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The Geology of the Claiborne (Eocene) Group of Mississippi as Far North as Grenada County.

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THE GEOLOGY OF THE CLAIBORNE (PLEISTOCENE) GROUP OF
MISSISSIPPI AS FAR NORTH AS GRENADE COUNTY

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The School of Geology

By

Emil Paul Thomas
B. S., Oklahoma Agricultural and Mechanical College, 1935
M. S., Louisiana State University, 1939
June, 1942
TO

J. R. H.
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ABSTRACT

The Claiborne group of Mississippi is divided into six formations in this report. They are (youngest to oldest): Cockfield, Autubbee, Kosciusko, Zilpha, Winona and Tallahatta. The Autubbee formation is subdivided into three new members in eastern Mississippi. They are (youngest to oldest): Gordon Creek shale, Potterchitto member and Archosa marl. This subdivision is not practicable in the central part of the outcrop belt and the formation is not differentiated there. The marine Autubbee lenses out into non-marine sands and shales in southwestern Attala County, but its non-marine extension, the new Shipp's Creek shale, is recognized as far northwest as the alluvial valley of the Mississippi River. The Tallahatta formation is divided into the Basic claystone member and the new Neshoba sand member in the eastern and central parts of its outcrop belt, but this subdivision becomes infeasible in Grenada County and the formation is not differentiated there. The other four formations are not subdivided. The history of the terminology, original definition, lithology, contact relationships, distribution, topographic expression, soils and depositional conditions of each of the lithologic units are discussed. The areal distribution of the different formations is shown on the geologic map (Plate 1) and the facies changes along strike are shown on a composite diagram (Plate 2). These two
plates combined give all of the essential features of the Claiborne group in the area mapped. Five surface profiles are also included.

Each of the Claiborne formations of Mississippi has a lithologic equivalent in western Alabama. The stratigraphic relationships of the Claiborne beds in that area are discussed briefly and tentative correlations with the type Claiborne section are made.

The Claiborne group of central and eastern Mississippi exhibits a cyclic depositional pattern which is:

- non-marine sands and shales (top)
- carbonaceous shales or transition facies
- marine facies (bottom)

Disconformities or stratigraphic breaks at which there is evidence of erosion occur at the base of each marine section, while all other contacts are conformable. It is believed that this pattern is caused by subsidence under load and epeirogenic movements combined.
INTRODUCTION

The Claiborne group is one of the four groups which constitute the Eocene series of the Tertiary system of the southeastern United States. This report covers most, but not all, of the Claiborne of Mississippi. In recent years it has become apparent that the lower Claiborne beds extend much farther north than is shown on the state geological map of 1926 (1). It is probable that they will be found to extend to the northern state line. These beds were mapped only as far north as the northern Grenada County line during this work.

GENERAL FEATURES OF THE AREA MAPPED

The area mapped covers approximately 5,000 square miles and includes all or part of fifteen counties situated in the central part of the state of Mississippi. Its general outline and position are shown on the geological map (Plate 1). The area is a belt crossing the state from the Mississippi-Alabama state line on the southeast to the alluvial valley of the Mississippi River on the northwest. It averages about 20 miles in width at the Alabama line, gradually increases northwestward to a maximum width of 60 miles across Attala and Holmes Counties and then decreases northward to about 20 miles in width in Grenada County. This area was mapped in a thirteen months' period beginning in the spring of 1940. All of it was covered by the writer except the Claiborne outcrop area of northern Madison County which is taken from a map by Mr. C. L. Moody and is included in order to make the regional map complete.

The Claiborne outcrop pattern reflects the regional structure. The normal strike of the beds in the extreme southeastern part of the area is about 50 degrees west of north. The strike of the basal Claiborne contact gradually changes northwestward to about 10 degrees west of north in Grenada County, while the strike of the upper contact averages about 35 degrees west of north all the way across the state. This difference in strike reflects a marked northwestward thickening of the Claiborne section from about 330 feet at the Mississippi-Alabama
state line to more than 1200 feet at the edge of the alluvial valley of the Mississippi River. The normal dip is to the southwest and west. It ranges from 25 to 35 feet per mile, being steeper on the lower beds than on the upper.
PHYSIOGRAPHY
The Claiborne group outcrops in two physiographic regions.
The greater portion of the outcrop lies in the area generally known
as the North Central Hills, a well-dissected sand hills upland broken
by several pronounced cuestas and escarpments which follow the strike
of the beds. The local relief varies from 50 to 300 feet and is
greater on the outcrop of the beds in the lower part of the Claiborne
section than on those in the upper. The beds are well exposed
throughout the area except along the western border where an exten­sive
blanket of brown silt often obscures the outcrop. The only
other superficial deposits are the recent alluvium and Quaternary
terrace materials along the streams.

The second physiographic region in which the Claiborne beds
outcrop is commonly called the Loess Hills. This is a region of
rugged topography which forms a belt from 5 to 12 miles wide along
the western border of the Claiborne outcrop. The Tertiary is
covered by thick deposits of Quaternary sands and gravels and loess
throughout the area. The Loess Hills adjoin the alluvial valley of
the Mississippi River and are sharply defined on the west by a
continuous series of bluffs which rise abruptly above the valley
floor. The typical Loess Hills topography merges with typical sand
hills topography eastward and the eastern boundary is arbitrarily
taken as the eastern limit of the Quaternary mantle deposits mapped
as Q on Plate 1. Tertiary exposures are found only along the streams and in ravines along the bluffs in this region, but they include some of the best exposures in the state.
CLAIBORNE STRATIGRAPHY

INTRODUCTION

The term Claiborne (2) was first used by Conrad in 1847 for the "Claiborne sand" exposed at Claiborne Bluff, Alabama from which he had described a number of fossils. He assigned it to the "Lower or Older Eocene". Hilgard first identified the Claiborne group in Mississippi in 1860 and divided it into an upper "Calcareous Claiborne group" and a lower "Siliceous Claiborne group". Seven years later he excluded the "Siliceous Claiborne or Buhrstone" from the Claiborne proper and his restricted definition was used until 1894 when Harris included the Buhrstone (Tallahatta formation of later reports) in his "Lower Claiborne stage". The United States Geological Survey has included the Tallahatta formation in the Claiborne group since 1906.

As now generally accepted, the type Claiborne section is divided into three formations in the area around Claiborne Bluff, Alabama. They are:

Gosport fossiliferous sand

Lisbon sandy marl

Tallahatta formation or "Buhrstone"

The group is overlain by the Jackson formation (uppermost Eocene) and is underlain by the Wilcox group (middle Eocene).

Figure 1 is a tabular summary of the history of Claiborne nomenclature in Mississippi. It shows that the more modern writers have divided the Claiborne of Mississippi into three formations which correspond to the three formations of the type Claiborne section of Alabama. They are:

- Cockfield or Yegua formation
- Lisbon formation
- Tallahatta formation

In this report the Lisbon formation of these authors is subdivided into four formations because it is composed of several mappable units which can be traced across the state. The Claiborne group, then, consists of six formations. They are:

- Cockfield formation
- Wautubbee formation
- Kosciusko formation
- Zilpha shale
- Winona greensand
- Tallahatta formation

The Cockfield formation of this report includes all beds above the predominantly marine Wautubbee formation and below the marine basal Jackson (Moody's Branch formation). The marine Wautubbee formation is subdivided into three new members in eastern Mississippi, is undifferentiated in central Mississippi, and is
extended northwestward into the non-marine Shipp’s Creek shale member of this report. The Kosciusko formation includes all beds above the Zilpha shale and below the Nautubbee formation. The terms Zilpha and Winona are used as originally defined by Moore (1940) and Lowe (1919), respectively. The Tallahatta formation is divided into the Basic claystone member (Lowe, 1919) and a new member, the Neshoba sand. The Meridian sand, which is considered basal Claiborne by the Mississippi Geological Survey, is excluded from the group.

These subdivisions are shown graphically on Plate 2, which is a composite diagram showing changes of facies and thicknesses of the different formations along strike from the Mississippi-Alabama state line to the western and northwestern limits of the area mapped. The plate is necessarily highly diagrammatic because it is impossible to show the true complexity of the section on a two dimensional figure. It is constructed from data obtained from highway profiles, measured sections, surface contours, well information and reconnaissance mapping. The plane to which all data are referred is the Zilpha-Winona contact, the most persistent and reliable contact in the Claiborne section. Horizontal intervals on Plate 2 represent distances along the normal strike of the datum plane, while vertical intervals indicate thickness of section. The geologic section shown along any given vertical line is the approximate section which would be shown by a surface geological profile run perpendicular to the normal strike of the datum plane from the point where the vertical line crosses that plane. The towns and villages and a few localities on the outcrop are shown beside vertical arrows which indicate the
When properly interpreted, Plate 2 shows all of the essential elements of the Claiborne group in the area mapped. A set of examples showing the use of the figure is taken from the area around the town of Newton, Newton County. The plate shows that the geological section exposed in and around the town ranges from the uppermost few feet of the Wautubbee to about 60 feet up in the Cockfield. It indicates that the Wautubbee section near Newton is about 90 feet thick and is divisible into three facies or members and that along the strike northwestward the formation changes facies and becomes thinner. The figure also shows that in the area between Newton and Decatur the Wautubbee section and the upper half of the Kosciusko section are exposed and that between Decatur and Neshoba the lower Kosciusko, a rather thick section of Zilpha shale with a greensand bed at the top, the Cinoma greensand and the Neshoba sand are exposed.

Five selected surface geological profiles run along main highways traversing the Claiborne outcrop belt are also included. Their primary purpose is for use in inspecting the Claiborne in the field. Nearly all of the essential features of the section are shown on these profiles.
TALLAHATTA FORMATION

Introduction

The name Tallahatta first appeared in print in an article by Dall (3). It was suggested to him by E. A. Smith to take the place of the term "Buhrstone" which had a lithologic, rather than a geographic, connotation. The term Tallahatta has been in general use in Mississippi since its introduction by Johnson in 1905 to replace Hilgard's term "Siliceous Claiborne".

The typical Tallahatta "buhrstone" section, herein called the Basic claystone member, is well developed throughout eastern Mississippi, but in the central and western portions of its outcrop the typical facies is largely replaced by a sand section called the Nashoba sand member. In the extreme northern part of the area mapped the entire section changes facies and is called undifferentiated Tallahatta formation in this report.

Basic Claystone Member

Introduction - The Basic claystone member is the stratigraphic and lithologic equivalent of the type section of the Tallahatta formation of Choctaw County, Alabama. The term Basic is used for this section in preference to Tallahatta because it was found necessary to set up another member in Mississippi and the two members together logically constitute the Tallahatta formation. The name Basic is well established in Mississippi literature, having been proposed

by Lowe in 1919 (4) and used since in several Mississippi Geological Survey bulletins. The type locality is a deep cut on the railroad just north of Basic City, a railroad station in northwestern Clarke County, Mississippi. As shown on Profile B, a full section 80 feet in thickness is exposed in this immediate vicinity. It overlies the micaceous, lignitic sands of the uppermost Wilcox (Meridian) and is overlain by the Minona greensand.

**Lithology** - The Basic member has the most distinctive lithology of any of the beds in the Claiborne section of Mississippi. It is composed chiefly of siliceous claystone with interbeds of silicous siltstone and sandstone. These indurated rocks are the "buhrstone" of the older authors. Buhrstone is any siliceous rock suitable for use as a millstone. Very little of the material in the Basic could be so used and the term "buhrstone" has been so loosely applied that the tendency of the more recent authors has been to drop it from the literature.

The claystone of the Basic forms by surface induration from a dark greenish gray, somewhat micaceous, silty clay that usually contains scattered plant fragments. The indurated material is a light-colored, brittle rock which is remarkable for its low specific gravity and which breaks with a sub-conchoidal fracture. The contraction caused by the evaporation of the connate water shatters the claystone into angular blocks the surfaces of which are usually

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stained yellow-brown and which commonly exhibit a regular concentric banding extending to the center of the block. The claystone commonly contains small lenses, angular inclusions and fucoidal structures of glauconitic silt which impart a heterogeneous texture to the sediment.

The siltstone interbeds of the Basic member are formed by surface induration of a dark greenish gray, lignitic, argillaceous, glauconitic, micaeous, coarse grained silt. They are also light in color and often stained by iron oxide. The siltstones are usually irregularly indurated and have a characteristic knobby appearance on the outcrop. Inclusions of clay and sand similar to the inclusions in the claystone are abundant.

Sandstones are the least common of the indurated beds in the Basic. They are similar in general appearance to the siltstones and range from fine-grained to coarse grained. They vary from highly glauconitic to non-glauconitic and from semi-indurated to quartzitic.

Shale or blocky clay similar in lithology to the fresh clay from which the claystone arises but lacking the property of becoming indurated upon exposure is abundant in the Basic. Greensand (5) occurs rarely in the member in the form of thin stringers which are found both at the top and at the bottom of the section.

Throughout eastern Mississippi the base of the Basic member

(5) The term "greensand" is used in this report for a sand which contains over 15% of glauconite grains. Glauconite-bearing sand containing less than that amount is called "glauconitic sand".
is marked by a bed of coarse-grained, poorly sorted, light greenish-gray glauconitic sand with an abundance of white quartz granules and small, rounded quartz pebbles. This basal sand of the Basic ranges up to 10 feet in thickness and grades upward through a glauconitic sandy clay or shale into the overlying indurated material.

The structure of the Basic member is even-beded and thin-beded to thick-beded, the different facies being interbedded throughout the section. The beds are extensively jointed on the outcrop and large, vertical, dike-like bodies of claystone are occasionally seen cutting across the individual beds.

In Newton and Neshoba Counties lenses of non-glauconitic sand become abundant in the Basic. This material is stained red, brown, yellow, pink and purple on the outcrop and is fine-grained, micaceous and well sorted. Its structure varies from massive to cross-beded. Pellets, partings and stringers of gray clay occur in this sand.

The characteristic indurated Basic materials become progressively thinner and more lenticular northwestward along the strike until, in northern Montgomery and Grenada Counties, the only remnants are a few local developments of soft, white glauconitic siltstone. Interbedded with this siltstone and lying both above and below it in Montgomery County there is found a distinctive black, carbonaceous, silty, micaceous, fissile shale which dries out into a very light gray or white, slightly indurated flaky shale. Associated with this flaky shale are partings, stringers and interbeds of micaceous, sparingly glauconitic to non-glauconitic silt and sand. These flaky shales and associated beds reach a maximum thickness of 100 feet in the hills east of Grenada, Grenada County, and constitute at least part of Lowe's Grenada formation which was long considered to be of upper
Wilcox age. This relationship was first pointed out by the authors of the Claiborne and Wilcox Field Trip Guidebook of the Mississippi Geological Society (March, 1940). If this shale section is persistent northward from Grenada County, the Grenada beds should be considered a member of the Tallahatta formation.

In Grenada County the flaky shales are overlain by 3 to 30 feet of light greenish gray glauconitic sand or greensand which is characterized by an abundance of fusoidal structures and small clay inclusions. These glauconitic beds should be given the rank of a new member in the Tallahatta formation if they are persistent northward. Until more detailed work is done between Grenada and the Mississippi-Tennessee state line, it is considered preferable to leave the Tallahatta section undifferentiated in Grenada County.

**Lower Contact** - In this report the base of the Claiborne group is placed at the base of the Basic member. The Mississippi Geological Survey, following Lowe (6), places it at the base of the Meridian sand, a non-marine sand section which underlies the Basic throughout the area mapped. The Meridian sand is named from exposures near the city of Meridian, Lauderdale County, Mississippi and was considered to be a member of the Tallahatta formation in state survey publications until Foster (7) recently raised it to

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formational rank. It is a massive to highly cross-bedded, lignitic to non-lignitic sand which ranges up to 125 feet in thickness and which contains a few lenses of glauconitic sand, greensand, glauconitic sandy shale and lignitic silty shale in Clarke and Lauderdale Counties. The reasons for excluding the Meridian sand from the Claiborne group are:

1. It is lithologically much more similar to the underlying non-marine Wilcox than to the overlying marine Tallahatta. It was deposited under conditions very similar to those which prevailed throughout most of Wilcox time in the eastern Mississippi area.

2. The marine Tallahatta section overlies the Meridian sand with distinct disconformity throughout eastern Mississippi and western Alabama.

3. The lower Meridian contact changes over short distances along the strike from conformable to locally disconformable (local erosional channels).

The lower contact of the Basic member is disconformable as far northwest as the Pearl River in Neshoba County. The details of the contact and lithology of the underlying and overlying beds indicate that it represents a small erosional and chronological break in which the uppermost few feet of the low-lying Meridian deltaic plain deposits were truncated by wave-erosion during the advance of the Tallahatta sea. The contact itself is sharply defined, the change from non-marine to marine facies occurring within 6 inches to 2 feet of section in which the two facies are intimately mixed.

Small blocks and fragments of lignitic shale and quartz pebbles
from the underlying beds are found in the basal few feet of the marine section and branching fucoidal structures from the beds above extend a foot or two down into the underlying non-marine sand. The basal, pebble-bearing glauconitic sand of the Basic member in eastern Mississippi apparently represents a beach deposit thrown up by the waves along an advancing shore-line. The continuity of this deposit indicates a strong, unbroken advance throughout the area. Near Philadelphia, Neshoba County, there is a 10 foot lens of Basic material lying about 10 feet below the main body of the member. It also has a basal, pebble-bearing sand and probably represents marine materials deposited in a small estuary on the Meridian deltaic plain ahead of the main advance of the Basic sea.

Northwestward from the Pearl River the lower contact of the Basic member becomes quite gradational and shows little evidence of an erosional break. The basal, pebble-bearing sand is not developed and the transition from non-marine to marine facies occurs through 5 to 20 feet of interbedded glauconitic sand, non-glauconitic sand, carbonaceous shale and Basic-type clay. The marine advance was apparently not so strong in this area and this contact probably represents a gradual replacement of non-marine deposition by marine deposition. In the Montgomery-Grenada County area the lower Tallahatta contact is conformable. The flaky shales which lie at the base of the Tallahatta section grade downward into the underlying Meridian sand through an interbedded sand and shale transition facies which ranges up to 10 feet in thickness. This contact represents an even more gradual change from non-marine to marine conditions.
**Thickness** - The Basic claystone member averages about 60 feet in thickness in eastern Mississippi. Its range in thickness in that area is from 50 to 115 feet. These figures are comparable with the thickness of the Tallahatta formation in western Alabama where the average is 100 feet and the maximum is 125 feet. In the central portion of its outcrop the Basic member becomes thinner and the thickness varies greatly over short distances along the strike. The range in thickness here is from 10 to 90 feet and the average is about 50 feet. Through southern and central Montgomery County the thickness varies from 5 to 30 feet. In the area around Grenada the thickness of the undifferentiated Tallahatta section reaches a maximum of about 200 feet.

**Fossils** - No detailed paleontological work has been done on the Basic member, but it is apparent that it contains a large fauna. Most of the finer grained rocks contain molds of thin-shelled mollusks, but no localities were found where fresh fossils could be collected. Many of the fossils in the claystone are opalized. Grim (8) records both diatoms and radiolaria in his thin sections.

**Distribution** - See distribution of the Neshoba sand on page 21.

**Topographic Expression** - The Basic claystone member forms the strong Buhrstone Cuesta (9) in eastern Mississippi. Along the bajada or steep side of the cuesta there is found some of the most rugged

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topography in the entire Coastal Plain Province. The local relief averages about 175 feet and ranges up to 300 feet. On the gentle slope of the cuesta typical sand hills topography developed on the overlying Kosciusko sand is superimposed upon the more rugged claystone topography and the average local relief is about 75 feet. This cuesta becomes progressively less pronounced northwestward along the strike as the claystone becomes thinner until, in the northern part of the area mapped, it is absent to very weakly developed.

Soils - The Basic claystone gives rise to fine sandy loam and stony clay soils of the Lauderdale series. They are among the poorest agricultural soils formed on the Claiborne outcrop in Mississippi.

Depositional Conditions - The presence of the mineral glauconite and of marine fossils are generally regarded as prima facie evidence for a marine origin of the associated sediments. The Basic claystone also exhibits other features which are indicative of marine deposition among which are the persistence of the facies over 200 miles along the strike, the thin-bedded, even-bedded structure and the abundance of fusoidal structures. None of these features are common in non-marine sediments in the Tertiary system of Mississippi. The thin-bedded, interbedded nature of the main body of the Basic member indicates that it was deposited in quiet water in a position near enough to shore that slight changes in the grain size of the sediment introduced into the sea were recorded in the interbedding of the clays, silts and sands. This depositional activity was interrupted in the central part of the outcrop area by the intro-
duction of large quantities of sand now incorporated in the section as the Neshoba sand.

The undifferentiated Tallahatta section of Grenada County was deposited under nearer-shore conditions than the Basic. The flaky, carbonaceous shales of the lower part of that section are probably coastal marsh deposits (see Depositional Conditions of the Alpha shale). The deposition of these materials was followed by an encroachment of the sea over the coastal marsh and the deposition of the overlying glauconitic sand and greensand.

The siliceous cement which binds the rocks of the Basic is apparently primary, since it is quite uniformly distributed through 160 feet of sediments in eastern Mississippi. It was probably precipitated from the sea water under relatively quiet conditions.

**Neshoba Sand Member**

**Introduction** - Overlying the Basic claystone and underlying the Winona greensand throughout the central and northern portions of the area mapped, there is a section of non-glaucositic to sparingly glauconitic sand which has heretofore been considered to be lower Winona. This sand section is a useful mapping unit and it is herein named the Neshoba sand from typical exposures in and around the village of Neshoba, Neshoba County. The type section is designated as that shown lying above the Basic claystone and below the Winona greensand on Profile C along the present highway through Neshoba.

The Neshoba sand is considered to be a member of the Tallahatta formation because:

1. It is the stratigraphic equivalent of part of the type
Basic claystone section and of part of the type Tallahatta section of Choctaw County, Alabama. This relationship is illustrated on Plate 2 where the overlying Winona greensand is shown maintaining a constant thickness and lithology across the area where the Neshoba lenses cut into the Basic.

2. The Neshoba sand is overlain and underlain by typical Basic material in Newton and Lauderdale Counties.

3. The Neshoba and Basic facies are intimately interlensed over a wide area and the thickness of the Neshoba fluctuates inversely with the thickness of the Basic.

Lithology - The Neshoba sand is composed of non-glaucousitic to sparingly glauconitic, non-fossiliferous, marine sands which are typically well sorted, fine grained and micaceous and which vary in structure from massive to irregularly bedded to cross-bedded. When fresh, the sands are white, but on the outcrop they are usually stained red, brown, yellow, purple and mottled. The sands in the upper 5 to 15 feet of the member are normally quite different in appearance from the sands in the remainder of the section. They are dark, brick red in color, highly argillaceous, medium grained and poorly sorted. Their high clay content and dark color are derived from the overlying weathered Winona greensand through the action of percolating ground-water. Greensands and glauconitic sands are occasionally found in the Neshoba. They are local concentrates of glauconite which grade laterally and vertically into non-glaucousitic sands.

Gray clay is abundant in the Neshoba in the form of pellets, partings, stringers and lenses in the sands. Impure bentonite and
bentonitic clays are found at or near the top of the member in Attala and Grenada Counties. In northeastern Newton and northwestern Lauderdale Counties thin, discontinuous lenses of typical greenish gray, Basic-type clay and shale occur at the top of the member. In northern Montgomery and Grenada Counties the Neshoba section thins and shows a decided change of facies. Carbonaceous clays and shales become abundant as lenses and partings in the glauconitic to non-glauconitic, micaceous sands and silts and at a few localities discontinuous, Basic-type siltstone ledges occur within the section. These sands and shales are included in the undifferentiated Tallahatta section of Grenada County.

**Lower Contact** - The Neshoba sand lies conformably upon the Basic claystone. Throughout the central part of the Tallahatta outcrop belt, the red sands of the Neshoba usually rest directly upon typical Basic clay or shale and occasionally they lie upon siltstone or sandstone. The contact is normally sharply defined, there being no interbedding of the two facies. In the Montgomery-Grenada County area the contact is more gradational and is usually marked by an interbedding of the two facies.

**Distribution** - The outcrop areas of the basic claystone and Neshoba sand members are grouped together as Tallahatta formation on the geological map (Plate 1) because its small scale limits the amount of detail which can be shown. A study of figures 1 and 2 in conjunction will give the approximate distribution of the two facies. In northeastern Clarke and southeastern Lauderdale Counties the Basic constitutes the entire Tallahatta formation and the outcrop area is
a very narrow and irregular belt with numerous topographic outliers which reflects the marked development of the Buhrstone Cuesta and the sharpness of the bajada in that area. Northwestward along the strike the Tallahatta outcrop widens to an average width of about 6 miles and becomes less irregular and the Neshoba sand outcrop area becomes predominant over the Basic outcrop area.

**Topographic Expression** - Throughout most of its outcrop the Neshoba sand gives rise to a rugged sand hills topography in which the local relief averages about 75 feet. Elevations on this outcrop are in general quite high because it lies between the strong Buhrstone Cuesta on the east and the well-developed cuesta on the Ninona greensand to the west.

**Soils** - The Neshoba sand gives rise to loose, light gray or light brown fine sandy loam and fine sand soils. The top-soil ranges up to 1 foot in thickness and the sub-soil, which is a reddish brown or mottled clayey sand or sandy clay, ranges up to 6 feet in thickness. These soils are mapped as Ruston or some closely allied soil series, such as Greenville, Orangeburg or Norfolk. They are fairly good soils for general agricultural purposes.

**Depositional Conditions** - The manner in which the Neshoba sand is interlenssed with the Basic claystone, the slightly glauconitic nature of the beds and the conformable nature of the lower contact indicate a marine origin for the Neshoba. The irregular bedding and cross-bedding point to a near-shore site where currents were active.

During the time in which the upper Basic clays and silts were being deposited in eastern Mississippi, an abundance of sand was intro-
duced in the sea in the central and northern parts of the area mapped and was incorporated in the section as the Neshoba. Conditions in the Neshoba sea were unfavorable to the precipitation of siliceous material, probably being too near-shore in agitated waters. Either marine life was impoverished in the Neshoba sea or conditions for its preservation were extremely unfavorable because there is no fossil evidence of its existence.
**WINONA GREENSAND**

**Introduction** - The name Winona was proposed by Lowe (10) in 1919 for greensands which are well exposed near the town of Winona, Montgomery County. His original definition is:

"The Winona sand as found in the western part of its outcrop, especially well developed around Winona, Vaiden and eastward into adjacent counties, consists of highly glauconitic sands and clayey sands that weather to an intense Indian red color where exposed at the surface. This material is marine in origin and locally abundantly fossiliferous. --------

On the Southern Railroad both east and west of Winona, are characteristic notable deposits of this material, that at Elliott, three miles east of Winona, being especially striking. From Winona southward on the Illinois Central Railroad frequent outcrops of the material are seen as far south as Vaiden and Beatty. --------

The thickness of this division of the Tallahatta in northwest Mississippi is estimated to be approximately 350 feet."

Although Lowe's estimated thickness is several times too high and the upper and lower limits of the Winona are not drawn, the description of the lithology and the localities mentioned satisfactorily delimit the formation.

Lowe erroneously considered the Winona to be the lower member of the Tallahatta formation and correlated it with the Meridian sand of eastern Mississippi. He (11) had previously applied the name Enterprise to a greensand exposed in the town of Enterprise, Clarke County, and had considered it to be the basal member of the Lisbon formation. Cooke (12) was the first to recognize that the greensands

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exposed at Winona and Enterprise are parts of the same formation and
he dropped the term Enterprise because it was preoccupied. Cooke and
most later workers have considered the Winona to include all of the
beds above the Basic member and below the Zilpha shale. In this
report the term Winona is restricted to those greensands to which
the name was originally applied and the underlying sands are included
in the Neshoba.

Most authors have considered the Winona greensand to be a
member of either the Tallahatta or Lisbon formations. It is raised
to formational rank in this report because it is a very distinctive
lithological unit which has a wide areal distribution, it being the
only formation in the Claiborne group which extends all the way
across the state without extensive facies changes.

**Lithology** - The Winona formation is composed of greensands
and glauconitic sands which vary from light greenish gray to dark
green when fresh and which weather to a distinctive dark, brick red
color. The glauconite content of the Winona sands ranges from 10
to 90%. There is a noticeable tendency for the glauconite grains
to be coarser than the quartz grains and the sands are usually
poorly sorted. These greensands and glauconitic sands are unusually
course grained for sands of this type, although the median grain
size is rarely larger than medium sand size. The structure of the
sands is commonly massive to poorly bedded and occasionally
thin-bedded and even-bedded. High angle cross-bedding occurs
rarely. In eastern Mississippi the Winona becomes lenticular and
thin and lenses of non-glauconitic, massive to highly cross-bedded
sand occur in the formation at a few localities. Quartz pebbles are common in the greensands in that area. Clay occurs in the Winona sands as formless inclusions and there are a few exposures where thin lenses of black, carbonaceous shale occur in the section. The Winona sands are locally calcareous and fossiliferous lenses are common, but surface localities where fresh fossils can be collected are rare.

Siderite occurs in the Winona as thin beds outcropping as ledges and as isolated concretionary masses of dense, light brownish gray material, but it is rarely seen in the fresh state on the surface because it weathers readily to limonitic claystone or ironstone. It is particularly abundant near the top of the formation in the northern part of the area and its first appearance in well samples can usually be taken as the top of the Winona. This fact is of particular value in the interpretation of old water well logs where siderite is logged as "rock".

The deeply weathered Winona outcrop is marked by an abundance of concretionary limonitic sandstone bodies which exhibit all shapes and sizes and degrees of induration. They are very useful indicators for the weathered outcrop and for both the upper and lower contacts. The upper contact lies immediately above the uppermost concretionary ledge and the basal contact is usually not far below the lowermost concretionary material.

Lower Contact - The Winona-Tallahatta contact is conformable and sharply defined. The details of the contact differ somewhat with the nature of the underlying material. The contact between the Winona greensand and the Basic claystone in eastern Mississippi is
slightly irregular and there is a heterogeneous mixing of the two facies at the contact proper, but the uniform thickness and persistence of the uppermost basic beds in individual exposures disproves any significant truncation of basic materials. Borings and pockets filled with material from above extend a few inches down into the underlying beds. Several authors have considered this contact to be unconformable or disconformable upon this evidence, but such contacts are common between the different beds in many marine sequences and they apparently have little significance. At least seven such breaks occur in 140 feet of fairly homogeneous Lisbon sandy marl in the Little Stave Creek section near Jackson, Clarke County, Alabama. The homogeneity of this section precludes the existence of seven large depositional breaks during Lisbon time and the contacts must represent minor breaks in sedimentation, or diastems in which submarine erosion was active.

In the area where the Winona greensand overlies the Neshoba sand the contact shows more variation. At some exposures the two facies are intimately mixed through two or three feet of section and small lenses of glauconitic material are found several feet below the main body of the greensand. The glauconite is abundant and irregularly distributed at and immediately below the contact and becomes increasingly rare downward. There is no reason to believe that this contact does not represent the same set of conditions as the Winona-basal contact in eastern Mississippi. The differences in the details are probably due to the comparatively unconsolidated nature of the Neshoba sand as compared with the basic clays. At other outcrops the transition from Winona to Neshoba facies is
uniformly gradational through several feet of transition beds. This type of contact apparently represents a gradual, uniform change in the type of material being deposited.

**Thickness** - The thickness of the Winona greensand varies from 0 to 50 feet. Over most of the area mapped it is consistently about 25 feet and variations of over 10 feet from that figure are rare. The formation is thin and poorly developed in Clarke and Lauderdale counties, ranging in thickness from 0 to 20 feet and averaging about 10 feet. The few places where it is absent seem to be cases of simple non-deposition of the facies. The maximum development of the Winona greensand occurs in the general vicinity of the type locality.

**Fossils** - The Winona greensand contains two excellent index fossils. They are Cetrea sellaformis var. lisbonensis and Proscutella mississippiensis. The formation has a rather large and varied fauna which includes pelecypods, gastropods, echinoids, crabs, shark's teeth, foraminifers and ostracods, but there are very few localities in the state where fresh material can be collected. The best localities are in and around the town of Enterprise, Clarke County. Foster (13) lists 42 species of macrofossils identified by Cooke from several localities in this vicinity. The microfauna of the Winona has not been studied in detail.

**Distribution** - See Distribution of the Zilpha on page 35.

**Topographic Expression** - The Winona greensand has little or no topographic expression in eastern Mississippi where it overlies

(13) V. M. Foster, op. cit., pp. 62-64.
the Basic because it is poorly developed and its influence is over-
shadowed by that of the Basic claystone. In the central part of the
area mapped the Winona forms a secondary cuesta lying to the west of
the stronger Buhrstone Cuesta, but northwestward along the strike the
cuesta developed on the Winona becomes more marked as the Buhrstone
Cuesta grows weaker and in the northern part of the area the Winona
cuesta is the dominant topographic feature.

Soils - The Winona greensand gives rise to a very distinctive
light brown to gray sandy loam soil of considerable fertility. The
top-soil is thin, ranging up to 6 inches in thickness, while the
sub-soil is from 18 to 24 inches in thickness and is a red to reddish
brown, friable sandy clay which usually contains fragments of sand-
stone concretions. This soil is known as the Nacogdoches or some
closely allied series.

Depositional Conditions - The oysters, echinoids and crabs
present as fossils in the Winona greensand indicate a shallow-water,
near-shore environment for its deposition. Such an environment
would have currents capable of handling such coarse-grained material.
Winona deposition represented an epoch of shallow-water conditions
which closed the cycle of marine deposition initiated by the advance
of the Tallahatta sea.
ZILPHA SHALE

Introduction - The term Zilpha first appeared in print in the guidebook for the Claiborne and Nilex Field Trip of the Mississippi Geological Society (March, 1940). The original definition appears on page 3. It is:

"A workable bed of gray white and chocolate brown clay, having a thickness of about 60 feet, was found to lie between the Inona and the Kosciusko in North Central Mississippi in Carroll, Grenada, and Attala Counties. Dr. Raymond Moore, formerly with the Arkansas Fuel Oil Company, found this to be a good key horizon, and suggested the name of Zilpha, from Zilpha River in Attala County."

Although the term has never been formally defined by its author, the conditions are such that there can be little confusion regarding the beds to which it was first applied. The name Zilpha is in common use in Mississippi at the present time and is used in this report as defined in the guidebook. The Zilpha shale does not outcrop on Zilpha Creek (or River) proper, but these beds reach their maximum development in that general area. The best exposure of the shale in the vicinity of Zilpha Creek is found along the county road at Bucksnort Hill and that locality is herein set up as the type locality of the Zilpha shale in order to avoid any confusion in the future. The type section is described under Lithology.

The Zilpha shale is given formational rank in this report because:

1. It is a distinctive lithological unit which can be traced without serious interruption across the state of Mississippi.

2. Giving it the rank of a member along with the Inona or Kosciusko would necessitate the introduction of a new formational name, since both of those terms are restricted to other beds and
should not be expanded to include the Zilpha section.

Lithology - The characteristic lithology of the Zilpha shale may be seen at the exposure herein selected as the type locality which is along the county road at Bucksnort Hill, one and a half miles north of Zilpha Creek and near the center of section 8/T16N/R6E, extreme northwestern Attala County, Mississippi. The section here is:

ZILPHA SHALE - upper contact not exposed

29' carbonaceous shale - chocolate brown to light gray to dark red; abundant partings of light gray silt and many pockets, stringers and interbeds of highly glauconitic material occur to within 4 feet of the top; few thin stringers of soft, white, glauconitic siltstone; plant fragments common in the chocolate material; grading down into

22½' carbonaceous shale - similar to above but non-glauconitic; upper 14' badly weathered and slumped; grading down into

2½' glauconitic sandy clay - chocolate to light gray; glauconite and quartz sand concentrated in pockets and stringers near base and becoming rare toward top; few thin, irregular concretionary ledges of limonitic claystone; scattered molds of fossils; this bed is really the transition section between typical Zilpha and Inonna facies

Contact conformable

54' Total thickness of Zilpha exposed

INONNA GREENSAND

4' heavy concretionary ledge of limonitic sandstone developed on weathered greensand; most prominent bed in section
19' fossiliferous greensand - light greenish gray to yellow-brown to dark, brick red; massive to irregularly bedded; fossils abundant as molds concentrated in small lenses; upper 4 to 8 feet of this section very irregularly indurated; disoriented pellets, tubes and inclusions of gray clay common; much of glauconite of coarse sand size; grading down into

5' glauconitic sand or greensand - similar to above but less glauconitic and less fossiliferous

4' carbonaceous clay - chocolate to gray; sandy and honeycombed with sand-filled borings and pockets; pinches out in cut

6½' glauconitic sand or greensand - light greenish gray to yellow-brown and red; upper half thin-bedded and banded; lower half contains an abundance of disoriented pellets and filled tubes of gray clay; beds irregularly stained black by manganese oxide(?)

35' Total thickness of Minona exposed

Base of section at floodplain level of Big Black River -
Elevation 285 (barometer)

Total section exposed - 89'

As indicated by the described section, the Kilena formation is composed chiefly of carbonaceous shale and clay. When fresh, this material is black, but it is readily oxidized to a chocolate brown or gray color and is usually seen on the surface in that condition. It ultimately weathers to a dark, brick red clay. The lower part of the section is typically a nearly-pure, blocky clay, while the upper portion is much more silty and shaly. Partings, stringers and lenses of micaceous silt and sand, many of which exhibit high angle cross-bed-
ting, are the most common associates of the chocolate shales. Plant fragments are found throughout the section, but tend to be much more abundant in the upper, shaly facies.

The lowermost few feet of the Zilpha are glauconitic and sandy, these two materials being abundant and irregularly distributed near the basal contact and becoming increasingly rare above. Glauconite also occurs in small lenses and pockets which are found all the way to the top of the formation. In northwestern Attala County where the Zilpha reaches its maximum development, the shales of the upper part of the section are often highly glauconitic. Several glauconitic beds can be recognized at some outcrops in that area.

Throughout the southeastern part of the Zilpha outcrop there is a discontinuous greensand bed at the top of the formation. It is a dark greenish gray, fine grained, argillaceous, lignitic greensand which is sparingly fossiliferous at a few localities. It reaches a maximum thickness of 15 feet in the area west of Union, Newton County. This greensand is separated from the overlying basal Kosciusko sand by a few feet of sparingly glauconitic silt. In southern Neshoba County there are several lenses of glauconitic sand and greensand which lie from 20 to 30 feet above the main body of the Zilpha. These lenses were mapped as part of the Zilpha in order to include as much marine material as possible in that formation rather than in the non-marine Kosciusko formation.

Some of the concretions formed in the Zilpha are very useful in identifying the deeply weathered outcrop. By far the most abundant type found is a soft, flaky, yellow-brown limonitic siltstone which is formed along the silty partings of the shale by the deposition of
iron oxide from circulating ground-water. A similar type of claystone often forms as ledges of dense, hard material at the top of the shale section. In the northern and southeastern parts of the area mapped these ledges are strong and persistent and serve as good markers for the top of the formation.

Throughout north-central Attala County, where the Zilpha is best developed, rounded, yellow-brown limonitic claystone or ironstone concretions are commonly found. These concretions are hollow or spongy in the interior and have a characteristic shelly or concentric structure. They occur at definite horizons as weak ledges and are derived from weathered siderite.

**Lower Contact** - The Zilpha-inaona contact is conformable and sharply defined. The material at the contact proper is a heterogeneous mixture of carbonaceous clay, glauconite and quartz sand. Below this horizon the clay diminishes and disappears, while above it the glauconite and quartz sand gradually do likewise. The actual transition from one facies to the other occurs within \( \frac{1}{2} \) to 3 feet of section except in a few places in Attala County where the two facies are found interbedded at the contact. The lithology of the overlying and underlying beds and the sharpness of the contact indicate that this contact represents a rapid change from shallow marine to marsh conditions. The heterogeneity of the material at the contact was probably caused by wave agitation during the change of conditions.

This contact is the sharpest and most reliable one in the Claiborne section in Mississippi and it is the only one which persists across the state without extensive facies changes. For these reasons it was used as the datum plane upon which Plate 2 was constructed.
**Thickness** - The thickness of the Zilpha shale ranges from 0 to 75 feet in Mississippi and varies widely over short distances as shown on Plate 2. The formation is thin and absent at a few localities in Clarke and Lauderdale Counties, averaging about 15 feet and ranging up to 35 feet in thickness in that area. It becomes thicker through the central part of its outcrop, averaging about 25 feet and ranging from 0 to 60 feet and being absent at a few localities in eastern Leake County. The maximum development is reached in Attala and Holmes Counties where the average thickness is about 40 feet and the maximum of 75 feet is attained. North of that area the average thickness decreases to about 15 feet and there are numerous localities where the formation is thin to absent.

**Fossils** - In places where the Zilpha overlies fossiliferous Winona material, the basal few feet of the shale usually contain fossil molds, but fresh fossils are very rare in the formation. Both *Cetrea sellaeformis var. lisbonensis* and *Proscutella mississippiensis* occur in this basal part of the formation. Neither the macrofauna nor the microfauna of the Zilpha have been studied in detail.

**Distribution** - The small scale of the geological map precludes showing both the Zilpha and Winona outcrop belts and so they are combined. The relative areal distribution of the two formations can be obtained by a study of Figures 1 and 2 together. The outcrop of the Zilpha and Winona formations in eastern Mississippi is a thin and very irregular belt which follows the Tallahatta outcrop closely and has but a few topographic outliers and inliers. In the central part of the area this belt expands to an average width of about two miles and its
irregularity and the numerous topographic outliers reflect the strength of the Tinoma Guesta. In northeastern Carroll, northern Montgomery and Grenada Counties the outcrop is an irregular belt averaging about half a mile in width and having several topographic outliers and inliers.

**Topographic Expression** - The Zilpha shale has a weak topographic expression. The outcrop is usually marked by a topographic flat or bench which is often of considerable aid in mapping operations.

**Soils** - The Zilpha shale gives rise to a gray or brownish gray, very fine sandy loam soil. The top-soil ranges up to 8 inches in thickness and the sub-soil is of from 14 to 20 inches of brown to red, heavy, plastic silty clay or clay. The sub-soil is usually underlain by a mottled gray and red, heavy, plastic clay and in places the top-soil rests directly upon this material. These soils are known as the Boswell or Susquehanna or some closely allied series. They are distinctive and of considerable help in mapping, but are generally regarded as poor agricultural soils.

**Depositional Conditions** - The nature of the overlying and underlying materials indicates that the Zilpha shale was deposited during a time of change from marine to non-marine conditions. The formation has the characteristics of both types of deposits. Its lithology suggests that, following the deposition of the Inona, the shore line retreated in the face of accelerated non-marine sedimentation. The first indication of a change in conditions is the appearance of clay which was apparently deposited in very shallow water where wave action mixed it thoroughly with the underlying greensands. As the shore line retreated farther seaward, this clay was covered by silty clays, silts and sands deposited on the tidal flats and in
the coastal marsh. The high angle cross-bedding in the silt interbeds in the upper, shaly portion of the Zilpha indicates depositional conditions in which currents played an important part. The probable site of deposition of this material was in lakes and bays in the coastal marsh where the waves and bottom currents winnowed the silts out of the marsh deposits.

The greensand bed at the top of the Zilpha in eastern Mississippi, the glauconitic sand lenses above the main body of the Zilpha in southern Neshoba County and the several glauconitic beds in the formation in Attala County were all apparently deposited during local, minor advances of the sea.

The contact relationships indicate that the absence of the Zilpha shale at a few localities in the state is due to simple non-deposition of the facies rather than unconformable overlap.

The thinness of the lower transition facies, rarity of a repetition of facies at the contact and the general thinness of the Zilpha section across the state indicate that the change from marine to non-marine conditions occurred rapidly over a wide area.
**Kosciusko Formation**

**Introduction** - The term Kosciusko was proposed by Cooke (14) to replace Lowe's term "Decatur" which was preoccupied. Cooke's original definition of the Kosciusko is:

"The name Kosciusko sandstone member is here proposed as a designation for the lages of saccharoidal to quartzitic sandstone exposed in the vicinity of Kosciusko, the county seat of Attala County, Mississippi, and for the unconsolidated sands of the same age in Mississippi."

The beds specified by Cooke lie near the base of a thick section of non-marine sands and shales which cannot be satisfactorily subdivided and so the term Kosciusko is redefined in this report to include all beds above the Zilpha shale and below the Autubbee formation.

Most workers since Cooke have considered the Kosciusko to be a member of the Lisbon formation. It is herein raised to the rank of a formation because it is a lithologic unit with definable upper and lower boundaries which has a wide areal distribution.

**Lithology** - The Kosciusko formation is a heterogeneous, highly lenticular, non-marine section in which sands and shales are the dominant facies. The basal 50 to 200 feet of the formation is typically composed of massive to highly cross-bedded sands which are colored red, brown, yellow, purple, pink, violet, gray and white on the outcrop. This vivid coloration is a surface effect, since the sands are invariably light colored in well samples. These samples also show that some of the sands are sparingly lignitic. The sands are predominantly fine grained and fairly well sorted, but ex-

hibit all variations in grain size and degree of sorting. The individual grains are usually coated with a thin film of iron oxide.

Clay occurs in the sand as pellets, balls, irregular inclusions, partings and stringers. In a few places these inclusions become abundant enough to form clay-ball conglomerates. The clay is a light gray, sandy or silty material which becomes mottled pink or purple when slightly weathered.

Shales increase in abundance above the basal sand until they usually predominate over the sand in the upper part of the section. There are three types of shale in the Kosciusko. The light gray to mottled purple and gray, silty clay which is found as stringers and pellets in the sands also occur as lenses of shale distributed throughout the formation. Black to chocolate brown, carbonaceous shales identical to the carbonaceous shales of the Zilpha and other Claiborne formations are common as lenses in the Kosciusko throughout the central and western part of its outcrop. The third type is a dark gray to greenish gray (fresh) to light gray or brownish gray (weathered), lignitic, silty shale which grades into the carbonaceous shales on one hand and into argillaceous silts on the other. These silty shales vary in structure from even-beded and laminated to highly cross-beded. Plant fragments are abundant and well preserved fossil leaves are found at a few localities. Weathered remains of siderite concretions up to one foot largest diameter are quite common. These shales are particularly abundant in the Kosciusko in Carroll County and are well exposed along the highway between Minona and Carrollton.

The ledges of quartzitic sandstone mentioned by Cooke in
his original definition of the Kosciusko are the most distinctive feature of the formation. They are light gray, siliceous, coarse siltstones which form by surface induration from light gray, compact, argillaceous silt lenses in the massive Kosciusko sands and which appear on the outcrop as quartzitic boulders and ledges. They are best developed in Attala and Holmes Counties where they form discontinuous ledges which occupy a stratigraphic horizon 50 to 75 feet above the top of the Zilpha. They also occur in Grenada, Carroll, Leake and Neshoba Counties, but they are only locally developed in those counties. Most of the older authors mistook these ledges in Attala and Holmes Counties for Tallahatta material and considered the Claiborne section below them to be of Tallahatta age. Cooke (15) was first to recognize their true stratigraphic position.

Retrified wood and lignite are very rare in the Kosciusko formation which sometimes serves to differentiate the formation from Silcox and Cockfield beds. Also, the sands of the Kosciusko are rarely micaceous, a fact which helps to differentiate them from the lower Claiborne sands.

Limonitic sandstone, siltstone and claystone are the common concretionary materials occurring in the Kosciusko. Each has its characteristic lithology and place of occurrence. All are produced by the deposition of limonite by circulating ground-water and are surface phenomena. Limonitic sandstone forms as irregular ledges or inclusions in the iron-stained sands. It occasionally has a fluted or tubular structure. It varies from yellow-brown and some-

(15) Ibid., p. 135.
what indurated to dark brown and very hard. Sometimes these bodies form on top of clay stringers where ground-water circulation has been impeded. Elsewhere they form in massive sands where there is no apparent reason for their location. This material is abundant throughout the Kosciusko and all similar sands in the Claiborne in Mississippi. Limonitic siltstone occurs as flaky, yellow-brown concretions which form along the silty partings in the shales of the Kosciusko and shaly facies of other formations. Limonitic claystone is the least abundant of the three types. It occurs rarely at the top of chocolate brown shale lenses in the formation. The siderite concretions in the silty shales weather to shelly or concentric-structured limonitic claystone or ironstone bodies.

Lower Contact - The Kosciusko-Zilpha contact is conformable and gradational. The gradation occurs from the basal Kosciusko sand through an interbedded sand and shale section into the typical Zilpha shale. The thickness of the transition section varies from a few inches to 30 feet and often changes quite markedly over short distances. In eastern Mississippi where the top of the Zilpha is marked by a greensand bed the transition takes place through a thin section of sparingly glauconitic silt and a similar situation exists in the few places where the Kosciusko lies directly upon the inona greensand.

Thickness - The thickness of the Kosciusko formation gradually increases northwestward along the strike from 55 feet at the Alabama line to a maximum of 400 feet in Attala, Holmes and Carroll Counties. The thicknesses in the eastern part of the state were measured directly on the outcrop, those in the central part are derived from profiles, and those in the western part are taken upon projections of surface
dips combined with water and oil well data.

**Fossils** - Fossil leaves are found in the silty shales in Carroll County. The flora has not been studied.

**Distribution** - In eastern Clarke County the Kosciusko outcrop forms an irregular belt averaging about 8 miles in width. Northwestward across the state this belt increases in width to a maximum of 20 miles in Attala and Holmes Counties. Details of the distribution of the formation are shown on Plate 1.

**Topographic Expression** - The basal sands of the Kosciusko support a comparatively rugged sand hills topography. In eastern Mississippi this sand hills topography is superimposed upon the gentle slope of the Buhrstone Cuesta and throughout the remainder of the area mapped it is superimposed upon the gentle slope of the cuesta developed on the Winona. In the areas where the Zilpha formation is well developed these sands form an escarpment overlooking the topographic flat developed on the outcrop of the shale. The average local relief in the sand hills is about 75 feet, while the maximum is about 150 feet. The upper, more shaly portion of the formation supports a more rolling type of topography in which the local relief averages about 50 feet.

The quartzitic siltstone ledges in the Kosciusko in Attala and Holmes Counties exert a strong influence upon the topography. They support a bold escarpment along which the most rugged topography in the Kosciusko outcrop belt is found.

**Soils** - The sands of the Kosciusko give rise to fine sandy loam and fine sand soils known as Buston, Greenville, Orangeburg
The sand and shale sections of the Kosciusko give rise to a similar fine sandy loam which has more clay in the sub-soil. This is the Shubuta fine sandy loam or some closely allied type.

In eastern Attala, eastern Leake and southwestern Neshoba Counties the sandy soils of the Kosciusko contain abnormal quantities of silt and grade into silty loam soils. This silt is residual from a thin blanket of brown silt which once covered the area. In the area bordering the Leese Hills region on the west the Kosciusko is covered by a mantle of brown silt which gives rise to silt loam soils.

Depositional Conditions - Many features indicate that the Kosciusko is a non-marine deposit. Its heterogeneity and lenticularity and the lignitic nature of its finer grained materials all point to this conclusion. It lacks the marine fossils, glauconite and lime so characteristic of marine Tertiary deposits. The extensive cross-bedding of its sands and silty shales and the presence of clay-ball conglomerates and local erosional channels in the sands indicate a stream-laid origin. Its rather consistent thickness over a wide area precludes a flood plain site of deposition. All of these facts indicate that the formation was laid down on the coastal or deltaic plain by a number of small streams. The presence of an abundance of Zilpha-type carbonaceous shale lenses through the section indicates conditions not greatly different from the marshy conditions at or near sea-level under which the Zilpha was deposited. Only along a subsiding coast line could as much as 400 feet of such near-sea-level materials be deposited.
The lithology of the Kosciusko suggests that, following the deposition of the Zilpha, the coastal marsh was flooded by stream-borne sands while the finer grained materials were carried farther out and deposited in the coastal marsh or incorporated in the marine deposits. The general thinness of the transition facies between the Zilpha and Kosciusko formations indicates that this change occurred rapidly. During middle and upper Kosciusko time the gradients of the streams on the deltaic plain were diminished and much of the finer grained material was dropped on the coastal plain where it now appears as silts and shales.

There is little positive evidence regarding the conditions under which the quartzitic siltstones of the Kosciusko were deposited. They are derived from lenses of silt which are overlain and underlain by fine-grained, non-marine sands. Although the ledges are discontinuous, their main development occurs at about the same stratigraphic horizon. The facts that they arise from a distinctive type of compact silt and that the overlying and underlying materials are not silicified suggest that the siliceous cement may be primary. A possible site of deposition for these beds is in fresh-water lakes on the deltaic plain in which small quantities of opal were being precipitated.
Wautubbee Formation

Introduction

The term Wautubbee was introduced by Lowe in 1919 (16), the name being taken from Wautubbee Station on the Southern Railroad in northwestern Clarke County. The original definition is:

"The Wautubbee marls constitute the most extensive division of the Lisbon, since other members of the formation have unimportant outcrops. The Wautubbee beds are all marine, consisting of highly calcareous and fossiliferous marls, of gray to almost white color, or of darker bluish and greenish tints, due to the presence of glauconite. In the vicinity of Newton and a few other localities these marls pass vertically into clays or sands which are often lignitic and fossiliferous.

The Wautubbee marls are locally rich in marine fossils, exhibiting a very characteristic fauna. The large saddle-shaped oyster, Ostrea selinaiformis, is especially abundant.

These beds in southeast Mississippi have a thickness of about 100 feet, and dip southward at a rate of 23 to 25 feet to the mile. The thickness in west Mississippi is perhaps as great, though not so evident."

Since the term Wautubbee is satisfactorily defined and is well established in the literature, it is used in this report in preference to "Lisbon", Lisbon marl" or "typical Lisbon" because, although the Wautubbee section includes beds which are lithologically and faunally identical with the Lisbon formation at its type locality, those beds constitute a minor part of the section which has been called Lisbon formation in nearly all of the later Mississippi reports and it would be confusing to restrict such a well established term.

The term Wautubbee is used in this report essentially as applied by Lowe. It includes all of the marine section above the Hoskinsko and below the Cockfield in eastern and central Mississippi and its non-marine equivalent, the Chipp's Creek shale, in western Mississippi.

Mississippi. The upper contact is placed at the top of the carbonaceous shale section overlying the marls (Gordon Creek shale member of this report) rather than at the top of the marls themselves because these shales exhibit many marine characteristics and logically belong in the marine section.

Most workers in Mississippi have considered the Tautubbee beds to be a member of the Lisbon formation. The Tautubbee is considered to be a formation by the author because it can be subdivided into several lithologic units which are logically members and because it has a wide areal distribution.

In eastern Mississippi the Tautubbee section is divisible into three distinctive and persistent lithologic units which are named and given the rank of members in this report. They are:

Gordon Creek shale member (top)
Potterchito member
Arshusa marl member (bottom)

This subdivision becomes impracticable in central Newton County and the formation is mapped as undifferentiated Tautubbee as far northwest as the Yockmohockany River in northwestern Leake County. Beyond that point the section becomes highly lenticular and in southwestern Attala County the marine material disappears, interfingerling along the strike with non-marine beds. In western Holmes and Carroll Counties there is a thick tongue of carbonaceous shale lying at the stratigraphic horizon of the marine Tautubbee. It is named the Chipp's Creek shale member in this report and is considered to be the non-marine extension of the Tautubbee formation. As shown on Plate 2, the Tautubbee contacts are arbitrarily drawn across the gap.
between the northwesternmost exposure of the marine Autubbee and the type locality of the Shipp's Creek shale.

Archusa Marl Member

Introduction - The name Archusa is taken from Archusa Springs, a well-known locality and former health resort on the Chickasawhay River south of the town of Quitman, Clarke County, Mississippi. The type locality of the member is a bluff beneath the south end of the highway bridge and across the river from the springs. This member has the same lithology as the Lisbon formation at Lisbon and Claiborne Bluffs, Alabama. It constitutes the major part of Lowe's Autubbee marl and has been called "Calcereous Claiborne" by Hilgard and "Lisbon marl" and "typical Lisbon" by other authors.

Lithology - Characteristic Archusa lithology is well exposed at the locality selected as the type, which is a bluff beneath the south end of the bridge across the Chickasawhay River on highway 6. S. 45 two miles south of Quitman in the 37 of 37 of section 14/T29/N.15E. The section here starting one foot below road level at an elevation of 222 feet is:

Archusa Marl Member of Autubbee Formation - Type Section

1/2' marl or soft limestone - light gray to white, fossiliferous, sandy and glauconitic

3 1/2' marl - light gray to white, fossiliferous, sandy and sparingly glauconitic; abundant irregular clay inclusions; less indurated than bed above; scattered weathered pyritiferous concretions; abundant Astrea ellipsiformis and other fossils in basal foot

1 1/2' limestone - light gray, sandy, glauconitic and fossiliferous; forms 1/2 of small falls
10′ marl - similar to 3′ bed above; *Ustrea sellaeformis* and many other forms

1′ oyster bed - dark green, medium-grained greensand with an abundance of *Ustrea sellaeformis* and comminuted shells

8′ marl - similar to 10′ bed above

1′ limestone - discontinuous ledge of material similar to that above and below but slightly more indurated

21′ marl - similar to 10′ bed above

Base of section - low water level of Chickasawhay River

46′ Total thickness of measured section - neither contact exposed

In the area around Crandell in eastern Clarke County, the Archusa becomes quite lenticular and contains bodies of non-glauconitic sand, but elsewhere it is a persistent, homogeneous unit. In the weathered outcrop the lime is leached from the sandy marls and the residual material is a dark red, sparingly glauconitic sand with an abundance of irregular clay inclusions. When deeply weathered, the marl closely resembles some of the weathered non-marine Claiborne sands.

The basal few feet of the Archusa are typically more sandy than the remainder of the member. This part of the section is a fine to medium grained, sparingly glauconitic, calcareous sand which is relatively unfoesiliferous. It bears the same relationship to the Archusa as the pebble-bearing, glauconitic sand at the base of the basic bears to that member. The uppermost few feet of the marl contain angular fragments and irregular inclusions of tan bentonite at a few localities in Newton County.
**Lower Contact** - The Archusa-Kosciusko contact is disconformable and sharply defined. It closely resembles the Basin-Meridian contact in the eastern Mississippi area and undoubtedly represents the same sequence of events. The transition from marine to non-marine facies occurs within a 2 to 3 foot section in which the two facies are mixed in a heterogeneous fashion. The basal portion of the Archusa contains small blocks and inclusions of material from the beds below and small lenses and pockets of marl are found in the uppermost few feet of the Kosciusko. Marl-filled borings extend a foot or so down into the non-marine beds and disseminated glauconite is sometimes found as much as 15 feet below the contact. The uppermost Kosciusko beds upon which the Archusa rests change lithology over short distances along the strike from sands to carbonaceous shales to lignitic, silty shales. This is the condition which would logically be expected after truncation of the uppermost beds of the deltaic plain by wave-erosion along an advancing shore line.

This contact is a reliable mapping horizon, but is often difficult to identify on the deeply weathered outcrop.

**Thickness** - The Archusa maintains a thickness of 45 to 60 feet in Clarke, Jasper and southeastern Newton Counties. It lenses out in central Newton County, but reappears as a 15 foot lens in northeastern Scott and northwestern Newton Counties.

**Fossil** - The Archusa marl constitutes part of the Catree *sellaeformis* zone of Mississippi. It also contains a large fauna very closely related to that of the middle and upper Lisbon at Lisbon and Clifton Bluffs, Alabama.
Potterchitto Member

Introduction - The Potterchitto member is named for an outcrop near Potterchitto Creek in south-central Newton County, Mississippi. The type section is exposed in a series of road cuts along the Newton-Secatur highway (State Highway 15) on the south valley wall of the creek about 2 miles northeast of the town of Newton and in the NE of 26 and SE of 5E of 23/T6N/R16E (see Profile C). The member is lithologically the most heterogeneous of the three members of the Vautubbee formation of eastern Mississippi, but certain features make it one of the most easily identified on the weathered outcrop.

Lithology - Characteristic lithology of the Potterchitto member is well exposed at the type locality. Starting at road level at the top of a hill 0.6 miles northeast of the junction of highways U. S. 80 and State 15 at an elevation of 425, the section exposed is:

COCKFIELD FORMATION
12' sand with shale interbeds - sand red and red-brown; shale gray contact conformable and irregularly slumped

VAUTUBBEE FORMATION

GORDON CREEK SHALE MEMBER
12' carbonaceous shale to blocky clay - chocolate brown to light yellowish gray to red; basal 2' sandy and glauconitic and heterogeneous; 2' above base is a thin ledge of white, sparsely glauconitic, siliceous siltstone which is a typical feature of the member in this area contact conformable

POTTERCHITTO MEMBER - TYPE SECTION
6' glauconitic sand - dark greenish gray to light greenish gray to
red; argillaceous and lignitic; 1 foot below top of this bed is a weakly developed concretionary ledge with molds of fossils; bed locally incured into soft, white, siliceous sandstone concretionary bodies of irregular shape; basal 2 feet contain abundant molds of fossils

1 1/4' clay - chocolate brown; sandy and glauconitic; heterogeneous; many molds of fossils

6' greensand - light greenish gray to brown; argillaceous; abundant molds of fossils; near top are many irregular, concentric-structured limonitic claystone or ironstone concretions, some of which contain a core of light brownish gray siderite; 4 feet below top is an oyster bed which contains an abundance of Ostrea sellasformis and many other forms

Base of exposed section

3' missing section

Section continued starting at top of cut immediately south of Potterchitto Creek bridge

5' glauconitic sand - light greenish gray to brown; argillaceous; few molds of fossils; really a deeply weathered sandy marl or calcareous sand

1 1/2' clay - medium gray; blocky and lignitic; grading down into

1 1/2' clay - light greenish gray; sandy and glauconitic; heterogeneous; sparingly fossiliferous; scattered weathered siderite concretions near center

3' glauconitic sand - light greenish gray to yellow; very fine grained; calcareous and very fossiliferous with Ostrea sellasformis and many other forms; abundant small calcareous concre-
Oyster bed - greensand loaded with *Ostrea sellasformis* and many other forms; light greenish gray to yellow-brown; loose to slightly indurated; most prominent bed in section

Glaucitic sand or greensand - light greenish gray to yellow-brown; banded appearance; brown bands are indurated and contain earthy siderite; few thin stringers of fossiliferous greensand; six inch, dark green, medium grained, fossiliferous greensand stringer one foot above base

Total thickness of Potterchitto member

Contact conformable

Archesa Marl Member

Sandy marl - medium greenish blue to gray and yellow-gray; argillaceous, sparingly glauconitic and highly fossiliferous; lens with abundant *Ostrea sellasformis* near middle; two discontinuous 6 to 8 inch ledges of white to light gray, sandy limestone near base; about 3 feet below top is a bentonitic section in which irregular inclusions of bentonite and bentonitic clay occur in a matrix of fossiliferous marl

Base of section at road level at base of cut - elevation 359'

Total Vautubbee section measured - 66½'

Total section measured - 78½'

... nearly complete Potterchitto section similar to the type section is exposed in a cut on the county road on the south side of Potterchitto Creek 3/8ths of a mile west of the type locality and in the NE of SW of 23/T6N/R11E. The section there is less fossiliferous and the thicknesses and sequence of beds are slightly different. The
total thickness as measured by hand level is 36 feet. This section may be considered an alternative type section in case the other one is destroyed.

As shown in the described section, there is considerable variation in the lithology of the Potterchitto. All gradations from greensand to non-glaucalicite sand are found. These sands vary from calcareous and marly to non-calcereous and from highly fossiliferous to non-fossiliferous. They contain pellets, partings, interbeds and lenses of carbonaceous clay and shale. Some of the clay inclusions are tubular and filled with matrix material. The different materials are usually interbedded and poorly bedded. Occasionally they are even-bedded and thin-bedded and, in rare instances, they are cross-bedded. None of the individual beds can be traced any distance along the strike. The glauconite of the Potterchitto is both light and dark green in color and is much finer grained than the inona glauconite.

Bentonite and bentonitic clay similar in appearance and occurrence to the bentonite in the Archosa are found in the Potterchitto at a few localities. Earthy siderite is common in the member. When fresh, it is a light brownish gray color and contains considerable clay, but it weathers so readily that the unaltered material is rarely seen on the outcrop.

The weathered Potterchitto outcrop is always marked by weak concretionary ledges most of which are of brown, limonitic sandstone developed on the weathered greensand and glauconitic sand beds. They resemble the concretionary bodies in the Vinona, but are never so well developed. Some of the ledges are of brown limonitic claystone or
Ironstone derived from weathered siderite. The concretionary bodies often contain molds of fossils and weathered grains of glauconite. These concretions greatly aid in identifying the Potterchitto on the deeply weathered outcrop.

**Lower Contact** - The Potterchitto-Archusa contact is conformable and gradational. In mapping this member it was found most satisfactory to arbitrarily include as much as possible of the Potterchitto-type material in that member even if this procedure involved placing lenses of Archusa-type marl in the Potterchitto. The position of the contact at the Potterchitto type locality was established on that basis. The thickness relationships show that the type Potterchitto section is at least in part contemporaneous with the upper Archusa in Jasper and Clarke Counties (see Plate 2).

This contact represents a change of conditions similar to that represented by the cinena-basic contact in eastern Mississippi.

**Thickness** - The thickness of the Potterchitto member ranges between 12 and 30 feet in Clarke, Jasper and southeastern Newton Counties. It reaches a maximum of 36 feet at the type locality and becomes lenticular and loses its identity in northwestern Newton County.

**Fossils** - The index fossil *Gestrea selliformis* ranges throughout the Potterchitto member. In addition, the Potterchitto contains a large fauna which is closely related to that of the Archusa, but localities where fresh fossils can be collected are rare. The type locality is the best fossil locality for this member as well as one of the best Bautubbee localities in the state.
**Gordon Creek Shale Member**

**Introduction** - The name Gordon Creek is taken from a small creek which flows through Sautubbee Station and which is crossed by the Laurel-Meridian highway (U. S. 11) a short distance south of that station. The type section is designated as that shown on the profile along the highway (see Profile B). All of the important features of the lithology of the member are well exposed along this highway.

**Lithology** - The Gordon Creek member has the same lithology and stratigraphic relationships as the alpha shale. It is predominantly a carbonaceous shale which varies in color from black to chocolate brown to gray to red, depending upon the stage of weathering. Glauconite and quartz sand are abundant and irregularly distributed in the basal few feet and small pockets and lenses of that material are occasionally found well up in the section. The lower portion is characteristically a nearly pure, blocky clay, while the upper part is more silty and shaly. Plant fragments are found throughout the section, but are more abundant in the upper, shaly portion. Thin, irregular partings and interbeds of gray, lignitic, micaceous silt are abundant in the upper part of the section. This typical lithology is best exposed on the type profile in a cut along the old highway immediately east of the present highway location at a point 1.0 miles north of the highway overpass near Sautubbee Station and again at the type locality of the Potterschitto member.

The second facies of the Gordon Creek exposed along the type profile is that of a dark greenish gray (fresh) to light gray (weathered), lignitic, argillaceous, sparingly glauconitic silt or silty shale. This facies is well exposed in the cut beneath the overpass near Sautubbee Station and in cuts along the highway for several
miles south of that point. It is a comparatively rare facies of the member.

Thin beds of light gray to white, platy, sparingly glauconitic, siliceous siltstone with a superficial resemblance to some of the Basic siltstones are common in the Gordon Creek in Newton, Jasper and northwestern Clarke Counties. The best development of these beds is found in the area west of Decatur, Newton County, where a five foot section occurs at the top of the member. Elsewhere they occur as two or three thin beds near the base of the section.

A six inch stringer of the bentonite is found at the base of the Gordon Creek in Jasper County and small quantities of light green bentonite or bentonitic clay are found at the same horizon at several localities in Clarke County.

**Lower Contact** - The Gordon Creek-Potcherchitto contact is conformable and sharply defined. It is very similar in details to the Zilpha-Sinona contact and represents the same sequence of events. The material at the contact proper is a heterogeneous mixture of carbonaceous clay, glauconite and quartz sand. Downward from this horizon, the carbonaceous clay becomes increasingly rare, while upward the quartz sand and glauconite become rare and disappear.

This contact is a good one on which to do detailed field work. It normally comes a foot or two above the uppermost concretionary material of the Potcherchitto and can readily be picked on the outcrop.

**Thickness** - In contrast to the wide variations in thickness of the Zilpha, the Gordon Creek member maintains a consistent thickness of between 15 and 25 feet throughout its extent.
Fossils - *Ostrea sellasformis* ranges up into the basal few feet of the Gordon Creek. Wolls of fossils occur occasionally in the basal, glauconitic portion of the member, but no localities were found where fresh material could be collected. No check has been made on these shales for microfossils.

**Undifferentiated Wautubbee of Central Mississippi**

**Introduction** - The three-fold subdivision of the Wautubbee formation of eastern Mississippi can be satisfactorily carried northwest to Township 7 North, Range 11 East, central Newton County. Beyond that township the different facies become so lenticular that satisfactory subdivision of the section is impractical and the formation is undifferentiated. This undifferentiated marine sequence continues unbroken along the strike to the Yockahockany River in northwestern Leake County. Northwest of that river the marine materials occur only as discontinuous lenses which lie near the same stratigraphic horizon and which can be traced into the area around the village of Newport, southwestern Attala County without serious difficulty. Northwest of Newport the stratigraphic equivalent of the marine Wautubbee is a highly lenticular section of non-marine sands and carbonaceous shales.

**Lithology** - The Wautubbee of central Mississippi is composed of carbonaceous shales, fossiliferous to non-fossiliferous greensands and glauconitic sands, non-glauconitic sands and fossiliferous, sandy marls. The section is essentially a highly interlensed mass of the three eastern Mississippi facies of the formation. The lower part is usually composed of greensands, glauconitic sands and marls, while
the upper portion is typically composed of carbonaceous shales, but in local areas the shales extend to the base of the section and in other places the sands are found at the top. In central Leake County there are two 5 to 15 foot lenses of shaly glauconitic sand which lie well above the main body of the Mautubbee and are separated from it by non-marine sands. These lenses appear to be deposits which were laid down during local, minor advances of the sea and they are included in the Mautubbee in order to keep all marine materials in that formation.

Lower Contact - The lower contact of the Mautubbee of central Mississippi is disconformable as far northwest as the Yockahockany River. Beyond that point the main advance of the Mautubbee sea was broken into several localized minor advances. The details of the contact in the area southeast of the river are very similar to the details of the Archusa-Kosciusko contact in eastern Mississippi and the contact forms a valuable mapping horizon which is often marked by weak concretionary ledges.

Thickness - The thickness of the Mautubbee section in northwestern Newton and northeastern Scott Counties ranges from 45 to 75 feet. Northward along strike the thickness varies somewhat but gradually diminishes to 12 feet at the Yockahockany River. The inclusion of the two marine lenses lying above the main body of the formation increases the thickness to a maximum of 75 feet in central Leake County. Elevations of the lenses of marine material in the section northwest of the Yockahockany River show that they lie at slightly different horizons, the maximum vertical difference between these horizons being about 40 feet.
**Fossils** - The Wautubbee beds of central Mississippi are locally highly fossiliferous, but there are few localities in the area where satisfactory collecting is possible. As in the case of the Rotterchitto, most of the fossiliferous beds are porous sands which are deeply leached and the fossils are seen as molds. These molds are found in the beds as far northwest as the marine lenses are found. The best fossil localities in the central Mississippi area are found in the marls at the base of the formation in northeastern Scott and northwestern Newton Counties. The beds at these localities contain about the same fauna as the Archusa.

*Cotrea sellasformis* is found as far northwest as fossils are found in the formation.

**Shipp's Creek Shale Member**

**Introduction** - Beneath the Quaternary sands and gravels in northwestern Holmes and southwestern Carroll Counties, there outcrops a thick section of carbonaceous shales which constitutes a distinctive lithologic unit. There is very little similar material in the 450 feet of overlying non-marine Cockfield beds and the section below is predominantly a non-marine sand section with lenses of carbonaceous shale and lignitic, silty shale. This thick section of carbonaceous shale is herein named the Shipp's Creek shale, the name being taken from Shipp's Creek, a tributary to Black Creek in east-central Holmes County, Mississippi.

The Shipp's Creek shale is at least in part the stratigraphic equivalent of the marine Wautubbee of central Mississippi because it lies at the same stratigraphic horizon in an area in which non-marine
sedimentation was continuous throughout upper and middle Claiborne time. The Shipp's Creek occupies a position in the middle of the section between the top of the Sinoma and the top of the Claiborne. The marine autubbee occupies the same position in the section on the outcrop in central Mississippi and in the subsurface section in Yazoo County. The Shipp's Creek outcrop also lies along the projection of the normal strike of the marine autubbee.

Lithology - Lithology typical of this member is well exposed along practically every stream in the Less Hills region of northwestern Holmes and southwestern Carroll counties. The best exposures are found on a series of bluffs on Chicopa Creek and its tributary Jordan's Branch (Phillip's Creek) in extreme northwestern Holmes County where 80 to 100 feet of the section can be seen in the fresh state. These outcrops are relatively inaccessible and so an exposure in a cut along the county road immediately south of the iron bridge across Shipp's Creek in the SE of NE of section 28/T15N/R3E and about 4 miles (airline) east-northeast of Lexington, Holmes County, Mississippi was selected as the type. The section here is:

Cockfield Formation

23' sand - iron-stained; irregularly bedded to massive; abundant slab-like pieces of dark brown, limonitic sandstone up to 2 inches thick; brown silt mantle

Autubbee Formation

Shipp's Creek Shale Member - Type Section

14' carbonaceous shale - chocolate brown to light gray; laminated and with irregular partings and interbeds up to 4 inches
thick of light gray coarse silt; fresh material highly lignitic and with an occasional fossil leaf; flaky yellow-brown siltstone concretions along silty partings; at the top is a thin limonitic sandstone ledge of the type commonly formed on the top of shale sections by circulating ground-water.

2½' sand — gray to yellow to brown; very fine grained and loose; few partings of gray shale; grading down into

7½' sand — similar to above but more partings and stringers of gray to chocolate shale with abundant flaky siltstone concretions in the more weathered material

2' carbonaceous shale - chocolate brown

6' covered

Section continued beneath bridge

16' carbonaceous shale - black to chocolate brown; laminated; whole mass regularly bedded, but individual laminae extremely irregular and lenticular; partings, interbeds and pockets of coarse silt; abundant fragments of plants and an occasional fossil leaf

ater level of Shipp's Creek - elevation 234' (altimeter)

46' Total Shipp's Creek section - base not exposed

Total section measured - 71 feet

The Shipp's Creek member is much more lenticular than could possibly be illustrated on Plate 2. The carbonaceous shales are interbedded and interlensed with silts and sands in an extremely complex manner. The best illustration of this condition is found in a comparison of the type section with the section exposed at a bluff on
the south side of Shipps Creek on the Chuck Swinney place about half a mile above the type locality and near the center of section 27/T15N/R3E. The section there is:

SHIPPS CREEK SHALE MEMBER OF WATUDBBE FORMATION

20' sand - light gray, white and yellow-brown; very fine grained and micaceous; partings, stringers and interbeds of carbonaceous shale; this bed changes laterally into a carbonaceous shale section at the lower end of the bluff (within a hundred yards)

6 to 8' carbonaceous shale - black to chocolate brown; irregular partings of medium gray, lignitic, micaceous coarse silt and a few thin stringers of black lignite; shale nearly pure clay and contains an abundance of plant fragments

3 to 5' sand - white to yellow-brown; bands and partings of black, lignitic concentrates and brown, lignitic clay; micaceous; individual beds lenticular and cross-bedded

1½' shale or clay - dark gray to black; silty and lignitic; yellowish efflorescence on slightly oxidized surface; lenses of light gray silt; extremely irregular structure; this bed truncates underlying bed

2½' coarse silt - medium gray to brown; micaceous; yellowish efflorescence on slightly oxidized surface; few irregular partings and oriented blebs of gray, lignitic clay

5' silty shale or interlaminated silt and clay - medium gray to brown; lignitic and micaceous; structure of whole even-bedded and of individual laminae highly irregular and lenticular

lower level of Shipps Creek - elevation 240' (alimeter)

Total section measured - 40 feet
In addition to the carbonaceous shales and more or less lignitic silts and sands, the Shipp's Creek member contains a few thin interbeds of black, impure lignite.

**Contacts** - The lower contact of the Shipp's Creek is conformable and highly transitional. It is arbitrarily drawn at the base of the section in which carbonaceous shales are the predominant facies in southwestern Carroll and northwestern Holmes Counties. As shown on Plate 2, the section in the eastern Holmes-southwestern Attala County area is a lenticular mass of carbonaceous shales and non-glauconitic sands which cannot be satisfactorily subdivided and the basal contact is arbitrarily projected through this area on convenient carbonaceous shale lenses in order to join the basal contact of the marine autunbee.

The upper contact is also conformable. It varies from sharply defined to transitional, but is a much more definite horizon than the lower contact, since there is little carbonaceous shale in the Cockfield section in Holmes and Yazoo Counties. This contact is projected across southwestern Attala County on carbonaceous shale lenses to join the upper marine autunbee contact. Both the upper and lower contacts are dashed on Plate 1 throughout the area northwest of the Yockahockany River because of their arbitrary nature in that area.

**Thickness** - The maximum development of the Shipp's Creek is reached along the bluffs which border the alluvial valley of the Mississippi River. The thickness of the member here is about 200 feet, that figure being derived by reference to subsurface contours on top of the Mississippian. The thickness decreases rapidly eastward and is only about 65 feet in the Shipp's Creek area. The arbitrarily defined section included in the Shipp's Creek across eastern Holmes and southwestern
Atalla Counties averages about 40 feet in thickness.

**Fossils** - Fossil leaves occur throughout the Shipp's Creek but are nowhere abundant. They have not been studied in detail.

**General Features of the Wautubbee Formation**

**Distribution** - The distribution of the Wautubbee outcrop is shown on Plate 1. It is an irregular belt averaging about two miles in width and ranging from one-half to six miles wide which extends from the Alabama-Mississippi state line near Crandall, Clarke County northwest across the state to the bluffs in northwestern Holmes and southwestern Carroll Counties.

**Topographic Expression** - The weak carbonaceous shales which constitute the Gordon Creek member in eastern Mississippi and the upper portion of the undifferentiated Wautubbee of central Mississippi give rise to a distinctive topographic flat or bench which greatly aids in mapping the formation. The other beds of the section have no distinctive topographic influence and their outcrop is a continuation of the sand hills topography of the Cockfield and Kosciusko formations.

**Soils** - The materials of the Wautubbee give rise to a number of different soils. The sparingly glauconitic to non-glaucousitic sands give rise to fine sandy loams or fine sands of the Ruston, Greenville, Orangeburg and Norfolk series which have been described under the soils of the Neshoba sand on page 22. The greensands and highly glauconitic sands give rise to fine sandy loams of the Nacogdoches and allied series described under soils of the Winona and the carbonaceous shales give rise to the distinctive Boswell and Susque-
hanna very fine sandy or silty loams described under soils of the Zilpha.

**Depositional Conditions** — The deposition of the Wautubbee was initiated by an advance of the sea over the Kosciusko deltaic plain. The maximum northern extent of this advance was to the latitude of southwestern Attala County. The decreasing thickness and lithologic changes of the formation along strike indicate that this advance probably did not occur simultaneously throughout the area, but was initiated in eastern Mississippi and gradually extended northward to its maximum advance. If so, the upper part of the Kosciusko and the lower part of the Cockfield formations of western Mississippi are the time equivalents of part of the Wautubbee section in eastern Mississippi.

The disappearance of the marine Wautubbee section in southwestern Attala County is not due to overlap or truncation of the marine section. This is evidenced by:

1. The marine lenses in southwestern Attala County do not lie at the same stratigraphic horizon as they would if they were remnants of a formerly continuous section.

2. The carbonaceous shales and marine sands of the Wautubbee exhibit a normal and conformable relationship in the area where the marine section disappears. The carbonaceous shales which normally overlie the marine beds are present throughout. They would be absent had truncation occurred.

3. The Wautubbee beds become progressively more shallow-water deposits northwestward along strike.

This disappearance of a marine section is an example of what probably
happens to all marine sections in the Tertiary of the Gulf Coastal Plain in the area of maximum marine advance. In such an area non-marine sedimentation occurs on the deltaic plain simultaneously with marine sedimentation just off-shore and minor retreats and advances of the sea produce an interlensing of the two facies.

The abundance of the large oyster, *Ostrea sellaeformis*, and other shallow-water forms, the clay inclusions and the sandy nature of the Archusia marl indicate that it was deposited fairly near shore in clear, shallow waters in which lime was being precipitated. The lack of bedding and lithologic breaks and the homogeneity of the materials indicate uniform conditions throughout its deposition. The irregular bedding and lenticular nature of the beds of the Potterchitto indicate that it was deposited nearer shore than the Archusia in an environment in which current action was quite strong. This shallow­ing of the sea corresponded closely to conditions during Winona time. The greensands and glauconitic sands of the undifferentiated Autobbee of central Mississippi were deposited under the same conditions as the Potterchitto.

Marine conditions were brought to a close by an advance of the deltaic plain over the shallow marine deposits in the same manner that the deposition of the Zilpha ended the Tallahatta-Winona marine epoch. The deposits which were laid down during this change from marine to non-marine conditions were incorporated in the section as the Gordon Creek shale and the carbonaceous shales of the upper Autobbee of central Mississippi. The sharp nature of the Gordon Creek-Potterchitto contact indicates that this change was very rapid in eastern Mississippi, but the lenses of greensand and glauconitic sand in the carbonaceous
shales throughout central Mississippi and above the main body of the formation in central Leake County point to many minor, localized advances of the sea in that area.

The thick, non-marine section between the top of the Kilpha and the top of the Cockfield in western Mississippi indicates unbroken deltaic plain depositional conditions throughout Kosciusko, Mautubbee and Cockfield times in that area. During Shipp's Creek time the shore line apparently drew near the northwestern Holmes-southwestern Carroll County area and marshy conditions probably existed while that member was deposited.
Cockfield Formation

Introduction - The beds in Mississippi which are called Cockfield in this report were first noted by Hilgard (17) in 1860, but Lowe (18) first gave them a formal name, calling them the Cockfield Lignite member of the Lisbon formation. Later authors have called them both Cockfield and Yegua. Most of these writers have restricted the Cockfield or Yegua to the upper, more shaly portion of the section herein called Cockfield. In this report the formation is expanded to include all beds below the Moody's Branch (basal Jackson) and above the Autunbee. This usage is in agreement with the usage of the term Cockfield in Louisiana where the type locality is situated and gives the formation a definite basal contact rather than an arbitrary and highly transitional one.

Stenzel (19) has summarized the history of the names Yegua and Cockfield. He points out that the type locality of the Yegua is in reality a part of the marine Crockett formation and that the term Lufkin has priority over the term Yegua. The only point in favor of retention of the term Yegua is its common usage. On the other hand the type section of the Cockfield is representative of the lithology of the formation and occurs near the middle of the Cockfield section. The term Cockfield does not have priority over either Yegua or Lufkin,


but is well established in Louisiana literature and is preferred over Yegua in this report.

The name Cockfield was proposed by Vaughn (20) in 1895. He called the section the "Cocksfield Ferry beds" after a locality in Grant Parish, Louisiana. Veatch (21) later changed the spelling slightly and abbreviated the name to Cockfield.

The Cockfield of Mississippi has been considered both a member of the Lisbon formation and a separate formation. The tendency in later reports has been to give it formational rank and that procedure is followed in this report because the section is a well-defined lithologic unit which has a wide areal distribution.

**Lithology** - The lithology of the Cockfield beds is essentially the same as that of the Kosciusko section. The basal 25 to 125 feet of the formation are composed of massive to highly cross-bedded, iron-stained sands. Upward in the section lenses of shale become more and more abundant and usually predominate over the sands in the uppermost part of the formation. The shales are of both the carbonaceous and lignitic, silty types described under the lithology of the Kosciusko. The transition from the basal, sandy portion to the upper sand and shale part of the section is so gradual that no logical separation of these two facies can be made in the field.

As shown on Plate 2, a marked lithologic change occurs in the Cockfield section in western Mississippi. On the bluffs in western

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Holmes and northwestern Yazoo Counties the upper 300 feet of the formation consists of dark greenish gray (fresh) to light gray (weathered), lignitic, argillaceous silt and silty shale with irregular partings and interbeds of lighter colored silt. Lenses of gray, lignitic, leaf-bearing clay and lignitic to non-lignitic sands occur in the silts. The sands vary from black to gray in color, depending upon the lignitic content, and from massive to cross-bedded. Carbonaceous shales are very rare in this sequence.

Lignite is abundant as beds up to 5 feet thick in the finer grained Cockfield sediments. The lignites are typically black and impure. Some of them show roots extending down into the underlying materials and have obviously formed in place, while others appear to be composed of material transported to the site of deposition. The best exposures of the lignites are found along the bluffs where the outcrops are fresh. They are rarely seen on the surface in central and eastern Mississippi because of the deep weathering in that area. These beds contain an abundance of well preserved fossil leaves and other plant fragments.

A thin stringer of tan bentonite which lies near the top of the formation is found at a few exposures in extreme southwestern Holmes County. Along the bluffs east of Tchula, Holmes County a thick bed of quartzitic siltstone similar to the ledges in the Kosciusko is found.

The most common concretionary materials found in the Cockfield are the familiar limonitic sandstones and siltstones formed by circulating ground-waters. The lignitic, argillaceous silts and silty
shales contain both pyrite and siderite concretions. The pyrite concretions are small, cylindrical bodies which are formed in vertical, silt-filled pipes in the argillaceous silts. The pyrite binds the silt into an indurated pyritiferous siltstone. The siderite occurs as rounded to spheroidal to flattened boulders which range up to 5 feet largest diameter and which occur at a definite horizon about 50 feet below the top of the formation in northwestern Yazoo and southwestern Holmes Counties. At a few localities the argillaceous silts contain rounded calcareous siltstone concretions up to 8 inches in diameter.

**Lower Contact** - The Cockfield-Mautubbee contact is conformable and transitional. It is similar in its details to the Kosciusko-Zilpha contact and represents the same sequence of events. Throughout central and eastern Mississippi the basal Cockfield sand grades down into the underlying carbonaceous shale through an interbedded sand and shale section which ranges from a few inches to 10 feet in thickness. Scattered lenses of carbonaceous shale are found in the basal Cockfield sand. At some outcrops in Scott and Leake Counties the Cockfield rests directly upon greensands and glauconitic sands and the basal few feet of the Cockfield contain glauconite which gradually disappears upward in the section. A similar condition exists in the vicinity of Mautubbee Station where the Cockfield overlies the sparingly glauconitic silts of the Gordon Creek member.

This contact is easily identified on the outcrop and makes a satisfactory mapping horizon as far northwest as the Yockahockany River. The details of the contact between the Cockfield and the
Shipp's Creek shale have been discussed under the contacts of the Shipp's Creek on page 63.

**Upper Contact** - The contact between the Moody's Branch (basal Jackson) and the Cockfield is disconformable. The Moody's Branch is composed of fossiliferous greensands and glauconitic sands which become more marly near the top of the section and which are overlain conformably by the marine Yasoo clay. The Moody's Branch is a basal, sandy concentrate which bears the same relationship to the overlying marine Jackson section that the basal, pebble-bearing glauconitic sand bears to the main body of the Basic claystone and that the basal, sandy portion of the Wautubbee bears to the overlying marine section.

The contact resembles the lower Wautubbee and lower Basic contacts in its details and represents a similar sequence of events. The transition between the two facies occurs within a 1 to 10 foot section in which the Moody's Branch and Cockfield materials are intimately and heterogeneously mixed. The basal few feet of the marine section contain small blocks and other inclusions of material from below and the uppermost part of the Cockfield contains small pockets and filled borings and lenses of fossiliferous material from the bed above as well as disseminated glauconite.

The Moody's Branch-Cockfield contact is a good one on which to base detailed mapping but is seldom used because the Moody's Branch is thin and its upper contact is one of the best in the Tertiary section of Mississippi.

**Thickness** - The Cockfield maintains a constant thickness of about 50 feet across Clarke County and gradually thickens northwestward from that area to a maximum thickness of about 450 feet in
Holmes and Yazoo Counties. Thicknesses under 75 feet were measured directly on the outcrop, those in the central part of the area were obtained by a projection of dips on surface contours and those in the western part by reference to subsurface contours on top the Pinona.

**Fossils** - There are a number of good fossil, leaf localities in the lignites and leaf-bearing clays of the Cockfield along the bluffs. The remainder of the outcrop is so badly weathered that such localities are very rare. This flora has not been studied in detail.

**Distribution** - The Cockfield outcrop is shown on Plate 1. It forms a belt with irregular boundaries which trends about 45 degrees west of north across the state. This belt is quite sinuous in Clarke County and ranges from ½ to 7 miles in width. Northwestward from that area it gradually increases in width to an average of about 15 miles in western Mississippi.

**Topographic Expression** - The basal sands of the Cockfield support a rugged sand hills topography and form a marked escarpment overlooking the topographic bench formed on the weak shales of the upper Autunbee throughout central and eastern Mississippi. The average local relief throughout this belt is about 75 feet and the maximum is about 125 feet. The upper, more shaly portion of the Cockfield supports a more rolling sand hills topography in which the average local relief is about 50 feet. These rolling sand hills merge with the very gently rolling Jackson or Yazoo prairie region to the southwest.

**Soils** - The Cockfield sediments give rise to soils very similar to those found on the Kosciusko outcrop. The massive sands form fine
sandy loams and fine sands of the Huston and allied series, while the 

sands and shales give rise to fine sandy loams of the Shubuta and 

allied series. These soils have been described under the soils of 

the Kosciusko and Kosheba.

As in the case of the Kosciusko, the soils of the Cockfield 
in western Mississippi contain abnormal amounts of silt and in 
western Madison, northeastern Yazoo and southeastern Holmes Counties 
the outcrop is covered by a mantle of brown silt which gives rise to 
silt loam soils. In Leake, Scott and Newton Counties the soils of 
the Cockfield often contain an abundance of small, white quartz 
pebbles which are residual from a younger Pliocene or Pleistocene 
(Citronelle) blanket which once covered that area.

Depositional Conditions - The conditions under which the 
Cockfield sediments were deposited were the same as those under 
which the Kosciusko beds were laid down. The nature of the lower 
contact shows that the deposition was initiated by a rapid flooding 
of the coastal marsh by a thick section of stream-deposited sands. 
The gradients of the streams on the deltaic plain gradually dimin-
ished and during upper Cockfield time considerably more fine grained 
material was deposited. Conditions were apparently much more marshy 
and swampy in the southwestern Holmes-northeastern Yazoo County area 
during middle and upper Cockfield time than elsewhere in the outcrop 
area and a thick section of fine grained, lignitic material was laid 
down there.

Non-marine Cockfield depositional conditions were ended by 
the concerted advance of the Jackson sea.
CORRELATION OF THE CLAIBORNE OF MISSISSIPPI WITH THE

TYPE CLAIBORNE SECTION

INTRODUCTION

As generally accepted, the type Claiborne section of western Alabama consists of three formations. They are:

Gosport fossiliferous sand
Lisbon sandy marl
Tallahatta formation or "buhrestone"

This section is entirely marine and is quite different from the alternating marine and non-marine Claiborne sequence of eastern Mississippi. The transition from one section to the other occurs in Clarke, southern Choctaw and northeastern Washington Counties, Alabama. In this area two large structural features, the Hatchetigbee anticline and the Jackson fault, bring Claiborne beds to the surface which would normally be 20 to 30 miles down-dip from the normal outcrop. Marked changes occur in the Claiborne section both along the normal outcrop and down-dip (on structure). Figure 2 is a diagram showing the author's interpretation of the stratigraphic relationships of the Claiborne group in eastern Mississippi and western Alabama. It shows only the general features of the correlation, since the problem is in reality quite complex and the data is incomplete in many instances. The largest and most important gap in the data is along the normal strike of the Claiborne group across Clarke County, Alabama.
Figure 2 - Diagram Showing Correlation of Claiborne Group of Eastern Mississippi with Type Claiborne Section of Western Alabama

By Paul Thomas

Vertical Scale - 1"=150'
Horizontal Scale - 1"=10 Mi

1941
TALLAHATTA FORMATION

The Tallahatta formation takes its name from the Tallahatta Hills in southeastern Choctaw County, Alabama where the beds are well exposed. The type section is the lithologic and stratigraphic counterpart of the Basic claystone of eastern Mississippi. The Tallahatta persists throughout western Alabama, averaging about 100 feet in thickness and reaching a maximum thickness of 125 feet. Most Alabama reports give this thickness as about 300 feet after Smith and Johnson (22), but this is a carefully preserved error. The basal, pebble-bearing glauconitic sand is persistent throughout western Alabama.

LISBON AND GOSPORT FORMATIONS

Introduction

The type middle and upper Claiborne section at Lisbon and Claiborne Bluffs on the Alabama River in Clarke and Monroe Counties, Alabama and about 65 miles along the normal strike east-southeast of the Mississippi-Alabama state line has been described by Smith and Johnson (23) and copied in most later Alabama reports. A generalization of their lower Jackson and Claiborne section with the formal names later given is:


<table>
<thead>
<tr>
<th></th>
<th>Beds</th>
<th>Thickness</th>
<th>Present Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>white limestone</td>
<td></td>
<td>45'</td>
<td>Jackson</td>
</tr>
<tr>
<td>&quot;Scutella bed&quot;</td>
<td></td>
<td>3'</td>
<td></td>
</tr>
<tr>
<td>coarse glauconitic sand</td>
<td></td>
<td>6'</td>
<td>Gosport (24)</td>
</tr>
<tr>
<td>sparingly glauconitic sand loaded with shells</td>
<td></td>
<td>15-17'</td>
<td></td>
</tr>
<tr>
<td>interbedded glauconitic sandy marls, calcareous clays and calcareous sands</td>
<td></td>
<td>92'</td>
<td></td>
</tr>
<tr>
<td>glauconitic sands</td>
<td></td>
<td>23'</td>
<td></td>
</tr>
<tr>
<td>bluish black clay (only partially exposed)</td>
<td></td>
<td>13'</td>
<td>Tallahatta</td>
</tr>
</tbody>
</table>

A very similar Gosport-Lisbon section is exposed down-dip along the Jackson fault on Little Stave Creek about 3 miles north of Jackson, Clarke County, Alabama.

The eastern Mississippi section which is equivalent to the above Gosport-Lisbon section is:

<table>
<thead>
<tr>
<th>Formation</th>
<th>Beds</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>J'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C'Moody's</td>
<td>Sandy, sparingly glauconitic limestone</td>
<td>1-3'</td>
</tr>
<tr>
<td>K'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S'Branch</td>
<td>fossiliferous greensand</td>
<td>5-10'</td>
</tr>
<tr>
<td>C'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N'</td>
<td>non-marine sands and shales</td>
<td>50'</td>
</tr>
<tr>
<td>C'Lautubee</td>
<td>sandy marls and glauconitic sands with 20'</td>
<td>60'</td>
</tr>
<tr>
<td>C'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K'Ocosiusko</td>
<td>non-marine sands</td>
<td>85'</td>
</tr>
<tr>
<td>C'</td>
<td>Zilpha</td>
<td>10'</td>
</tr>
<tr>
<td>C'</td>
<td>Chinona</td>
<td>10'</td>
</tr>
</tbody>
</table>

(24) The original definition of the Gosport includes all beds below the white limestone ("St. Stephens limestone") and above the Lisbon.
Each of these eastern Mississippi formations has a lithologic equivalent in western Alabama.

**Winona Equivalent**

Coarse grained greensands of typical Winona aspect and carrying both *Proscutella mississippiensis* and *Ostracella sellaformis var. lisbonensis* are found overlying the Tallahatta throughout most of western Alabama. They are absent to poorly developed along the crest of the escarpment formed on the normal Tallahatta outcrop, but become progressively thicker and more marine in aspect down-dip on the Hatchetigbee anticline. Both the upper and lower contacts of this section are conformable, indicating that this is a simple up-dip lensing out of a marine section rather than an unconformable overlap.

The Winona equivalent is mappable around the Hatchetigbee anticline and occurs as a 2 foot section on Little Stave Creek. The extent of its development along the normal outcrop through Clarke County is unknown, but it is present as 6 feet of cross-bedded glauconitic sand with coarse-grained glauconite and quartz pebbles along highway U. S. 43 near Alameda, Clarke County, Alabama and can probably be traced into Lisbon Bluff where its probable equivalent is at least part of the 23 foot glauconitic sand section which overlies the Tallahatta. The distinctive lithology and persistence of these beds throughout western Alabama warrant their recognition as a member of the Lisbon formation.

**Zilpha Equivalent**

The carbonaceous shales which overlie the Winona throughout Mississippi are very poorly developed in western Alabama. They are
found only at isolated outcrops and have little value as a mapping unit.

**Kosciusko Equivalent**

The massive to cross-bedded, non-glaucnonitic sands of the Kosciusko of eastern Mississippi can be traced well into western Alabama. This section averages about 65 feet in thickness along the normal outcrop in Choctaw County, Alabama and is exposed over a wide area on the gentle slope of the Bulrstone Cuesta. The extent of the development of these sands along the normal outcrop belt through Clarke County, Alabama is not known, but they can be recognized as 14 feet of medium to coarse grained, pebble-bearing, non-glaucnonitic sand along highway U.S. 43 near Alameda. It apparently lenses out into the lower part of the type Lisbon section in eastern Clarke County, Alabama. These beds can be traced around the southwestern flank of the Hatchetigbee anticline. They become progressively thinner down-dip and lense out near the Tombigbee River in northeastern Washington County. These sands form a mappable unit over a considerable area in western Alabama and should be recognized as a member of the Lisbon formation in that area.

**Wautubbee Equivalent or Typical Lisbon Facies**

The Archusa member of the Wautubbee formation of eastern Mississippi is in reality a tongue of the marine Lisbon section developed at Lisbon and Claiborne Bluffs, Alabama. The Potterchitto member contains essentially the same fauna, but has a slightly different facies from any of the type Lisbon beds, while the Gordon Creek shale is a facies developed only where the marine autubbee section is overlain by non-marine beds and is absent at Claiborne Bluff. The three-fold subdivision of the Wautubbee section of
eastern Mississippi can be made at some localities, but the facies are not persistent enough to warrant subdivision of the section.

The typical Lisbon marl facies or Autubbee equivalent of Choctaw County, Alabama is very similar to the Autubbee section of eastern Clarke County, Mississippi. It is quite lenticular, but can be traced without serious interruption around the southwestern flank of the Hatchetigbee anticline into the down-dip Lisbon marl section on Little Stave Creek where it reaches 140 feet in thickness. The basal contact shows less and less evidence of being disconformable and the upper contact becomes more and more gradational southeastward from the state line.

The extent of development and the relationships of this typical Lisbon marl section along the normal outcrop belt in Clarke County, Alabama are not known. The stratigraphic relationships in this area are apparently quite complex because only 25 feet of fossiliferous, silty clay which might be considered to be of typical Lisbon facies are found overlying the Kosciusko equivalent along highway U. S. 43 between Alameda and Fulton. This section is only 20 miles along the normal strike from Claiborne and Lisbon Bluffs where the marl and clay section is 92 feet thick.

**Cockfield Equivalent**

The Gosport sand has long been considered to be the correlatives of the Cockfield formation, although the evidence for this correlation has never been adequately presented. Cooke (25) and

Gardner (26) have recently presented stratigraphic and paleontological evidence in companion papers to show that the Gosport sand is at least in part the equivalent of the Moody's Branch of Mississippi. Stenzel (27) disagrees with this correlation on the basis of both stratigraphic and faunal evidence. Blanpied and Hazzard (28), after detailed field work in western Alabama, say: "It is the writer's opinion that the lithologic change from marine Gosport sands of southwestern Alabama to the non-marine Cockfield of eastern Mississippi represents a lateral and gradational interfingering of marine fossiliferous green sands with lacustrine, non-fossiliferous sands and carbonaceous clays."

The writer's conclusions regarding the stratigraphic relationships of the Gosport, Moody's Branch and Cockfield are:

1. The uppermost few feet of the Gosport (as originally defined) are probably the stratigraphic equivalent of the middle and lower Moody's Branch of eastern Mississippi. The Moody's Branch of Clarke County, Mississippi consists of an upper 1 to 3 feet of sandy, glauconitic limestone, while the lower 5 to 15 feet are fossiliferous greensands. The upper Moody's Branch is tentatively correlated with the limestone overlying the "Acetella bed" on Little Stave Creek on the basis of its field relationships and lithology. If this correlation is correct, the upper part of the fossiliferous greensand section

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underlying the limestone on Little Stave Creek is the stratigraphic equivalent of the lower fossiliferous greensands of the Moody's Branch of Clarke County, Mississippi. Since the Gosport sections at Claiborne Bluff and Little Stave Creek are quite similar, the same correlation probably holds at Claiborne Bluff.

2. The lower part of the Gosport interfingers with upper Cockfield shales and is of upper Cockfield age. Blanpied and Hazzard (29) record from 24 to 37 feet of Gosport in a series of core-holes in northeastern Washington County, Alabama. The upper 10 feet or so of this section is the stratigraphic equivalent of the Moody's Branch of eastern Mississippi, while the lower part of this section can be seen interfingered with upper Cockfield shales on the surface at the well-known Yellow Branch locality a few miles northwest along strike from the core-holes.

3. The lower part of the Cockfield section of eastern Mississippi is older than Gosport. This lower Cockfield section can be traced around the southwestern flank of the Hatchetigbee anticline as far as the Tombigbee River where it lenses out between the Gosport and typical Lisbon marl. Blanpied and Hazzard (30) record from 20 to 44 feet of "typical Cockfield" underlying the full Gosport section in their core-holes in northeastern Washington County, but this "typical Cockfield" section is absent across the Tombigbee River on Little Stave Creek. The full section of overlying Gosport across

(30) B. W. Blanpied and R. T. Hazzard, Ibid.
this area and the thickening of the Lisbon marl section with the thinning of the lower part of the Cockfield equivalent indicate an upper Lisbon age for the lower Cockfield.
CYCLIC DEPOSITIONAL PATTERN

Several geologists working in various parts of the Gulf Coastal Plain have recognized that the Tertiary beds were deposited in definite cyclic patterns which are of fundamental importance to a logical interpretation of the stratigraphy and depositional history in that area. The Claiborne section of eastern and central Mississippian exhibits such a cyclic depositional pattern. It is:

- disconformity
- non-marine sands and shales (top)
- conformity
- carbonaceous shales or transition facies
- conformity
- marine facies (bottom)
- disconformity

The contacts between the different lithologic units in this pattern are quite similar in many of their details and radically different interpretations of their significance have been presented by different geologists who have worked on the Claiborne of Mississippi. These contacts which are considered disconformable in this report are horizons at which it can be established that an erosional break of some importance occurred. The lines of evidence used to establish this relationship are listed below in order of decreasing significance.

1. The lithologic nature of the underlying and overlying materials - a sharp transition from non-marine to marine beds, such
as occurs at the base of both of the marine sequences in the Claiborne of eastern and central Mississippi, could only be brought about by a strong marine advance accompanied wave-erosion.

2. The presence of a basal concentrate - The basal, sandy portion of the marine sequences are apparently beach deposits thrown up along the shore line as it advanced onto the deltaic plain. They usually contain small fragments and inclusions of material eroded from the bed below and incorporated in the beach deposit. Similar features sometimes occur at conformable contacts, but they can be logically explained by submarginal erosion and it can often be proven by the persistence and constant thickness of the bed immediately below the contact that little or no truncation occurred.

3. The nature of the uppermost portion of the underlying section - In most cases where a marine section lies upon a non-marine section, the lithology of the uppermost part of the non-marine sequence changes over short distances from sand to shale to silt, etc. This is exactly the condition which would be produced by truncation of the uppermost portion of the deltaic plain during a marine advance.

4. Irregular line of contact - This is perhaps the least reliable criterion for determining the existence of a disconformity. The irregularities must be of considerable magnitude before they have any significance, since slight irregularities occur along most conformable contacts and along many minor breaks or diastems within marine sequences.

The filled borings which occur at disconformable contacts in the Claiborne of Mississippi have little or no significance in the interpretation of the contact, since they are common within the
marine beds and at conformable contacts within marine sequences.

The contacts which are considered conformable in this report are horizons at which no significant break in sedimentation occurred. The lines of evidence used to establish this relationship are listed below in order of decreasing significance.

1. An interbedding of the two facies at the contact
2. Persistent lithology and constant thickness of the uppermost bed of the section immediately below the contact
3. The lithology of the section involved - If the beds above and below the contact were deposited under essentially the same environment, the contact is normally conformable. Also, the presence of a carbonaceous shale section or transition facies indicates a change of depositional conditions during which there was continuous sedimentation.

The field evidence indicates that the sequence of events which caused the formation of the depositional pattern in the Claiborne section of Mississippi was:

1. A strong advance of the sea over a low-lying deltaic plain
2. Deposition of the main body of the marine section under off-shore, shallow water conditions
3. Shoaling of the sea
4. A rapid advance of the coastal marsh over the marine sediments
5. Flooding of the marsh by stream-deposited sands
6. Gradual replacement of stream deposition by more marshy conditions
7. Another advance of the sea over the deltaic plain
Fisk (31), in a discussion of the causes of similar events in central Louisiana during Oligocene and Eocene time, attributes them to subsidence under sedimentary loading with the shifting of the centers of deposition accounting for the advances and retreats of the shore line. Subsidence under load has probably been a major factor in the sedimentary history of the Claiborne section of Mississippi because the presence of a thick section of beds which have accumulated at or near sea level can most logically be explained in that manner, but there is some reason to believe that other factors may also have played a part in causing the transgressions and regressions of the Claiborne sea. The indications of this are:

1. The rapidity of the widespread marine advances - The field evidence indicates that the Tallahatta and Moody's Branch marine advances occurred rapidly and covered wide areas. In all probability they occurred in the face of non-marine sedimentation. There are no large, nearby deltas of contemporaneous age which would promote lateral downdragging sufficient to permit such advances and the Claiborne beds are predominantly sands which would undergo little compaction.

2. The rapidity of the change from marine to non-marine depositional conditions - The field evidence indicates that a sudden acceleration of the rate of sedimentation caused a rapid advance of the land into the sea over a wide area during each change from marine

to non-marine conditions. Again, the absence of any large Claiborne
deltaic mass nearby precludes the possibility of a shift of a center
of deposition which could account for such a widespread acceleration
of the rate of sedimentation. The most logical explanation is that
the gradients of a number of smaller streams were suddenly increased.

3. Large overlaps exist in the Neocene section along the
Atlantic Coastal Plain and there is no reason to believe that the
factors which caused them did not operate elsewhere in the Coastal
Plain Province.

In the writer's opinion, these points indicate that epeiro-
genic movements probably played an important role in causing the
oscillations of strand-line in Mississippi during Claiborne time.
AUTOBIOGRAPHY

The author was born on October 25, 1913 at Arco, Idaho. He received his grammar and high school education in the public schools of Boise, Idaho, graduating from high school in June, 1931 with high honors. He studied one year at Edinburg, Texas, Junior College and transferred to Oklahoma Agricultural and Mechanical College where he received his Bachelor of Science degree in Civil Engineering in January, 1935. As an undergraduate, he was a member of Phi Theta Kappa and Phi Kappa Phi honorary scholastic fraternities, belonged to several student organizations and was a basketball letterman.

Upon graduation from college, he worked for two years as a petroleum geophysicist and resigned in January, 1937 to return to college at Louisiana State University where he received his Master of Science degree in Geology in July, 1939. In April, 1940 he left school to take a job as field geologist with the Ohio Oil Company. That company granted him leave of absence in September, 1941 to return to school to complete work on his doctorate in Geology.
EXAMINATION AND THESIS REPORT

Candidate: Emil Paul Thomas

Major Field: Geology

Title of Thesis: The Geology of the Claiborne (Eocene) Group of Mississippi as Far North as Grenada County

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination: February 20, 1942
COMPOSITE DIAGRAM SHOWING FACIES CHANGES AND THICKNESSES IN THE SURFACE CLAYSTONE SECTION ACROSS MISSISSIPPI

BY PAUL THOMAS

EXPLANATION - THIS DIAGRAM IS CONSTRUCTED FROM DATA OBTAINED FROM HIGHWAY PROFILES, MEASURED SECTIONS, SURFACE CONTURS, WELL INFORMATION AND RECONNAISSANCE MAPPING. IT SHOWS ALL OF THE ESSENTIAL FEATURES OF THE SECTION IN THE AREA MAPPED. HORIZONTAL INTERVALS INDICATE DISTANCES ALONG STRIKE AND VERTICAL INTERVALS DENOTE THICKNESS OF SECTION. SYMBOLS DENOTE FACIES. THE TOWNS AND VILLAGES AND A FEW SPECIAL LOCALITIES ON THE OUTCROP ARE SHOWN BEFORE VERTICAL ARROWS WHICH MOUNT THE GEOLOGIC SECTION EXPOSED IN AND AROUND EACH. THE DATUM PLANE USED IS THE ZILPHA-WILSON CONTACT. A MORE COMPLETE EXPLANATION IS INCLUDED IN THE REPORT.
ELEVATIONS ABOVE SEALEVEL. TOPOGRAPHY.

RUGGED SAND MOUNTAINS.

VERTICAL SCALE: 50 FEET.

MILES FROM STARTING POINT.

NOTE: SYMBOLS REPRESENT FACIES, NOT NECESSARILY FORMATIONS. SEE LEGEND ON PLATE TWO.

CENTRAL LINE PROFILE OF HIGHWAY APPROXIMATELY

PROFILE D

GEOLGIC PROFILE ALONG STATE HIGHWAY 12 FROM NEAR ETHEL TO McADAMS, ATTALA CO., MISS.

BY RAUL THOMAS OCT., 1940

VERTICAL SCALE: 50 FEET.

HORIZONTAL: 1" = 1 MILE.

NOTE: SYMBOLS REPRESENT FACIES, NOT NECESSARILY FORMATIONS. SEE LEGEND ON PLATE TWO.
Profile B

Geologic Profile along Highway US 11 from Basic City to Pachuta, Clarke and Lauderdale Cos., Miss.

By Paul Thomas

March, 1941

Vertical Scale: 1 ft = 50 feet

Note: Symbols represent relative positions of outcrops, not necessarily actual formations. See legend on Plate Two.

Center line profile of ground.

Approximate profile of ground.

Exposed contact - letter indicates quality of contact.

This profile shows the cross-section of the highway US 11 between Basic City and Pachuta, Clarke and Lauderdale Cos., Miss. It includes a vertical scale of 1 ft = 50 feet and a horizontal scale of 1 mile. The profile is marked with symbols representing outcrops and contacts, with letters indicating the quality of the contacts. The profile includes annotations for various geological formations and features along the highway. The legend on Plate Two provides additional information on the symbols used in the profile.

Profile B
Profile A
Geologic profile along Highway 1266 from Meridian to Quitman, Clarke and Lauderdale Co., Miss.

By Paul Thompson, Feb. 1946

Note: Symbols represent formations, not necessarily formations. See legend on Plate Two.

Typical sand hills topography.

Profile A

Concrete slab 6 ft. above ground level.

Vertical scale: 50 ft. = 1 mile.
QUATERNARY DEPOSITS - sand and gravel and loess

JACKSON GROUP

Cockfield Fm. - 50 to 300 ft. of non-marine sands, silts, clays and clays with lignite, siltstone, etc., heterogeneous

Nautilus Fm. - 5 to 200 ft. of fossiliferous marls, greensands, glauconitic sands and limestones with associated carbonate clay or shale non-glauconitic, sand, bentonite, etc.; becomes non-marine northwest of the Yocahockany River.

Kosciusko Fm. - 75 to 450 ft. of non-marine sands, silts, clays and clays with siliceous siltstone, etc., heterogeneous

Zilpha Shale - 0 to 75 ft. of carbonaceous shale and blocky clay with silt, sand and glauconite

Winona Greensand - 0 to 50 ft. or more of less fossiliferous medium to coarse-grained greensand

Tallahatta Fm. - 50 to 175 ft. of siliceous claystone, siltstone and sandstone, non-glauconitic to sparingly glauconitic sand, greensand, carbonaceous shale, etc.

Willcox Group

--- Indeterminate or Arbitrary Contact

Definite Contact

SKETCH SHOWING REGIONAL POSITION OF AREA MAPPED

PLATE I - GEOLOGICAL MAP OF THE CLAIBORNE GROUP OF MISSISSIPPI AS FAR NORTH AS GRENA COUNTY

GEOLOGY BY PAUL THOMAS
WITH ADDITIONS FROM THE MADISON COUNTY MAP OF C.L. MOODY
1941
**FIGURE 1 - TABULAR SUMMARY OF THE HISTORY OF CLAIBORNE NOMENCLATURE IN MISSISSIPPI**