, more prominent secondaries, and wider dentate teeth.

No specimen is complete enough to form the basis for a photographic illustration, and I therefore give a restoration, the drawing for

which is based on a number of fragments, which give a much better idea of the general character of this distinctive leaf.

Its reference to *Grewiopsis* is somewhat uncertain, but whatever its botanic relationship it is the same as that of the Claiborne form, which is referred to *Grewiopsis claiborniana*. It is in my opinion certainly not related to the genera *Platanus* or *Liquidambar*.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, half a mile north of Hickman; Hickman, upper part of bluff, Fulton County, Ky. (collected by Bruce Wade).

Collection: U. S. National Museum.

Genus TILIA Linné.

Tilia jacksoniana Berry, n. sp.

Plate LXIII, Figure 5; Plate LXIV, Figure 5.

Leaves of medium to large size, cordate in general outline, with an acute to acuminate tip and a wide cordate base. Margins have small serrate teeth, which are larger at the termini of the principal veins and smaller in the intervening areas. Length 9 to 13 centimeters. Maximum width, below the middle, 9 to 12 centimeters. Petiole long and stout, whole length not seen. Midrib stout and prominent; there diverge from its base at wide angles pseudolateral primaries. The balance of the secondaries, comprising seven or eight pairs, which are subopposite below and in some specimens alternate in the upper part of the leaf, are more closely spaced and subparallel; they diverge from the midrib at angles of 45° or more, curve regularly, and are craspedodrome. The basal laterals give off on the outside eight laterals, which curve to the marginal teeth, and the lower ones of these laterals give off two or three curved subordinate laterals. Most of the secondaries give off one or two laterals on the outside toward the margins. The tertiaries are well marked and curved percurrent. The aerolation can not be made out.

This is a characteristic new species of *Tilia*, almost identical with the existing basswood, *Tilia americana* Linné, from which it differs merely in the character of the marginal teeth. It is not especially close to any previously described member of the genus and is the first representative of *Tilia* to be discovered in the Coastal Plain Tertiary.

Its largest specimens are as large as *T. speciosissima* Knowlton,[26] of the Raton formation of Colorado, but it has more numerous and consequently more closely spaced secondaries and more pointed teeth.

The family is essentially tropical, with some 400 existing species in about 35 genera, massed around the Indian Ocean and in northern South America. *Tilia*, however, is essentially temperate and is found throughout the North Temperate Zone, except in western North America and central Asia. There are about a score of existing species divided almost equally between North America and Europe and Asia. About 30 fossil species are known, ranging in age from the early Eocene to the present.

Occurrence: Fayette sandstone, Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Family BOMBACEAE.

Genus BOMBACITES Berry.

Bombacites jacksonensis Berry, n. sp.

Plate XXXIV, Figure 14; Plate XXXV, Figures 1, 5.

Leaflets broadly lanceolate in general outline, about equally pointed at both the apex and base. Margins entire, evenly rounded. Texture subcoriaceous. Length from 8 to 11 centimeters. Maximum width, about midway between the apex and the base, from 3 to 4.25 centimeters. Petiolule very broad, about 1 centimeter in length. Midrib slightly curved, broad but not prominent. Secondaries numerous, regularly spaced, subparallel, opposite to alternate; they diverge from the midrib at angles of 55° to 70°, pursue a rather straight course for two-thirds of their length, and then curve rapidly upward to form camptodrome arches. Tertiaries immersed but visible on the lower surface of the leaflets, forming rather open, isodiametric, mostly pentagonal meshes.

This entire-margined species closely resembles a variety of living and fossil forms that are referred to the genus *Bombax*. Among the living forms that are similar enough to be worth mentioning are *Bombax macrocarpa* (Schlechtendal) Schumann, of Central America,

[26] Knowlton, F. H., Geology and paleontology of the Raton Mesa and other regions in Colorado and New Mexico: U. S. Geol. Survey Prof. Paper 101, p. 336, pl. 67, 1918.

Bombax erianthos Schott, of Brazil, and especially two undetermined species of *Bombax* figured by Ettingshausen, one from Guatemala [27] and another from Mexico [28] which is practically identical with the fossil form. The previously described fossil forms that are similar include *Bombax oblongifolium* Ettingshausen,[29] which comes from the Aquitanian of Bohemia.

The genus *Bombax* comprises about fifty existing species of mostly large trees, nearly all of which are confined to tropical America, there being but one in Africa, six in Asia, and one in northern Australia, a distribution clearly indicative of an extended geologic history.

The family Bombaceae, which has 20 genera and about 120 existing species, is confined to the equatorial regions, chiefly in America. The fossil forms, which number more than twenty, are referred to *Bombax*, *Bombacites*, or *Bombaciphyllum*. The oldest of these forms, one that is supposed to be of Upper Cretaceous age, has been described by Velenovsky from the Perucer beds (Cenomanian) of Bohemia. There are three species in the Ypresian of southern England and two well-marked species in the Wilcox group of the Mississippi embayment. There are two additional Eocene forms, of eastern Australia. There are five Oligocene species, recorded from France, Saxony, Bohemia, and Carniola. The genus is represented in the early Oligocene of southeastern France (Sannoisian), not only by foliage but by beautifully preserved flowers. Miocene species have been recorded from Bohemia, Croatia, Chile, and Styria.

Occurrence: Jackson formation, Paul Taylor place, 1½ miles northeast of Somerville, Burleson County, Tex. (collected by Alexander Deussen). Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson); 1¼ miles northeast of Christie, La. (collected by Alexander Deussen and G. C. Matson).

Collection: U. S. National Museum.

[27] Ettingshausen, C. von, Über die Nervation der Bombaceen, p. 5, pl. 2, fig. 3, 1858.

[28] Idem, pl. 6, fig. 4.

[29] Ettingshausen, C. von, Die fossile Flora des Tertiär-Beckens von Bilin, Teil 3, p. 12, pl. 42, figs. 8, 9, 1869.

Family STERCULIACEAE.

Genus DOMBEYOXYLON Schenk.

Dombeyoxylon jacksonensis Berry, n. sp.

Plates XXXVI, XXXVII.

Transverse section.—No growth rings are observable. Although the wood is somewhat decayed and crushed the elements show no definite radial variations in size. The vessels are single and round or oval or are arranged in radial pairs or triplets. Here and there a radial row comprises five or six vessels and a few groups consist of a single large and a number of small vessels, as in the drawings shown on Plate XXXVI. Maximum size of lumen observed, 36 millimeters; average diameter 0.18 to 0.22 millimeter. Vessel walls thick, about 0.01786 millimeter. Rays thin and flexuous, about 0.22 millimeter apart. Xylem parenchyma plentiful, somewhat variable in size, about 0.0268 millimeter in diameter. Prosenchyma smaller, 0.015 to 0.02 millimeter in diameter, with slightly thickened walls.

Radial section.—Rays of variable height, generally from ten to fifteen cells high, containing relatively small amounts of gum, sparingly connected by longitudinal stringers. Marginal cells larger than central cells, scarcely if at all radially elongated, approaching a square outline and about 0.02 millimeter high. Central cells less high, commonly about 0.01 millimeter, generally much elongated radially, 0.06 to 0.12 millimeter long, end walls mostly rectangular, no pores visible. Parenchyma is seen to be much septate and provided with bordered pits. Prosenchyma fails to show any pitting or septation; fibers with pointed ends.

Tangential section.—Rays are seen to be numerous and irregularly fusiform in shape, not over 3 cells wide; ray cells 0.01 to 0.02 millimeter in diameter. Vessels with numerous small oval pits with transversely slit pores.

This species is very close to *Dombeyoxylon affine*, described by Felix [30] from the Tertiary of Abyssinia. It shows the same septation of

[30] Felix, Johannes, Untersuchungen über fossile Hölzer: Deutsche geol. Gesell. Zeitschr., Band 39, p. 520, pl. 25, figs. 2, 3, 5, 1887.

the parenchyma, and this tissue and the prosenchyma have the same relative sizes, the prosenchyma has the same pointed ends, and the rays have the same large square marginal cells and here and there longitudinal stringers. Only one other species of *Dombeyoxylon* has been previously described, and it comes from the lower Oligocene of Egypt and was named *Dombeyoxylon aegypticum* by Schenk.[31]

The knowledge of the secondary wood of the existing species of Sterculiaceae will have to be much extended before the generic affinities of the petrified woods of this family can be intelligently discussed.

The genus *Dombeyoxylon* was named from its obvious resemblance to the wood of the existing genus *Dombeya* Cavanilles, which includes about forty shrubs and trees of Africa and Madagascar. The extinct genus *Dombeyopsis* Unger, although badly in need of revision, includes some forms undoubtedly ancestral to *Dombeya*, and was not uncommon in Europe during the Tertiary. As regards the several species from the Denver formation of Colorado, which Lesquereux referred to this genus, much doubt respecting the correctness of the identification may be justly entertained.

Only two forms of Sterculiaceae based on foliage are known from the deposits of Jackson age, but the family is abundantly represented in the closely allied flora of the underlying Claiborne group and in the flora of the Wilcox group.

Occurrence: Fayette sandstone, 3 miles north of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson).

Collection: U. S. National Museum.

Genus STERCULIA Linné.

Sterculia cf. S. labruscoides Berry.

A medium-sized *Sterculia* leaf, too fragmentary for proper identification or description, is present in considerable numbers in the more argillaceous layers that are packed with leaves at the Stryker outcrop. It shows the following characters: Leaf trilobate with conical acuminate lobes. Sinuses narrow, extending about halfway to the base. Length about 8 centimeters. Maximum width about 6 centimeters. Primaries three, diverging at angles of about 30°, thin but prominent on the lower surface of the leaf. Secondaries thin but prominent, numerous, subparallel, and camptodrome.

This species appears to be closely related to if not identical with *Sterculia labruscoides* Berry, of the Lisbon formation of the eastern Gulf area and the Yegua formation of the western Gulf area. It is very much like the existing *Sterculia diversifolia* Don and also like the wide-ranging *Sterculia labrusca* Unger, of the European Tertiary; it belongs to the section Lobatae, the second of the three sections into which the genus *Sterculia* is segregated and the one especially prominent in the existing flora of the American Tropics and most abundant in American fossil floras from the Upper Cretaceous onward.

Occurrence: Catahoula (?) sandstone (not regarded by me as the Catahoula sandstone, but older and of Jackson age), Stryker, Polk County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Genus BUETTNERIA Linné.

Buettneria jacksoniana Berry, n. sp.

Plates LVI, LVII; Plate LVIII, Figure 1.

Leaves large and somewhat variable in appearance, elliptical in general outline, widest in the median part, and in some specimens equally and broadly rounded at the apex and base. Some specimens somewhat narrowed distad and cordate proximad. The tip may be broadly rounded or apiculate, the latter condition being especially noticeable in the smaller and narrower leaves. The base may be ultimately truncated or rounded but is generally more or less broadly and shallowly cordate, the proximal margins in many specimens being slightly decurrent on the base of the lateral primaries, just before these join the petiole. The margins are entire, full, and rounded, rather evenly so. The leaf material is distinctly thin but of considerable consistency. Length from 8.25 to 18 centimeters. Maximum width from 7 to 15 centimeters. A single small leaf of this species measures 6.5 centimeters in length by 5 centimeters in maximum

[31] Schenk, August, in Zittel, K. A., Beitraege zur Geologie und Palaeontologie der Libyschen Wüste: Palaeontographica, Band 30, teil 2, Abt. 1, p. 13, 1883.

width. Petiole short and stout, about 15 millimeters in length in the larger leaves; it is fully preserved in three specimens. Midrib approximately straight, fairly stout, but relatively slender for such large leaves, prominent on the under side of the leaf. Lateral primaries one on either side of the midrib, from which they diverge at angles of 45° or over, at the top of the petiole; they are generally less stout than the midrib and relatively equally slender; they curve upward and ultimately join a lateral branch from the lowest secondary, this union taking place halfway from the base to the apex or as much as two-thirds of the distance to the tip. This feature differs from leaf to leaf and results in considerable difference in appearance. When the primaries ascend long distances there is a considerable interval between them and the lowermost secondaries from the midrib. When the primaries do not preserve their identity for so great a distance, there is much less of an interval, and there are four or five pairs of regularly spaced secondaries from the midrib, from the lowest of which the primaries differ merely in having outside lateral camptodrome branches. The secondaries are thin, either subordinate or prominent, regularly spaced, rather straight or evenly curved, and camptodrome. There are five or six, generally regularly curved camptodrome secondaries from the outside of the lateral primaries. The tertiaries are thin but well marked, in general rather straight, some of them percurrent but more commonly anastomosing, and generally rather openly spaced. Percurrent and anastomosing nervilles result in an open, almost isodiametric, and prevailingly quadrangular-appearing mesh, although it is really polygonal. The ultimate ramifications of the veins appear to end freely within the areolae.

This striking species is entirely unlike previously described fossil forms familiar to me, the only approach to similarity, and that a remote one, being between the more ovate forms of the present species and the larger leaves of *Menispermites wilcoxensis* Berry,[32] of the Wilcox. However, the two are obviously not related. *Cecropia heeri*, described by Ettingshausen from the European Miocene, is also somewhat similar in appearance but likewise obviously unrelated.

The present type of leaf is commonly referred to the genus *Ficus*, although it must be confessed that the ultimate venation is not typical of that genus, the most similar recent species known to me being *Ficus leucostica*, which is not triveined. The venation of the fossil appears to me to be that of the family Sterculiaceae, and in that family the genus that is most like the fossil is *Buettneria*. This genus comprises about 50 existing species, mostly confined to the warmer parts of the Western Hemisphere, although there are a few in the Old World Tropics. In America the genus ranges from the Antilles southward to Argentina and consists, for the most part, of climbing herbs and shrubs, although there are a few arborescent species.

The fossil record of the genus is very imperfectly known. There is an unquestionable species in the Miocene of Costa Rica and Colombia, a very doubtfully determined form in the Miocene of Florissant, Colo., and a third in the Miocene of Europe. Other fossil representatives of this genus have very probably been collected but have remained unrecognized, the tendency of workers to consult pictures of fossils rather than the leaves of existing species resulting in the perpetuation of most original errors of identification.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, and Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order PARIETALES.

Family TERNSTROEMIACEAE.

Genus TERNSTROEMITES Berry.

Ternstroemites variabilis Berry, n. sp.

Plate LII, Figures 4–6.

Leaves of variable size, lanceolate to ovate in outline, widest at or below the middle, the smaller leaves about equally pointed at both ends, the larger more slender and produced distad. Tip more or less produced into a slender, bluntly pointed acumen. Base narrowly or broadly cuneate. Margins with remote teeth, variously emphasized in different

[32] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 218, pl. 115; pl. 116, figs. 2, 3, 1916.

leaves but never prominent. The teeth are uniformly spaced and not close set, the lower limb almost straight and three or four times the length of the more curved upper limb; they may be typically crenate, as in the upper half of the larger leaf figured, and from this development they vary until they are merely crenate undulations of a sort difficult to describe but perfectly distinctive and characteristic of a considerable number of species of different ages which have been referred to this genus. Texture coriaceous. Petiole short, stout, and curved. Midrib stout, not prominent. Secondaries relatively thin, numerous, subparallel, camptodrome. Tertiaries obsolete.

This species belongs to a readily recognizable type of leaf that is abundantly represented in southeastern North America from the Upper Cretaceous through the older Tertiary and that is believed to represent the synthetic ancestors of the modern genera of the Ternstroemiaceae. The particular lanceolate type, like that of the species here described, is present in the Upper Cretaceous Ripley formation of the eastern Gulf region and in the Wilcox, Claiborne, and Jackson deposits of the Eocene epoch.

The present species is common but fragmentary and not especially well preserved.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, on the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Ternstroemites claibornensis Berry?

This species is described under the flora of the Claiborne group (p. 78). It is represented in the Jackson of southwestern Texas by scanty and not certainly determined material.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Order THYMELEALES.

Family LAURACEAE.

Genus CINNAMOMUM Blume.

Cinnamomum spectabile Heer.

Cinnamomum spectabile Heer, Flora tertiaria Helvetiae, vol. 2, p. 91, pl. 96, figs. 1–8, 1856.

Saporta, Études sur la végétation du sud-est de la France à l'époque tertiaire, vol. 2, p. 279, 1866; vol. 3, pp. 84, 178, pl. 5, fig. 8; pl. 6, figs. 1, 2, 1867.

Ettingshausen, Die fossile Flora des Tertiär-Beckens von Bilin, pt. 2, p. 11, pl. 34, figs. 11, 15, 1868.

Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 727, pl. 94, fig. 6, 1899.

Leaves usually relatively large, elliptical and commonly slightly inequilateral in general outline, with a narrowed base and acuminate tip. Primaries three, stout, suprabasilar. Secondaries close, subparallel, transverse between the primaries, camptodrome in upper part of leaf and from the outside of the lateral primaries.

This species was described by Heer from the Aquitanian of Switzerland, and it has been recorded from this same horizon in Bohemia, Germany, and France, as well as from earlier and later horizons. The question of the relation of these forms to those referred to *Cinnamomum buchii* Heer [33] is one that demands restudy. I am inclined to think that the two species represent the same tree; certainly if two species are represented each should be carefully redefined and its synonymy revised. Knowlton [34] has recorded *C. spectabile* Heer from beds of Fort Union age in the Yellowstone Park, although the material is not altogether typical. Hollick [35] recorded *C. buchii* Heer from the Wilcox of Louisiana, and I have accepted this determination in my paper on the Wilcox flora largely with a wish to avoid unwarranted changes and influenced by a feeling that the two species were hardly distinct, although if I had been making the original identification I would have referred the material to *C. spectabile* Heer, which is represented by a single incomplete specimen in the small collection from a locality near New Edinburgh.

Occurrence: Jackson formation, 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris).

Collection: U. S. National Museum.

Cinnamomum angustum Berry.

Plate XXXV, Figures 3, 4.

This species is described under the flora of the Claiborne group (p. 78). It is but sparingly represented at all horizons.

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[33] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 90, pl. 95, figs. 1-8, 1856.

[34] Knowlton, F. H., Fossil flora of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, p. 727, 1899.

[35] Hollick, Arthur, in Harris, G. D., and Veatch, A. C., A preliminary report on the geology of Louisiana, p. 283, pl. 43, fig. 1, Louisiana Geol. Survey, 1900.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Cinnamomum sp.

A single specimen, incomplete distad, indicates a lanceolate leaf about 9 centimeters long and 3 centimeters in maximum width, acuminate at both ends, with a prominent stout midrib and suprabasilar, rather short primaries.

It is of the type usually referred to *Cinnamomum* and resembles several previously described species, among them *Cinnamomum affine* Lesquereux,[36] especially the Midway (?) and Wilcox forms referred to that species, but it is, however, more elongated. It is also like some of the forms referred to *Cinnamomum sezannense* Watelet[37] and to *Cinnamomum bendirei* Knowlton.[38]

Specific determination of fossil forms of *Cinnamomum* is well nigh impossible because of the polymorphism of the leaves, and the present form is therefore not certainly determinable. It suggests to me several existing species of *Camphoromoea*.

The incompleteness of the material precludes discussing it at the length that I should like to do. However, I may definitely advance the hypothesis that the ancestral forms referred to *Cinnamomum*—those of the Cretaceous and early Tertiary—are definitely related to the existing genera *Camphoromoea* and *Goeppertia* of the South American flora. It is quite true that modern systematists do not recognize any such relationships, but the Lauraceae offer exceptional difficulties to generic segregation, and the last word on this subject remains to be written. Certainly the latest monographs of the family appear to be far more unsatisfactory than some of the earlier attempts, and the usual practice of regarding the Lauraceae as a member of the order Ranales seems to me to be equally unnatural.

Occurrence: Fayette sandstone, near Miraflores, Webb County, Tex. (collected by A. C. Trowbridge).

Collection: U. S. National Museum.

[36] Lesquereux, Leo., The Tertiary flora, p. 219, pl. 37, figs. 1-5, 7, 1878.

[37] Watelet, A., Description des plantes fossiles du bassin de Paris, p. 175, pl. 50, fig. 2, 1866. Saporta, G. de, and Marion, A. F., Revision de la flore heersienne de Gelinden, p. 60, pl. 9, figs. 2-6, 1878.

[38] Knowlton, F. H., Fossil flora of the John Day Basin, Oreg.: U. S. Geol. Survey Bull. 204, p. 59, pl. 10, fig. 4, 1902.

Genus MESPILODAPHNE Nees.

Mespilodaphne caudata Berry?

This species is described under the flora of the Claiborne group (p. 81). Its occurrence in the Jackson is based upon rather scanty and not altogether satisfactory material.

Occurrence: Lagrange formation, in beds of lower Jackson (?) age, Randolph Bluff, Tipton County, Tenn. (collected by E. W. Berry).

Collection: U. S. National Museum.

Mespilodaphne caudata major Berry, n. var.

Plate XLII, Figure 2.

This form is possibly only a variant of the Claiborne species *Mespilodaphne caudata* Berry, which has been tentatively identified from rather poorly preserved material of lower Jackson (?) age, in the Lagrange formation at Randolph Bluff, Tenn., and may represent this variety.

It is larger and somewhat more linear than *Mespilodaphne caudata* but otherwise similar and has the same extended acuminate tip. Length, 11 centimeters. Maximum width, 1.3 centimeters.

Occurrence: Fayette sandstone, Alum Creek, S. W. Robertson League, about 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Mespilodaphne texana Berry, n. sp.

Plate XXXVIII, Figure 1.

Leaves small, broadly lanceolate in general outline, with an acute apex and a rather more narrowed acuminate base. Length from 6 to 7.5 centimeters. Maximum width, at or slightly above the middle, 1.75 to 2.75 centimeters. Margins entire but somewhat undulate in all the specimens collected. Texture coriaceous. Petiole not preserved. Midrib thin but prominent. Secondaries thin; six or seven alternate pairs diverge from the midrib at angles of about 45°, ascending with slight but even curves to the marginal region, where they are camptodrome. Tertiary venation not preserved.

This species, which appears to be different from previously described forms, is comparable with the leaves of the existing species of *Mespilodaphne*. It is represented by a small

amount of not especially well preserved material and is not notably close to the numerous Wilcox species of this genus.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson); Barrera League, about 3 miles northeast of Millican, and Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball). Jackson formation, White Bluff, Jefferson County, Ark. (collected by E. W. Berry). Lagrange formation (in beds of lower Jackson (?) age), Randolph Bluff, Tipton County, Tenn. (collected by E. W. Berry); in beds of upper Jackson (?) age, Slip in Hill, near Corona, Tipton County, Tenn. (collected by Bruce Wade). Catahoula (?) sandstone (not regarded by me as Catahoula sandstone but older and of Jackson age), in cut on the International & Great Northern Railway in Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Mespilodaphne jacksonensis Berry, n. sp.

Plate LX, Figure 5.

Leaves ovate, widest in the middle, with full, entire margins, narrowing equally toward the abruptly acuminate tip, and with abruptly decurrent base. Texture coriaceous. Length from 6.5 to 11.5 centimeters. Maximum width from 3.4 to 4.4 centimeters. Petiole short and very stout. Midrib stout, prominent. Secondaries thin, prominent, six or seven camptodrome pairs. The areolation, difficult to adequately describe, is almost exactly represented in the leaves of the existing *Mespilodaphne glauca*.[39]

The genus has four Wilcox species, of which *Mespilodaphne coushatta* Berry [40] is very close to the present form and possibly stands in an ancestral relationship to it. The chief difference is the greatly reduced length of the petiole in the later form.

Of the other known Claiborne and Jackson species of *Mespilodaphne* the only one at all close to the present species is *Mespilodaphne texana* Berry, which comes from practically the same horizon in the area farther to the southwest. The present species differs from *Mespilodaphne texana* in its relatively shorter and wider form and more abruptly acuminate apex and base. It is quite possible that the two are variants of a single botanic species of Jackson time, but until the connecting links are discovered I prefer to consider them distinct, although closely related.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Mespilodaphne columbiana Berry.

This species is described under the flora of the Claiborne group (p. 81), in which it is rather wide ranging but not individually abundant. It is sparingly represented in the lower Jackson.

Occurrence: Jackson formation, 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris).

Collection: U. S. National Museum.

Genus OREODAPHNE Nees.

Oreodaphne brazosensis Berry, n. sp.

Plate LX, Figure 1.

Relatively small, linear-lanceolate leaves, with a decurrent base and acuminate tip, generally somewhat falcate in outline, with entire, somewhat undulating margins and coriaceous texture. Length about 7 centimeters. Maximum width, below the middle of the leaf, about 12 millimeters. Petiole stout, more or less extended. Midrib stout, curved, channeled on the upper and prominent on the lower surface of the leaf. Lateral primaries, one on either side, diverging from the top of the petiole, pursuing a course parallel with and close to the lateral margins, becoming lost before reaching the middle of the leaf. Upper half of the leaf has four or five pairs of camptodrome secondaries. Areolation obsolete on the upper surface of the leaf, which is all that is shown in the present material: well marked on the lower surface, as is indicated by small areas of abrasion, forming a very close and typically lauraceous mesh.

This species is very similar to and is probably descended from *Oreodaphne pseudoguianensis* Berry,[41] of the Wilcox. It is also close to several existing forms of the American Tropics. Only sparingly represented in the present collections.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

[39] Figured in U. S. Geol. Survey Prof. Paper 91, pl. 80, fig. 5.

[40] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 307, pl. 80, fig. 6; pl. 87, fig. 3, 1916.

[41] Berry, E. W., op. cit., p. 305, pl. 81, figs. 3, 4.

Genus NECTANDRA Roland.

Nectandra antillanafolia Berry, n. sp.

Plate XXXVIII, Figure 3; Plate XLII, Figure 3; Plate LII, Figure 7; Plate LIII, Figures 1, 2; Plate LXV, Figure 5.

Leaves large but variable, broadly lanceolate in general outline, with an equally pointed apex and base, or the tip slightly extended and the base decurrent. Length from 15 to 30 centimeters. Maximum width, at or slightly below the middle, from 4 to 6 centimeters. Margins entire but slightly undulate. Petiole stout and curved, tumid proximad, relatively short. Midrib more or less curved, thin but prominent, on the lower surface of the leaf. Secondaries thin but prominent, remote, somewhat irregularly spaced, camptodrome, one or more of the lower pairs in some specimens straighter, more ascending, and longer than the others. Tertiaries fine, mostly percurrent, largely obsolete. Texture coriaceous.

The present species shows a great deal of variation in size and consequently in proportions, some of the leaves being long and narrow and others much wider. In some specimens the apex is produced into a narrow acumen and in others it is relatively short pointed. The base varies also, but less so than the tip, and is usually narrow. The accompanying pictures partly illustrate these features. *Nectandra antillanafolia* has not yet been discovered outside of the Texas area, but it is exceedingly common there and may represent an invasion from Central America that had reached only as far as Texas by Jackson time.

It shows considerable resemblance to *Nectandra glenni* Berry, described from beds of middle Wilcox age in the Lagrange formation of Tennessee, where it was apparently not abundant. *Nectandra glenni* was compared more especially with the leaves of the existing *Nectandra patens* Grisebach and *Nectandra krugii* Mez, of the West Indies. The Texas material may represent merely a variant of the Wilcox species, but this question can not be decided without more abundant material from both areas. In general the southwestern form is relatively broader and has a shorter, thinner petiole, a more acuminate base, which appears to lack the inframarginal veins, thinner and less ascending secondaries, and more obscure tertiaries (possibly owing to the manner of preservation). The midrib is thinner and does not show longitudinal striations, and the secondaries are not decurrent proximad.

The present species also resembles the Wilcox form *Nectandra lancifolia* (Lesquereux) Berry, and like that species it is very close to the existing *Nectandra antillana* Meissner, a common form of woods and river banks throughout the Greater and Lesser Antilles. Attention should also be called to the very great resemblance between the leaves of the present fossil species and those of the existing *Guatteria dolichopoda* Donnell Smith, belonging to a varied and exclusively American genus of the family Anonaceae.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson). Catahoula (?) sandstone (not regarded by me as the Catahoula sandstone but as older and of Jackson age), in a cut on the International & Great Northern Railway in Trinity County, Tex. (collected by C. L. Baker); 1½ to 3 miles east of Wellborn and Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Nectandra arkansana Berry.

Plate XXXVIII, Figure 2.

This species is described under the flora of the Claiborne group (p. 82).

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Nectandra gosportensis var. jacksonensis Berry, n. var.

Plate XXXV, Figure 2.

Leaves lanceolate in outline, with full, even, entire margins, somewhat elongated distad. Length about 13 centimeters. Maximum width, strictly below the middle, about 2.6 centimeters. Texture coriaceous. Petiole missing. Midrib stout and prominent. Secondaries, 9 or 10 pairs, diverging from the midrib at angles of about 50°, regularly curved, camptodrome.

This species appears to be a variety of the common Claiborne species *Nectandra gosportensis* Berry, which occurs in the Lisbon, Gosport, and Yegua formations and is found throughout the embayment region in the middle Eocene. The Jackson form is considerably

larger, with somewhat straighter, more extended lateral margins distad. The general form is much the same, as are the texture and venation. The secondaries are slightly more prominent.

Nectandra is common throughout the Eocene of southeastern North America, and very similar forms are still found in the American Tropics.

Occurrence: Catahoula (?) sandstone (not regarded by me as the Catahoula sandstone but as older and of Jackson age), in a cut on the International & Great Northern Railway in southern Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Genus MALAPOENNA Adanson.

Malapoenna sp.

Malapoenna sp. Berry, U. S. Geol. Survey Prof. Paper 84, p. 144, pl. 27, fig. 10, 1914.

A single poorly preserved lauraceous fruit was obtained from beds of lower Jackson age in Georgia. It is too poor for adequate description and is referred with hesitation to the genus *Malapoenna*.

Occurrence: Barnwell formation (Twiggs clay member), 10 miles south of Macon, Twiggs County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus LAURINOXYLON Felix.

Laurinoxylon branneri Knowlton.

This species is described under the flora of the Claiborne group (p. 84). It has been doubtfully recorded from the Wilcox and is present in the Claiborne as well as in the lower Jackson. These occurrences probably represent distinct species, not distinguishable by the characters of the poorly preserved secondary wood.

Occurrence: Jackson formation, on Big and Little Crow creeks, in sec. 36, T. 5 N., R. 3 E., St. Francis County, Ark. (collected by R. E. Call).

Collection: U. S. National Museum.

Laurinoxylon? sp. Knowlton.

Laurinoxylon? Knowlton, Arkansas Geol. Survey Ann. Rept. for 1889, vol. 2, p. 259, 1891.

This species is based on silicified material in a very poor state of preservation but is said to be distinct from *Laurinoxylon branneri* and *L. lesquereuxiana* Knowlton. The horizon is unknown and is either the top of the Yegua or the base of the Jackson.

Occurrence: Jackson (?) formation, base of Red Bluff, right bank of Arkansas River, Jefferson County, Ark. (collected by R. E. Call).

Collection: U. S. National Museum.

Lauraceous fruit.

Plate LII, Figure 3.

A small lauraceous fruit similar to that of *Sassafras*, *Cinnamomum*, and other genera of the Lauraceae is contained in the collection from Cane Creek. The peduncle is stout, about 1 centimeter in length, expanding distad into a cup-shaped receptacle 6 millimeters in diameter, which incloses a spherical fruit about 5 millimeters in diameter.

The genus to which it belongs can not be determined, and there are no lauraceous leaves present in the same outcrop, although the genus *Mespilodaphne* occurs at this horizon at the outcrop in Tipton County, Tenn.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, on the E. H. Russell place, 8 miles west of Union City on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Order MYRTALES.

Family RHIZOPHORACEAE.

Genus RHIZOPHORA Linné.

Rhizophora eocenica Berry.

Rhizophora eocenica Berry, U. S. Geol. Survey Prof. Paper 84, p. 144, pl. 29, figs. 1, 2, 1914.

Leaves small (presumably young) and medium in size, elliptical in outline, rounded or obtusely pointed at the apex, a few somewhat emarginate in smaller-sized variants from the normal form. The base slightly narrowed and broadly cuneate. Margins entire. Length about 7 to 8 centimeters; greatest width about 3.3 centimeters. Texture coriaceous, especially in the leaf shown in Figure 1 of the work cited, in which the margins were apparently somewhat revolute. Midrib and petiole extremely stout. Secondary venation immersed and not seen.

Leaves of this species are not common, doubtless because of the small size of the collections, which are far from representative.

The species is, however, of peculiar interest, for it sheds much light on the environment of a part at least of the Jackson flora. Because of this fact, great care has been taken to compare the present fossils with the leaves of all living or extinct forms that might be expected to occur at this horizon. The species shows so many points of contact with the modern forms of *Rhizophora*, especially with *Rhizophora mangle* Linné, of the American Tropics, that its reference to this genus seems clearly warranted. With the exception of a single species of *Rhizophora*, described by Massalongo [42] from the late Tertiary (Messinian) of the east coast of Italy, and a form referred to this genus from Austria by Ettingshausen [43] (Ligurien-Aquitanian), it is the only known fossil representative of this widespread modern genus. Ettingshausen compared his form with the existing *Rhizophora parvifolia* Roxburg, of the East Indies, but in regard to this identification Schenk [44] expressed doubt, calling attention to its similarity to members of the Myrtaceae and Leguminosae. Possibly, however, leaves belonging to this genus may not have been recognized when collected. For example, the leaves from the "Eolignitic" that Lesquereux [45] identified with *Quercus chlorophylla* Unger are almost certainly not that species and are very similar to leaves of *Rhizophora*.

There are at least three existing species of *Rhizophora*. *Rhizophora mangle* Linné, of the American Tropics, is found as far north as Mosquito Inlet and Cedar Key in peninsular Florida and in the Mississippi Delta. It extends from the Mexican coast for some distance along the coast of Texas. It occurs throughout the Bahamas and West Indies and very generally throughout Central America and northern South America. In comparatively recent times it has extended its range northward through the Bahamas to Bermuda. On the west coast it is found northward to Lower California and southward to the Galapagos Islands. *Rhizophora macronata* Lamarck ranges from southern Japan to northern Australia and westward to east Africa, and *Rhizophora conjugata* Linné is confined to tropical Asia. Doubtless modern systematists will differentiate additional specific forms, but the rather uniform habitats of these plants lead to the inference that such differentiation will be based on minor characters. The mangrove plants possess the singular ability to flourish in sea water, and their manner of life and development has become well adapted, both structurally and physiologically, to their mode of existence, so that they have become widely disseminated and individually abundant. In fact, they are the most remarkably specialized plants for this habitat known—a specialization that was in a measure reached in the Eocene. They are very notable as makers of land, as has been so often described, and they are especially well developed on low shores around the heads of tropical or subtropical bays and estuaries.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, near Grovetown, Ga.; one-fourth of a mile southwest of Forrest Station, Ga.; from a well 13½ miles west of Sandersville, Washington County, Ga.; (collected by S. W. McCallie); 10 miles south of Macon, Twiggs County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Family COMBRETACEAE.

Genus TERMINALIA Linné.

Terminalia phaeocarpoides Berry.

Plate XXXVIII, Figure 4; Plate XXXIX, Figure 1; Plate XLVI

Terminalia phaeocarpoides Berry, U. S. Geol. Survey Prof. Paper 84, p. 146, pl. 29, fig. 3, 1914.

Leaves of medium and large size, broadly obovate in general outline, with a rounded or pointed apex and a cuneate base. Margins entire. Length about 15 or 16 centimeters, and greatest width, which is above the middle, about 7 or 8 centimeters. Midrib stout. Secondaries about 8 pairs, subopposite or alternate, branching from the midrib at angles of about 50° and curving upward, approximately parallel, camptodrome. Tertiary venation not seen. As the remains of this species are merely impressions, the texture can not be determined; from their size it would seem that they were at least subcoriaceous.

In a more northern flora this species would doubtless be compared with a *Magnolia*, and possibly some of our fossil species of *Magnolia*

[42] Massalongo, Abramo, Studii sulla flora fossile e geologia stratigraphica del Senigalliese, p. 407, 1859.

[43] Ettingshausen, C. von, Die tertiäre Flora von Haering in Tirol, p. 82, pl. 27, figs. 28, 29, 1853.

[44] Schenk, August, in Zittel, K. A., Handbuch der Palaeontologie, Abt. 2, p. 632, 1890.

[45] Lesquereux, Leo, On species of fossil plants from the Tertiary of the State of Mississippi: Am. Philos. Soc. Trans., vol. 13, p. 416, pl. 17, figs. 5–7, 1869.

may be properly compared with *Terminalia;* otherwise the abundance of forms of *Terminalia* in the European Tertiary, where they furnish both leaves and characteristic fruits, and their absence from America is difficult to understand.

This species is very similar to the modern widespread *Terminalia catappa* Linné if the apical portion, which is unfortunately missing, is broad and rounded, and very similar to the modern *Terminalia phaeocarpa* Eichler, of northern South America, if the apex is pointed.

The modern species of *Terminalia* are all tropical and number more than a hundred forms, distributed in different regions in the following proportions, according to Engler and Prantl: America 24, Asia 27, Madagascar 16, Africa 17, Australia 19. One indigenous species reaches the United States, *Terminalia buceras,* which is often referred to the allied genus *Bucida.* It is common along the shores of the Caribbean Sea, extending northward through the West Indies to Elliotts Key, Fla., and growing generally on coral soil.

About a dozen fossil species are described from Europe, the oldest, which is not positively identified, coming from the Upper Cretaceous of Bohemia. One species is described from the upper Eocene or lower Oligocene of Aix (Provence, France), and the rest range in age from the Oligocene to the Pliocene and are represented by both leaves and fruit. They are especially common along the extended late Tertiary seacoast of south-central Europe, the Messinian showing four species, the Sarmatian three, and the Astian two. The European fossil form nearest to the form here described, though its resemblance is not especially close, is *Terminalia radobojensis* Unger, which has a recorded range from the Tongrian to the Astian. I have recently discovered abundant remains of the Combretaceae, consisting of leaves, flowers, and fruits, in the Wilcox flora. These forms include at least two species of Terminalia.

Terminalia catappa is one of the prominent elements in the oriental littoral forest or beach jungle of the Tropics (*Barringtonia* formation of Schimper), its buoyant fruits having enabled it to become widespread within its limits of range through the agency of ocean currents.

Occurrence: Barnwell formation (Twiggs clay member), Fiske property, Grovetown, Columbia County, Ga. (collected by S. W. McCallie). Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson); 1¼ miles northeast of Christie, La. (collected by Alexander Deussen and G. C. Matson); Alum Creek, S. W. Robertson League, 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus CONOCARPUS Linné.

Conocarpus eocenicus Berry?

Plate XXXV, Figure 5; Plate XXXIX, Figure 2.

This species is described under the flora of the Claiborne group (p. 86). It is abundantly represented in beds of Jackson age in Georgia and by not certainly identified material from the Jackson of southwestern Texas.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Fiske property, Grovetown, Ga.; one-fourth of a mile southwest of Forrest Station, Columbia County, Ga.; Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. Fayette sandstone, 1¼ miles northeast of Christie, La. (collected by Alexander Deussen and G. C. Matson); 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Genus COMBRETUM Linné.

Combretum petraflumense Berry.

Plate LVIII, Figures 2–4; Plate LIX, Figures 1–5.

This species is described under the Claiborne flora (p. 85). It is very common in that part of the Yegua formation which I regard as of Jackson age. It is generally rare in the Fayette sandstone but is exceedingly abundant in beds of that age in Brazos County, Tex.

Occurrence: Fayette sandstone, lens of kaolinite 1½ to 3 miles east of Wellborn; Barrera League, about 3 miles northeast of Millican; on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Family MYRTACEAE.

Genus MYRCIA De Candolle.

Myrcia catahoulensis Berry?

Myrcia catahoulensis Berry, U. S. Geol. Survey Prof. Paper 98, p. 242, pl. 60, figs. 5, 6, 1917.

This species I have described as follows:

Leaves of small size, linear-lanceolate and often somewhat falcate in general outline, with a gradually narrowed and acuminate apex and a similarly pointed base. Length from 4.5 to 7 centimeters. Maximum width, in the middle part of the leaf, 5 millimeters to 1.1 centimeters. Margins entire. Texture coriaceous. Petiole missing. Midrib stout, somewhat prominent on the lower surface of the leaf. Secondaries thin, immersed in the substance of the leaf and only seen with difficulty, their tips joined by an acrodrome marginal vein on each side close to the margin, and like the secondaries nearly obsolete by immersion in the leaf substance.

This species was represented by several fragmentary specimens in the Chalk Hills collection from the Catahoula sandstone, two of which, showing the extremes of size, were figured. The genus is one definitely recognized for the first time in the flora of the Wilcox group, but probably represented in Upper Cretaceous floras by some of the forms referred to the genus *Eucalyptus*. I have since definitely referred some of these to the genus *Myrcia*. It is an abundant element in the Wilcox flora, where it has four described species, among which *Myrcia bentonensis* Berry, a form found along the shores of the Mississippi embayment from central Arkansas to northern Mississippi, is most like the present species. It is, however, invariably larger and usually much larger and is more obtusely pointed. It also occurs in the Claiborne Eocene.

The genus *Myrcia* is one of the principal existing American genera of the Myrtaceae, with more than four hundred tropical species, massed in northern South America but extending southward to Uruguay and Chile and northward through the West Indies. The present fossil form may be compared with a number of still existing American species, and evidently the genus was present in the flora of tropical and subtropical America from the dawn of the Eocene down to the present, invariably extending its range northward over southeastern North America whenever the climatic conditions were favorable.

The Jackson remains are fragmentary and are provisionally identified. Relatively wider leaves of this type from Brazos County, Tex., are also provisionally referred to this species.

Occurrence: Fayette sandstone, three-fourths of a mile above the junction of Caney and White Rock creeks, Trinity County, Tex. (collected by C. L. Baker); Barrera League, about 3 miles northeast of Millican, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Myrcia ambiguaformis Berry, n. sp.

Plate LXIII, Figure 2.

Leaves small, ovate in general outline, widest at or below the middle, with a broadly cuneate or somewhat rounded base and a shortly acuminate falcate tip. Margins entire. Texture coriaceous. Length about 4.5 centimeters. Maximum width about 2 centimeters. Petiole short and stout, only 1 to 2 millimeters in length. Midrib stout, curved, and prominent on the under side of the leaf. Secondaries thin, largely immersed, about 3 millimeters apart, diverging from the midrib at wide angles, straight and parallel, their tips connected by acrodrome marginal veins some distance from the margins below but approaching them distad. Areolation obsolete.

This species is much like *Myrcia puryearensis* Berry,[46] of the Wilcox, in general form but has a shorter petiole, about half as many secondaries, and the marginal veins farther within the margins. It suggests the existing *Myrcia splendens* De Candolle and *Myrcia ambigua* De Candolle, the specific name proposed being derived from its resemblance to the latter species. It is very similar to some of the leaves from the late Eocene of Hesse that Engelhardt[46a] identifies as *Cassia lignitum* Unger.

Occurrence: Fayette sandstone, on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

[46] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 316, pl. 91, figs. 1, 2, 1916.

[46a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, p. 117, figs. 8, 9, 1922.

Myrcia bentonensis Berry?

Quercus retracta Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 416 (part), pl. 16, fig. 4 (not fig. 5), 1869.

Knowlton, in Harris, Arkansas Geol. Survey Ann. Rept. for 1892, vol. 2, p. 56, 1894.

Myrcia bentonensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 317, pl. 90, figs. 7–9, 1916.

Leaves linear-lanceolate in outline, with a bluntly pointed or rounded apex and a narrowly pointed base. Length from 7 to 12 centimeters. Maximum width, in the middle part of the leaf, from 0.7 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 first 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 doubtfully present in the lower Jackson of Cleveland County, Ark. The lower Jackson form may represent the Mount Selman *Myrcia trowbridgi* Berry. It suggests various fossil forms 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 several of these existing species of *Myrcia*. Among fossil forms it is similar to *Nerium parisiense* Saporta,[47] from the middle Eocene (Lutetian) of the Paris Basin. It is also much like the *Myrcia* from the Green River formation which Newberry [48] identified as *Salix angusta* and which may be a descendant of this southern Eocene form.

Occurrence: Lower part of Jackson formation, 2 miles south of New Edinburgh, Cleveland County, Ark. (collected by G. D. Harris).

Collection: U. S. National Museum.

[47] Saporta, G. de, Le monde des plantes avant l'apparition de l'homme p. 227, fig. 46, 1879.

[48] Newberry, J. S., The later extinct floras of North America: 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.

Order UMBELLALES.

Family ARALIACEAE.

Genus OREOPANAX Decaisne and Planchon.

Oreopanax mississippiensis Berry.

This species is described under the flora of the Claiborne group (p. 88).

Occurrence: Forest Hill sand, 11 miles north of Jackson, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Family CORNACEAE.

Genus NYSSA Linné.

Nyssa texana Berry.

Plate XXXIX, Figure 3.

This species, which is also abundant in the Yegua formation of the Claiborne group in Texas, is described under the Claiborne flora (p. 88).

It is equally common in the Catahoula sandstone of Texas but has thus far been found only in the form of casts in the windblown sands of this formation.

Occurrence: Catahoula (?) sandstone (not regarded by me as the Catahoula sandstone, but as older and of Jackson age), in a cut on the International & Great Northern Railway where a spur to the Government lock leaves the main line, in Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Nyssa jacksoniana Berry, n. sp.

Plate LXV, Figure 7.

Small, rather flat stones, subelliptical in outline, widest in the median region, rounded proximad, with a small chalazal scar, bluntly pointed distad, with about 10 rounded and not invariably continuous ribs on each face, separated by sharp sulcae. The outer flesh, which was apparently thin, is represented by a coaly incrustation on parts of some of the specimens. Length about 8 to 9 millimeters. Width 4 to 4.5 millimeters.

This species, which is tiny as compared with *Nyssa texana* Berry, of the Claiborne and Jackson, and which is also much more compressed, is somewhat suggestive of the smaller-fruited existing American Nyssas but less robust. There are two species of *Nyssa* based on stones in the Wilcox, the smaller of

which, *Nyssa wilcoxiana* Berry,[49] is about twice the size of the present species and much more inflated.

Many species of *Nyssa* stones have also been described from the Eocene lignite of Brandon, Vt., some of which, in the absence of other characters, are with difficulty distinguished from *Nyssa jacksoniana*.

Occurrence: Fayette sandstone, on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Superorder GAMOPETALAE.

Order PRIMULALES.

Family MYRSINACEAE.

Genus ARDISIA Swartz.

Ardisia sp.

Plate LXII, Figure 6.

Only a single imperfect specimen represents this apparently new species of *Ardisia*, and because of this unfortunate lack of more complete material I am not able to discuss it fully. It represents an ovate-lanceolate leaf, widest below the middle, with acuminate tip, 10 to 12 centimeters in length by about 3.5 centimeters in maximum width, with irregularly spaced, arched, camptodrome secondaries, and prominently crenate margins.

It belongs to a genus that has numerous existing species in all tropical lands, first recorded geologically in the Oligocene of Europe, to which all of the known Tertiary species are confined with the exception of one from Borneo and a lower Miocene form from South America.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican; on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order EBENALES.

Family SAPOTACEAE.

Genus CALOCARPUM Pierre.

The existing species of this genus have been referred by different authors to *Achras*, *Sapota*, *Sideroxylon*, *Lucuma*, *Achradelphia*, and other genera.

[49] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 331, pl. 99, fig. 5-7, 1916.

Calocarpum viridiforme Berry, n. sp.

Plate XL, Figure 4.

Leaves large, from 16 to 30 centimeters in length and from 6 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 being very close to 7 centimeters, whereas the length differs within the limits indicated. As a result there is considerable variation in the form of these leaves. The shorter leaves are decidedly obovate in general outline, the maximum width being considerably above the middle. From this point the fully rounded lateral margins curve gradually inward proximad to the extended decurrent or, more properly, narrowly cuneate base; distad they curve inward in a somewhat shorter distance to the obtusely pointed apex. The larger leaves are more nearly oblong-lanceolate in outline, for although the region of maximum width is still above the middle, it is disguised by the relatively narrower form of the leaf and the approximately equal narrowing of the apex and the base, the latter still somewhat more extended than the former. Margins entire. Texture relatively thin for such large leaves, apparently stiff but not warranting the term coriaceous. Petiole short and stout. Midrib stout, prominent on the lower surface of the leaf, somewhat curved. Secondaries relatively, not actually thin, prominent, distant, 12 to 15 pairs, varying from subopposite to alternate in a single leaf, diverging from the midrib at angles of more than 45°, averaging about 55°. The spacing of the secondaries is uniform, and they curve regularly in a subparallel manner and are camptodrome in the marginal regions. Tertiaries thin, largely percurrent.

These handsome leaves, although they suggest the genera *Terminalia*, *Crescentia*, and *Magnolia*, seem clearly related to the leaves of the existing species of *Calocarpum*, the sapote of the American Tropics. This determination of their relationship is considerably influenced by the occurrence of characteristic seeds of this or an ancestral genus in the upper Claiborne of Mississippi. The two existing species, both of which have very similar large leaves, are natives of Central America and possibly the West Indies and the north coast

of South America. *Calocarpum mammosum* (Linné) Pierre, the more widespread of the two, has been carried about by the natives and has been under semicultivation for so long a time that its natural limits are difficult to determine. The genus has been discussed recently by Pittier.[50] The fossil form is named from its resemblance to the existing *Calocarpum viride* Pittier. In this connection the account of *Eoachras eocenica* Berry in the flora of the Claiborne group (p. 90) should be consulted.

Occurrence: Fayette sandstone, Hamilton League, Fayette County, Tex. (collected by Alexander Deussen); 4 miles northwest of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson); Piedmont, Grimes County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus SAPOTACITES Ettingshausen.

Sapotacites miraflorianus Berry, n. sp.

Plate XL, Figure 1.

Leaves small and very coriaceous in texture, broadly and inequilaterally ovate in outline, with an obtuse tip and a broadly cuneate base. Margins entire, full and somewhat uneven, suggesting that they may have been slightly revolute. Length about 2.75 centimeters. Maximum width, at or slightly above the middle, about 1.8 centimeters. Petiole short and very stout, about 2.5 millimeters long. Midrib stout, curved, prominent below but becoming more or less obsolete distad. Secondaries thin, camptodrome, mostly obsolete by immersion in the thick leaf substance.

This small form suggests a number of existing genera of the Leguminosae, Rutaceae, Myrtaceae, and other families but appears to represent a species of Sapotaceae, perhaps of the genus *Bumelia*. In the absence of more complete material it is referred to the form genus *Sapotacites*.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

[50] Pittier, Henry, New or noteworthy plants from Colombia and Central America: Contr. U. S. Nat. Herbarium, vol. 18, pt. 2, pp. 76–86, 1914.

Sapotacites millicanensis Berry, n. sp.

Plate LXI, Figure 4.

Leaves obovate in outline, with a rounded apex and cuneate base, widest above the middle; margins entire; texture coriaceous. Length about 5 centimeters. Maximum width about 3 centimeters. Petiole short and stout, about 6 millimeters in length. Midrib stout, prominent. Secondaries five subopposite pairs; they diverge from the midrib at angles of about 45°, pursue rather straight courses, and are abruptly camptodrome close to the margins. Tertiaries thin, inosculating, forming an open mesh.

This species is not abundant in the kaolinite beds of the Fayette sandstone. It presents certain obvious characters of the family Sapotaceae but can not be referred with certainty to any of the existing genera, and I have accordingly referred it to the genus *Sapotacites*, a form genus established for leaves of this family which show inconclusive generic characteristics. The fossil suggests the genus *Mimusops*. A second species of *Sapotacites*, not at all like this one, is known from deposits of Jackson age in southwestern Texas. There are species of *Mimusops* and *Eoachras* in the Claiborne, and finely characterized species of *Sideroxylon*, *Chrysophyllum*, *Bumelia*, and *Mimusops* in the Wilcox of this general region.

Occurrence: Fayette sandstone, Barrera League, about 3 miles northeast of Millican; Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Genus CHRYSOPHYLLUM Linné.

Chrysophyllum preoliviforme Berry, n. sp.

Plate LXIII, Figures 3, 4.

Leaves small, ovate or broadly lanceolate in outline, widest at or below the middle, with acute tip and cuneate or acute base. Margins entire. Texture coriaceous. Length from 4.5 to 5 centimeters. Maximum width from 1.6 to 1.8 millimeters. Petiole stout, curved, 4 millimeters long. Midrib stout, prominent on the under side of the leaf. Secondaries thin, prominent, about six pairs, diverging from the midrib at angles slightly more than 45°, curving regularly upward and camptodrome. Tertiaries thin, percurrent,

A well-marked species, named from its resemblance to the existing *Chrysophyllum oliviforme* Lamarck, a small tree of southern peninsular Florida, the Bahamas, and many of the Antilles.

The present fossil species is much like leaves from the late Eocene of Hesse that Engelhardt [50a] identifies as *Palaeolobium haeringianum* Unger and *Sophora europaea* Unger, and it is not without interest in this connection that the former of these species is, in my opinion, identical with what Engelhardt [50b] identifies as *Pisonia eocenica* Ettingshausen.

The genus is tropical in existing floras and has about three score species, which are mostly American but are sparingly represented on all the continents except Europe. Only a few fossil species are known.

Occurrence: Fayette sandstone, on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Genus BUMELIA Swartz.

Bumelia balli Berry, n. sp.

Plate LXV, Figures 1–4.

Leaves relatively small, unsymmetrically obovate or subspatulate in general outline, widest below the middle, more or less narrowed upward to the broadly or narrowly rounded tip and more abruptly narrowed downward to the narrowly cuneate or acute sessile base. Margins entire. Texture coriaceous, suggestive of a tomentum in life. Length from 2.25 to 4 centimeters. Maximum width from 0.7 to 1.5 centimeters. Midrib very stout, almost obsolete on the upper surface of the leaf but prominent on the lower surface. Secondaries thin, immersed in the leaf substance, diverging from the midrib at acute angles, ascending, camptodrome. Areolation obsolete.

These characteristic leaves, which are named in honor of the collector, are much like those of several existing species of *Bumelia*, and they are also very similar to the Wilcox Eocene species *Bumelia pseudotenax* Berry,[51] differing most conspicuously in their departure from the strictly obovate form.

[50a] Engelhardt, Hermann, Die alttertiäre Flora von Messel bei Darmstadt: Hess. geol. Landesanst. zu Darmstadt Abh., Band 7, Heft 4, p. 114, pl. 38, figs. 3, 9, 11, 1922.

[50b] Idem, p. 51, pl. 12, fig. 2.

Occurrence: Fayette sandstone, on Mossy Creek, 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Family EBENACEAE.

Genus DIOSPYROS Linné.

Diospyros mirafloriana Berry, n. sp.

Plate XL, Figure 5; Plate XLIII, Figure 5.

Calyx relatively large, quinquelobate; the lobes deeply cleft, elongate-elliptical in outline, about 12.5 millimeters in length by 9.5 millimeters in maximum width, separated by narrow acute sinuses. Disk circular, elevated, with a coriaceous collar; about 1.25 centimeters in diameter. Diameter of the calyx, 3.5 to 4 centimeters.

This calyx indicates a very large-fruited species of *Diospyros*, as it is comparable in size with the calices of the existing large-fruited cultivated species. It is five-parted, whereas in the majority of species of *Diospyros* the calyx is four-parted with correspondingly wider lobes. No leaves of *Diospyros* have been found with the fossil calyx, which may indicate that the dried calyx was floated into the area of sedimentation from some locality more or less removed from the coast, although several existing species, such as *D. maritima*. Linné and *D. teysmanni* Miquel, are strand types.

Associated leaves, formerly referred to *D. brachysepala* Al. Braun, are now considered to represent the same species as the calyx described above.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson).

Collection: U. S. National Museum.

Order GENTIANALES.

Family APOCYNACEAE.

Genus APOCYNOPHYLLUM Unger.

Apocynophyllum texensis Berry.

Plate XL, Figure 4; Plate XLI, Figures 1, 2; Plate LV, Figures 2, 3.

This species is described under the flora of the Claiborne group (p. 91). It is the commonest form at the Miraflores locality, but most of the

[51] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 337, pl. 100, fig. 2, 1916.

material is fragmentary and comprises the basal halves of leaves, the most complete specimen being the one figured. This leaf has the lower lateral margins much fuller than they are in most of the specimens that are of the extended and gradually narrowed type.

Occurrence: Fayette sandstone, 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson); Hamilton League, Fayette County, Tex. (collected by Alexander Deussen); three-fourths of a mile above the junction of Caney and White Rock creeks, Trinity County, Tex. (collected by C. L. Baker). Forest Hill sand, 11 miles north of Jackson, Miss. (collected by C. W. Cooke).

Collection: U. S. National Museum.

Apocynophyllum grevilleafolium Berry.

Plate XXIII, Figure 6; Plate XXXIV, Figure 10; Plate LV, Figure 1.

This species is described under the Claiborne flora (p. 92).

Occurrence: Fayette sandstone, 4 miles northwest of Hornbeck, Sabine Parish, La. (collected by Alexander Deussen and G. C. Matson); 4 miles north of Miraflores, Webb County, Tex. (collected by G. C. Matson); Alum Creek, S. W. Robertson League, about 3 miles east of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Order PERSONALES.

Family BIGNONIACEAE.

Genus TECOMA Jussieu.

Tecoma preradicans Berry.

Plate LIV, Figures 1–7.

Tecoma preradicans Berry, U. S. Nat. Mus. Proc., vol. 48, p. 302, pl. 13, figs. 1–5, 1915.

Leaves odd-pinnate, not tendril-bearing, of five or more sessile leaflets. No complete leaves have been found, but from the small size of the basal pair of leaflets in specimens showing five leaflets it seems safe to assume that the normal number was from five to seven. Leaflets lanceolate to ovate or obovate in outline, ranging from 2 to 7 centimeters in length and from 1 to 4.5 centimeters in maximum width. Terminal leaflet equilateral, the base decurring to a pseudopetiolule. Lateral leaflets slightly inequilateral. Bases and tips about equally pointed. Margins entire for about one-third of the distance upward; above this they are beset with somewhat irregular, prominent, upwardly serrate teeth. Midribs relatively stout. Secondaries stout, numerous; about nine opposite to alternate pairs diverge from the midrib at angles that average about 45°, curving slightly upward, almost regularly spaced, subparallel and mostly craspedodrome, although they are camptodrome in the entire basal part of the leaflet, and higher up in some specimens the secondary will pursue a camptodrome course and send a short tertiary branch to the marginal tooth. Tertiaries mostly obsolete because of the coarseness of the matrix.

The present species is similar to the existing *Tecoma radicans* in general appearance, and specimens collected by Glenn at Hickman were identified by Knowlton [52] as this species or something near it. It differs from the existing species in the fewer leaflets, the existing species having generally 9 to 13, and extended search has not brought to light leaves with fewer than 7 leaflets. Other differences shown by the fossil are its smaller and more close-set marginal teeth, the tendency of the leaflets to assume an obovate outline, and the absence of the produced acumen that characterizes the leaflets of the trumpet creeper. The secondaries are also more uniformly craspedodrome in the fossil form.

The genus *Tecoma* consists of about eighty existing species of the tropical and warmer temperate regions of both hemispheres. They are massed in the northern South American region. Two species reach the United States—the tropical American *Tecoma stans* reaches Florida, and the familiar *Tecoma radicans* reaches northward as far as southern New Jersey on the Atlantic coast and as far as southern Illinois in the Mississippi Valley and is often hardy in cultivation still farther north. When in South America I was impressed with the much greater resemblance of this fossil form to species observed in the Peruvian valleys than to our common trumpet creeper. Unfortunately I made no collections, but I have no doubt that *Tecoma preradicans* could be very closely matched by recent material from tropical America.

[52] Knowlton, F. H., in 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. 38, 1906.

I find four other fossil species referred to the genus *Tecoma*. These are *T. basellii* Engelhardt,[53] from the Chattian of Bohemia, a very doubtful identification; *T. serrata* Engelhardt,[54] from the lower Miocene of Chile, which is based upon very poor material but is probably correctly identified; *T. austriaca* Ettingshausen,[55] from the Burdigalian of Bohemia, which is wholly untrustworthy; and *T. grandidentata* Engelhardt,[56] from the Miocene of Colombia, which is clearly a *Tecoma*. It is evident that much remains to be learned regarding the geologic history of this interesting genus.

At a locality 5 miles south of Hickman, although no leaves of this species have been discovered, there are winged seeds of some bignonaceous fruit that may represent this species. The seed is semicircular in form, about 4 millimeters in length, with oval wings about 4 millimeters wide and preserved on only one side of the nucellus in the two specimens found.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, Hickman, Fulton County, Ky., and Columbus, Hickman County, Ky. (collected by L. C. Glenn, E. W. Berry, and Bruce Wade).

Collection: U. S. National Museum.

Family VERBENACEAE.

Genus CITHAREXYLON Linné.

Citharexylon brazosense Berry, n. sp.

Plate LXIV, Figure 1.

Leaves broadly lanceolate in outline, widest in the median region, with an acute or slightly acuminate tip and a slightly decurrent base. Margins entire. Texture subcoriaceous. Length about 6.5 centimeters. Maximum width about 3.25 centimeters. Petiole short and stout, about 4 millimeters in length. Midrib stout, prominent on the under side of the leaf. Secondaries fairly stout, about seven pairs, unequally spaced; they diverge from the midrib at angles of about 45°, curve upward, and are camptodrome in the marginal region. Tertiaries comprising pseudosecondaries subparallel with and between some of the secondaries and numerous thin transverse nervilles, which fork and anastomose midway between the larger veins.

This species, which is rare, resembles *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. It is also something like *Citharexylon eolignitícum* Berry,[57] of the Wilcox, but is relatively shorter and wider. The genus *Citharexylon* includes more than a score of species which are 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: Fayette sandstone, on Mossy Creek 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

FORMS OF UNCERTAIN POSITION.

Carpolithus callitriformis Berry, n. sp.

Plate XL, Figure 3.

Fruit or cone of small size, 4-valved, about 8 millimeters in length and 10 or 11 millimeters in diameter. Valves full ovate, pointed distad and rounded proximad. Based upon a single specimen preserved in a coarse friable sandstone of apparently wind-blown origin and not well enough preserved for definite identification or description. It is clearly vegetable in origin and bears a striking resemblance to the fossils described as cones of *Callitris*, but as no traces of this genus have ever been described from North America I hesitate to draw the conclusion that it was present in the upper Eocene from such imperfect material, although the presence of the allied genera *Frenelopsis* and *Widdringtonites* in both the Lower and Upper Cretaceous of southeastern North America has been established with certainty.[58] In one of the latest discussions of the Cupressineae, by Eichler,[59] four perfectly distinct

[53] Engelhardt, Hermann, Die Tertiärflora des Jesuitgrabens bei Kundratitz in Nordböhmen: K. Leop.-Carol. Deutsch. Akad. Naturf. Nova Acta, Band 48, p. 336, pl. 16, fig. 13, 1885.

[54] Engelhardt, Hermann, Ueber Tertiärpflanzen von Chile: Senckenberg. Naturf. Gesell. Abh., Band 16, p. 660, pl. 3, fig. 6, 1891.

[55] Ettingshausen, C., Die fossile Flora des Tertiär-Beckens von Bilin: K. Akad. Wiss. Wien, Math.-nat. Kl., Denkschr., vol. 28, p. 222, pl. 37, fig. 16, 1868.

[56] Engelhardt, Hermann, Ueber neue Tertiärpflanzen Süd-Amerikas: Senckenberg. Naturf. Gesell. Abh., Band 19, p. 31, pl. 4, figs. 9, 10, 1895.

[57] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 346, pl. 106, fig. 10, 1916.

[58] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, pp. 419, 430, 1911; Notes on the genus *Widdringtonites:* Torrey Bot. Club Bull., vol. 39, pp. 341, 347, pls. 24, 25, 1912.

[59] Engler, A., and Prantl, K., Die natürlichen Pflanzenfamilien, Teil 2, Abt. 1, p. 92, 1889.

genera are united to form the genus *Callitris* Ventenat, which is divided into four subgenera, embracing *Octoclinis* F. v. Müller (*Frenela* Bentham), with eight scales to the cone and a single species of Australia; *Hexaclinis* (*Frenela* Mirbel), with six unequal scales to the cone and nine or ten species of Australia and New Caledonia; *Pachylepis* Brongniart (*Widdringtonia* Endlicher), with thick woody cones of four subequal scales and with three or four species of South Africa and Madagascar; and *Eucallitris* Brongniart (*Tetraclinis*), with four subequal cone scales and a single species of Africa north of the Sahara.

Callitris in the restricted sense has been recognized at a large number of localities and horizons in Europe, ranging in age from the Ypresian through the Oligocene and Miocene into the Pliocene. Several species have been recognized, of which by far the commonest is *Callitris brongniarti* Endlicher, with the cones of which the Jackson remains compare very well.

Occurrence: Catahoula (?) sandstone (not regarded by me as the Catahoula sandstone but as older and of Jackson age), in a cut on the International & Great Northern Railway in southern Trinity County, Tex. (collected by C. L. Baker).

Collection: U. S. National Museum.

Carpolithus najasoides Berry, n. sp.

Plate XLI, Figure 4.

A tiny oblong-elliptical, somewhat flattened seed with a minutely reticulated surface. Length about 4 millimeters. Maximum width about 0.9 millimeter. Ends equally rounded and scarcely, if at all, narrowed; the proximal end has a slight central umbo.

This species is based on the single specimen figured, which appears to be referable to the Najadaceae with considerable certainty and may be closely matched by the fruits of some of the existing species of *Najas* as well as by some of the fossil fruits referred to that genus from the later Tertiary of Europe.

Occurrence: Barnwell formation (Twiggs clay member), Macon-Marion road, 10 miles south of Macon, Bibb County, Ga. (collected by C. W. Cooke and H. K. Shearer).

Collection: U. S. National Museum.

Carpolithus balli Berry, n. sp.

Plate LXIV, Figure 3.

A small ovate seed or fruit, broadly rounded proximad and pointed distad, somewhat compressed, especially near the margins, about 6 millimeters long and 3 millimeters in maximum width. Surface faintly longitudinally ridged.

This species, which is based on the single specimen figured and which is named from the locality, might represent a number of families, so that a discussion of its probable relationships is futile.

Occurrence: Fayette sandstone, at Piedmont, Grimes County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

Carpolithus bumeliaformis Berry.

Carpolithus bumeliaformis Berry, U. S. Geol. Survey Prof. Paper 98, p. 243, pl. 60, fig. 8, 1917.

This species I have described as follows from specimens in the Catahoula sandstone of Louisiana, of Vicksburg age:

Fruit oblate-spheroidal, nearly globose, about 7.5 millimeters in maximum diameter (length) and 5.75 millimeters in minimum diameter. Seed large, nearly globose, crustaceous; flesh thin and dry.

The present species is based on only a few specimens, which agree remarkably well with the fallen fruits of those of our American species of *Bumelia* that have dry instead of fleshy fruits.

The genus *Bumelia* is a prominent element in the earlier Tertiary floras of southeastern North America, the leaves of one species being associated with the present fruits. As the nature of the remains precludes certainty of identification I have referred these fruits to the convenient form genus *Carpolithus* and have emphasized their supposed botanic affinity in the specific name.

Occurrence: Lagrange formation, in beds of upper Jackson (?) age, at Hickman, in upper part of bluff in cove just north of city water tower, Fulton County, Ky.; in the E. H. Russell place, 8 miles west of Union City, on Cane Creek, Obion County, Tenn. (collected by Bruce Wade).

Collection: U. S. National Museum.

Genus CYPSELITES Heer.

Cypselites jacksonensis Berry, n. sp.

Plate XL, Figure 2.

A turbinate akene, pointed proximad, with a truncate or slightly rounded distal margin surrounded by a corona of short spines.

Surface longitudinally striated. Length 1.3 centimeters. Maximum diameter 6 millimeters.

Based on the single specimen figured, which is referred with some hesitation to the genus *Cypselites*, established by Heer for Tertiary fruits of Compositae of somewhat uncertain generic relationship and common in the European Miocene.

Occurrence: Jackson formation, McMurrains Crossing, 3.3 miles north of El Dorado, Union County, Ark. (collected by E. W. Berry).

Collection: U. S. National Museum.

Leguminosites sp.

Plate XLI, Figure 3.

A small ovate few-seeded pod with a roughened surface. About 1.6 centimeters in length and 8 millimeters in maximum width. Referred doubtfully to *Leguminosites*.

Occurrence: Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga. (collected by E. W. Berry).

Collection: U. S. National Museum.

Genus ANTHOLITHES Brongniart

Antholithes balli Berry, n. sp.

Plate LXV, Figure 6.

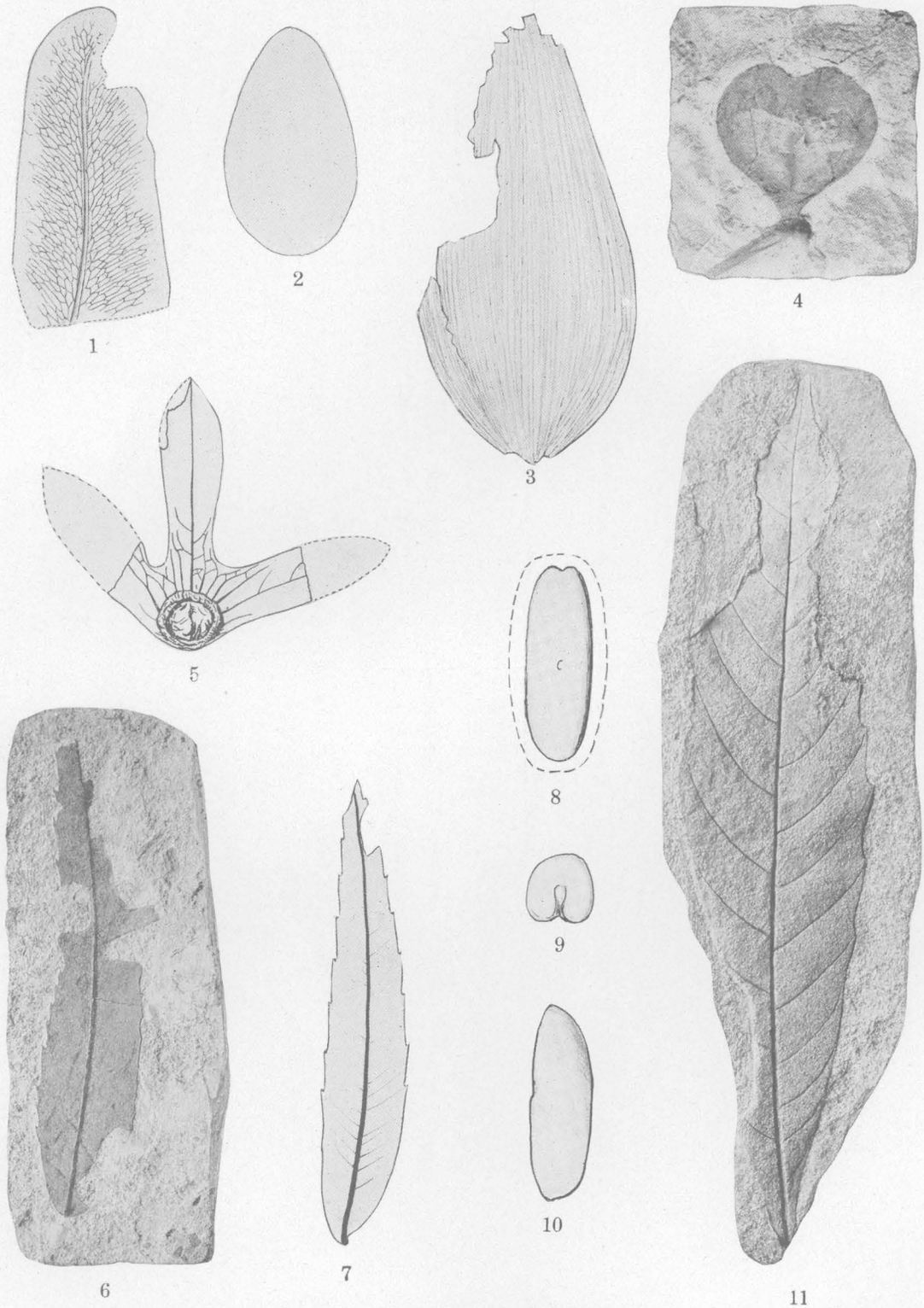
A flower about 11 millimeters in diameter with five sepals or petals of elliptical form and apparently a central disk about 4 millimeters in diameter. No trace of stamens or pistils.

The single specimen has the appearance of a rosaceous flower, but it is singular, if the form belongs to this family, that no traces of the stamens are preserved. The central part might represent a gamopetalous receptacle instead of a disk and could be as definitely considered as belonging to the families Zygophyllaceae, Sterculiaceae, Ternstroemiaceae, or Celastraceae. In the absence of more definite data it is referred to the form genus *Antholithes* and named in honor of the collector.

Occurrence: Fayette sandstone, on Mossy Creek 3 miles southwest of Wellborn, Brazos County, Tex. (collected by O. M. Ball).

Collection: U. S. National Museum.

PLATES XXVIII-LXV.

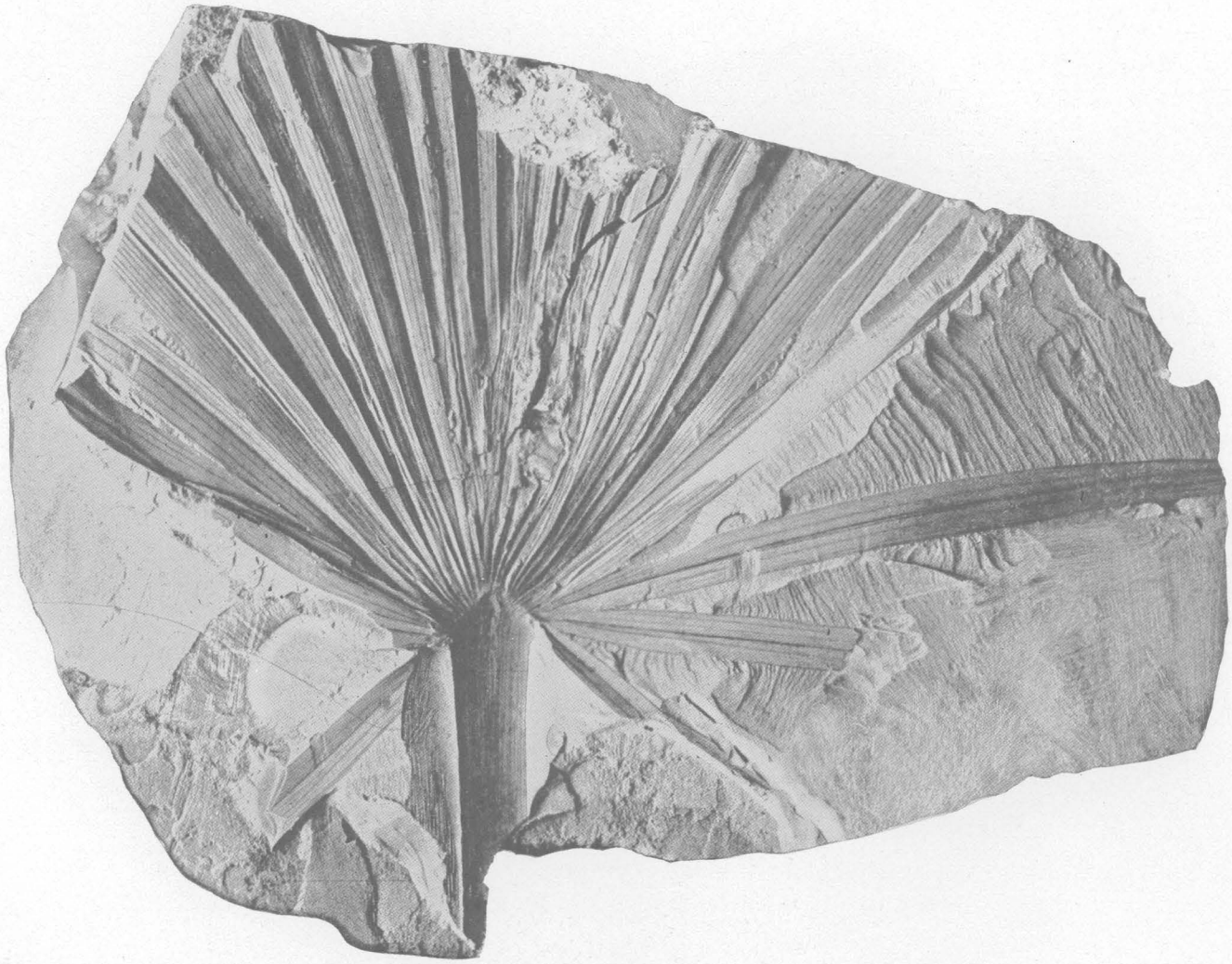


FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Acrostichum georgianum* Berry, Barnwell formation (Twiggs clay member), Phinizy Gully, Ga.; p. 143.
2. *Potamogeton* sp., Barnwell formation (Twiggs clay member), 10 miles south of Macon, Ga.; p. 145.
3. *Potamogeton megaphyllus* Berry, Barnwell formation (Twiggs clay member), Phinizy Gully, Ga.; p. 145.
4. *Pistia claibornensis* Berry, Barnwell formation (Twiggs clay member), Grovetown, Ga.; p. 146.
5. *Engelhardtia jacksonensis* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 153.
6, 7. *Myrica zachariensis* Lesquereux, Jackson formation, McMurrains Crossing, Ark.; p. 156.
8–10. *Phoenicites occidentalis* Berry, Catahoula (?) sandstone, along International & Great Northern Railway in Trinity County, Tex.; p. 148.
11. *Dryophyllum brevipetiolatum* Berry, n. sp., Fayette sandstone, Caney and White Rock creeks, Trinity County, Tex.; p. 157.

FOSSIL PLANT FROM DEPOSITS OF JACKSON AGE.

Sabalites vicksburgensis Berry, Fayette sandstone, Hamilton League, Tex.; p. 151.

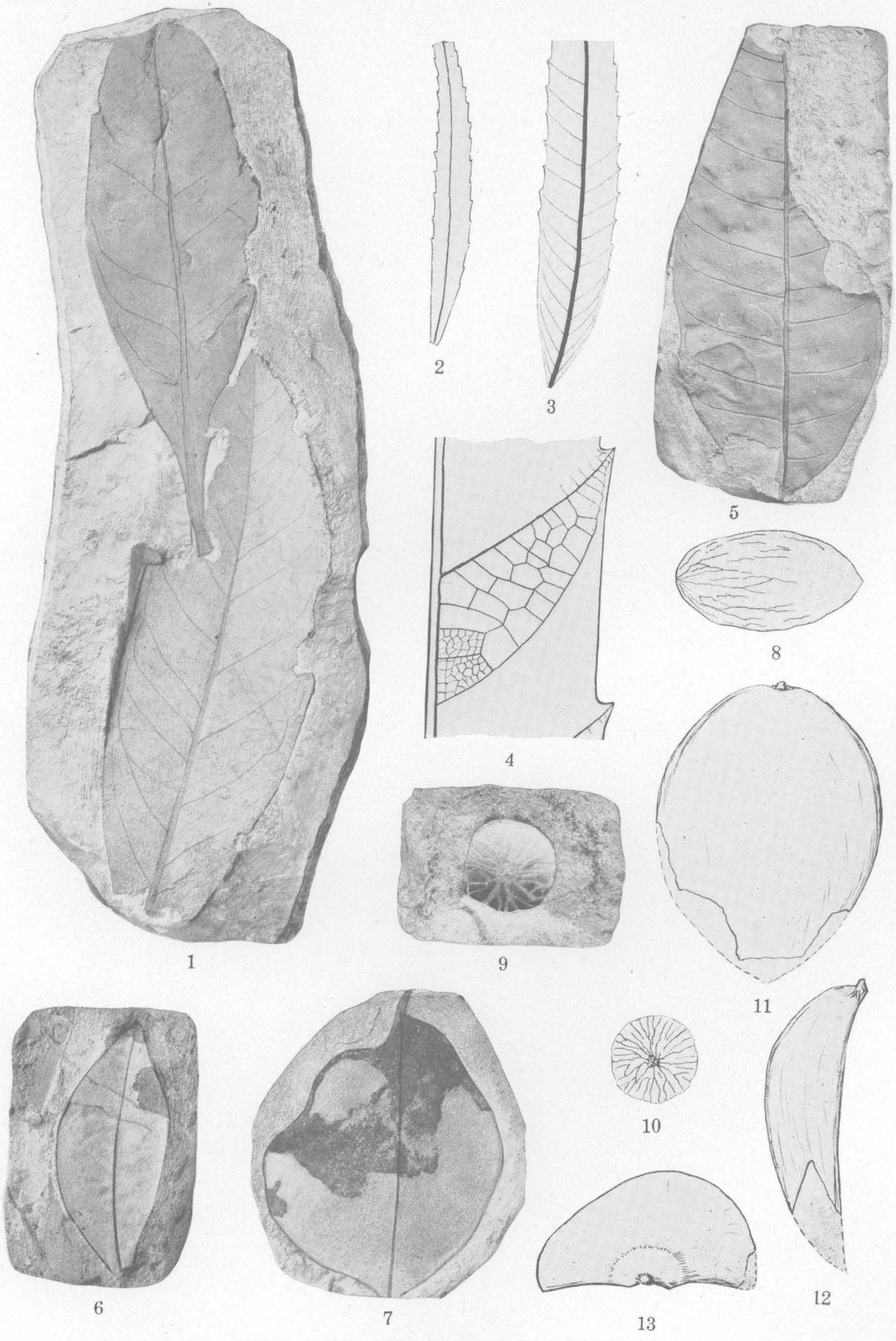


FOSSIL PLANT FROM DEPOSITS OF JACKSON AGE.

Thrinax eocenica Berry, Barnwell formation (Twiggs clay member), Grovetown, Ga.; p. 151.

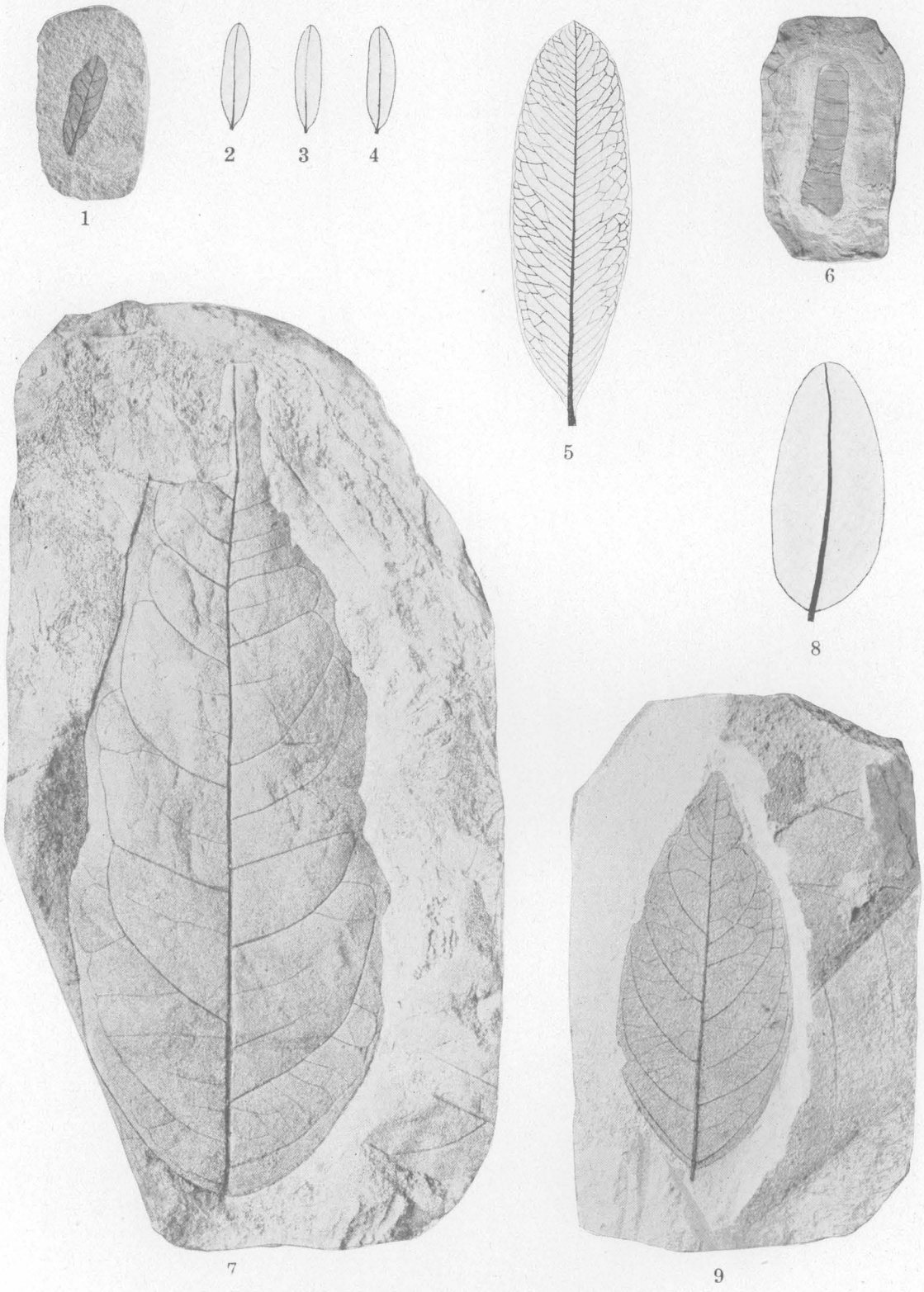
FOSSIL PLANT FROM DEPOSITS OF JACKSON AGE.

Dryophyllum brevipetiolatum Berry, n. sp., Fayette sandstone, Caney and White Rock creeks, Trinity County, Tex.; p. 157.



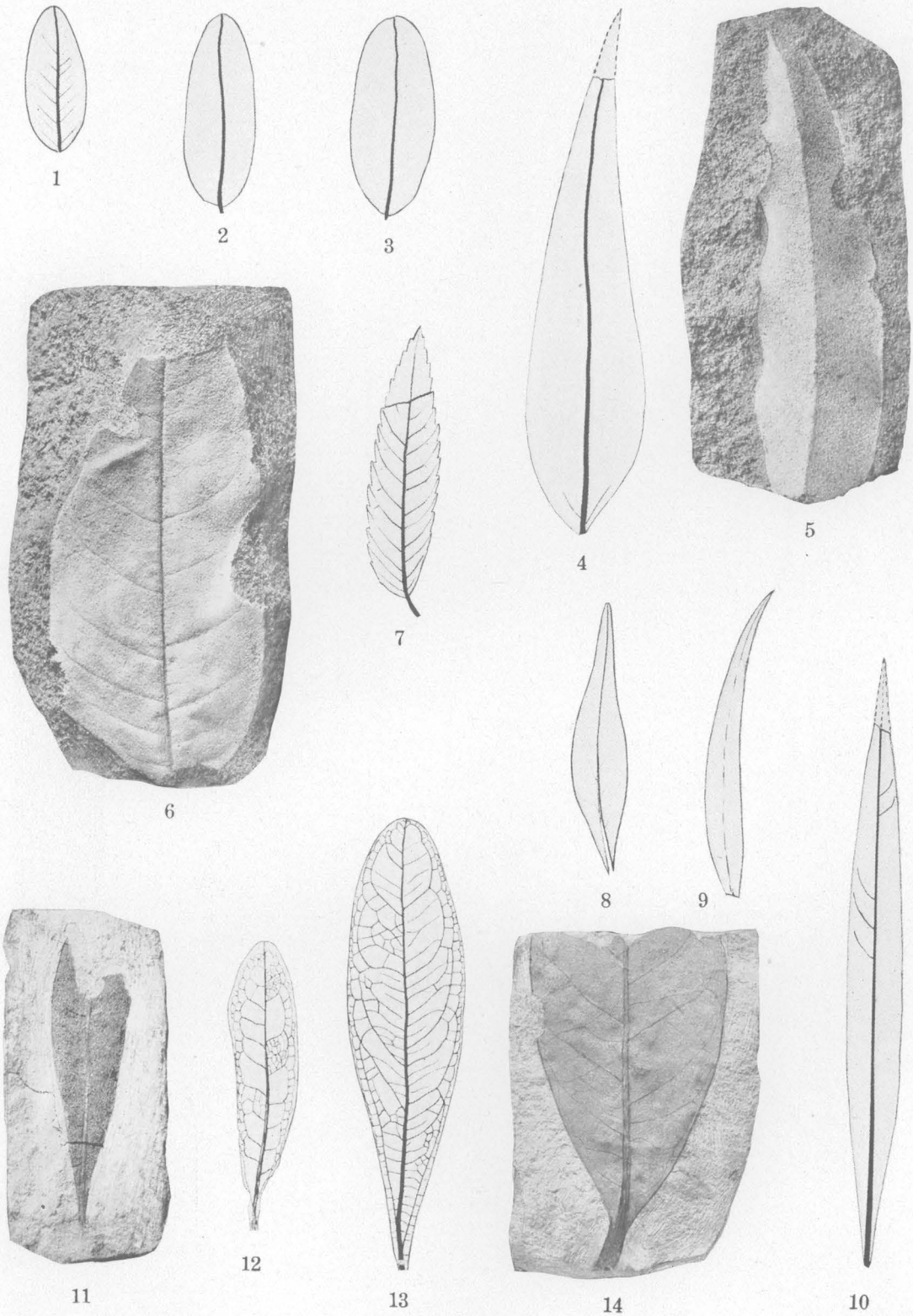
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Ficus claibornensis* Berry, Barnwell formation (Twiggs clay member), near Grovetown, Ga.; p. 159.
2–4. *Banksia jacksonensis* Berry, n. sp., Forest Hill sand, 11 miles north of Jackson, Miss., in beds regarded by me as of Jackson age; p. 161.
5. *Ficus unionensis* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 160.
6, 7. *Pisonia jacksoniana* Berry, n. sp., Jackson formation, White Bluff, Ark.; p. 162.
8–13. *Myristica catahoulensis* Berry, Catahoula (?) sandstone, along International & Great Northern Railway in Trinity County, Tex.; p. 163.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Mimosites spatulatus* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 167.
2–5. *Mimosites mississippiensis* Berry, n. sp., Forest Hill sand, 11 miles north of Jackson, Miss., in beds regarded by me as of Jackson age; p. 168. **5,** Specimen × 4.
6. *Cassia jacksoniana* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 169.
7. *Anona texana* Berry, Fayette sandstone, Caney and White Rock creeks, Trinity County, Tex.; p. 165.
8. *Cassia georgiana* Berry, n. sp., Barnwell formation (Twiggs clay member), 2 miles east of Gibson, Ga.; p. 169.
9. *Papilionites erythrinaformis* Berry, n. sp., Fayette sandstone ,Miraflores, Webb County ,Tex.; p. 171.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1–3. *Sophora claiborniana* Berry, n. sp.; p. 171. **1,** Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga.; **2, 3,** Barnwell formation (Twiggs clay member), Gibson, Ga.

4, 5. *Cedrela jacksoniana* Berry, n. sp.; p. 174. **4,** Jackson formation, White Bluff, Jefferson County, Ark.; **5,** Catahoula (?) sandstone, Stryker, Polk County, Tex.

6. *Banisteria texana* Berry, n. sp., Catahoula (?) sandstone, Stryker, Polk County, Tex.; p. 175.

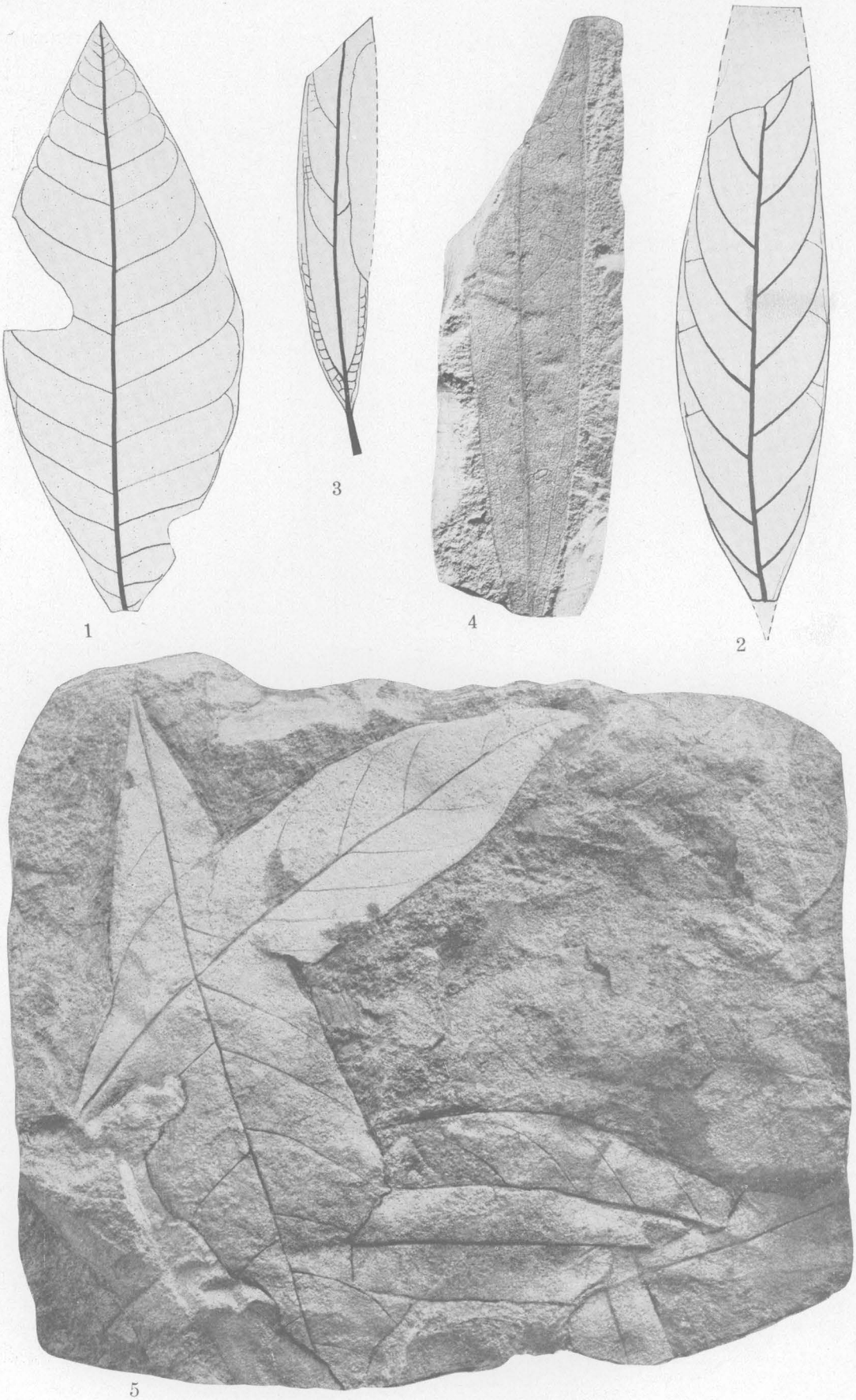
7. *Cupanites nigricans* (Lesquereux) Berry, Barnwell formation (Twiggs clay member), 10 miles south of Macon, Ga.; p. 176.

8, 9. *Sapindus georgianus* Berry, Barnwell formation (Twiggs clay member), Phinizy Gully, Columbia County, Ga.; p. 177.

10. *Apocynophyllum grevilleafolium* Berry, n. sp., Fayette sandstone, Miraflores, Webb County, Tex.; p. 196.

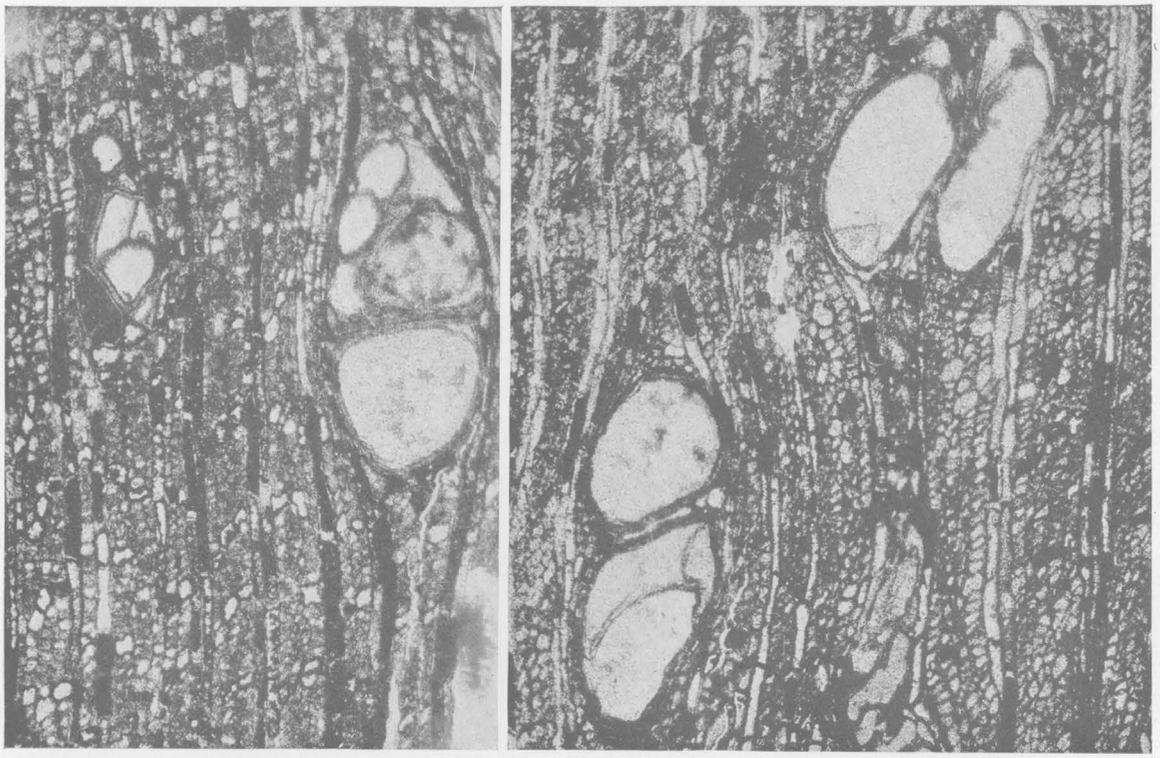
11–13. *Dodonaea viscosoides* Berry; p. 176. **11,** McMurrains Crossing, Ark. (Jackson formation); **12, 13,** Phinizy Gully, Ga. (Barnwell formation).

14. *Bombacites jacksonensis* Berry, n. sp., Jackson formation, Paul Taylor place, Burleson County, Tex.; p. 180.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Bombacites jacksonensis* Berry, n. sp., Fayette sandstone, 4 miles north of Miraflores, Tex.; p. 180.
2. *Nectandra gosportensis* var. *jacksonensis* Berry, n. var., Catahoula (?) sandstone, cut on International & Great Northern Railway in Trinity County, Tex.; p. 187.
3, 4. *Cinnamomum angustum* Berry, n. sp., Barnwell formation (Twiggs clay member), Phinizy Gully, Ga.; p. 184. **4,** Specimen × 2.
5. *Conocarpus eocenicus* Berry (p. 190) and *Bombacites jacksonensis* Berry, n. sp. (p. 180), Fayette sandstone, 1¼ miles northeast of Christie, La.



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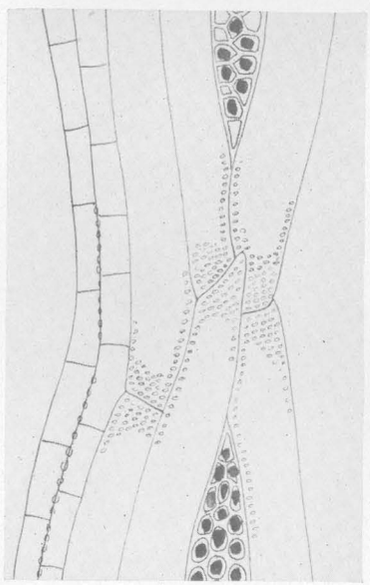

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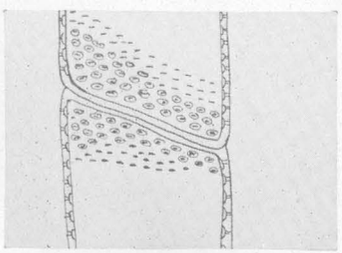

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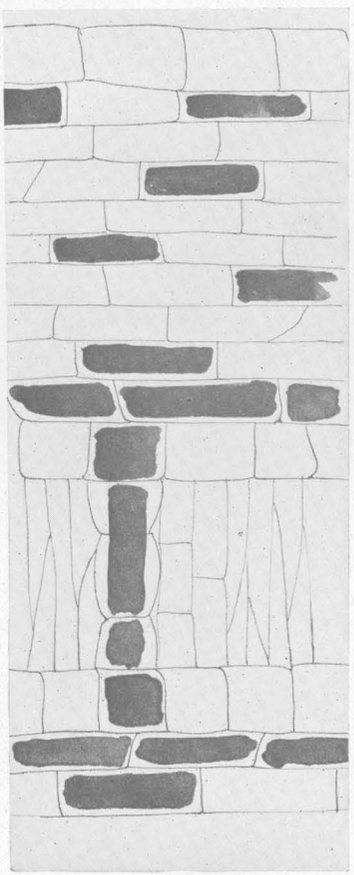

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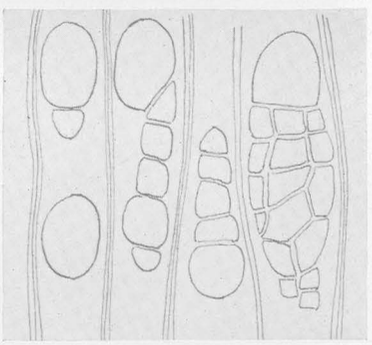

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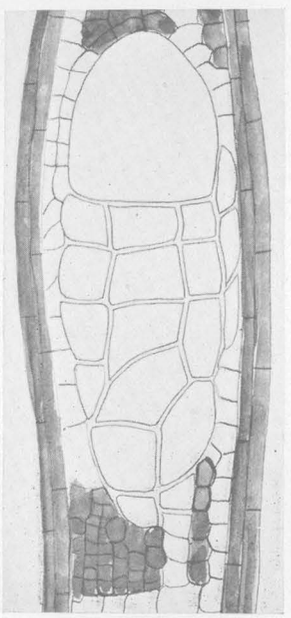
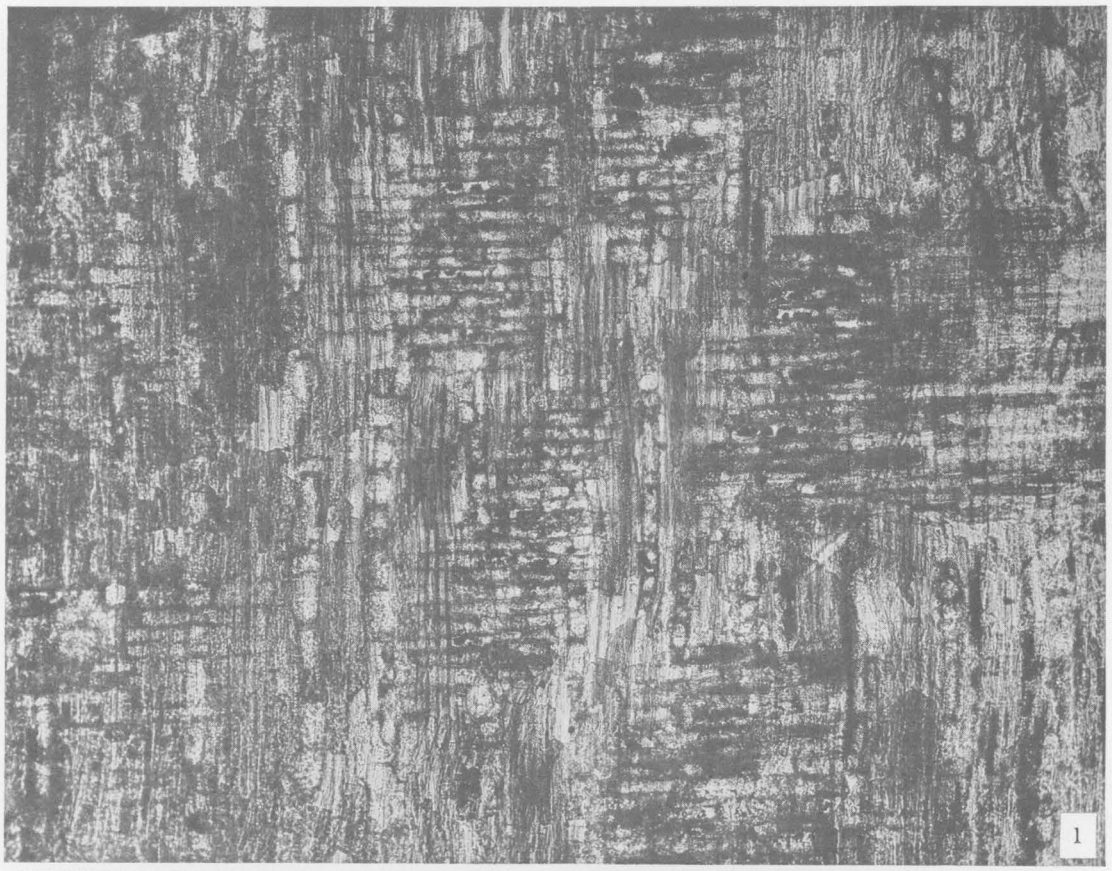
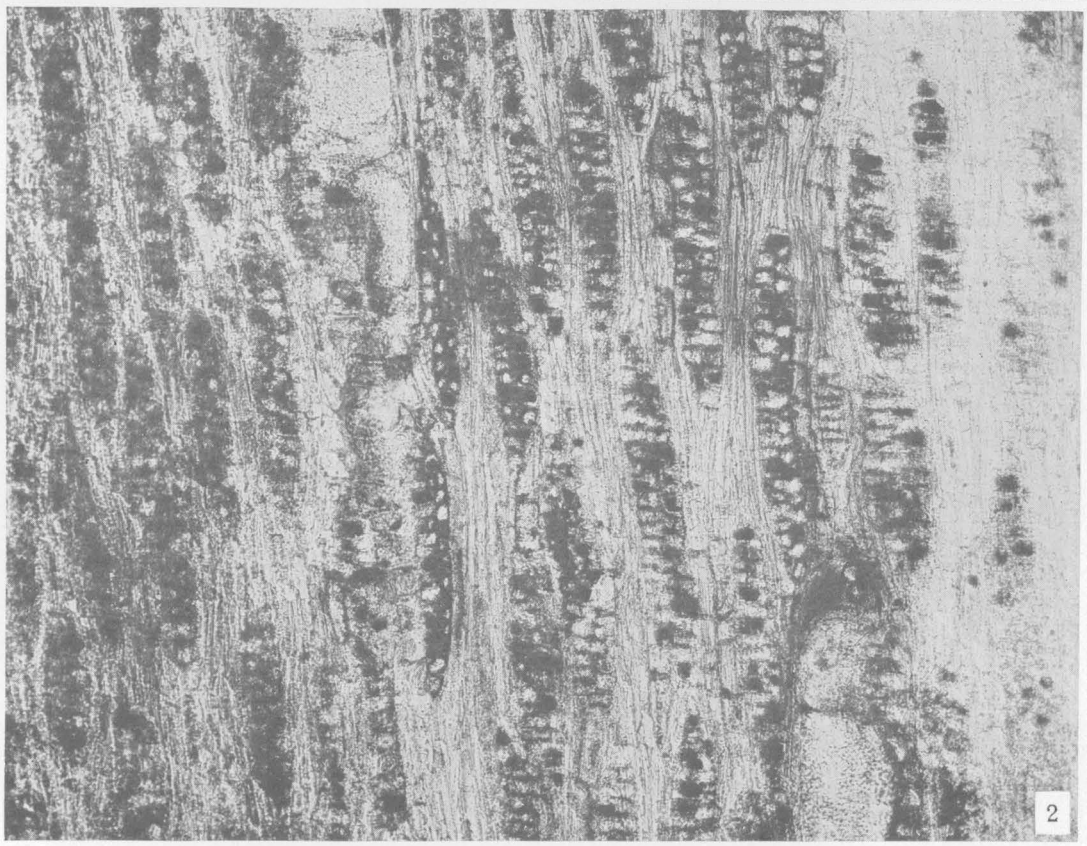


6

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

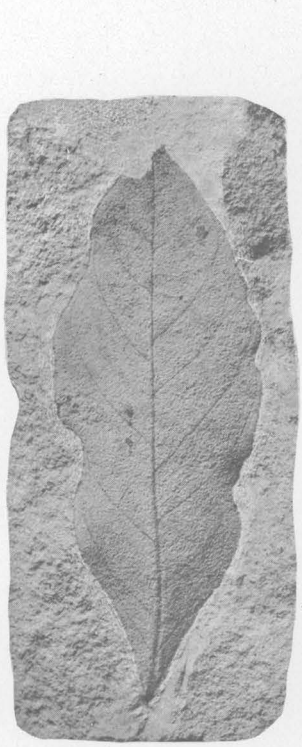
Dombeyoxylon jacksonensis Berry, n. sp., Fayette sandstone, Hornbeck, La.; p. 181. **1,** Transverse view (No. 272), × 100; **2,** tangential view showing rays, pitting of vessels, and xylem parenchyma, × about 150; **3,** character of ends and pitting of vessels, × about 150; **4,** radial view showing rays and prosenchyma, × about 150; **5,** transverse view showing character of vessels, × about 50; **6,** transverse view showing group of vessels, xylem parenchyma, and prosenchyma, × about 150.





FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

Dombeyoxylon jacksonensis Berry, n. sp., Fayette sandstone, Hornbeck, La.; p. 181. **1,** Radial view (No. 272), × 100; **2,** tangentia view (No. 272), × 100.



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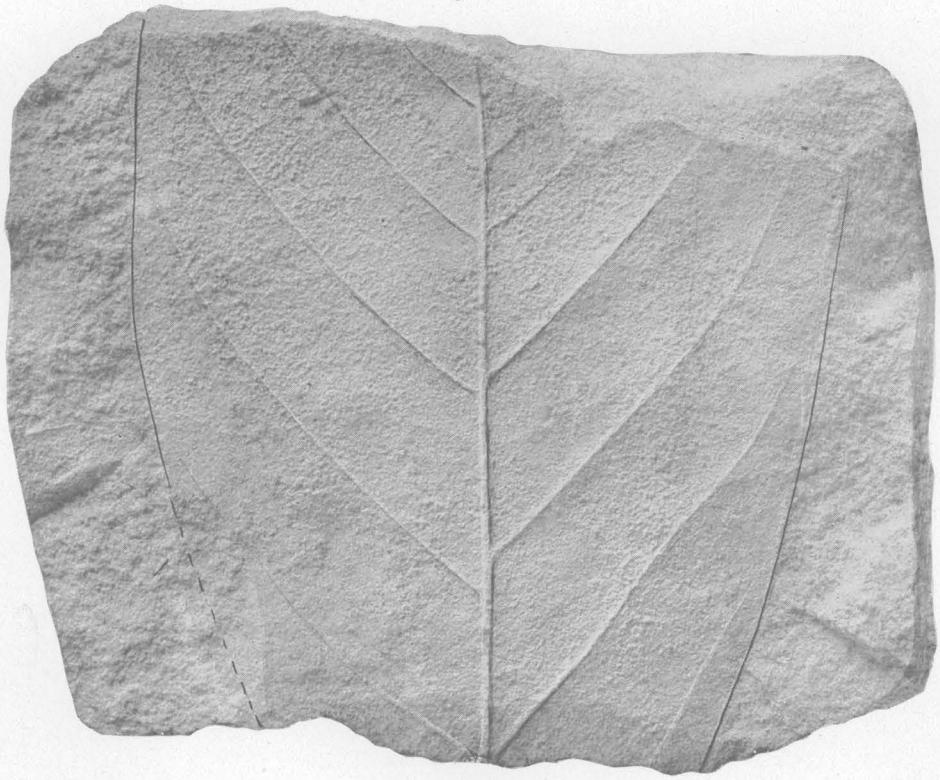
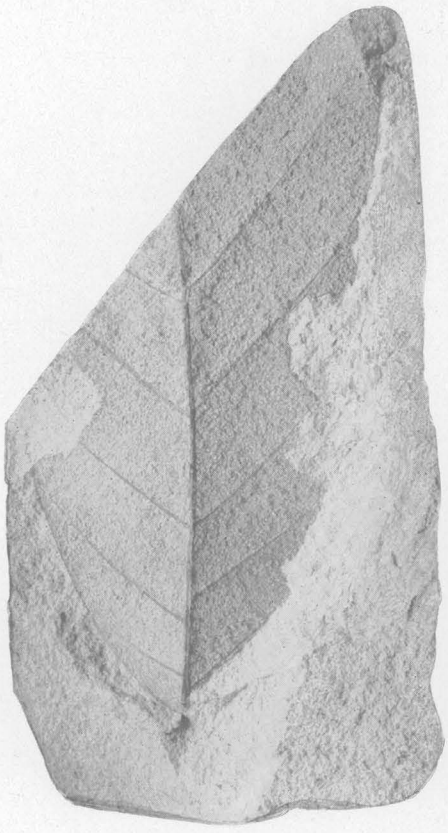


4

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Mespilodaphne texana* Berry, n. sp., Fayette sandstone, Miraflores, Tex.; p. 185.
2. *Nectandra arkansana* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 187.
3. *Nectandra antillanafolia* Berry, n. sp., Fayette sandstone, Miraflores, Tex.; p. 187.
4. *Terminalia phacocarpoides* Berry, Fayette sandstone, Christie, La., × 1.2; p. 189.



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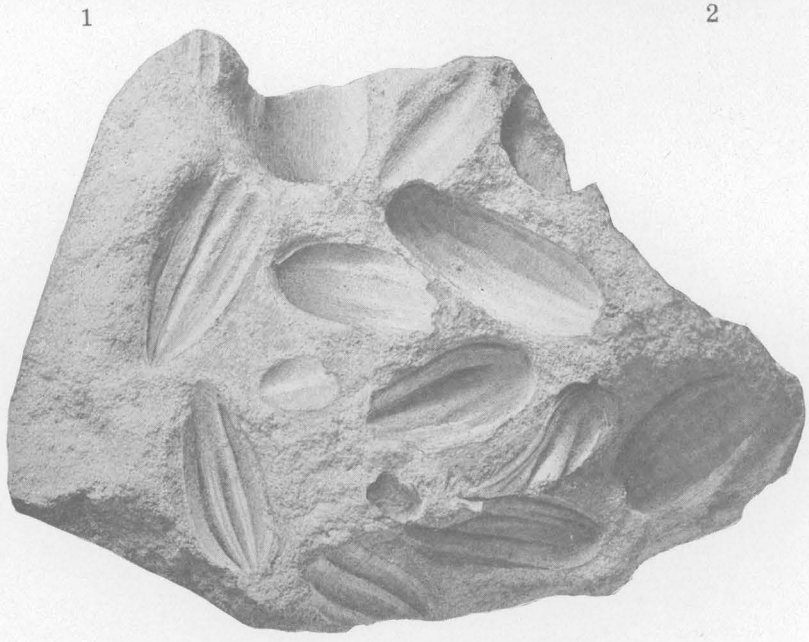
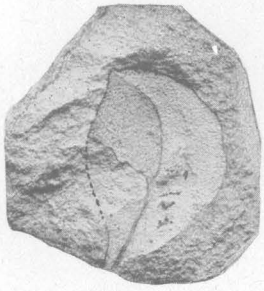


3

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Terminalia phaeocarpoides* Berry, Fayette sandstone, Miraflores, Tex.; p. 189.
2. *Conocarpus eocenicus* Berry, Barnwell formation (Twiggs clay member), Grovetown, Ga.; p. 190.
3. *Nyssa texana* Berry, n. sp., Catahoula (?) sandstone, cut on International & Great Northern Railway in Trinity County, Tex.; p. 192.



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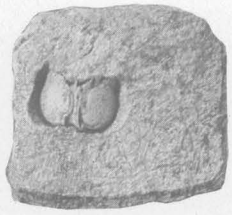

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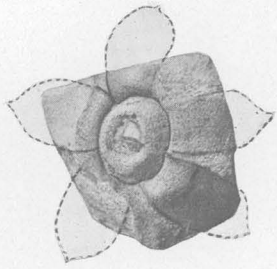

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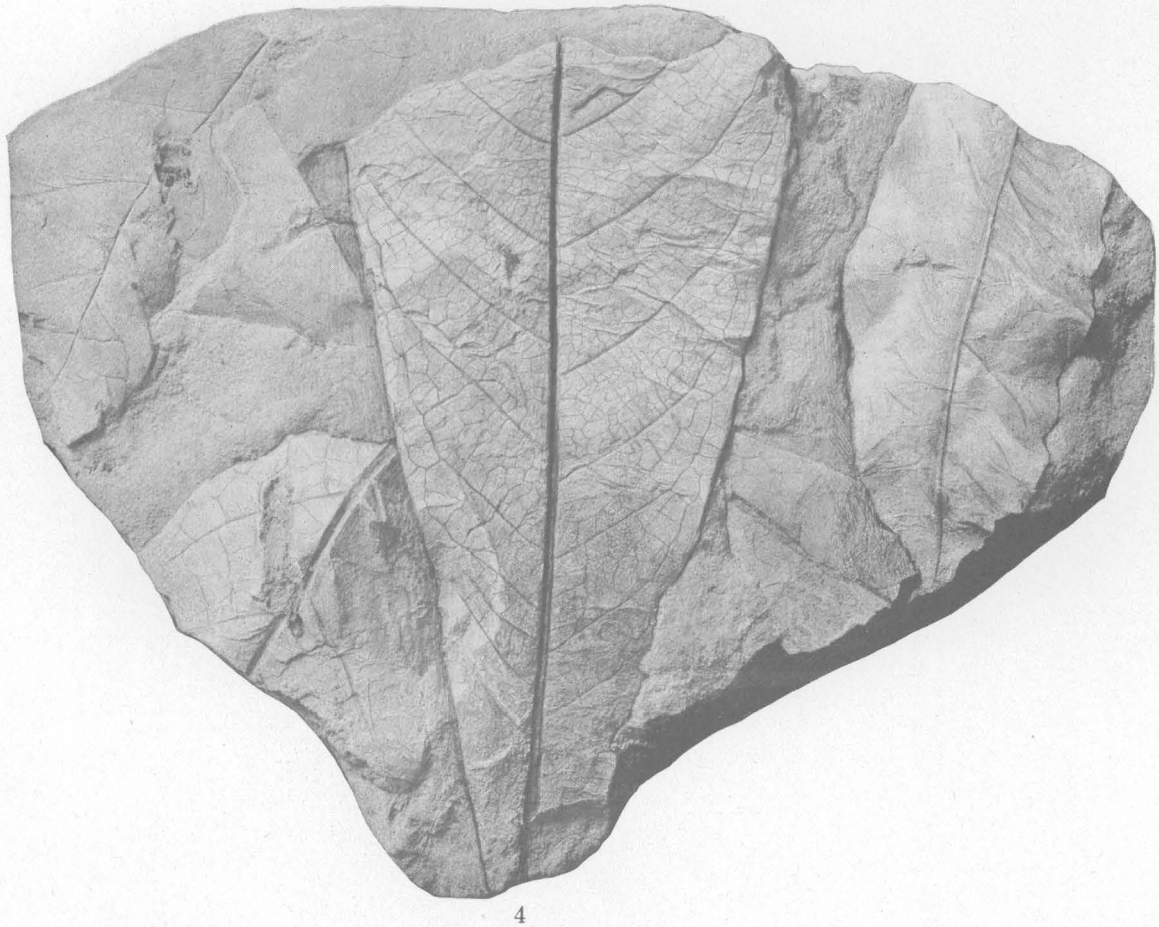
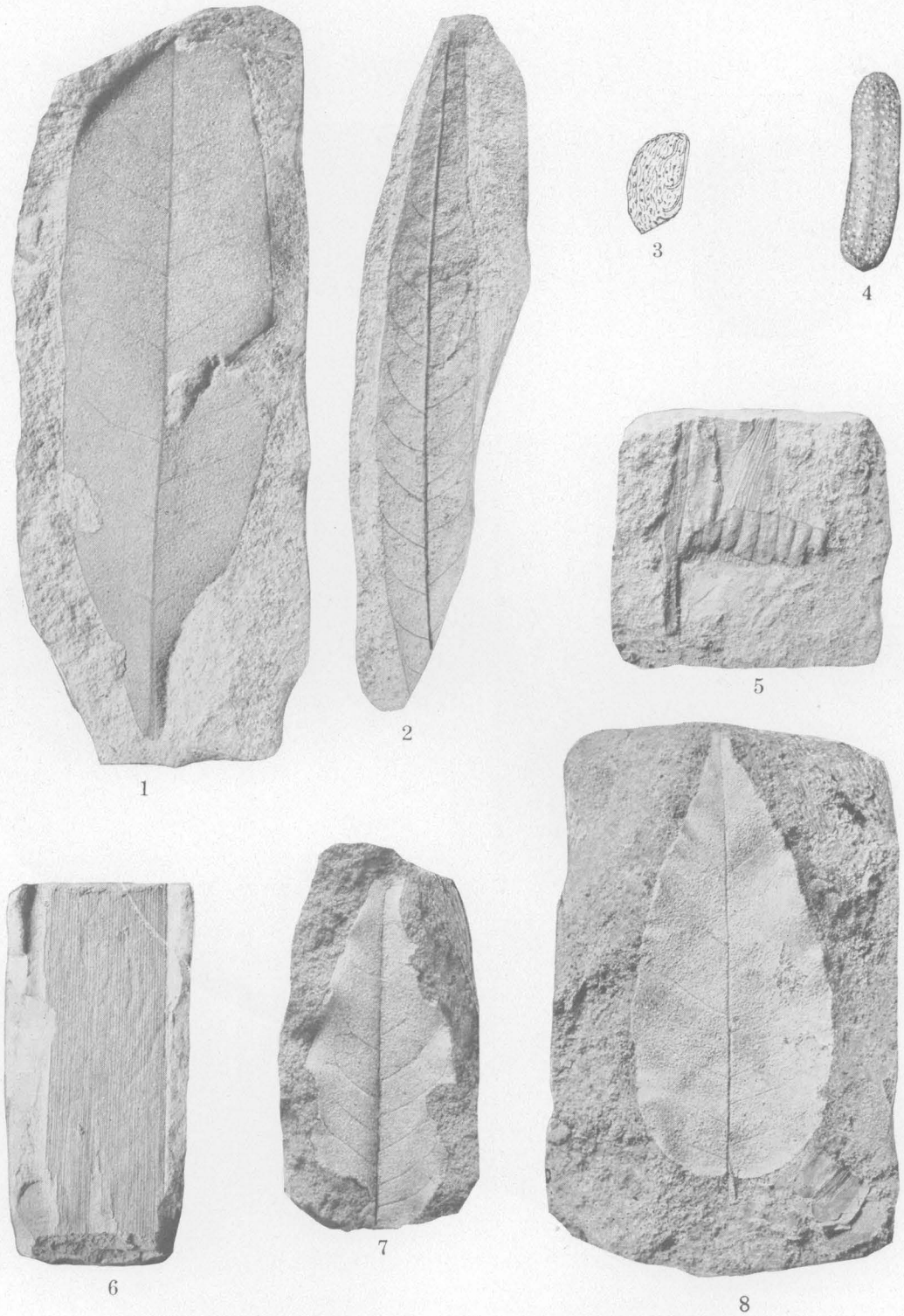


4

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Sapotacites miraflorianus* Berry, n. sp., Fayette sandstone, Miraflores, Tex.; p. 194.
2. *Cypselites jacksonensis* Berry, n. sp., Jackson formation, McMurrains Crossing, Ark.; p. 198.
3. *Carpolithus callitriformis* Berry, n. sp., Catahoula (?) sandstone, cut on International & Great Northern Railway in Trinity County, Tex.; p. 197.
4. *Calocarpum viridiforme* Berry, n. sp. (p. 193), and *Apocynophyllum texensis* Berry, n. sp. (p. 195), Fayette sandstone, Hamilton League, Tex.
5. *Diospyros mirafloriana* Berry, n. sp., Fayette sandstone, Miraflores, Tex.; p. 195.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1, 2. *Apocynophyllum texensis* Berry, n. sp.; p. 195. **1,** Fayette sandstone, Miraflores, Tex.; **2,** Fayette sandstone, Caney and White Rock creeks, Tex.

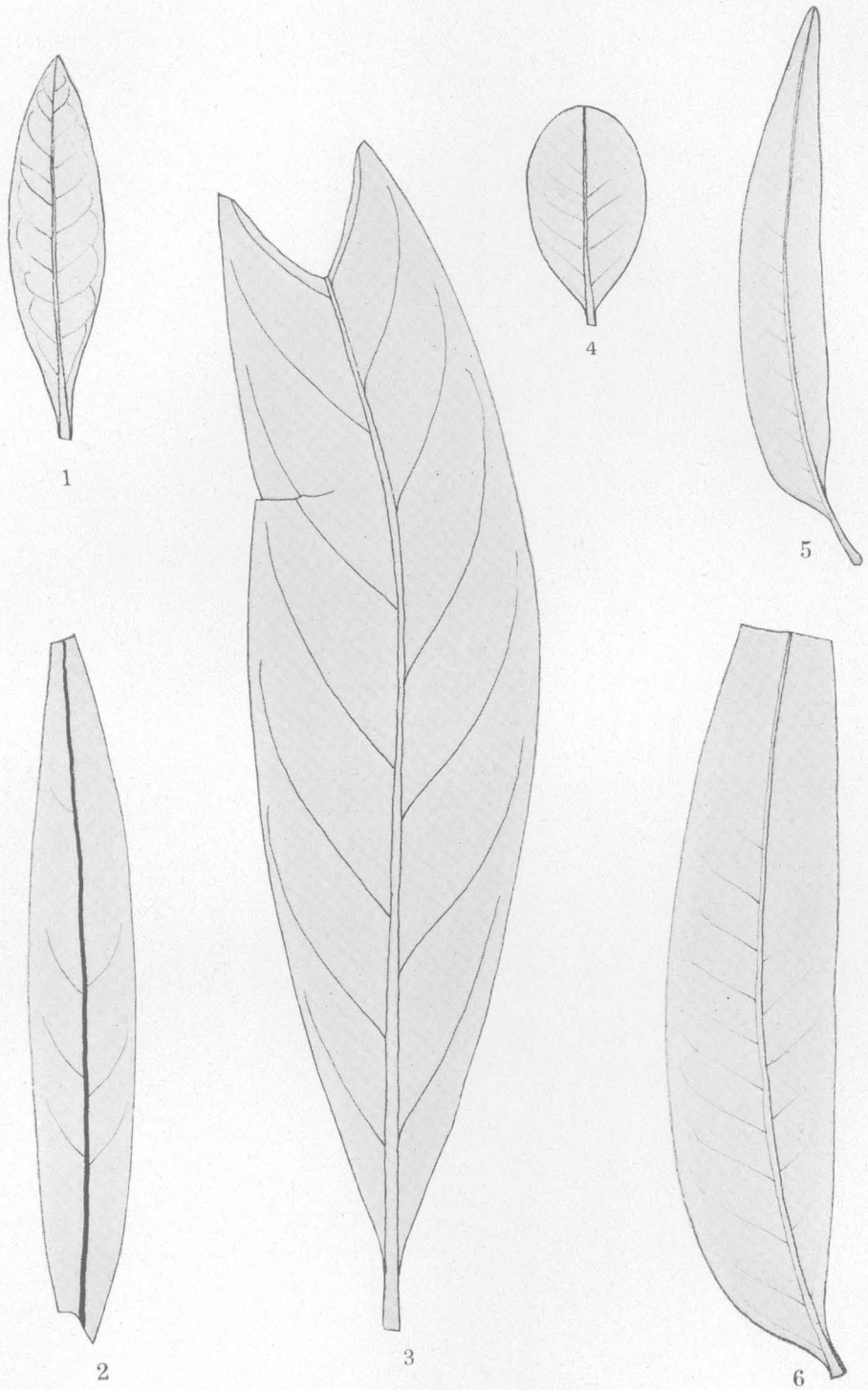
3. *Leguminosites* sp., Barnwell formation (Twiggs clay member), Phinizy Gully, Ga.; p. 199.

4. *Carpolithus najasoides* Berry, n. sp., Barnwell formation (Twiggs clay member), 10 miles south of Macon, Ga.; p. 198.

5. *Equisetum* sp., Jackson formation, McMurrains Crossing, Ark.; p. 142.

6. *Arundo pseudogoepperti* Berry, Jackson formation, McMurrains Crossing, Ark.; p. 148.

7, 8. *Burserites fayettensis* Berry, n. sp., Catahoula (?) sandstone, Stryker, Tex.; p. 175.

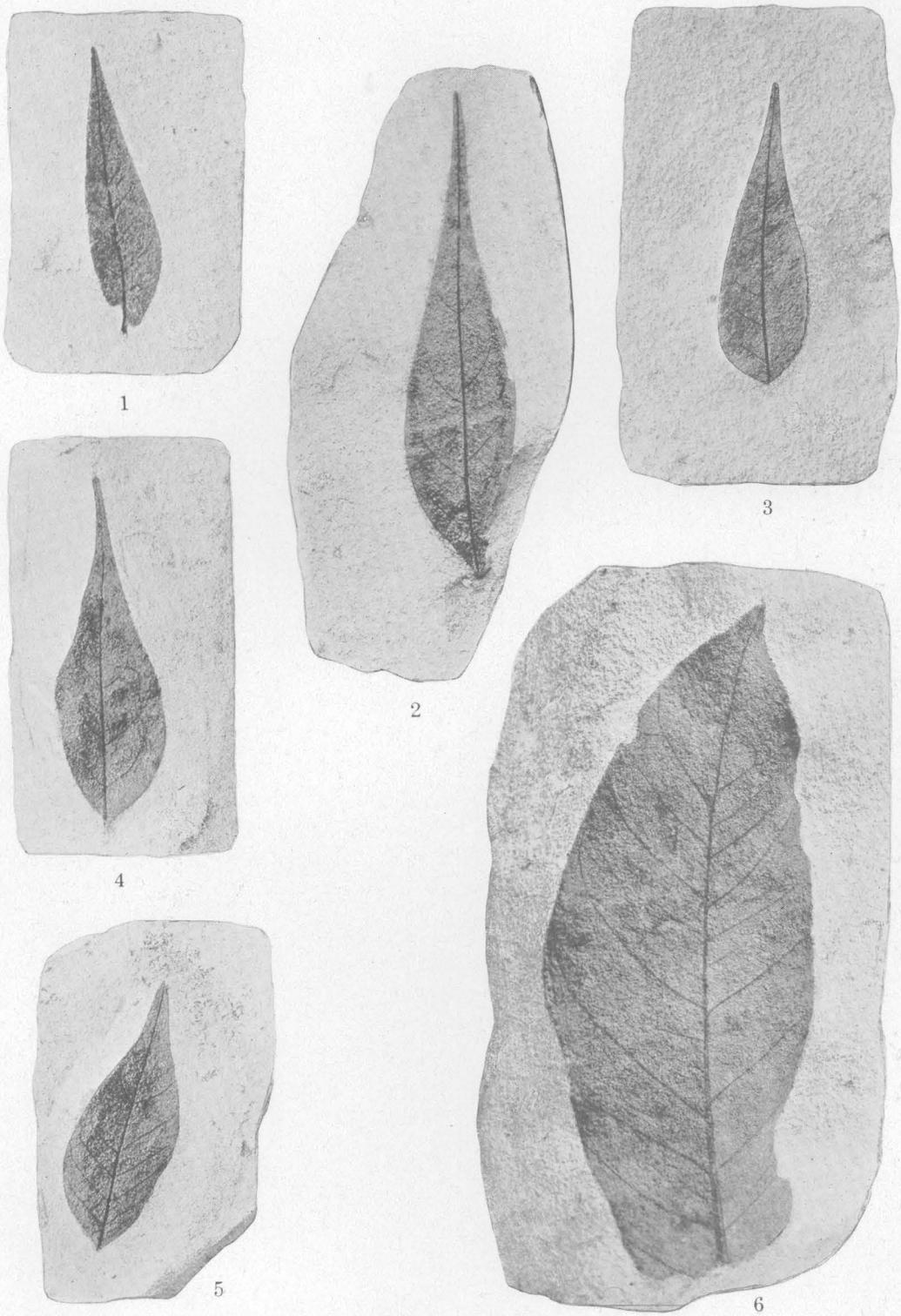


FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE

1. *Dodonaea viscosoides* Berry; p. 176.
2. *Mespilodaphne caudata major* Berry, n. var.; p. 185.
3. *Nectandra antillanafolia* Berry, n. sp.; p. 187.
4. *Pisonia balli* Berry, n. sp.; p. 162.
5, 6. *Inga jacksoniana* Berry, n. sp.; p. 167.
All from Fayette sandstone, Alum Creek, 3 miles east of Wellborn, Tex.

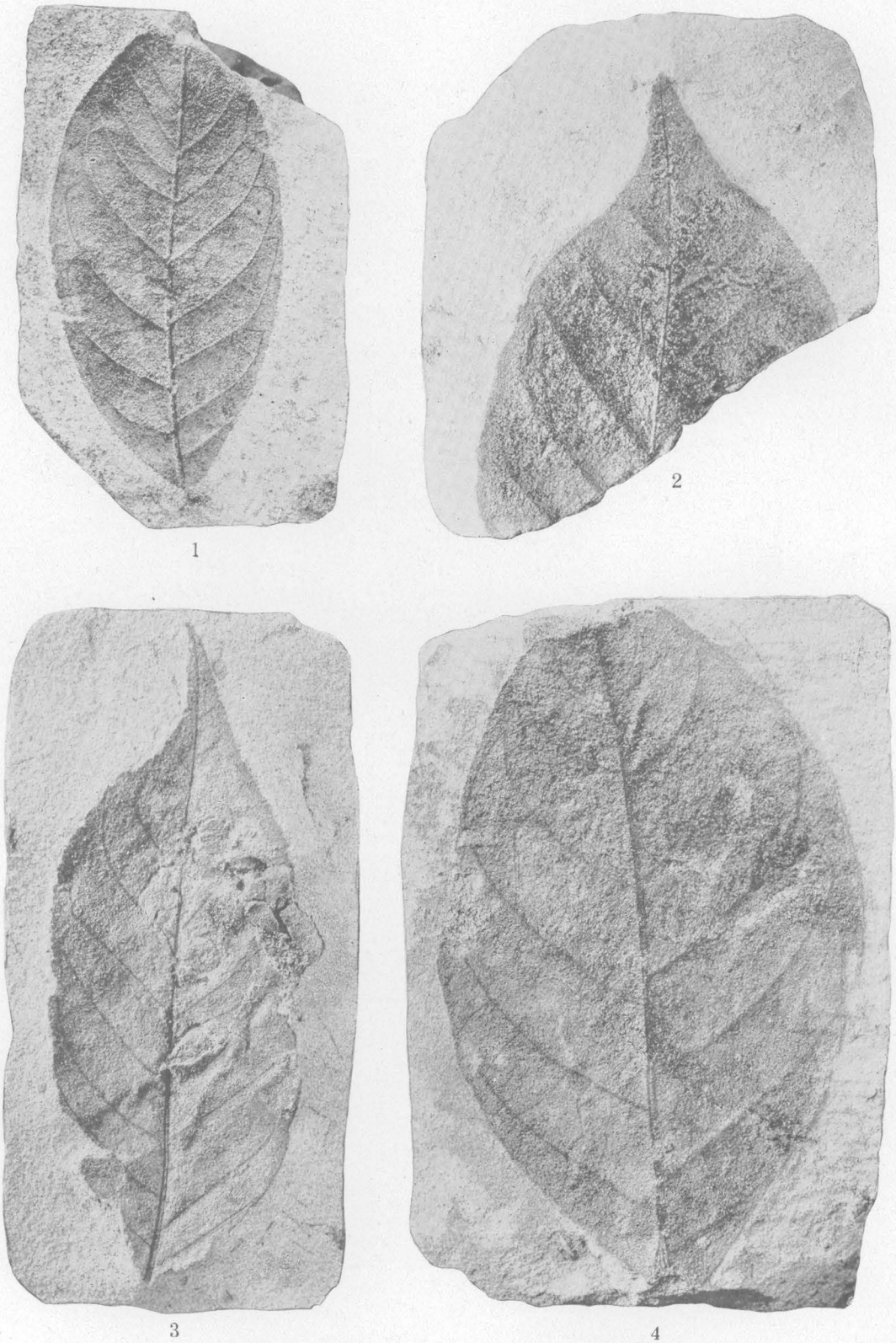
FOSSIL PLANTS FROM DEPOSITS OF CLAIBORNE AND JACKSON AGE.

1, 2. *Sapindus yeguanus* Berry, n. sp., Yegua formation, Rock Creek, Brazos County, Tex.; p. 73.
3. *Fagara petraflumensis* Berry, n. sp., Yegua formation, Rock Creek, Brazos County, Tex.; p. 66.
4. *Sophora balli* Berry, n. sp., Yegua formation, Rock Creek, Brazos County, Tex.; p. 65.
5. *Diospyros mirafloriana* Berry, n. sp., Jackson formation, Miraflores, Tex.; p. 195.
6, 7. *Hicoria jacksoniana* Berry, n. sp., Yegua formation, Rock Creek, Brazos County, Tex.; pp. 55, 155.



FOSSIL PLANTS FROM DEPOSITS OF CLAIBORNE AGE.

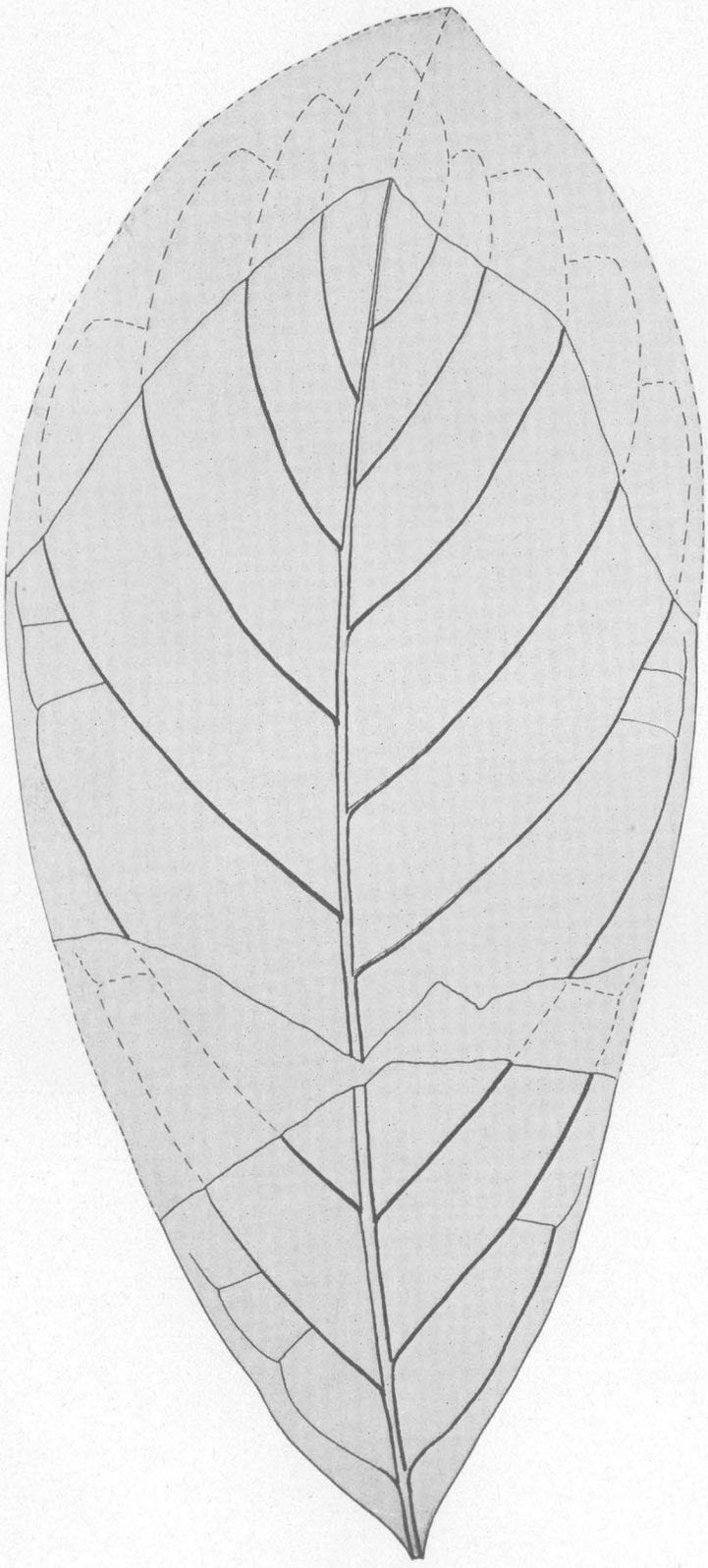
1–5. *Cedrela jacksoniana* Berry, n. sp.; p. 174.
6. *Oreodaphne inequilateralis* Berry, n. sp.; p. 80.
All from Yegua formation, Rock Creek, Brazos County, Tex.



1 2 3 4

FOSSIL PLANTS FROM DEPOSITS OF CLAIBORNE AGE.

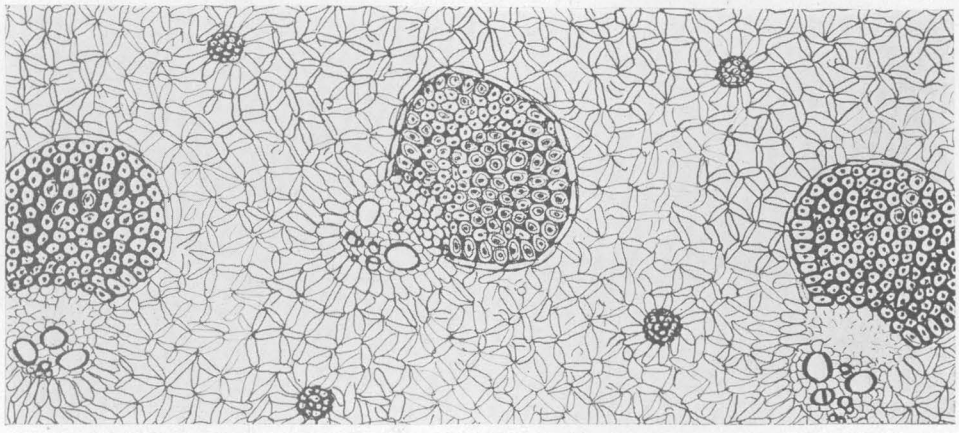
Combretum petraflumense Berry, n. sp., Yegua formation, Rock Creek, Brazos County, Tex.; p. 85.



FOSSIL PLANT FROM DEPOSITS OF CLAIBORNE AGE.

Terminalia phaeocarpoides Berry, Yegua formation, Rock Creek, Brazos County, Tex.; p. 189.

1



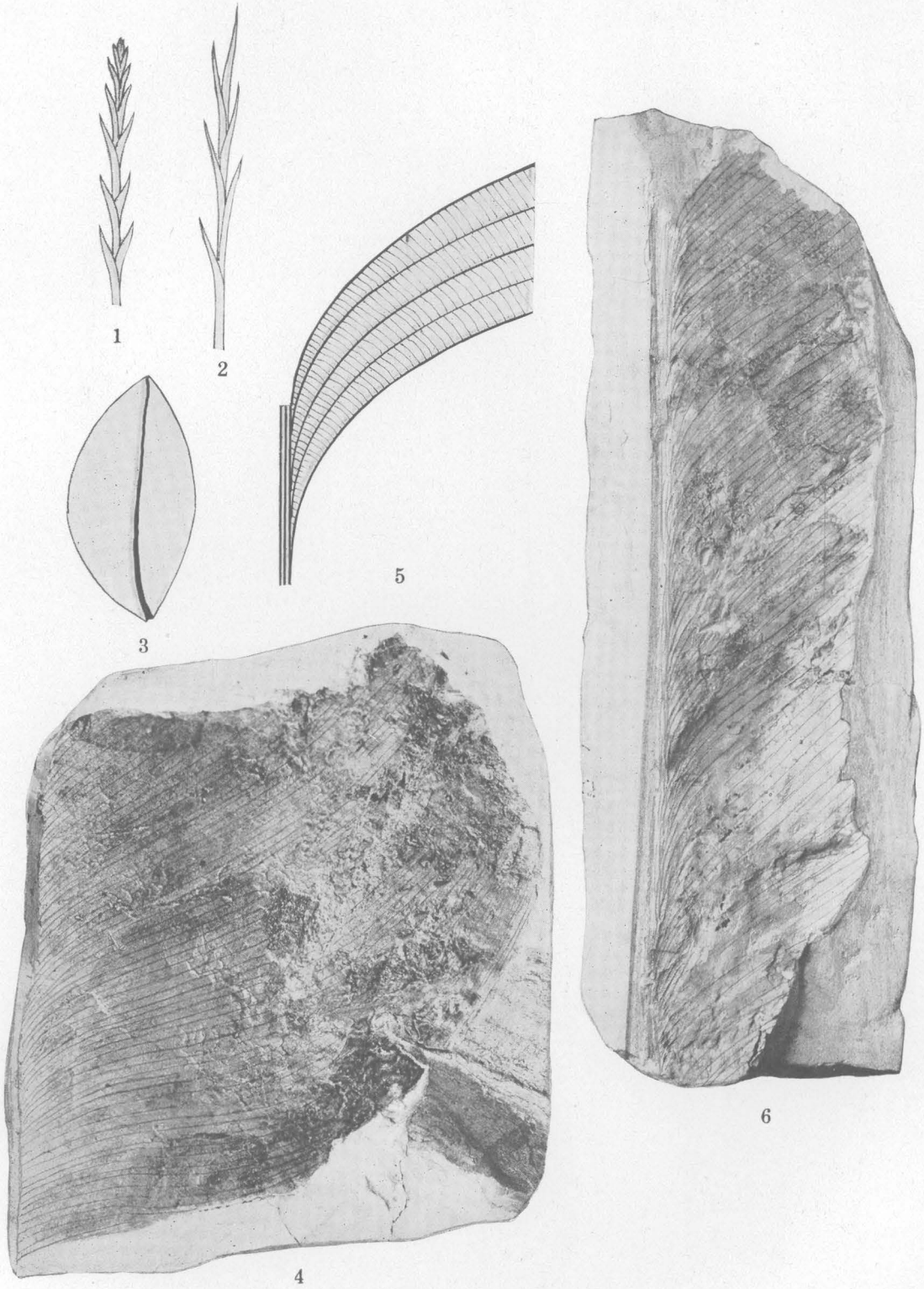
2

FOSSIL PLANTS FROM DEPOSITS OF CLAIBORNE AGE.

Palmoxylon lacunosum (Unger) Felix, upper part of Tallahatta formation or lower part of Lisbon formation, White Bluff, Clarke County, Ala.; p. 50. **1,** Specimen, natural size, showing roots being given off; **2,** drawing showing three fibrovascular bundles, lacunose groundmass, and several bundles of sclerenchyma, × 25.

FOSSIL PLANTS FROM DEPOSITS OF CLAIBORNE AGE.

1, 2. *Geonomites claibornensis* Berry, n. sp.; p. 53.
3–5. *Myrcia trowbridgi* Berry, n. sp.; p. 87.
All from Mount Selman formation, Palafox, Webb County, Tex.

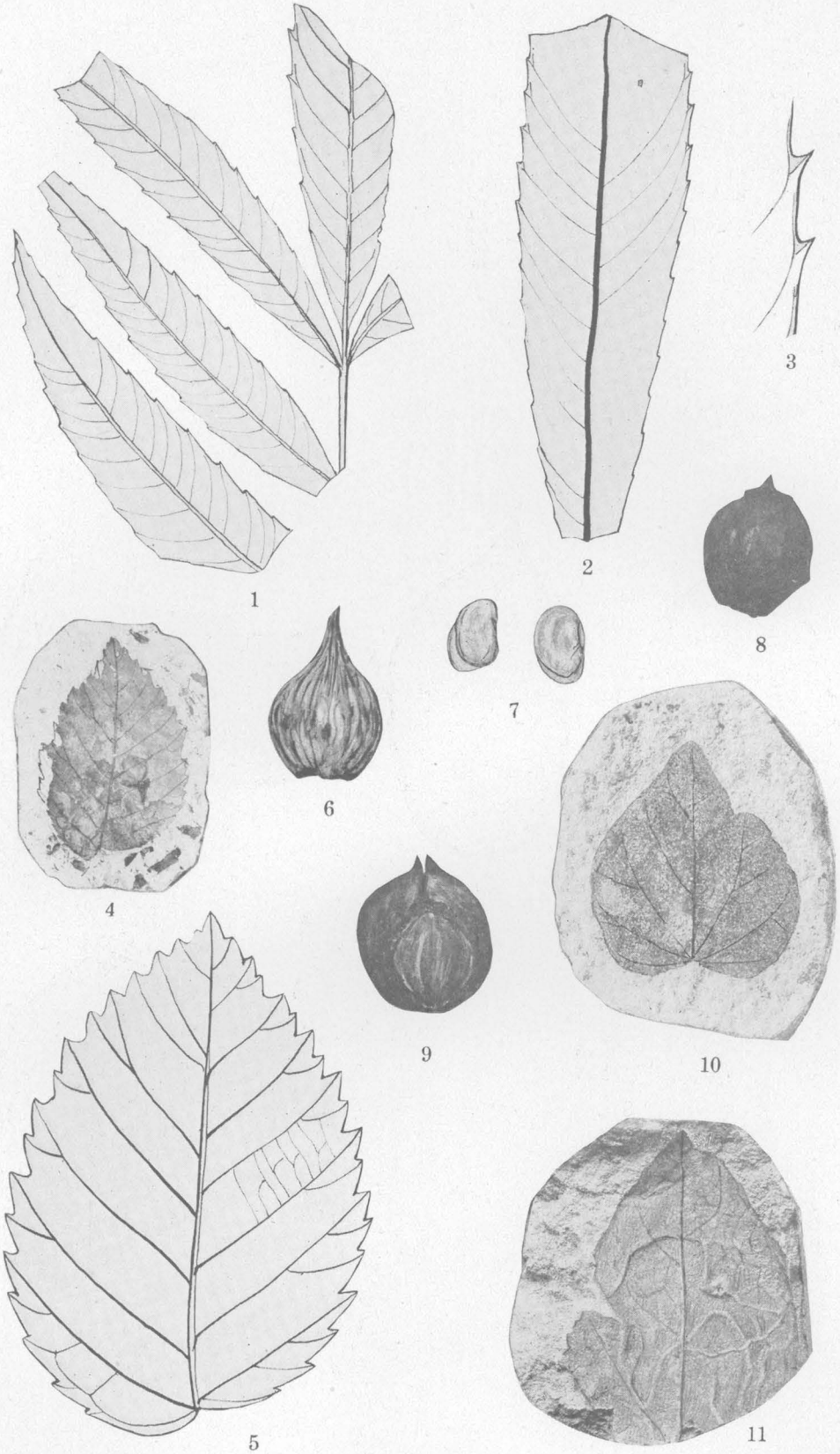


FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1, 2. *Glyptostrobus europaeus* (Brongniart) Heer (?), Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 144. Shows two types of shoots, × 3.

3. *Pisonia jacksoniana* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 162.

4–6. *Canna jacksoniana* Berry, n. sp., Fayette sandstone, east of Wellborn, Tex.; p. 147. **5,** Specimen showing details of venation, × 2.



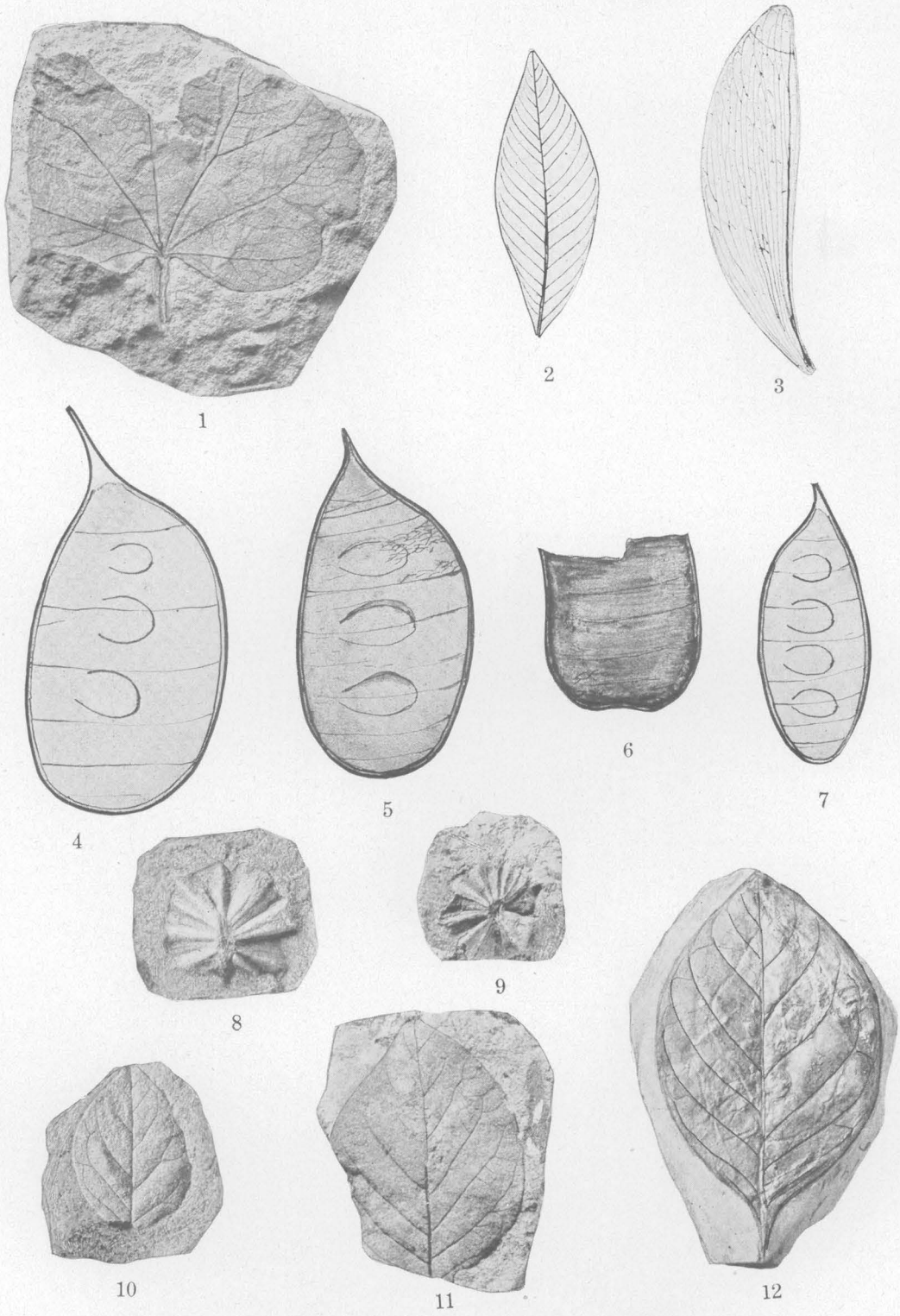
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1-3. *Hicoria jacksoniana* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.: p. 155. **3,** Specimen showing marginal teeth and venation, enlarged.

4, 5. *Planera hickmanensis* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, 5 miles south of Hickman, Ky.: p. 158. **5,** Specimen × 2½ to show details of venation.

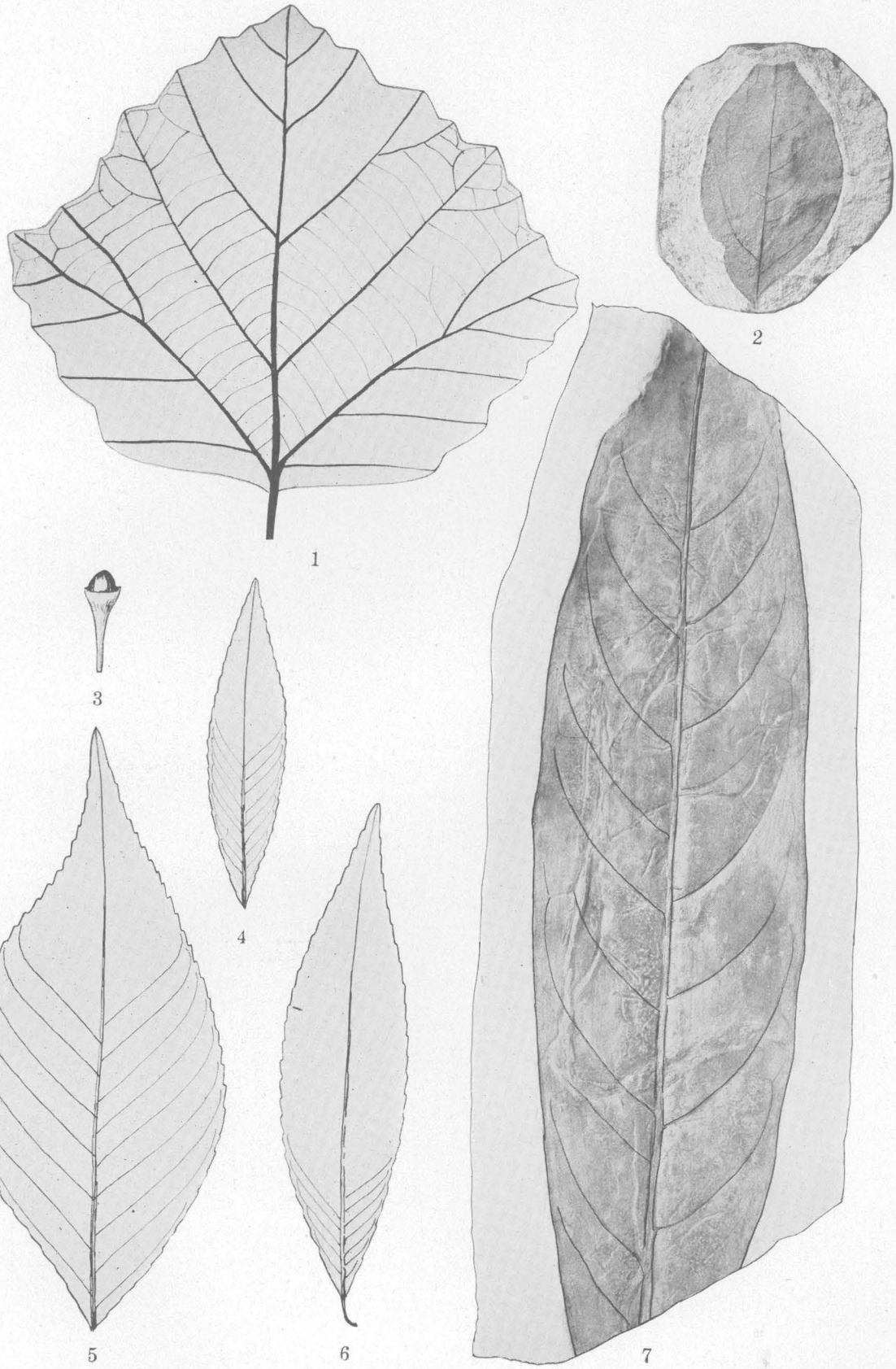
6-9. *Hicoria rostrataformis* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, upper bluff, Hickman, Ky.: p. 155. **6,** Indehiscent rostrate husk; **7,** two partial kernels; **8,** a less rostrate husk than that shown in Figure 6; **9,** nut inside partly removed husk.

10, 11. *Menispermites carolinaformis* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.: p. 165.



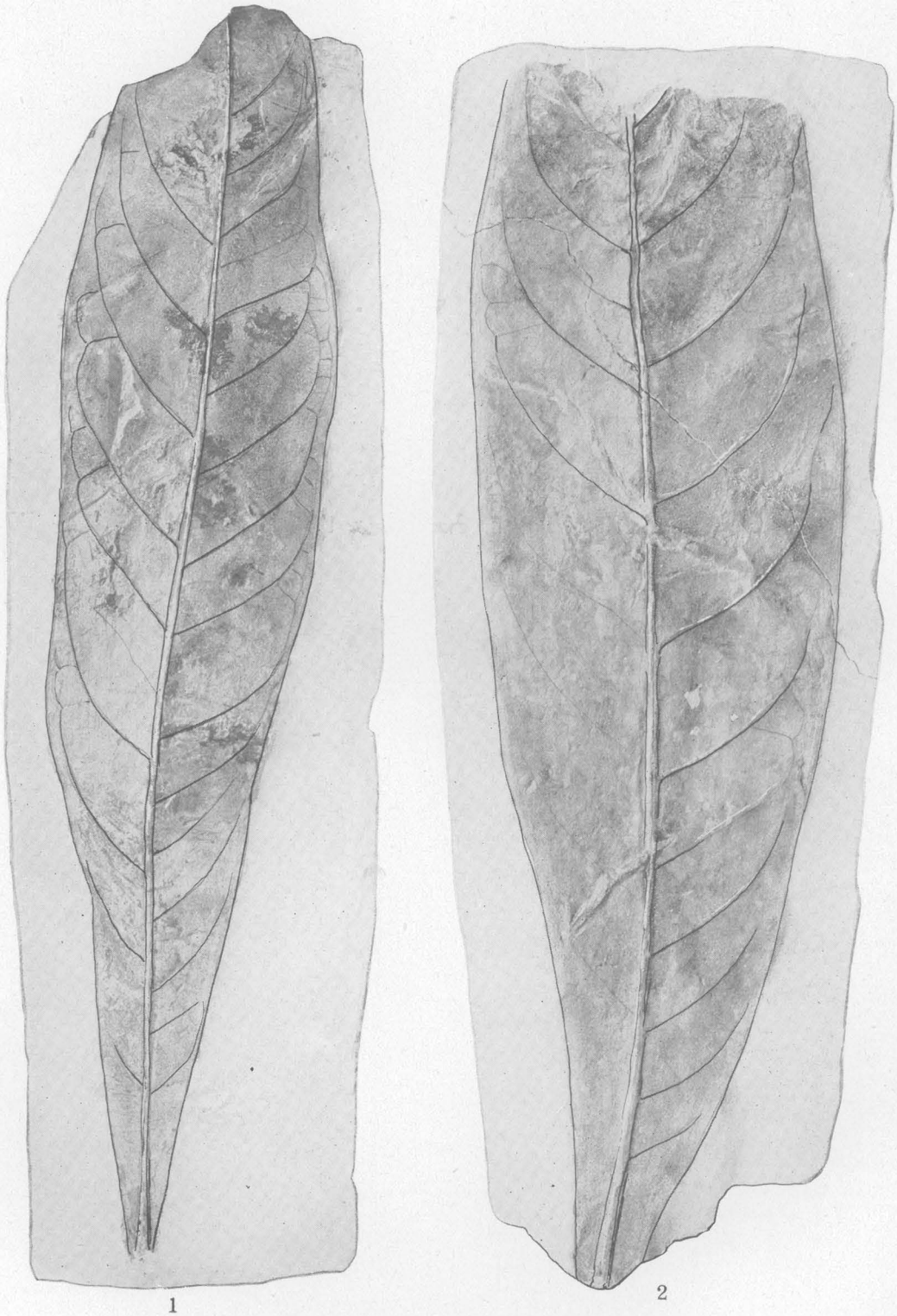
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Menispermites carolinaformis* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.: p. 165.
2. *Cassia obionana* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 169.
3. *Bauhinia wadii* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.; p. 169.
4–7. *Lonchocarpus anceps* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 171.
8, 9. *Liquidambar incerta* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age; p. 172. **8,** Upper bluff, Hickman, Ky.; **9,** half a mile north of Hickman, Ky.
10. *Fagara catahoulensis coriacea* Berry, Lagrange formation, in beds of upper Jackson (?) age, north of Hickman, Ky.; p. 174.
11, 12. *Fagara catahoulensis major* Berry; p. 173. **11,** Lagrange formation, in beds of upper Jackson (?) age, upper bluff, Hickman, Ky.; **12,** Fayette sandstone, east of Wellborn, Tex.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

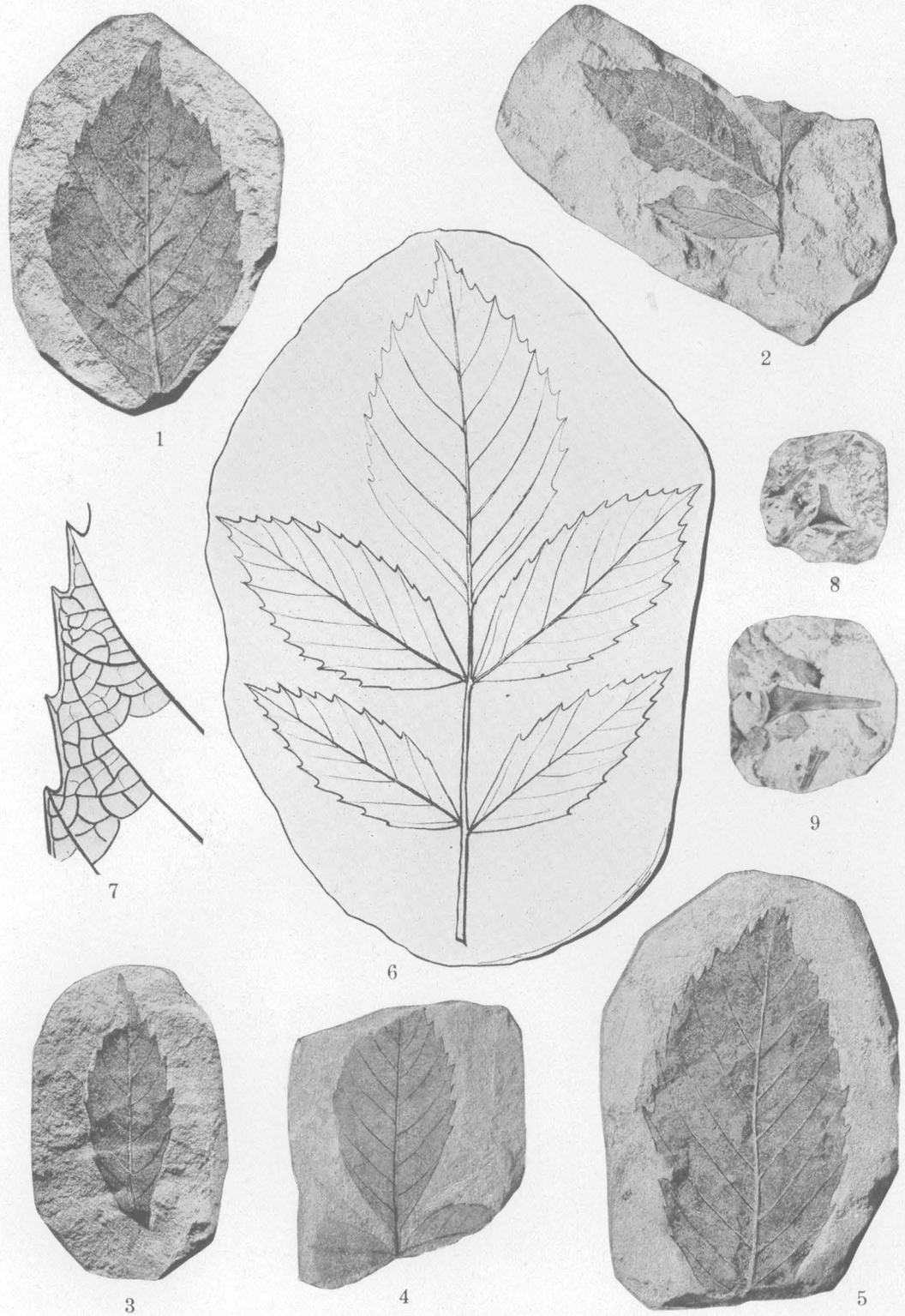
1. *Grewiopsis wadii* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, north of Hickman, Ky.: p. 179.
2. *Rhamnites krugiodendroides* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.; p. 178.
3. Lauraceous fruit, Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 188.
4–6. *Ternstroemites variabilis* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, Cane Creek, Obion County, Tenn.; p. 183.
7. *Nectandra antillanafolia* Berry, n. sp., Fayette sandstone, east of Wellborn, Tex.; p. 187.



1 2

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

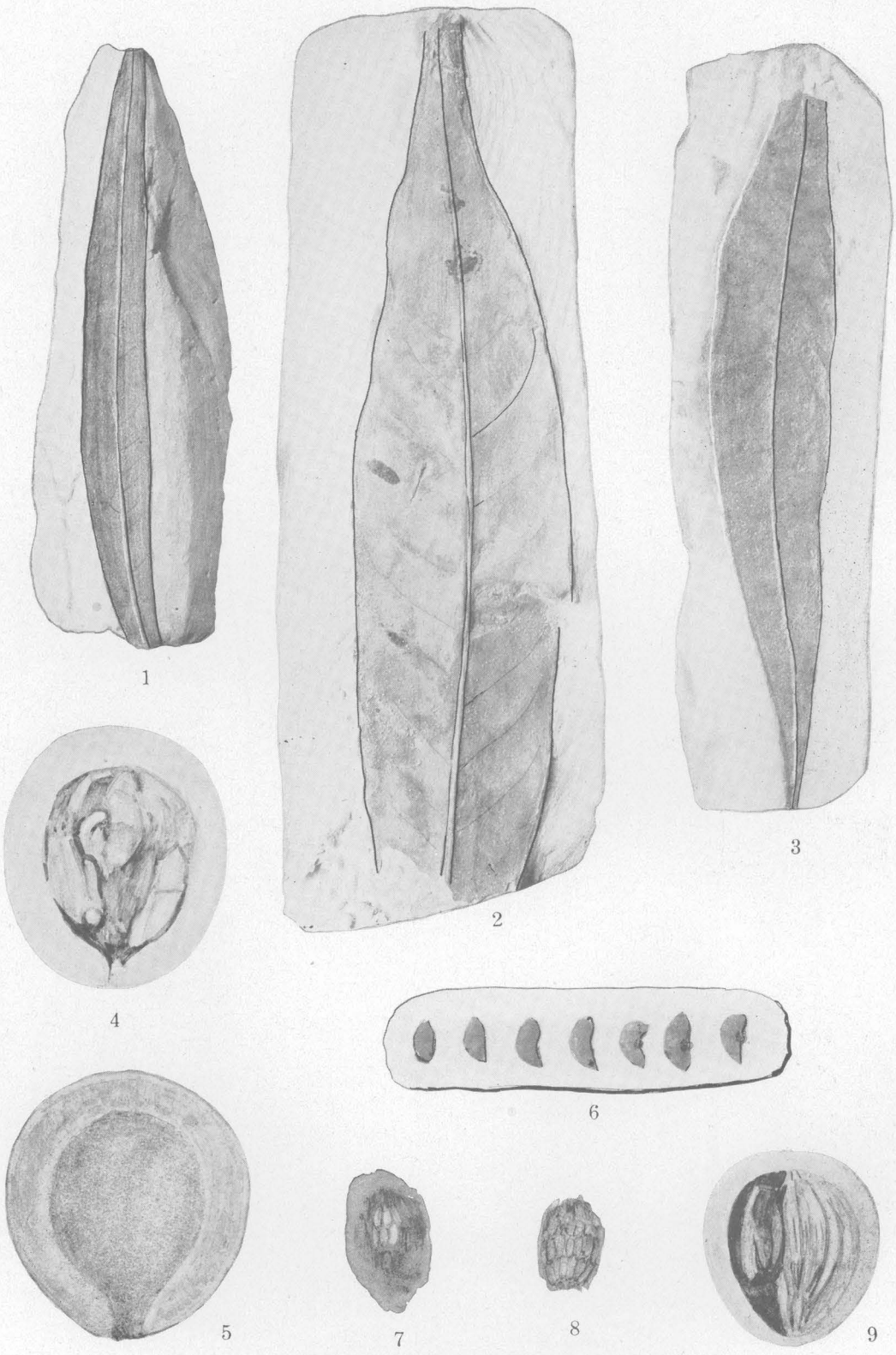
Nectandra antillanafolia Berry, n. sp. (two large leaves), Fayette sandstone, east of Wellborn, Tex.: p. 187



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

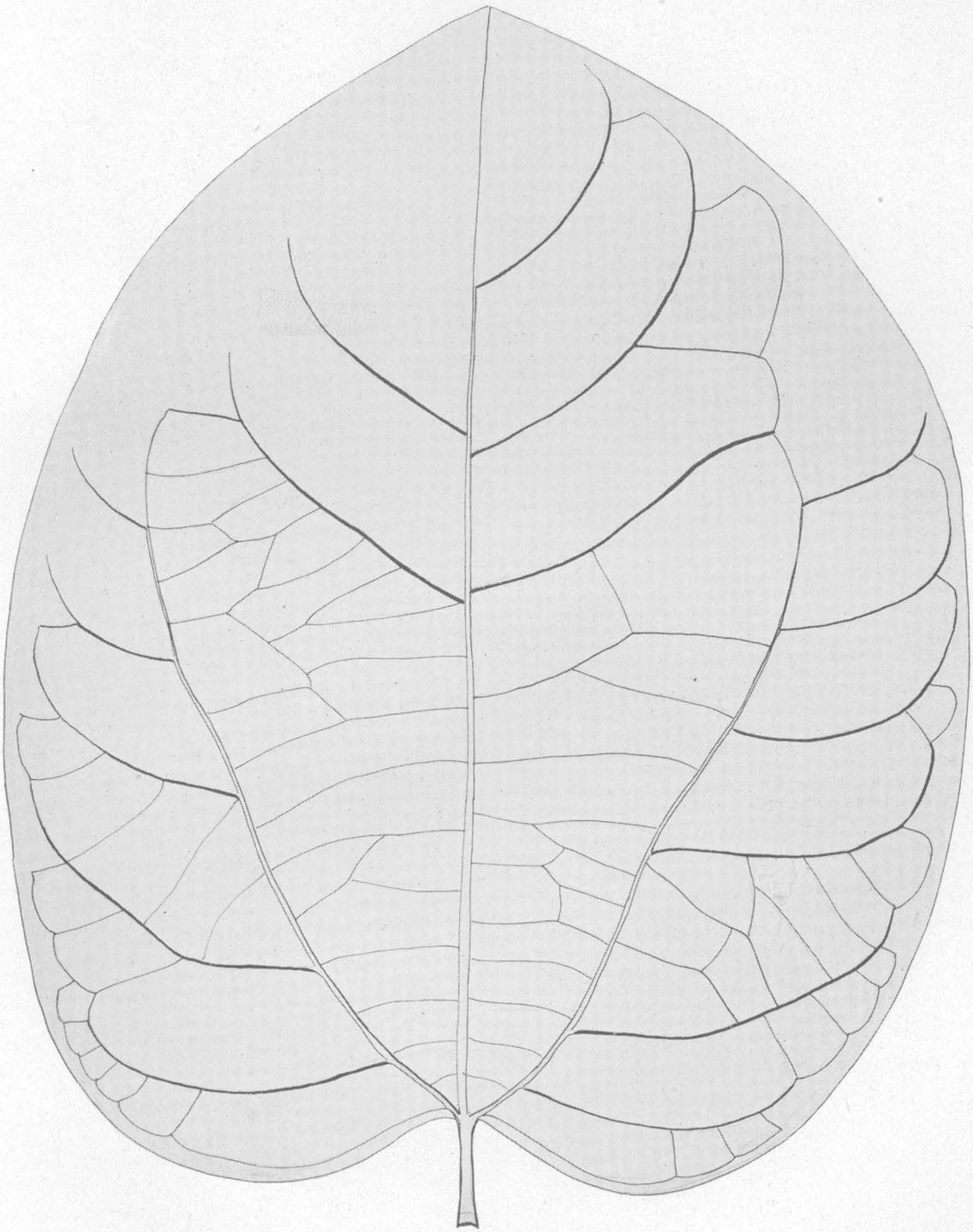
1–7. *Tecoma preradicans* Berry, Lagrange formation, in beds of upper Jackson (?) age, Hickman, Ky.; p. 196. **6,** Restoration; **7,** enlarged detail of margin and marginal venation.

8, 9. Thorns, probably of *Paliurus catahoulensis* Berry, Lagrange formation, in beds of upper Jackson (?) age, 5 miles south of Hickman, Ky.; p. 177.



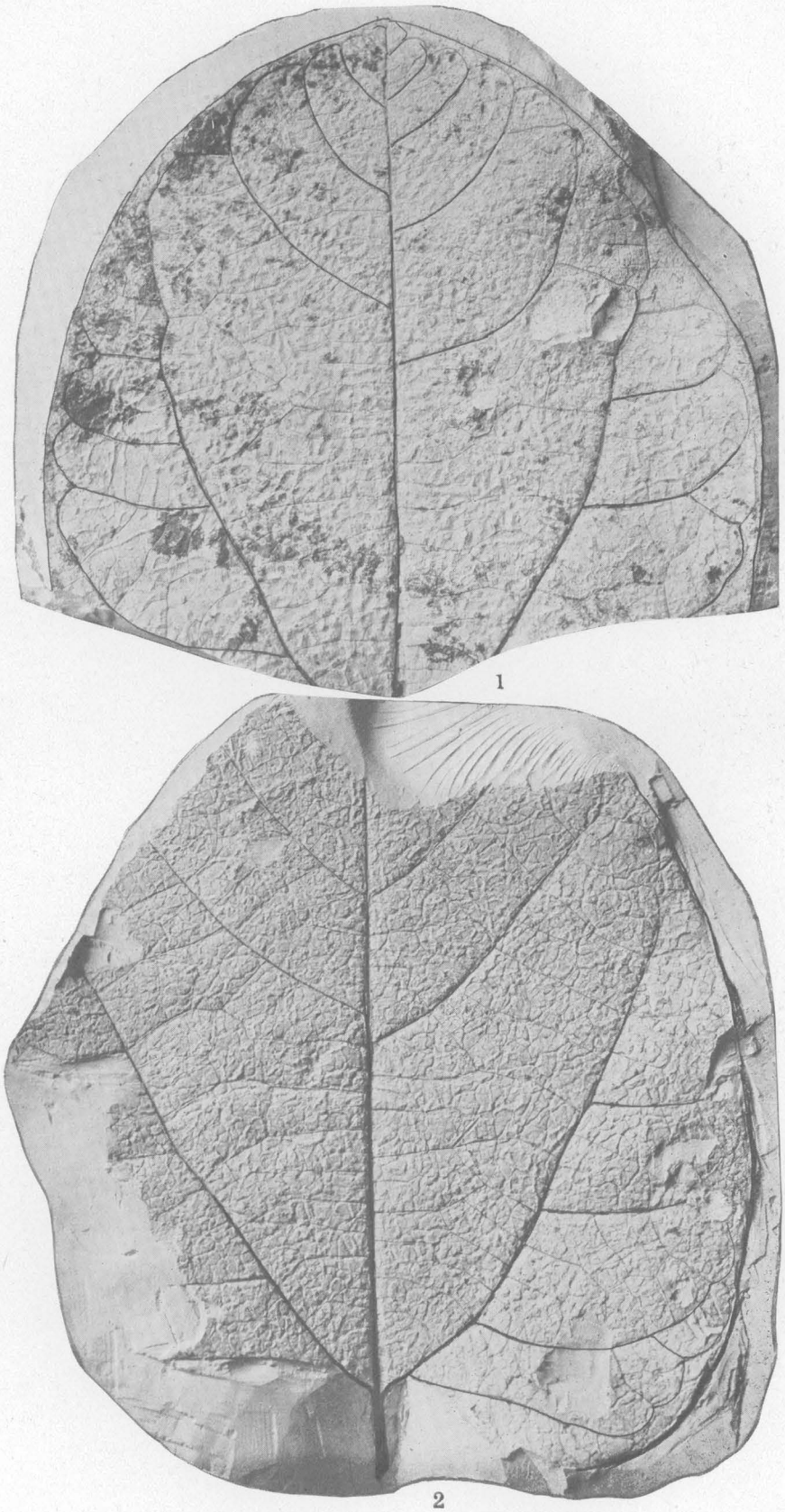
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Apocynophyllum grevilleafolium* Berry, n. sp., Fayette sandstone, east of Wellborn, Tex.; p. 196.
2, 3. *Apocynophyllum texensis* Berry, n. sp., Fayette sandstone, east of Wellborn, Tex.: p. 195.
4–9. *Capparidocarpus sphericus* Berry, n. sp., Lagrange formation, in beds of upper Jackson (?) age, upper bluff, Hickman, Ky.; p. 166. **4, 9,** Capsules partly filled with seed-bearing tissue: **5,** interior of empty capsule; **6,** seeds worked out from interior mass; **7, 8,** placental mass partly exposing seeds.



FOSSIL PLANT FROM DEPOSITS OF JACKSON AGE.

Buettneria jacksoniana Berry, n. sp., Fayette sandstone, Millican, Tex.; p. 182.



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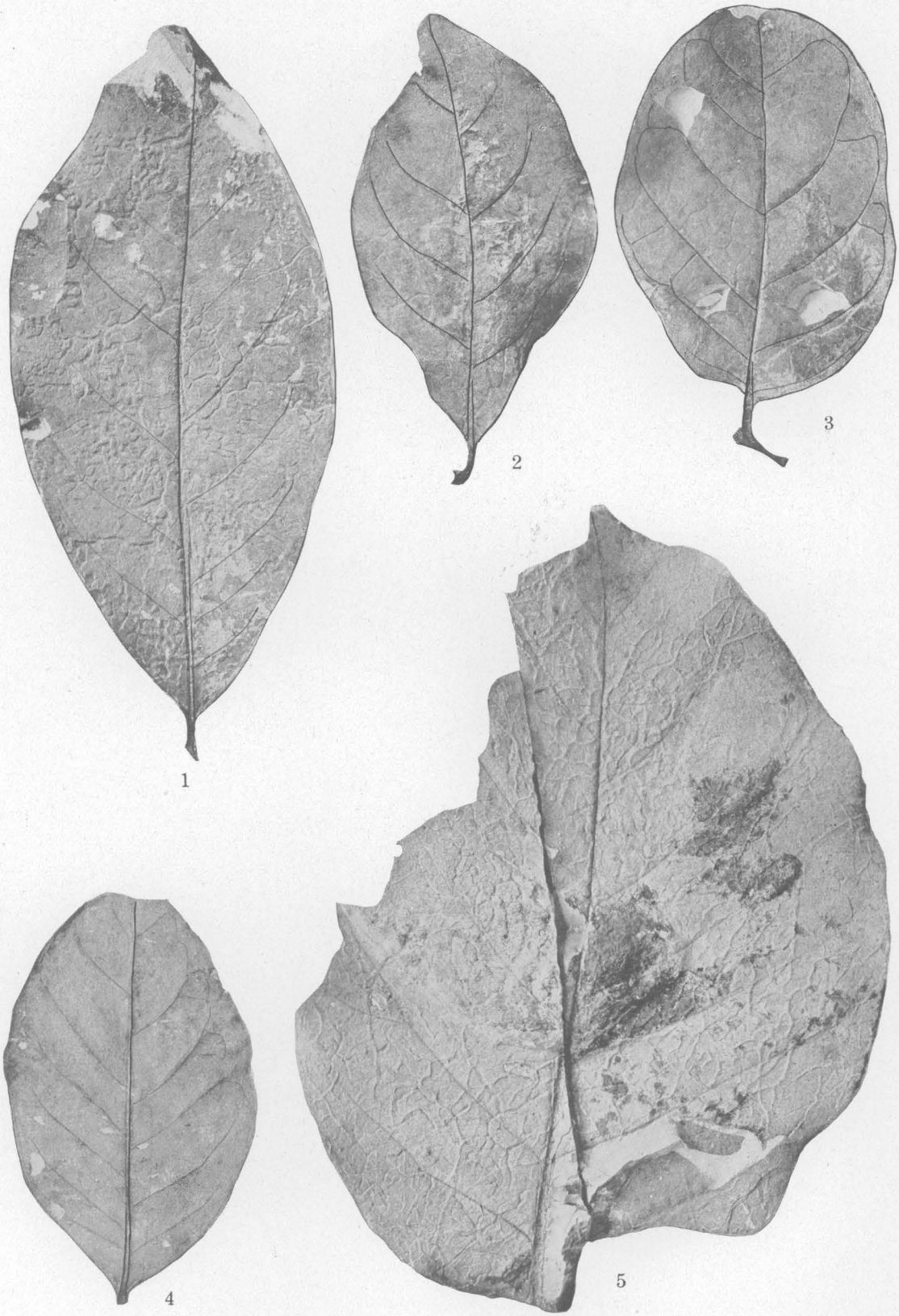
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

Buettneria jacksoniana Berry, n. sp., Fayette sandstone, Millican, Tex.; p. 182.

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Buettneria jacksoniana* Berry, n. sp.; p. 182.
2–4. *Combretum petraflumense* Berry, n. sp.; pp. 85, 190.
All from Fayette sandstone, Millican, Tex.

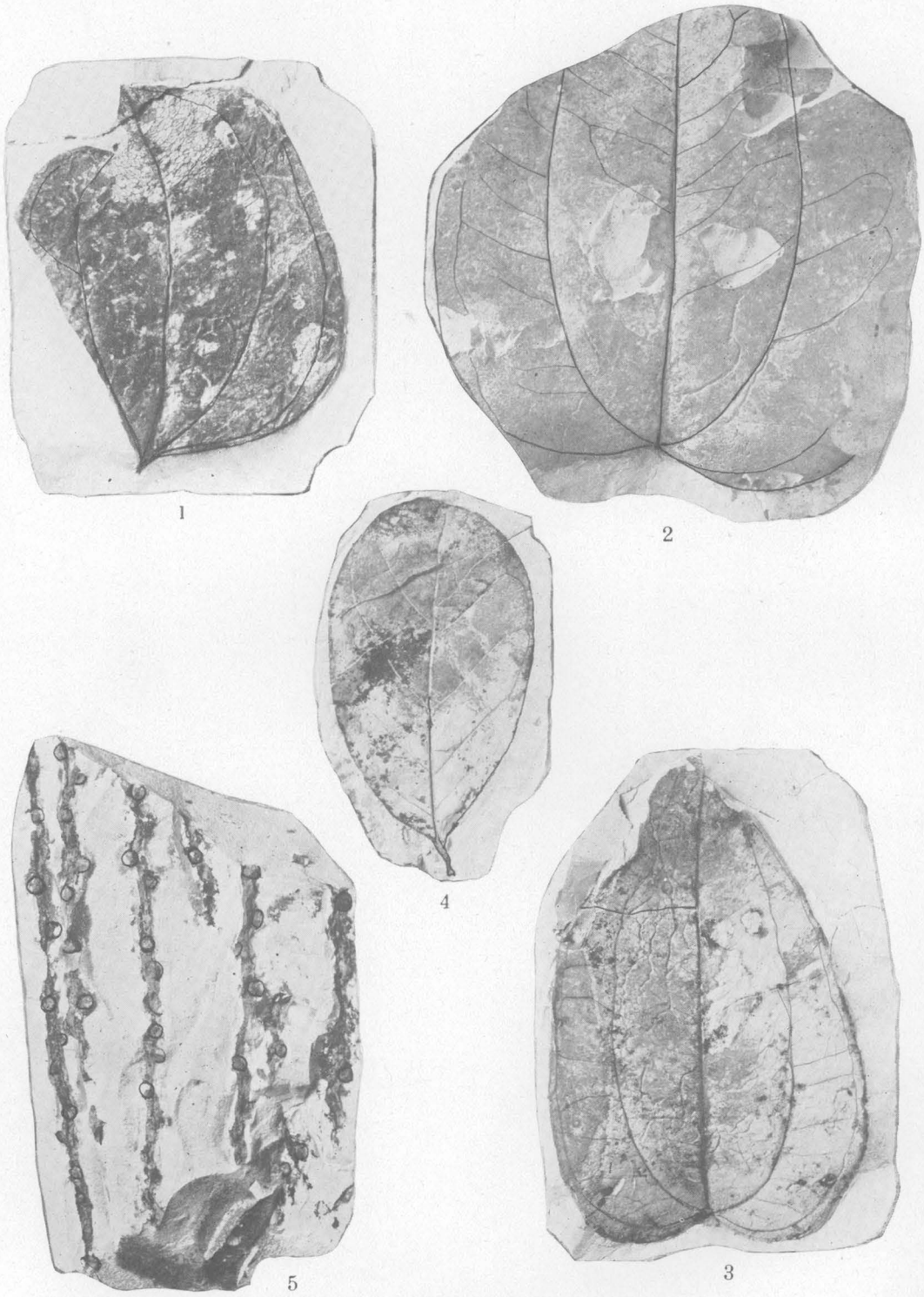


FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

Combretum petraflumense Berry, n. sp., Fayette sandstone, Millican, Tex.; pp. 85, 190.

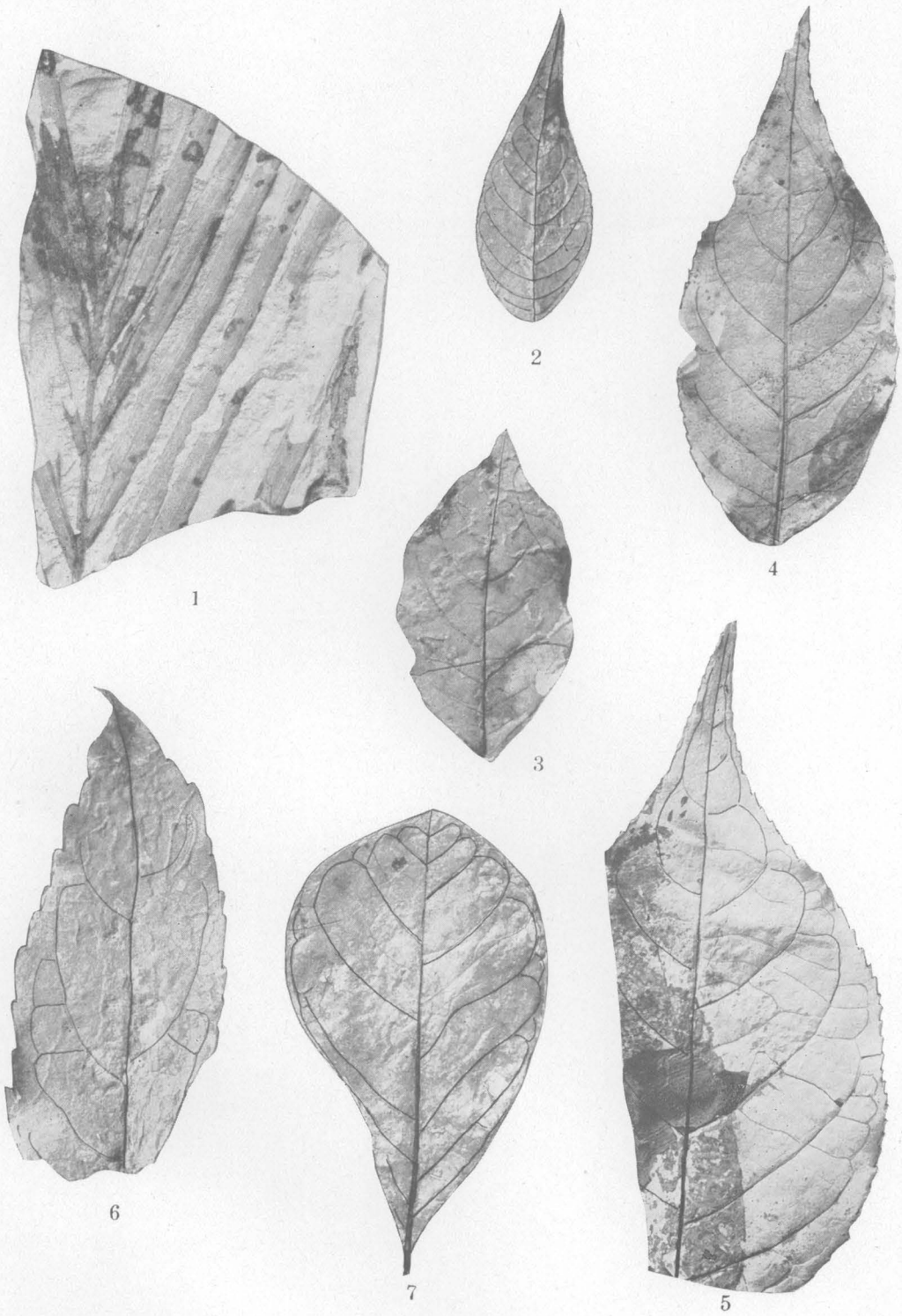
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Oreodaphne brazosensis* Berry, n. sp.; p. 186.
2. *Ficus brazosensis* Berry, n. sp.; p. 160.
3, 4. *Ceanothus jacksonensis* Berry, n sp.; p. 178.
5. *Mespilodaphne jacksonensis* Berry, n. sp.; p. 186.
6. *Ficus* sp.; p. 161.
All from Fayette sandstone, Millican, Tex.



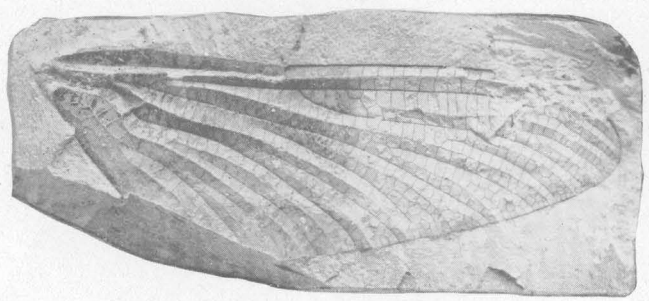
FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1–3. *Smilax fayettensis* Berry, n. sp.; p. 147.
4. *Sapotacites millicanensis* Berry, n. sp.; p. 194.
5. *Palmocarpon sessile* Berry, n. sp.; p. 152.
All from Fayette sandstone, Millican, Tex.



FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Phoenicites?* sp.; p. 150.
2–5. *Euonymus santotomasensis* Berry, n. sp.; p. 179.
6. *Ardisia* sp.; p. 193.
7. *Anacardites balli* Berry, n. sp.; p. 177.
All from Fayette sandstone, Millican, Tex.



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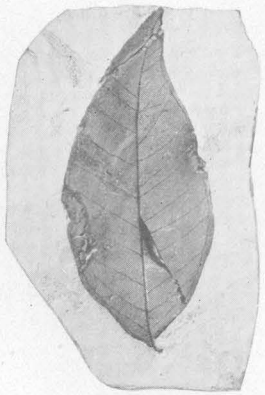

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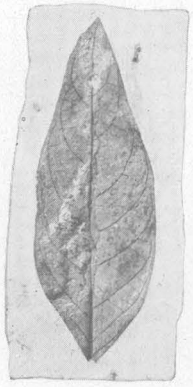

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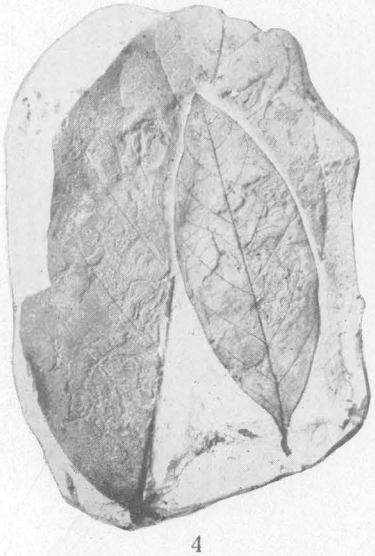

4

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Eodichroma mirifica* Cockerell; a dragon-fly wing, × 4.
2. *Myrcia ambiguaformis* Berry, n. sp.; p. 191.
3, 4. *Chrysophyllum preoliviforme* Berry, n. sp.; p. 194.
5. *Tilia jacksoniana* Berry, n. sp.; p. 180.
All from Fayette sandstone, Mossy Creek, Brazos County, Tex.

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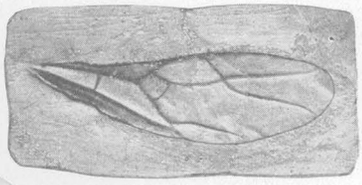

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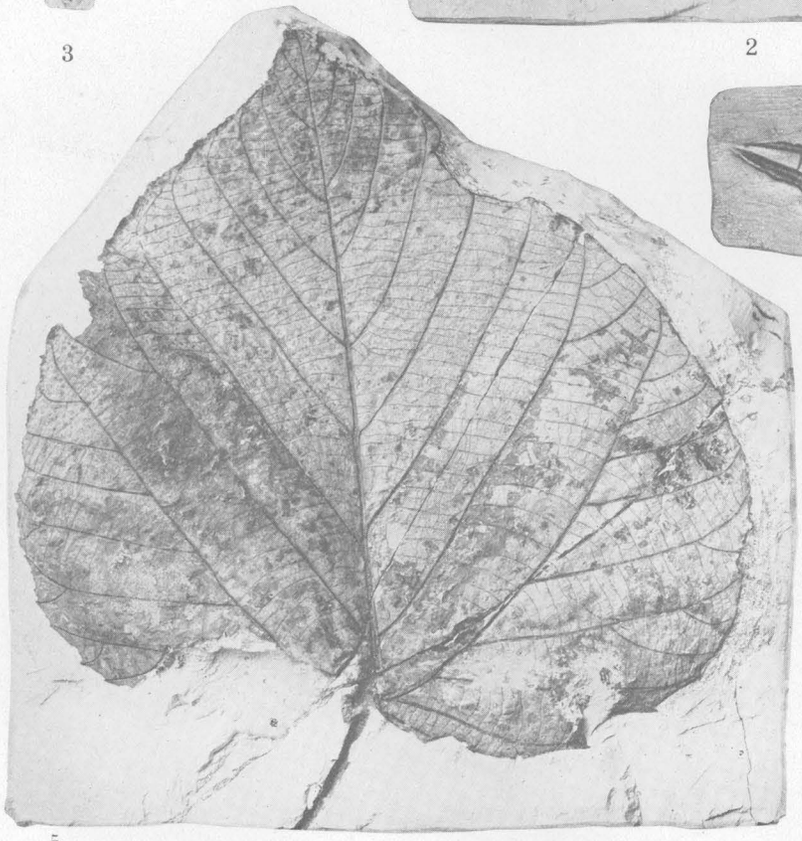

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6

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1. *Citharexylon brazosense* Berry, n. sp., Fayette sandstone, Mossy Creek, Brazos County, Tex.; p. 197.
2. *Marchantites stephensoni* Berry, Fayette sandstone, Mossy Creek, Brazos County, Tex.; p. 141.
3. *Carpolithus balli* Berry, n. sp., Fayette sandstone, Piedmont, Tex.; p. 198.
4. *Formica eoptera* Cockerell, Fayette sandstone, Mossy Creek, Brazos County, Tex.; an ant wing, × 4.
5. *Tilia jacksoniana* Berry, n. sp., Fayette sandstone, Mossy Creek, Brazos County, Tex.; p. 180.
6. *Nipadites burtini umbonatus* Bowerbank, Fayette sandstone, Mossy Creek, Brazos County, Tex.; p. 150.

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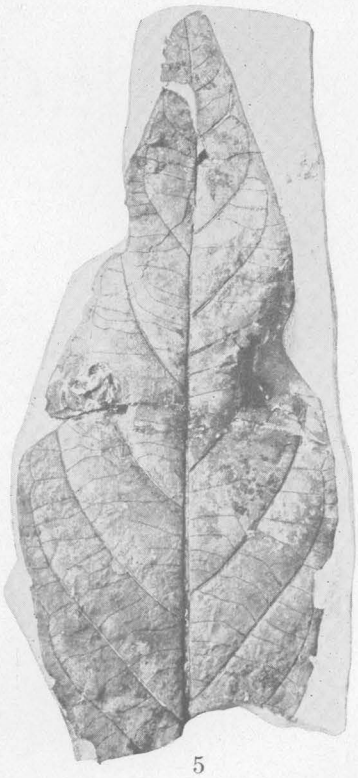

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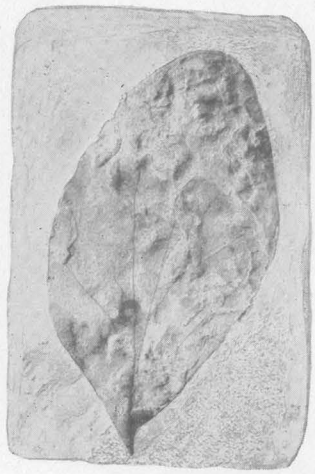

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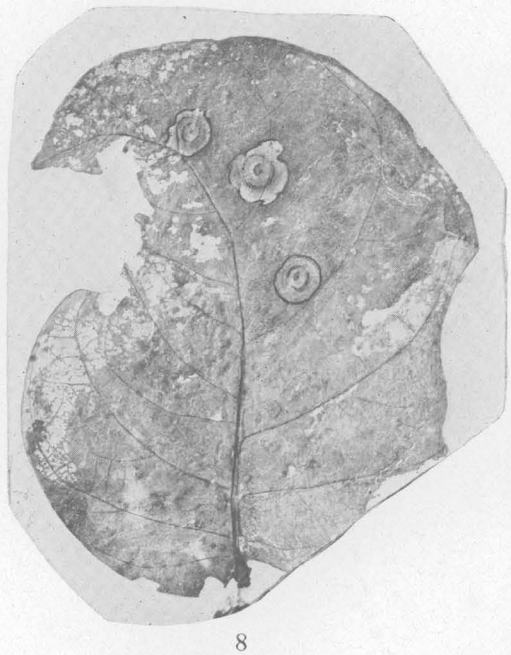

8

FOSSIL PLANTS FROM DEPOSITS OF JACKSON AGE.

1–4. *Bumelia balli* Berry, n. sp., showing the variations in form and size; p. 195.
5. *Nectandra antillanafolia* Berry, n. sp.; p. 187.
6. *Antholithes balli* Berry, n. sp., a Jackson flower; p. 199.
7. *Nyssa jacksoniana* Berry, n. sp., fruits of a Jackson gum; p. 192.
8. *Caenomyces jacksonensis* Berry, n. sp., a leaf-spot fungus on leaves of *Combretum petraflumense* Berry, n. sp.; p. 141.
All from Fayette sandstone, Mossy Creek, Brazos County, Tex.

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