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EROSION INTERVALS IN THE EOCENE OF THE MISSISSIPPI EMBAYMENT.

By EDWARD WILBER BERRY.

INTRODUCTION.

The unequaled series of older Tertiary deposits of the Gulf Coastal Plain comprise several thousand feet of sands, clays, marls, lignites, and impure limestones. These deposits have always been considered as forming an uninterrupted and conformable series, extending from the lower Eocene (Midway) to the top of the Oligocene (Vicksburg and Apalachicola). It is the purpose of the present paper to show that the strand line migrated back and forth over this area several times during the period represented by these deposits, and that the sedimentation of Eocene time was interrupted during several intervals, of considerable duration in terms of organic evolution. I have attempted to indicate the geologic history of the embayment Eocene in a general way in the diagram forming figure 27, which is self-explanatory.

The essential lithologic similarity of the great bulk of these deposits and their great variability, due to their littoral character and the reworking of unlithified deposits concomitant upon transgressions and withdrawals of the sea, inhibit the recognition of physical evidences of unconformity.

To ignore for the present the restricted formational names based on local lithologic characters, the standard section of the Eocene may be said to comprise a series of formations assembled in groups, at their base resting upon Upper Cretaceous rocks and succeeded by deposits of Oligocene age. These groups are the Midway, Wilcox, Claiborne, and Jackson, the oldest being named first.[1] There is a pronounced unconformity between the Upper Cretaceous and the basal Eocene, visible in a number of sections, and discussed by me with reference to the paleobotanic evidence in unpublished papers on the Upper Cretaceous and Eocene floras. Stephenson [2] has recently summarized the paleozoologic and physical facts bearing on this subject for the whole Coastal Plain. Obvious breaks indicating similar unconformities occur in the later Tertiary (post-Eocene) deposits at several points in the Mississippi embayment area.

EVIDENCE OF EROSION INTERVAL BETWEEN THE MIDWAY AND WILCOX EPOCHS.

The Midway or basal Eocene deposits form a border on the inner side of the Tertiary of the Gulf Coastal Plain, from Flint River in Georgia to the Rio Grande and beyond. Over this vast distance their continuity is uninterrupted except for the relatively short distance of about 125 miles in southeastern Missouri and northeastern Arkansas, where later Tertiary erosion and subsequent Pleistocene deposition have removed or concealed them. This continuity is important, for the Midway serves as a datum plane for succeeding deposits.

The Midway deposits retain their marine character and traces of marine faunas well toward the head of the embayment. (See fig. 28.) The overlying Wilcox deposits are readily distinguishable lithologically. The northernmost point at which marine faunas have been found in the Wilcox is about latitude 33° N., or at least 3° south of the known northward range of Midway invertebrates. The Wilcox deposits might presumptively be interpreted as representing

[1] Detailed tables of formations for different States have been compiled by T. W. Vaughan and published in U. S. Geol. Survey Prof. Paper 71, 1912.

[2] Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 90, pp. 155–182, 1915 (Prof. Paper 90–J).

a succession of estuarine, littoral, and continental deposits in the wake of the southward-retreating sea. This is doubtless true of a part of the basal Wilcox, but it is by no means the whole story. Before considering the evidence furnished by the fossil flora some of the details of the stratigraphy and the lithologic evidence of a break in the sedimentation should be discussed.

The Wilcox group in its area of greatest development, southern Alabama, comprises four formations—the Nanafalia, Tuscahoma, Bashi, and Hatchetigbee.

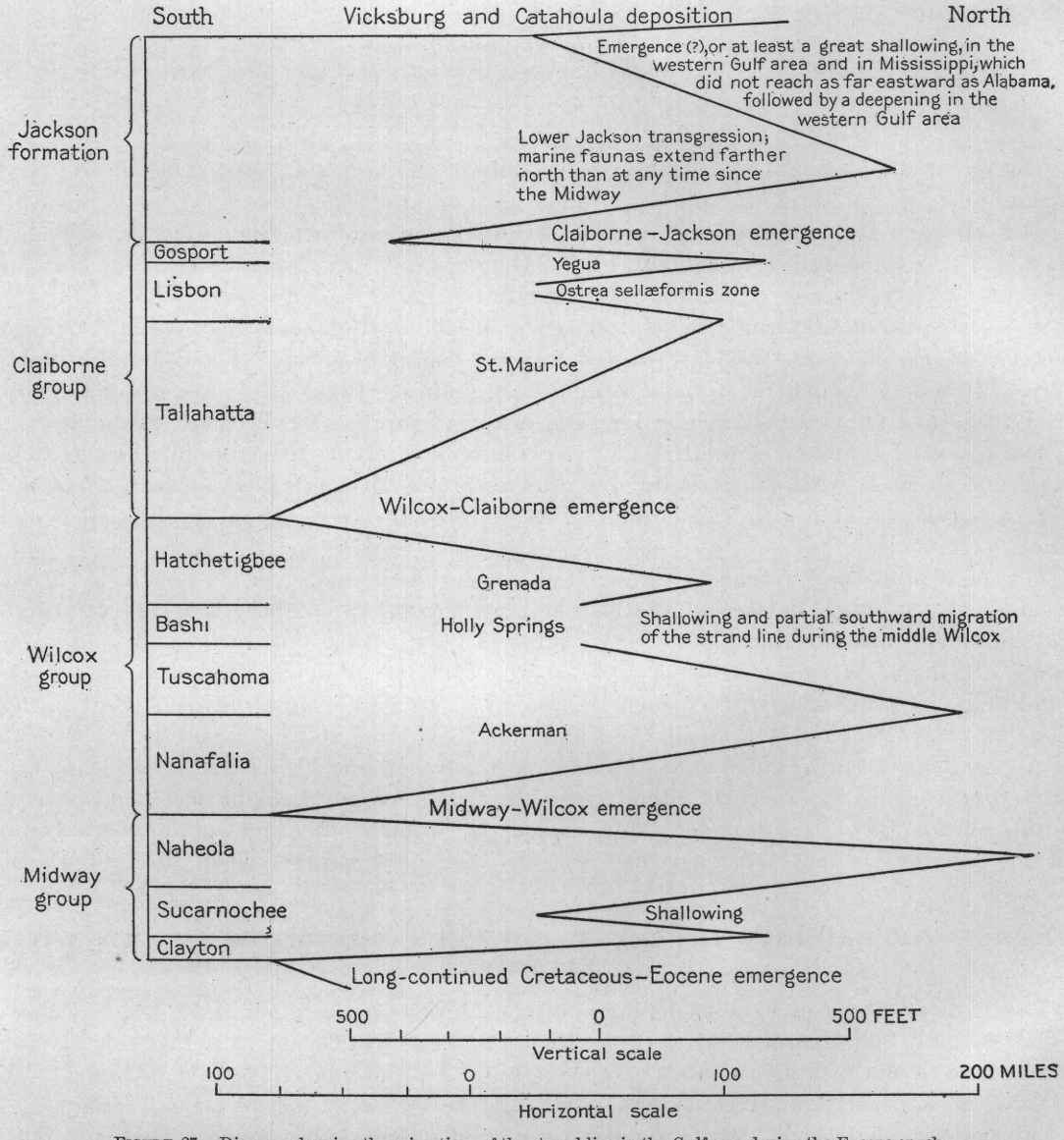

FIGURE 27.—Diagram showing the migrations of the strand line in the Gulf area during the Eocene epoch.

The Nanafalia or basal Wilcox formation consists of sandy glauconitic beds alternating with grayish calcareous clays, which in places are fossiliferous enough to be termed shell marls. At the base of the formation, resting on the top of the Naheola, the uppermost formation of the Midway group, is a bed of lignite from 5 to 7 feet in thickness which has been traced from Pike County, Ala., westward beyond Tombigbee River and which is represented by similar lignites through the greater part of the outcrop in Mississippi. The Nanafalia formation maintains a rather uniform thickness across Alabama of about 200 feet. The fauna of the Nanafalia as it stands recorded in the literature is small and of very shallow water facies, the most

abundant form being the small oyster *Ostrea thirsæ* Gabb. That few species are restricted to this horizon is partly explained by the lack of monographic studies which would tend to increase the number of forms recognized. Nine Nanafalia species, prevailingly long-lived forms, are common to the Midway, only four of which are, however, restricted to the Nanafalia and the Midway. The Nanafalia fauna is really very distinct from that of the Midway, for it marks the initiation of many of the most characteristic Gastropoda. The pelecypods known are of less than a dozen species, and evidently collectors have missed many of the smaller members of this order. The distinctly Wilcox types form about 87 per cent of the known Nanafalia fauna.

Overlying the Nanafalia formation is the Tuscahoma formation, a series of about 140 feet of gray or yellowish cross-bedded sands and sandy clays, massive below and laminated above, generally poor in the remains of marine life except at two horizons, where glauconitic shell marls carry an abundant fauna. This fauna includes about 168 species, well diversified and

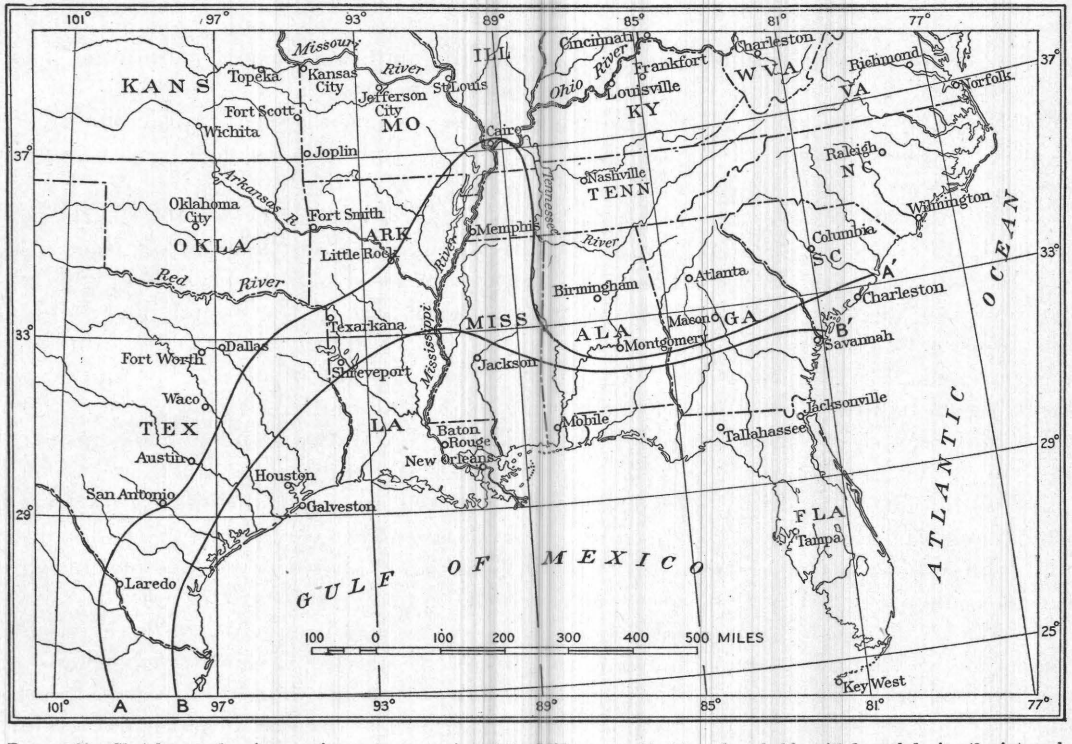

FIGURE 28.—Sketch map showing maximum transgression of the Midway sea (A–A′) and probable withdrawal during the interval between the Midway and Wilcox epochs (B–B′).

indicative of a slightly deeper habitat than the Nanafalia fauna. About 50 per cent of the Tuscahoma species are restricted to this horizon—a high percentage when it is recalled that additions of peculiar species would probably result from a detailed study of the fauna.

The Tuscahoma formation is overlain by the Bashi formation, at the base of which is a lignite bed 2 feet thick. Above the lignite occur sandy clays and thick lenses of calcareous glauconitic sands carrying an abundant and diversified fauna. This fauna has been studied more intensively than that of any of the other Wilcox formations. About 200 species are known, of which more than 50 per cent are peculiar to this zone.

The Hatchetigbee formation overlies the Bashi and consists of about 175 feet of laminated sandy clays and cross-bedded, more or less glauconitic and calcareous fossiliferous sands. The fauna of the Hatchetigbee is the most obviously shallow-water fauna known from the Wilcox. In this epoch were introduced a few new forms which later became prolific, but for the most part the fauna represents the end product of evolution during Wilcox time. About 85 species are recorded, of which about one-third are restricted to this horizon. Of the 38

species which persisted from earlier Wilcox time 33 became extinct during Hatchetigbee time, only 5 passing up into the Claiborne, and 14 additional Hatchetigbee forms are also recorded from the Claiborne.

This indication of shallowing water toward the close of Wilcox time is just what might be expected, and it is significant, if my interpretation of a series of transgressions and withdrawals of the sea is true, that the numerous and varied ostreids, capulids, and other forms which indicate a near-by strand line were found at localities in southern Alabama, several hundred miles south of the head of the embayment.

The lithologic differentiation of the Wilcox [1] in Mississippi is somewhat different from that of Alabama. In Mississippi a threefold division is recognizable. The basal formation is the Ackerman, which consists of about 300 feet of dark-gray lignitic and ferruginous sandy clays, beds of lignite reaching a maximum thickness of 6 feet, considerable concretionary and bedded carbonate of iron, and ferruginous sandstones, in places carrying fossil plants.

The Ackerman is overlain by the Holly Springs sand. As the name indicates, this formation is prevailingly arenaceous and consists of about 350 feet of cross-bedded, mostly coarse, micaceous, in many places highly colored, and locally indurated sands containing lenses of prevailingly pink or white usually siliceous clays and carrying an abundant flora.

The Holly Springs sand is overlain by the Grenada formation, which is prevailingly argillaceous and consists of about 200 feet of pinkish, yellow, or chocolate-colored sandy micaceous laminated clays and ferruginous sands.

The divisions of Wilcox time in Mississippi only partly retain their integrity in western Tennessee and Kentucky. The Ackerman formation can not be positively recognized, although it may be represented in the southeastern part of the area. In general the highly varied lithology of the deposits of Wilcox age in the northern part of the embayment falls into a twofold division, the lower part being more like the Holly Springs sand and the upper more like the Grenada formation but with a somewhat less amount of clay. The upper part is also much more lignitic in the northern area than it is in the south.

The only known erosional unconformity between the Midway and Wilcox is near Fort Gaines, Ga., where numerous pothole-like depressions in the Midway, as much as 20 feet deep, are filled with Wilcox deposits. Less certainly correlated erosional unconformities have been reported along the Rio Grande.[2] The most convincing evidence of such an erosion interval was brought to light during a study of the fossil floras, and this led to the assembling of much additional evidence, which will be given after a brief consideration of the flora.

The Wilcox flora comprises about 350 species scattered throughout the area of outcrop, but especially well represented in the eastern Gulf area in Mississippi and Tennessee and in the western Gulf area in northwestern Louisiana. It falls naturally into three florules—a lower, middle, and upper—corresponding to the threefold lithologic divisions established for Mississippi. The lower Wilcox flora is the smallest, as it has been found at fewer localities and as the outcrop of the Ackerman formation covers a smaller area than that of either of the two succeeding formations. Nevertheless fossil plants of Ackerman age occur in Kemper, Choctaw, Lauderdale, Lafayette, and Benton counties, Miss. The Ackerman flora consists of 36 species, of which 13 are restricted to beds of this age, 16 species persist into the Holly Springs sand, and 7 continue to the top of the Wilcox. The Holly Springs sand has furnished a flora of 256 species, of which 193 are found only at this horizon, 23 are common to the Ackerman, and 47 are common to the Grenada. The Grenada formation contains a flora of 116 species, of which 60, or over 50 per cent, are peculiar to the upper Wilcox. It may be considered established, without going into greater detail, that those three floras constitute well-defined units. Their distribution is most significant. The lower Wilcox or Ackerman flora is confined to northeastern Mississippi, where it characterizes beds resting on the Midway; in fact, the largest florule of this age, that from Hurleys, in Benton County, is less than 100 feet from the Midway contact.

[1] For numerous sections see Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91 (in press).

[2] See a recent paper by E. T. Dumble, Some events in the Eocene history of the coastal area of the Gulf of Mexico in Texas and Mexico: Jour. Geology, vol. 23, pp. 481–498, 1915, especially statements on p. 486.

The lithologically characteristic beds containing the middle Wilcox or Holly Springs flora, which, in Lafayette County, Miss., are between 300 and 350 feet above the Midway contact, are throughout Tennessee found to rest almost directly on beds of Midway age. Thus at Pinson, in Madison County, the plant bed is less than 100 feet above the beds of Midway age. At Peryear, in Henry County, in northern Tennessee, a flora of 181 species is not only near the top of the beds of middle Wilcox age—that is, stratigraphically above the flora from the middle Wilcox localities around Grand Junction, Holly Springs, and Oxford, Miss.—but also less than 100 feet above the contact with beds of Midway age. Although the Wilcox formations lose their lithologic identity at the head of the embayment and along its western shore in Arkansas, Louisiana, and Texas, it is found that only middle and upper Wilcox plants occur at the head of the embayment and throughout

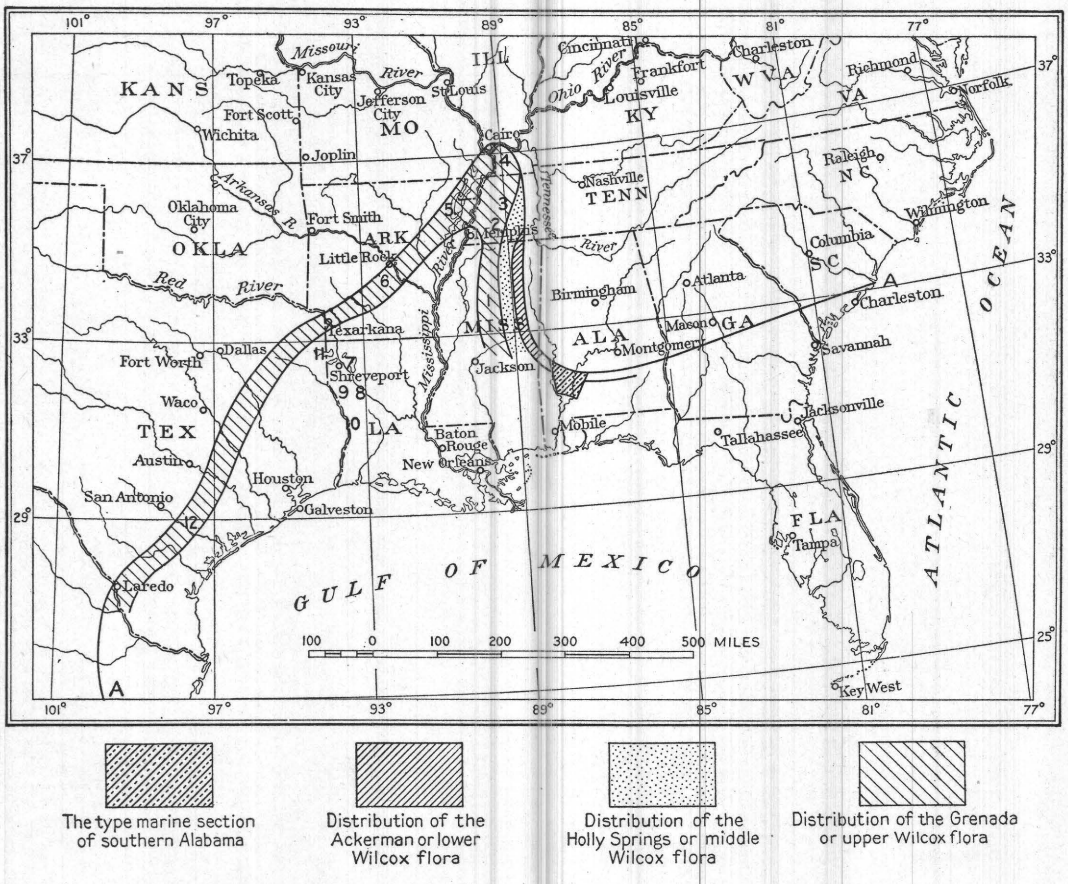

FIGURE 29.—Sketch map showing areal relations of the Wilcox floras. A–A, Maximum extent of the Wilcox transgression. Localities at which upper Wilcox species have been collected: 1, Grenada, Miss.; 2, Somerville, Tenn.; 3, near Trenton, Tenn.; 4, Wickliffe and Boaz, Ky.; 5, Bolivar Creek, Hardys Mill, and other localities on Crowleys Ridge, Ark.; 6, Benton and Malvern, Ark.; 7, several localities at or near Shreveport, La.; 8, Coushatta, La.; 9, around Mansfield and Naborton, La.; 10, Sabine River; 11, Old Port Caddo Landing, Tex.; 12, Calaveras Creek, Tex.

the western Gulf area. The distribution of these floras is shown on the accompanying sketch map (fig. 29).

In summarizing the evidence for an extensive erosion interval between the Midway and Wilcox, it may be noted that after the Midway epoch, during which marine animals penetrated northward at least into Tennessee and deposits of marine character reached southern Illinois, there was preserved on top of these marine beds in southern Alabama at the base of the Nanafalia formation an extensive 5 to 7 foot bed of lignite. That this bed of lignite was formed in place (autochthonous) by terrestrial vegetation and that the marine waters had withdrawn southward beyond the present outcrop of the lignite bed is almost certainly established. (See fig. 30.) Northward from this southernmost region along the Midway-Wilcox contact

successively younger beds rest upon the Midway, the Middle Wilcox of Oxford and Holly Springs, Miss., several hundred feet above the base in that latitude, being the extreme basal part of the beds of Wilcox age in Henry County, Tenn. From the numerous well records recently collected by Matson and Hopkins in the Naborton oil field of Louisiana, it is obvious that the lower and most if not all of the middle Wilcox are completely transgressed by the upper Wilcox. Furthermore, while the evidence is not as complete as would be desirable for positive conclusions, the available well records show a thickening of the Wilcox down the dip, a sure indication either of erosion or of deposition during an advance and subsequent retreat of the Gulf waters. I have attempted to indicate on the accompanying sketch map (fig. 30) the southward migration of the strand line from the maximum limit of the Midway transgression, its approximate position at the beginning of the Wilcox transgression, and the subsequent maximum extent of the Wilcox sediments.

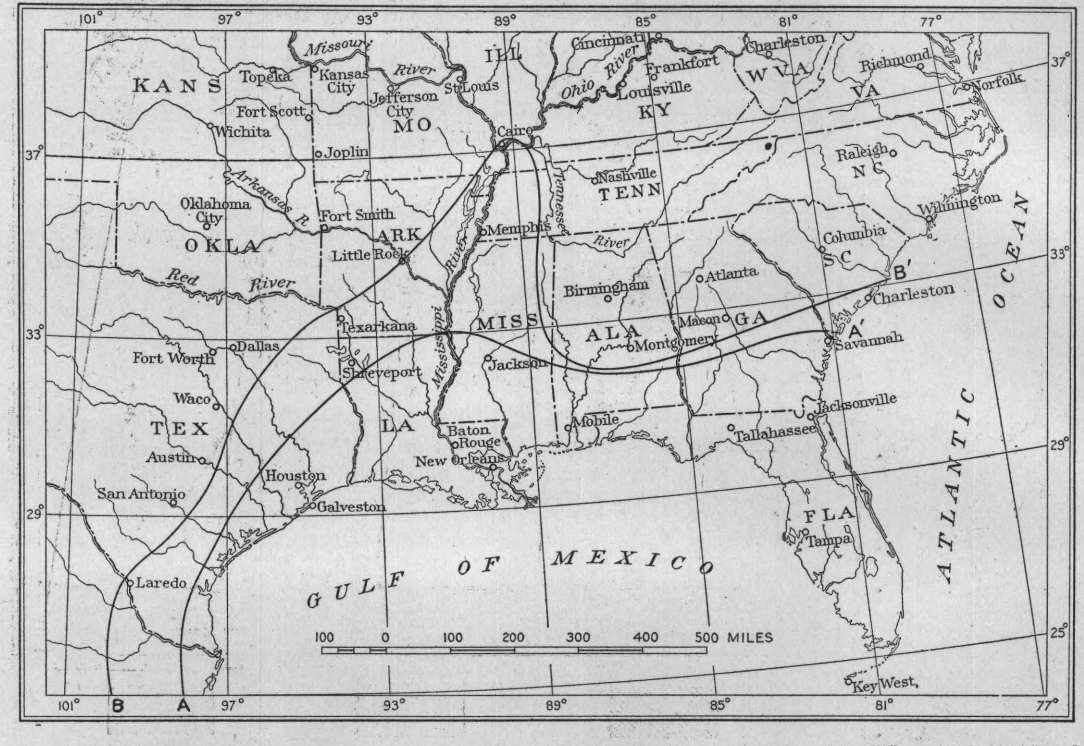

FIGURE 30.—Sketch map showing the approximate position of the strand line at the beginning of the Wilcox epoch (A–A') and the maximum extent of the Wilcox transgression (B–B').

That the geologic history was more complex than I have indicated is shown by the heavy beds of lignite at various levels toward the head of the embayment, by the 2-foot bed of lignite at the base of the Bashi formation in the Alabama section, by the extremely shallow-water character of the Hatchetigbee marine fauna, and by the marked littoral lithology of the Hatchetigbee deposits and the corresponding lagoon and sand flat lithology of the middle Wilcox deposits in the upper part of the embayment.

EVIDENCE OF EROSION INTERVAL BETWEEN THE WILCOX AND CLAIBORNE EPOCHS.

The evidence of an interval between the Wilcox and the Claiborne is not so conclusive as that of an interval between the Midway and the Wilcox, but rests on the complete agreement of all the various data. The type section of the Claiborne group is found in southern Alabama, where it is capable of a threefold division. The basal formation, known as the Tallahatta buhrstone, is an aluminous sandstone or siliceous claystone, calcareous and fossiliferous toward the east, where it is about 200 feet thick, but becoming practically unfossiliferous in western

Alabama, where it reaches a thickness of about 400 feet and is distinctly littoral, a character which it maintains in its outcrop northwestward across Mississippi. Overlying the Tallahatta is the Lisbon formation, consisting of 100 to 150 feet of calcareous, argillaceous, and glauconitic, abundantly fossiliferous sands, which also can be traced across Mississippi. The Lisbon is overlain by the Gosport sand, consisting of 30 or 40 feet of highly fossiliferous glauconitic sands which have not been recognized outside of the Alabama area.

The physical evidence for a Wilcox-Claiborne interval consists of erosional evidence reported by Veatch and Stephenson [1] from several localities in western Georgia on the littoral character of the basal beds or Tallahatta buhrstone, the undoubted great overlap of the lower Claiborne in Georgia, the overlap of the upper Claiborne toward the head of the embayment, and the great thinning of the deposits in that region.[2] This may be illustrated by the following section, kindly furnished by Mr. Stephenson:

Section along Bolivar Creek, Crowleys Ridge, Ark.

	Feet.
Pleistocene: Brownish loam underlain by gravel	5
Claiborne formation (incomplete):	
Argillaceous, faintly laminated sand	14
Massive sand	5
Argillaceous laminated sand	8
Lignite	5
Wilcox formation:	
Dark argillaceous sand	5
Lignitic sand	1
Chocolate-colored lignitic clays with fossil plants	3
Tough light-colored clay	2
	43

The significant feature is the 5-foot bed of lignite at the base of the Claiborne, indicating the site of terrestrial vegetation. The evidence is the same, whether this bed is referred to the top of the Wilcox or the base of the Claiborne. The Claiborne is unfossiliferous at this outcrop and therefore the reference may be open to question, but fossiliferous upper Claiborne beds occur at the near-by locality of Cherry Valley, and the field relations indicate that a part of the Bolivar section is of Claiborne age. It is true that the thinness of the Claiborne is partly accounted for by erosion, but erosion would not be sufficient to explain the disparity in thickness between the beds at this locality and those farther south. Lignitic beds at other localities in the upper part of the embayment indicate old land surfaces, but it has not yet been possible to determine at every locality whether they are at the base or the top of the Claiborne. The northernmost points at which the lower or middle Claiborne has been recognized in the embayment area are about latitude 34° N. in Mississippi and somewhat south of 34° in southern Arkansas. The upper Claiborne, however, carrying typical fossil plants, is found as far north as Cherry Valley, a distance of 150 miles farther north than the recognizable lower Claiborne.

The faunal and floral evidence is very striking. Fossil plants have not been found in the lower Claiborne (Tallahatta) of the eastern Gulf area, so that the time required for its deposition has to be considered in determining the amount of evolution shown by the later Claiborne floras. A few fossil plants have been found in the lower Claiborne (St. Maurice) of the western Gulf area, and the middle and upper Claiborne contains an extensive and well-distributed flora from Georgia westward to Texas.

The flora of the Claiborne group known at the present time amounts to 90 species. Of the 338 species known from the Wilcox group only six are found in the Claiborne, and two of these occur only in the basal Claiborne or St. Maurice formation of the western Gulf area, while one other, *Taxodium dubium*, is a very wide ranging and probably polymorphous form, both in this

[1] Veatch, Otto, and Stephenson, L. W., Preliminary report on the geology of the Coastal Plain of Georgia: Georgia Geol. Survey Bull. 26, p. 228, 1911. See U. S. Geol. Survey Prof. Paper 90, pp. 172–173, 1915 (Prof. Paper 90-J), for similar evidence along the Rio Grande.

[2] Dumble, in the recent paper previously cited, states that there is much evidence of emergence and erosion between the Wilcox and the Claiborne in southwestern Texas and northeastern Mexico.

country and Europe, so that it has no particular significance in the present discussion. This leaves only three species out of a total known flora of 428 species that are common to the Wilcox and the Claiborne, a fact which is very significant not only in its bearing on the interval unrecorded in exposed sediments between the Wilcox and Claiborne but in the evidence it affords that terrestrial floras are much more susceptible to climatic and other physical changes than marine invertebrates.

The Claiborne fauna embraces between 200 and 300 species, most of which occur in the Lisbon formation. A very small fauna is found in the Tallahatta buhrstone at the base. The Gosport at the top of the Claiborne presents no striking faunal differences when compared with the Lisbon formation. Over half the species in the Claiborne fauna are peculiar to this horizon, and there are striking differences between it and the Wilcox fauna. These differences represent not only different species but a different grouping of genera and indicate slightly deeper waters. Thus Terebra, which is absent in the Wilcox, has four species in the Claiborne.

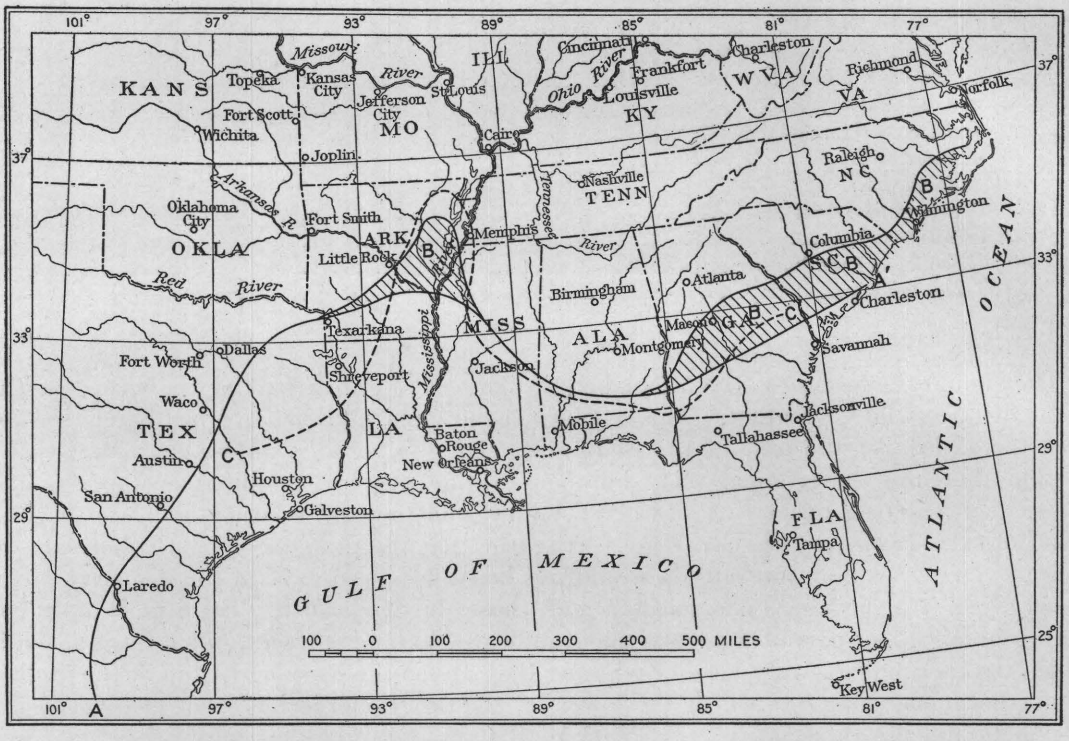

FIGURE 31.—Sketch map showing the extent of the lower Claiborne (A–A'), the area covered by the upper Claiborne transgression (B, B), and the strand line of the lower Jackson (C–C').

The Pleurotomidæ have twenty-seven Wilcox species and only six Claiborne species. Cancellaria, a shallow-water genus, has nine Wilcox and only one Claiborne species. The genera Marginella and Limopsis, unrepresented in the Wilcox, have respectively three and six Claiborne forms. Trophon, with four Wilcox species, Triton, with five Wilcox species, and Epitomium, with three Wilcox species, are unrepresented in the Claiborne. The Claiborne has fewer oysters than the Wilcox and many more species of Mitra, Sigaretus, Dentalium, Nucula, Astarte, Venericardia, Cytherea, and Corbula. These comparisons might be continued indefinitely, but in view of the absence of any monographic work on these faunas there is a certain lack of finality in comparative statements. The conclusion that there is a most decided change in the faunas between the Wilcox and the Claiborne is, however, not likely to be invalidated by future work.

From the foregoing concurrent testimony of lithology, areal distribution, and floral and faunal character, it is believed that the presence of an erosion interval between the Wilcox and Claiborne has been demonstrated. What I conceive to be the general relations are indicated on the accompanying sketch map (fig. 31).

EVIDENCE OF EROSION INTERVAL BETWEEN THE CLAIBORNE AND JACKSON EPOCHS.

The character of the transition from Claiborne to Jackson in the extreme western part of the embayment area has not been worked out in detail, and as I am personally more familiar with the region east of Sabine River I will confine my discussion to that region.

The Jackson is very well marked paleontologically, but its lithologic similarity to underlying and overlying deposits over part of its area of outcrop has prevented a complete elucidation of its extent and delimitation. The field work of the last few years, prosecuted under the direction of T. W. Vaughan by Vaughan, Stephenson, Matson, Deussen, and Cooke, as well as the accompanying studies of the Bryozoa by Bassler, the corals by Vaughan, the Mollusca by Cooke, and the plants by Berry, will shortly result in a complete account of this important upper Eocene horizon.

The evidence of a southward withdrawal of the Claiborne sea has been more or less indicated in the preceding section of this paper. Evidence of the partial emergence of the northern end of the embayment is furnished by the palustrine character of much of the upper Claiborne material (Yegua or "Cockfield"). Evidence from a more southern locality is furnished by the Claiborne-Jackson contact at Claiborne Landing, on the east (left) bank of Alabama River in Monroe County, Ala.

The celebrated section at Claiborne Landing, famous as having furnished the fossils which enabled Lea in 1833 to apply the term Eocene to American deposits for the first time, shows a very instructive contact between the top of the Claiborne group (Gosport sand) and the base of the Jackson. The detailed section was given by Hale [1] as early as 1848, and it has been discussed by Tuomey [2] and in great detail by Smith,[3] so that it is not worth while to repeat the complete section in this place. The top of the Gosport in this general region is a glauconitic fossiliferous sand, at this and neighboring outcrops, completely oxidized. In places it contains somewhat lignitic layers. At the top of that part of the section exposed along the old ferry road to the upper landing there is a lens of laminated gray clay carrying an abundance of leaf impressions. Fifteen species have been determined from this exposure, and these furnish intrinsic evidence of the upper Claiborne age of the deposits, for nearly all of them are represented in the Yegua formation ("Cockfield beds") of Louisiana and Arkansas. Overlying this clay is a few feet of coarse ferruginous or glauconitic, calcareous, more or less indurated sand, grading upward into the *Scutella lyelli* bed of the Jackson. There is no physical evidence of a break in sedimentation, but the following considerations are of some significance. Although all the formations of the Claiborne group are distinctly shallow-water deposits throughout southern Alabama, nowhere below the top has a similar lens of clay carrying the remains of terrestrial vegetation been discovered. The sand which replaces the clay in near-by sections is completely oxidized throughout, and this condition may be legitimately considered to be due to emergence at the close of the Claiborne, because in the immediately overlying beds of the Jackson, although the sands are ferruginous, the glauconite is not completely oxidized. No evidence of discordance in bedding would be expected, nor would erosion make itself visible where the materials in contact were practically identical in lithologic character. Furthermore, unless the emergence was considerable in a vertical direction, which is improbable, scarcely any erosion would take place.

The palustrine beds of upper Claiborne age toward the head of the embayment are overlapped by marine deposits of lower Jackson age which carry the life of marine waters farther northward than at any time subsequent to the Midway. (See fig. 31.) Numerous localities in Arkansas have furnished invertebrate remains, and along Little Crow Creek, in the northeastern part of the State, extensive oyster reefs are present as well as an abundant shallow-water fauna preserved in a glauconitic sand. East of Mississippi River traces of the marine Jackson fauna have not been found north of latitude 33° N., but the Jackson flora has been recognized as far north as latitude 35° 24′ N. in western Tennessee, which is 135 miles farther north than

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

the northernmost recognized upper Claiborne of this area, a fact clearly indicative of a greater or less emergence in the last third of Claiborne time and a pronounced transgression marking the beginning of the Jackson. The known flora of the Jackson is unfortunately meager, but the fauna is extensive. The available paleobotanic evidence corroborates the faunal evidence in suggesting that the erosion interval between the Claiborne and the Jackson was shorter than any of those which preceded it.

The Jackson flora, as at present known, comprises only 22 species, but this number is likely to be considerably increased with additional studies. Eleven of these species are restricted to the Jackson, notwithstanding the fact that much more abundant floras are known from the underlying Claiborne and the overlying Vicksburg and Catahoula. Two of the Jackson forms are characteristic Claiborne forms, and five additional Claiborne species have been doubtfully recognized in the Jackson. Four Jackson species are found in the Catahoula, and two of these are also found in the Vicksburg.

The Jackson fauna, according to unpublished information kindly communicated by C. W. Cooke, comprises over 200 species, of which about 23 per cent are common to the Claiborne. When it is recalled that the Claiborne fauna also comprises over 200 species, about 50 common species in a total of over 400 seems like a very small common element. The two faunas are, in fact, very well marked paleontologically, but there is little change in general facies, closely related species appearing in both faunas and the same association of genera being largely identical in both. 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 similarities between the floras and faunas of the Claiborne and Jackson, as well as comparable similarities between those of the Jackson and the basal Oligocene, might be considered to represent uniformity of climatic and other physical conditions rather than a greatly reduced interval of time.

The areal relations as I interpret them are shown on figure 31 (p. 80).