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STRATIGRAPHIC FRAMEWORK AND LIGNITE OCCURRENCE IN THE PALEOCENE OF THE ACKERMAN AREA

David E. Thompson
Mississippi Office of Geology

INTRODUCTION

The stratigraphy of the Paleocene section of Mississippi has been the subject of controversy for many years. Much of the published information on the subject is found in Mississippi Geological Survey county bulletins dating back as far as 1938. Very little conformity exists between county bulletins in regard to stratigraphy. Further, much of the earliest work was accomplished in northern Mississippi counties, far away from type Wilcox and Midway sections. The result is a Paleocene section in the state which is typically regarded as very complex and undifferentiable. The Paleocene contains economic deposits of lignite which Phillips Coal Company intends to mine in Choctaw County, Mississippi, for utilization in electric power generation. This report will address the formal stratigraphy of the area encompassing the mine prospect.

The Mississippi Office of Geology has been conducting a surface geologic mapping project involving the upper Midway and Wilcox groups of Paleocene age. The foundation for mapping horizons was developed by initiating the project along the Mississippi/Alabama state line and correlating the Mississippi Paleocene section to the classic section of Alabama. Surface mapping was enhanced through the use of the Office's Failing 1500 drill rig. Core and drill holes with geophysical logs were completed and palynological support was provided by the U. S. Geological Survey (USGS). The resulting stratigraphic division is one which closely mirrors the more marine Alabama section. The lack of abundantly fossiliferous marine beds in the Mississippi Paleocene places added importance on the use of lignite seams as correlatable features.

The study area for this report involves portions of Choctaw, Oktibbeha, and Winston counties, Mississippi, and will be referred to informally as the Ackerman area. Mapping was performed at a scale of 1:24,000. The region constitutes four 7.5-minute quadrangles and portions of two others: Sturgis, Double Springs, Ackerman, Reform, and portions of Weir and Tomnolen. Geologic contacts from the 7.5-minute quadrangle sheets were transferred to a 1:250,000 base, and then digitized (Figure 1).

Surface geologic mapping is continuing in the Paleocene section north of the Ackerman area, and will terminate at the Mississippi-Tennessee state line. It is hoped that the result of this work will help to update the Geologic Map of Mississippi (Bicker, 1969) and provide a uniform stratigraphic framework across the state.

SELECTED PREVIOUS WORKS IN ACKERMAN AREA

E. N. Lowe, in 1913, subdivided the Wilcox Group into three formations. The lowest he named "Ackerman Beds" for the clay, sandy clay, and lignite exposed at Blanton's Gap, a locality east of Ackerman in Choctaw County. The middle section he named "Holly Springs Sands" for a locality named after the county seat in Marshall County, Mississippi. The upper section he termed "Grenada Beds" for clays and lignites exposed at the county seat in Grenada County, Mississippi. Lowe designated the upper Midway section as "Porters Creek clay."

F. E. Vestal (1943) closely followed the stratigraphic nomenclature of Lowe. He recognized two divisions in the Wilcox Group, the Holly Springs Formation as the upper unit and the Ackerman Formation, the lower unit. He described the Holly Springs Formation as containing sand, sandstone, clay-shale, clay, silt, lignite, silty limonite, and siderite, and estimated its thickness at 300 feet. The Ackerman Formation was summarized as containing sand, sandstone, clay-shale, clay, silt, lignite, and iron ore. He further recognized a Fearn Springs unit in the lower part of the Ackerman Formation containing silty sand, sandy and silty clay-shale, gray and white silty clay, lignite, ferruginous sandstone, and siltstone. Vestal considered the Fearn Springs unit to be variable in thickness with undetermined boundaries and therefore did not recognize it as a formation. The entire thickness for the Ackerman was estimated to be 300 feet. The original reference for the Fearn Springs unit was made by F. F. Mellen (1938) in Bulletin 38, Winston County Mineral Resources, where he gave it formational status. Vestal designated the upper Midway section as the Porters Creek Formation, containing clay, sand, silt, clay-shale, and siderite. He noted the upper part of the Porters Creek Formation to be laminated clay, micaceous, and very silty or sandy.

Hughes (1958) utilized stratigraphic terms from the type Midway/Wilcox section in Alabama in his Bulletin 84 on Kemper County Geology. While studying the geology of Kemper County, Hughes drilled a stratigraphic test hole at Blanton's Gap in Choctaw County in an attempt to better characterize the geologic units. Hughes recognized the following stratigraphic units at Blanton's Gap, in descending order: the Tuscahoma Sand, Nanafalia Formation, and Fearn Springs Sand Member of the Wilcox Group, and the Naheola and Porters Creek formations of the Midway Group. In Kemper County, he recognized the Hatchetigbee Formation, with a basal Bashi Marl Member, as the uppermost Wilcox unit. The Hatchetigbee, which overlies the Tuscahoma Sand in the section, was not encountered in the Blanton's Gap test hole. Hughes, in his discussion of nomenclature and stratigraphic problems, conveyed his belief that the Ackerman Formation at its type locality correlated with beds well up in the Tuscahoma sand of Alabama. He also stated that he was able to trace the silts and clays at the top of the Nanafalia Formation along the Wilcox outcrop, at least as far north as the town of Reform in Choctaw County. F. S. MacNeil, of the USGS, concurred with this view.

Subsequent authors on the Midway/Wilcox section of Mississippi have largely abandoned the concept of differentiating subdivisions north of Lauderdale and Kemper counties, where correlatable marine horizons grade into a more deltaic/fluvial, nonmarine depositional environment. W. S. Parks (1961), E. H. Rainwater (1964), and D. R. Williamson (1976) all expressed the impracticality of subdividing the Wilcox Group of central and northern Mississippi into subordinate units. For these authors, the use of Wilcox Group (Undifferentiated) was preferred.

In 1958, R. J. Hughes expressed his wish for a Midway-Wilcox study involving single lithologic units carefully traced along the line of outcrop through the entire State of Mississippi. This is now being done.

SUBDIVISION OF THE MISSISSIPPI PALEOCENE REVISITED

In recent years, there have been significant contributions made in the Tertiary stratigraphy of the Gulf Coastal Plain. Advances in intercontinental zonations by planktonic foraminifers and calcareous nannofossils have prompted a shift of the Paleocene/Eocene boundary to a point considerably higher in the Gulf Coast section than previously thought (Gibson, Mancini, and Bybell, 1982). For years, the unconformity between the Midway and Wilcox groups was considered to be the Paleocene/Eocene boundary. Now, it is generally accepted that the boundary is more correctly placed at the Tuscahoma/Bashi contact, near the top of the Wilcox Group. Therefore, the Paleocene section now includes all of the Midway Group and a large portion of the Wilcox Group. The Paleocene/Eocene boundary will be obscured within a thick undifferentiated section of Wilcox sediments in central and northern Mississippi without a renewed interest in the discrimination of stratigraphic subdivisions.

E. A. Mancini, over the last fifteen years, has conducted research and published numerous papers on the lithostratigraphy, biostratigraphy, and sequence stratigraphy of the Paleocene section in Alabama. Similar work has been accomplished by T. E. Yancey regarding the Paleocene of Texas and by L. N. Glawe on the Paleocene of Louisiana. The Paleocene of Mississippi, which comprises over 1000 feet of section, will require additional study before it can be correlated with sections from neighboring coastal plain states into a regional geologic framework.

In Mancini's work for Alabama, the classic Paleocene stratigraphic units relate to worldwide sea level changes and associated sequence boundaries/unconformities (Mancini and Tew, 1991). Current mapping of the Paleocene in Mississippi strives to recognize the time equivalent depositional cycles, even where marine units are not present. The Mississippi nonmarine section is certainly complex, with cycles of sand, clay, and silt layers, abrupt lateral facies changes, and complicated bedding. Lithologically, one cycle looks very much like another. Therefore, it is crucial that the mapping endeavor rely on sufficient test hole data for proper correlation. Further,

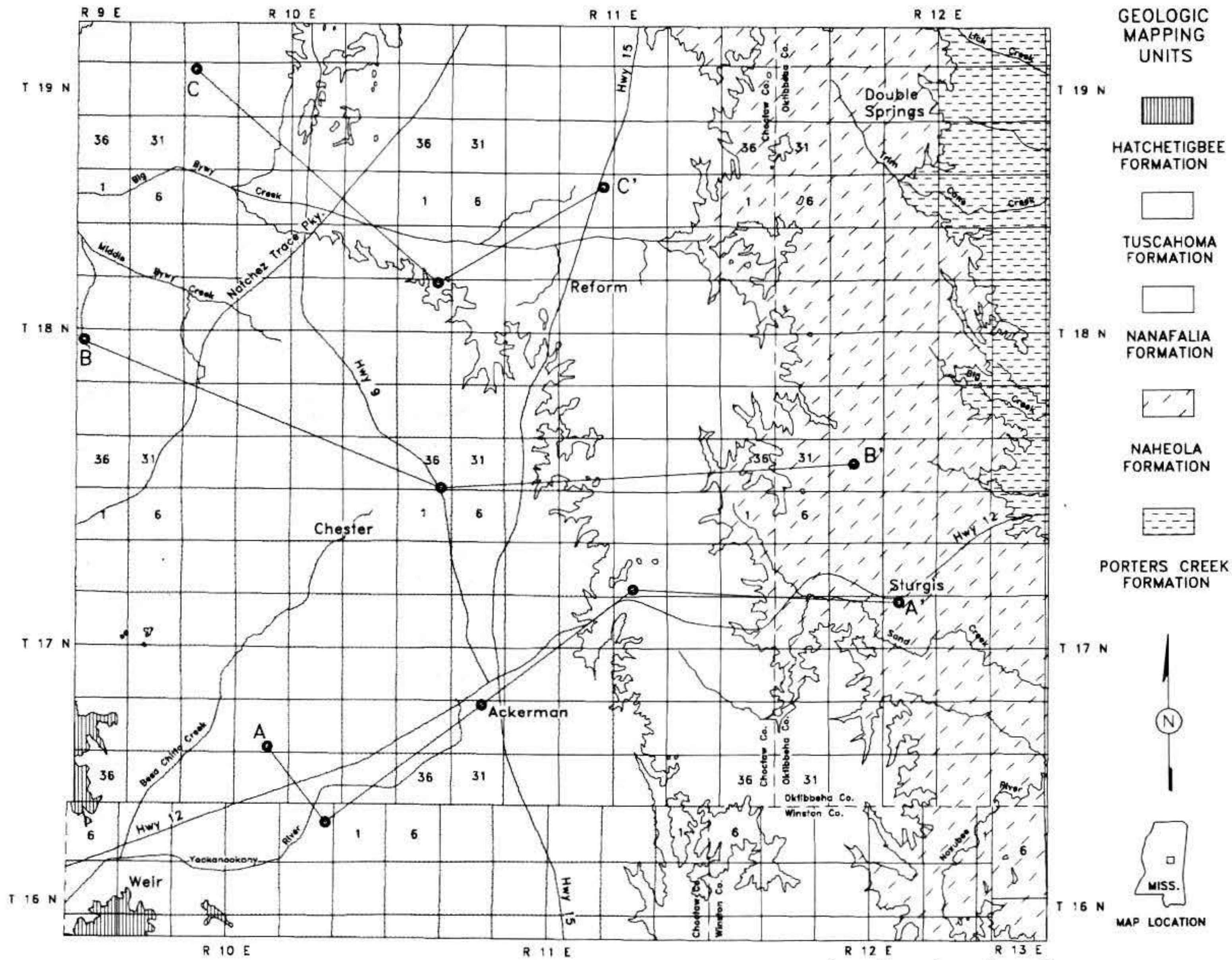

Figure 1

GEOLOGIC MAP OF THE ACKERMAN AREA

David E. Thompson, Geologist

the mapping effort should involve a broad expanse, preferably the entire outcrop area, in order to realize a regional stratigraphic framework. Earlier mappers of the Midway and Wilcox groups in Mississippi did not have that luxury. They were generally assigned to work individual counties with insufficient test hole data. There are pitfalls associated with excessive reliance on geophysical log data without sufficient lithologic data. However, geophysical logs provide invaluable aid in correlating near-surface geology. If there is lithologic and paleontologic control sufficient to interpret the geophysical log in terms of the sediments within a depositional system, then these systems can be correlated with other geophysical logs over relatively large areas (Keady, Russell, and Lins, 1974).

STRATIGRAPHY

The stratigraphic units recognized in this paper for the Ackerman area are a result of mapping that was initiated in Lauderdale County, Mississippi, where confident correlations could be made with the Alabama section. They were then traced carefully along strike into the study area. Paleocene units in ascending order include: the Porters Creek and Naheola formations of the Midway Group, and the Nanafalia and Tuscahoma formations of the Wilcox Group. The Eocene Hatchetigbee Formation is the uppermost unit of the Wilcox Group. Due to the large study area involved and the 1:250,000 scale of the base map, only the geologic formations, and not members, are depicted on the geologic map (Figure 1). Stratigraphic members within formations are addressed in a structural cross section (Figure 2) and in a stratigraphic cross section (Figure 3). The Paleocene units strike generally southeast to northwest and dip to the southwest at approximately 35 feet per mile.

Porters Creek Formation

The Porters Creek consists of grayish black, massive clay, occasionally silty, which weathers to light gray or brownish gray on the outcrop and typically exhibits a conchoidal fracture. It is the oldest deposit exposed in the Ackerman area and represents progradational, shelf margin deposits of a highstand regressive systems tract in Mancini and Tew's (1991) Midway Cycle TP1.3. These regressive clays form the top of a depositional cycle that begins in the middle Porters Creek (Mancini and Tew, 1991).

In Alabama, the top of the Porters Creek is marked by a thin, gray to green, fossiliferous, glauconitic sand which is called the Matthews Landing Marl Member. It is a transgressive, marine unit that unconformably overlies the regressive clays of the upper Porters Creek (Mancini and Tew, 1991). Previous mappers in Mississippi have recognized exposures thought to be equivalent to the Matthews Landing. One notable exposure is at Sciples Mill in northern Kemper County (Hughes, 1958). Current mapping has established doubt regarding that correlation. The Alabama Paleocene section, just across the state line, accommodates 242 feet of Naheola sediments overlying the Matthews Landing (Mancini, 1981), whereas the stratigraphic position of Mississippi's Matthews Landing equivalent greatly reduces the thickness of overlying Naheola sediments. Previously cited exposures of the Matthews Landing exposures in Mississippi are poorly defined, varying greatly in thickness (5 to 34 feet) and lithology (mostly clayey to mostly sandy, highly glauconitic to slightly glauconitic). Outcrops of the Matthews Landing in Alabama contain a diagnostic fossil fauna, whereas the Mississippi equivalent contains only fossil prints, none of which are diagnostic. Finally, numerous exposures of the Matthews Landing equivalent in Mississippi were sampled for pollen and dynocyst biostratigraphic zonation. Every sample that contained useful species indicated a Naheola age (Norman Frederiksen, personal communication). It seems probable that the true Matthews Landing equivalent in Mississippi is lower in the section than previously thought. Searches for the Matthews Landing at a lower stratigraphic position have been unsuccessful, primarily because relief is low and exposures are rare. A core hole is being planned by the Office of Geology that would penetrate deep into the Midway section in search of the Matthews Landing Marl Member, with its diagnostic fossil fauna.

Previous mappers of the Porters Creek clay in Mississippi recognized an upper division with laminated sands and silt, (Mellen, 1938; Vestal, 1943; and Parks, 1961), which has been described as resembling the Naheola. A lower pick for the Matthews Landing would place these sediments within the Naheola Formation as their lithologies suggest.

For the Ackerman area, the contact between the Porters Creek Formation and overlying Naheola is placed at the base of a sequence of interlaminated clay, sand, and silt and above the projected position of the Matthews Landing Marl equivalent. The total thickness of the Porters Creek Formation is approximately 450 feet. However, due to the dip of the strata, only the upper portion is present in the Ackerman area.

Naheola Formation, Oak Hill Member

The Oak Hill Member is composed of dark gray to white, carbonaceous clay interlaminated and interbedded with silt, and fine-grained sand; it rests conformably above the Porters Creek Formation. The upper zone of the member often contains lignite (Oak Hill Lignite, seam 1 of Figure 3), and represents an important correlatable feature. This unit was previously regarded as an upper laminated, sandy phase of the Porters Creek. The Oak Hill Member of the Naheola Formation is approximately 170 feet thick and includes the highstand regressive sediments of Mancini and Tew's (1991) Midway Cycle TP1.4.

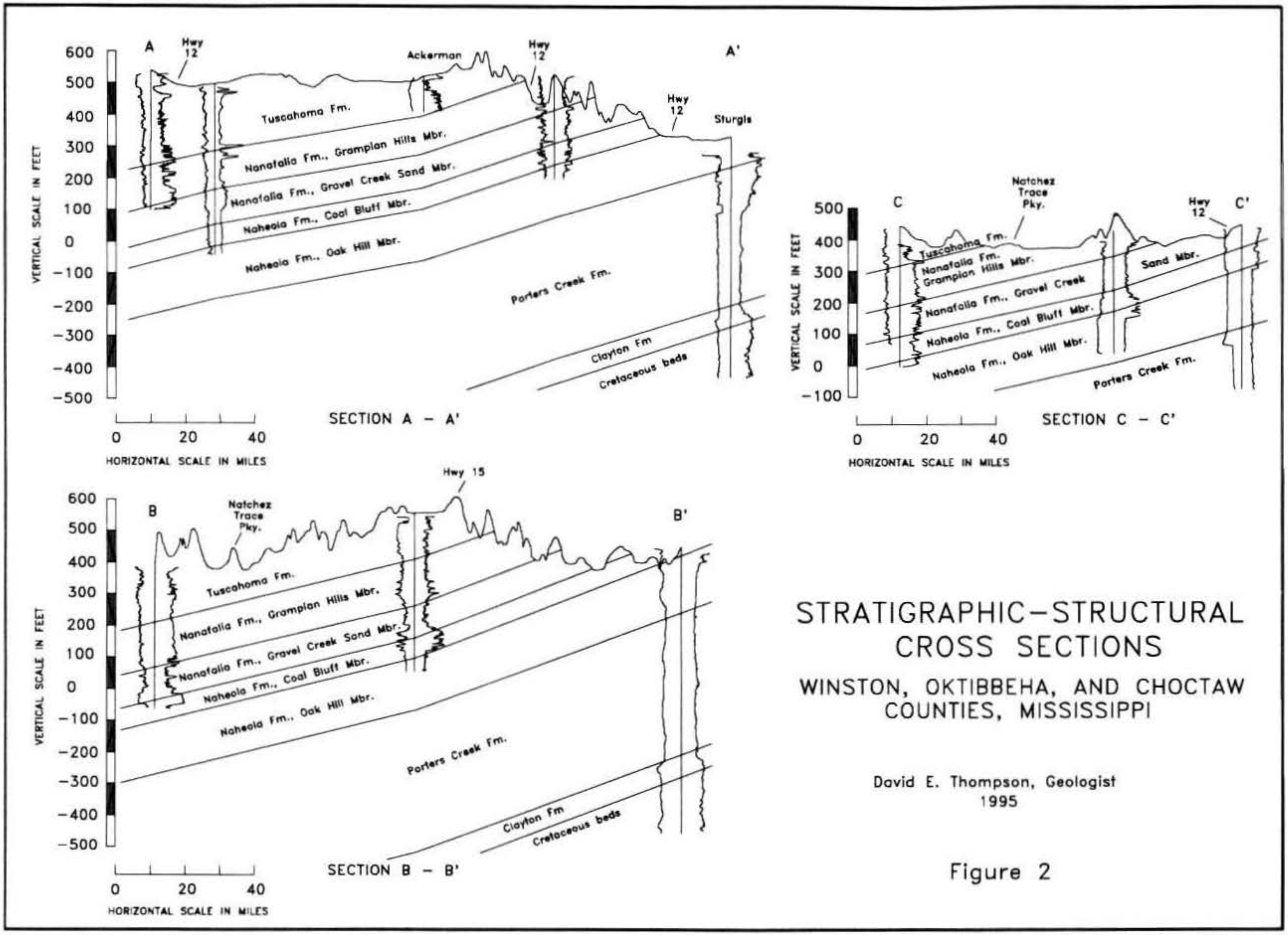
SECTION A - A'
A
A'
Hwy 12
Ackerman
Sturgis
Tuscahoma Fm.
Nanafalia Fm., Grampian Hills Mbr.
Nanafalia Fm., Gravel Creek Sand Mbr.
Naheola Fm., Coal Bluff Mbr.
Naheola Fm., Oak Hill Mbr.
Porters Creek Fm.
Clayton Fm
Cretaceous beds
VERTICAL SCALE IN FEET
HORIZONTAL SCALE IN MILES
SECTION B - B'
B
B'
Natchez Trace Pky.
Hwy 15
SECTION C - C'
C
C'
Sand Mbr.
Nanafalia Fm., Gravel Creek
STRATIGRAPHIC–STRUCTURAL CROSS SECTIONS
WINSTON, OKTIBBEHA, AND CHOCTAW COUNTIES, MISSISSIPPI
David E. Thompson, Geologist
1995

Figure 2

Naheola Formation, Coal Bluff Member

The Oak Hill Member is unconformably overlain by the sands, silts, and clays of the Coal Bluff Member of the Naheola Formation. In Alabama, it is referred to as the Coal Bluff Marl Member and represents a complete depositional cycle (Cycle TP1.5 of Mancini and Tew 1991), containing basal lowstand shelf sands; transgressive, marine sands and marls; and regressive sand, silt, clay, and lignite. In the Ackerman area, the Coal Bluff Member exhibits more nonmarine features and consists of fine- to coarse-grained sand interbedded and interlaminated with dark gray to white clay, silt, and lignite. The basal portion of the Coal Bluff is consistently sandy and may be equivalent to the basal shelf sands of the Alabama Coal Bluff section. The unconformable contact with the underlying clays and silts of the Oak Hill is sharp. No marine, transgressive sediments are present in the Coal Bluff of the Ackerman area. The remainder of the Coal Bluff above the basal sand is composed of sand, interbedded to interlaminated with silt, clay, and lignite, and is consistent with the regressive environment recognized in Alabama.

In many cases, lithologies of the Coal Bluff Member of the Naheola Formation in Mississippi were previously mapped as the Fearn Springs Formation or Fearn Springs Sand Member, a stratigraphic term originated by F. F. Mellen in 1938. Mellen considered this predominantly sandy unit to be basal Wilcox in Winston County, Mississippi, even though the Coal Bluff of Alabama is sandy, as is the upper Naheola of Lauderdale and Kemper counties in Mississippi. The Coal Bluff in these localities is typically fine-grained, with an abundance of mica.

A popular convention used to distinguish basal Wilcox sands from Coal Bluff is discrimination by grain size, with the lowest coarse-grained sand being Wilcox. This convention, however, breaks down in northern Kemper County, where coarse clastics appear in the Coal Bluff section. In fact, exposures of the Coal Bluff sand in southwestern Winston County (NW/4, Section 15, T. 13 N., R. 15 E.) contain large pebbles of meta-quartzite. This increase in grain size should be expected as the unit becomes more deltaic/fluvial near its source area. Previous surface geologic mapping north of Kemper County failed to recognize the presence of coarse-grained sands in the upper Midway. This largely explains the abrupt termination of the Naheola outcrop on the Geologic Map of Mississippi (Bicker, 1969).

A distinguishing characteristic of the Coal Bluff Member is the occurrence of bedded kaolinitic to bauxitic clay. However, it sometimes occurs near the top of the Oak Hill Member, below the basal sand of the Coal Bluff. This kaolinitic to bauxitic clay lithofacies was named by F. F. Mellen (1938) as the Betheden Formation. Mellen considered these clays to be a residuum, or weathered horizon, at the top of the Midway Group. There has been considerable controversy over the years as to whether or not these economic clays should be regarded as basal Wilcox or uppermost Midway. The controversy was fueled by the clay's position relative to coarse-grained sands. In instances where the "Betheden" clays occur below coarse-grained sands, most mappers considered them to be of Midway age, and where the clays were found to occupy a position above or between coarse-grained sands, they were thought to be of Wilcox age. Once again, recognition that coarse-grained clastics can and do occur in the upper Midway aids in resolving the controversy. This acknowledgment allows for the placement of the "Betheden" clay interval entirely within the Midway Group, and reinforces the idea that the interval's stratigraphic placement should not be based on a position relative to coarse-grained clastics. The placement of the Coal Bluff followed here relies on a careful correlation with the Alabama section and considers the depositional system thickness, related lithologic characteristics, geophysical log correlations, and the recognition of a regional unconformity above kaolinitic strata that marks the base of the Wilcox Group. It should be noted that kaolinitic clay rip-up clasts may be present in sandy intervals of both the lower Wilcox and upper Midway, and are not useful in differentiation of the two.

Seams of lignite in the Coal Bluff Member, in addition to bedded kaolinitic or bauxitic clay, are useful devices for correlation. The seams (seam 2 of Figure 3) are generally under a foot thick and tend to occur within the upper two thirds of the member.

The Coal Bluff Member of the Naheola Formation is approximately 70 feet thick, and is unconformably overlain by the sands, silts and clays of the Gravel Creek Sand Member of the Nanafalia Formation.

Nanafalia Formation, Gravel Creek Sand Member

The Midway/Wilcox unconformity marks the boundary between the Naheola Formation and the overlying Nanafalia Formation and represents a hiatus of considerable magnitude. Evidence for the hiatus, in addition to the lithologic break, is found in the biostratigraphic record of marine equivalent units (Toulmin, 1977), and in the extensive subaerial exposure time required to develop the bauxitic clays (Mellen, 1938) of the upper Midway.

In the Alabama Paleocene, the Gravel Creek Sand Member represents incised valley fill deposits at the base of depositional cycle TP2.1 of Mancini and Tew (1991), and is composed of cross-bedded sands. These sands are overlain unconformably by transgressive, marine, glauconitic, fossiliferous sands and marls known as the middle member or "*Ostrea thirsae* beds." The fossil *Odontogryphea thirsae* is a key biostratigraphic marker in Alabama for recognition of the Nanafalia (Toulmin, 1977). Unfortunately, this fossil has not been found in Mississippi, and the glauconitic characteristic of the unit is not recognized north of Lauderdale County. For this reason, nonmarine and marginal marine equivalents of

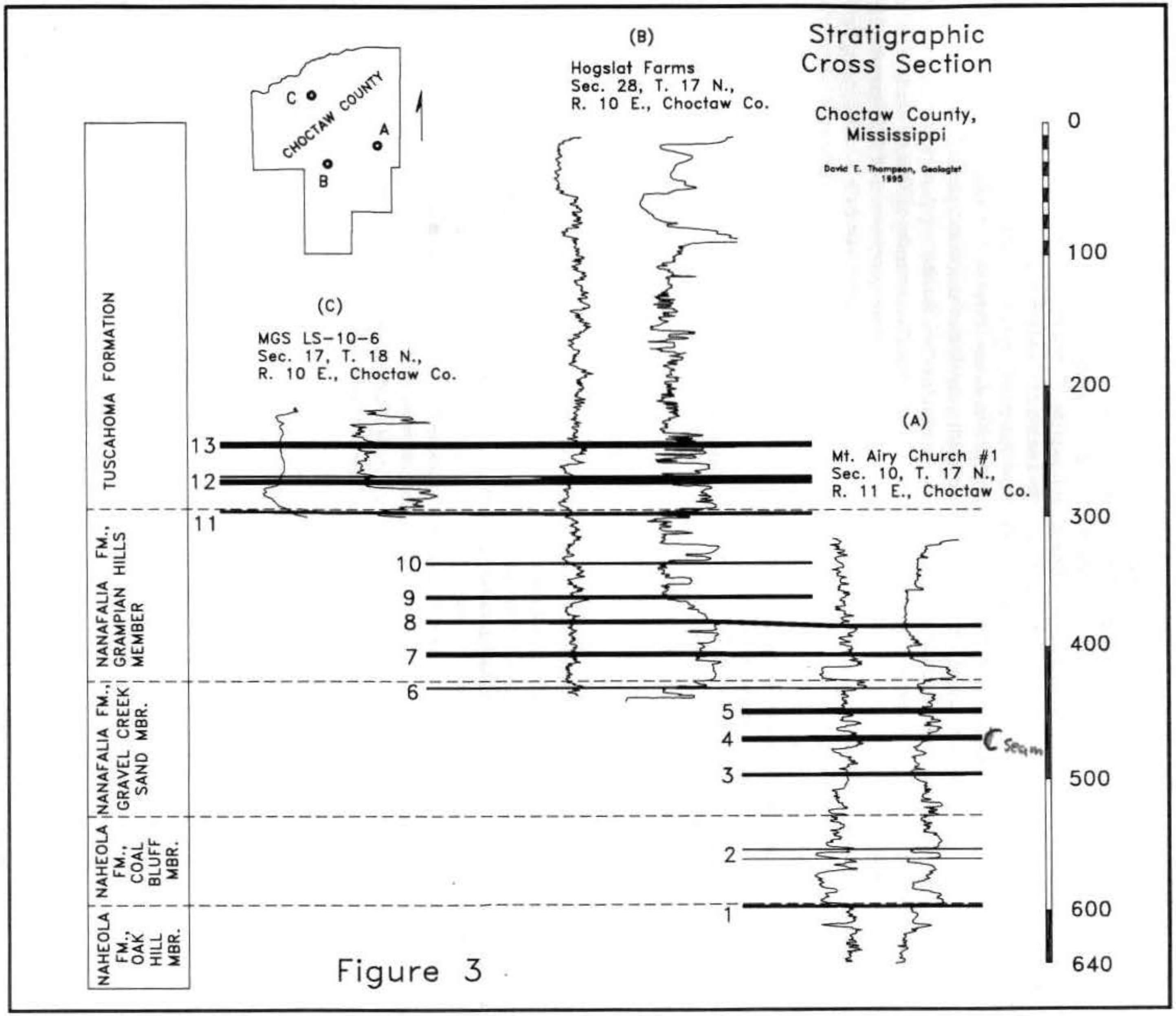
Stratigraphic Cross Section
Choctaw County, Mississippi
David E. Thompson, Geologist 1995
CHOCTAW COUNTY
A
B
C
(A)
Mt. Airy Church #1
Sec. 10, T. 17 N.,
R. 11 E., Choctaw Co.
(B)
Hogslat Farms
Sec. 28, T. 17 N.,
R. 10 E., Choctaw Co.
(C)
MGS LS-10-6
Sec. 17, T. 18 N.,
R. 10 E., Choctaw Co.
TUSCAHOMA FORMATION
NANAFALIA FM., GRAMPIAN HILLS MEMBER
NANAFALIA FM., GRAVEL CREEK SAND MBR.
NAHEOLA FM., COAL BLUFF MBR.
NAHEOLA FM., OAK HILL MBR.
1
2
3
4
5
6
7
8
9
10
11
12
13
C seam
0
100
200
300
400
500
600
640

Figure 3

the *Ostrea thirsae* beds are mapped together with the Gravel Creek Sand Member in Mississippi. The Gravel Creek Sand Member was referred to as the basal Ackerman by workers in the 1930s, 40s and 50s.

Throughout much of east-central Mississippi, the sands of the Gravel Creek Sand Member are a thick, recognizable feature and, along with the sand of the Coal Bluff Member, constitute the Lower Wilcox Aquifer. A typical section of the Gravel Creek might include 70 to 80 feet of white to reddish orange, fine- to very coarse-grained, cross-bedded sand and 20 to 30 feet of overlying gray, interbedded and interlaminated clay, silt and sand, with an occasional bed of lignite. In northern Winston County and into the Ackerman area, the lithologic character of the Gravel Creek changes. A typical section in this region might include 20 to 30 feet of cross-bedded, fine- to coarse-grained sand overlain by 70 to 80 feet of interbedded and interlaminated silt, clay, sand, and multiple seams of lignite (seams 3-6 of Figure 3). The sands may thicken locally, but are inadequate as a reliable ground-water source. The depositional environment of the Gravel Creek Sand in Mississippi is thought to be incised valley fill, similar to that in Alabama, with an overlying progradational, deltaic sequence instead of transgressive, marine sands and marls.

Nanafalia Formation, Grampian Hills Member

In the Ackerman area, the Gravel Creek Sand Member is overlain conformably by regressive deposits of silt, clay, sand, and lignite designated as the Grampian Hills Member. In Alabama, the Grampian Hills is a distinctive unit containing indurated, greenish gray claystone or "pseudobuhrstone," and sandy, fossiliferous marl (Hughes, 1958; Mancini and Tew, 1991). The distinctive "pseudobuhrstone" of the interval does not extend into Mississippi. However, several glauconitic marl beds containing the Nanafalia guide fossil *Ostrea arrosis* (Toulmin, 1977) are present in the interval at least as far north as southern Kemper County, Mississippi. The fossiliferous marls were encountered in two Mississippi Office of Geology core holes (K-002, SE/4, SW/4, SE/4, Section 7, T. 7 N., R. 18 E., Lauderdale County, 120 to 132 foot depth and 162 to 171 foot depth; S-002, SW/4, NW/4, NW/4, SE/4, Section 27, T. 9 N., R. 16 E., Kemper County, 77 to 90 foot depth), but have not been found in any surface exposures.

The Grampian Hills Member, in the Ackerman area, consists of nonmarine to marginal marine deltaic deposits with dark gray to pale green, interbedded to interlaminated silt, clay, sand, and lignite. The sand of the unit is typically very fine- to medium-grained and usually forms a basal bed 10 to 20 feet thick. The lignite (seams 7-11 of Figure 3) often occurs in multiple seams above the basal sand, in a mostly gray, argillaceous and silty interval. Locally however, sand may predominate anomalously throughout much of the interval and lignite occurrence is less likely. It seems that where channel sands were deposited, they tended to stack one atop the other, and interdistributary clays and silts were inclined to do likewise. There are vertical sections where both depositional environments are represented. The thickness of the Grampian Hills Member is approximately 130 feet.

Examination of unweathered Grampian Hills may reveal some marginal marine characteristics. A core hole drilled along Jenkins Creek, in central Choctaw County, recovered a full section of Grampian Hills displaying an anomalous, predominantly sandy deposit with thin carbonaceous intervals instead of lignite. The sands were pale green and glauconitic. A few thin zones reacted slightly to HCl. A few weeks after recovery, the core samples oxidized to a reddish orange hue, lost their marine appearance, and looked much like typical outcrop occurrences of Wilcox sands. Another possible marginal marine component of the Grampian Hills involves thin pale green silty clay beds often bounding lignite seams. These marine-looking clays are thought to be equivalent to the fossil-bearing marls found in the Grampian Hills to the south in Kemper and Lauderdale counties.

Tuscahoma Formation

Following Mancini and Tew's (1991) depositional model for the Paleocene, the regressive sequence (TP2.1) begun with the Grampian Hills Member continues into the overlying sands, silts, clays, and lignite beds of the Tuscahoma Formation. In Mississippi, the base of the Tuscahoma is marked by a predominantly sandy, often coarse-grained unit with a variable thickness of 10 to 110 feet. The variability in thickness is due to the occurrence of contemporaneously bedded clay, silt, and lignite. Like the Grampian Hills, the Tuscahoma is deltaic and lateral changes in depositional environment from channel sands to interdistributary silts and clays are common. Still, the consistent stratigraphic position of the Tuscahoma basal sand and its typically coarse-grained texture make it a correlatable horizon, regardless of the overall sand thickness. The basal sand of the Tuscahoma, where thickly developed, is an important source for ground water. The town of Ackerman utilizes this stratigraphic horizon for ground water at a relatively shallow depth. In locations where the basal sand is less well developed, the interdistributary clays and silts may yield multiple seams of lignite (seams 12-13 of Figure 3).

In Alabama, the regressive deposits of the lower Tuscahoma Formation are overlain by two depositional cycles which extend up to the Bashi/Hatchetigbee Formation. The marine, transgressive phases of these cycles are known as the Greggs Landing Marl Member and the Bells Landing Marl Member (Mancini and Tew, 1991). The Greggs Landing Marl Member has been recognized in a Mississippi Office of Geology core hole in Lauderdale County but neither the Greggs nor Bells has been recognized in the Ackerman area.

Approximately 250 feet above the base of the Tuscahoma Formation is another consistently sandy sequence that is variable in thickness and occupies a position which appears correlative to the Greggs and Bells marl horizons from Alabama. This sand is an important ground-water source most often referred to as the Middle Wilcox Aquifer. The upper Tuscahoma beds are typically argillaceous with thin beds of lignite.

Previous investigators of the Wilcox have tended to term predominantly sandy intervals as the Holly Springs Sand or the Meridian Sand, and named argillaceous, lignitic intervals the Ackerman beds. These types of lithologies are not stratigraphically restricted and confusion over these local terms sometimes resulted in the basal and middle sand of the Tuscahoma being mistakenly correlated as the same unit (Holly Springs). At other times, the middle Tuscahoma sand interval was mapped as Meridian Sand (the basal unit of the Claiborne Group) because of a similar coarse-grained texture. Without relatively deep test hole control, a stratigraphic boundary can easily be jumped or missed. Most of these understandable errors relate to the practice of stratigraphic placement based largely on general lithologic differences (sand-clay). Many of the formations mapped previously in northern and central Mississippi (Holly Springs, Ackerman, and Fearn Springs) are mappable units; however, they do not necessarily equate to the Wilcox units from the type section. Further, gross lithologic characteristics alone do not help to establish these subdivisions. The lithologic characteristics and lateral lithofacies changes of the entire section must be considered.

For the purposes of this paper, the entire Tuscahoma Formation will be recognized as a regressive, deltaic to marginal marine deposit composed of sand, dark greenish gray to light gray, weathers reddish orange to pale yellow orange, very fine-grained to coarse-grained, interlaminated to interbedded with clay and silt, greenish gray to light gray, and lignite. These sediments comprise the top of Mancini and Tew's (1991) Cycle TP2.1 to the top of Cycle TP2.3. The Tuscahoma Formation is approximately 400 feet thick.

Hatchetigbee Formation (including the Bashi Formation equivalent)

The top of the Wilcox Group is marked by a complete depositional cycle that includes the Bashi and Hatchetigbee formations (TE1.1 of Mancini and Tew, 1991). From Alabama, through Lauderdale County, and at least up to Kemper County, the Bashi Formation, which unconformably overlies the thick regressive deposits of the Tuscahoma Formation, contains marine, transgressive, glauconitic sands and marls. The Bashi Formation, typically 4 to 5 feet thick (Ingram, 1991), is conformably overlain by regressive sand, silt, clay, and lignite of the Hatchetigbee Formation. The thickness of the Hatchetigbee is reported to vary greatly depending upon the magnitude of incision of the overlying Claiborne section. Its maximum thickness is estimated to be 170 feet.

In the Ackerman area, the marine beds of the Bashi Formation have not been recognized. Here, the Bashi horizon appears to be marked by a nonmarine, channel associated, sand unit. This sand is similar in appearance and lithology to other Wilcox nonmarine sands but can be discriminated based on its position in the section, and may represent the lowstand deposit above the Paleocene-Eocene TP2/TE1 sequence boundary described by Ingram (1991). For this paper, the possible Bashi equivalent sand is included in the Hatchetigbee Formation.

In the Ackerman area, a small region in the extreme southwest quadrant is believed to accommodate the Hatchetigbee Formation, but exposures are poor. Only the basal part of this formation occurs in the mapped region. The outcrop pattern is based on a projection to the surface from geophysical well log data, in addition to a northeastward extension of previously mapped Attala County geologic units (Parks, 1963). The upper beds of the Hatchetigbee Formation persist as a regressive deposit of interbedded to interlaminated clay, silt, sand, and lignite, with silts and clays predominating.

LIGNITE OCCURRENCE

As mentioned in the discussion of stratigraphic units in the Ackerman area, every unit mapped contains beds of lignite with the exception of the Porters Creek Formation. Lignite deposits in the Paleocene have been characterized as being irregular in shape, limited in areal extent, and variable in seam thickness (Dueitt, Froelicher, and Rosso, 1985). This being the case, the lignites were not considered to be particularly useful as correlative tools at the outset of this mapping project. Surprisingly though, it was found that these intermittent swamp or marsh deposits tend to occupy the same stratigraphic/vertical position in the section when present.

Goddard, Echols, and Comet (1992) recognized the significance of lignites in respect to stratigraphic interpretation of the Paleocene in Louisiana. Their research indicated that more abundant lignite seam occurrences are located at the transgressive and regressive maxima of the eustatic curves (which are analogous to depositional cycles). This aspect was particularly evident once the sandy upper Midway equivalent was properly considered (not as Wilcox), and consistent regional correlations were accomplished. Core hole data not only allow for the correlation of lignites present in the same interval, but also permit the correlation of lignite seams to carbonaceous intervals which occupy the same horizon. Figure 3 is a stratigraphic cross section detailing the vertical position of Paleocene lignite seams in the Ackerman area and their stratigraphic placement. Individual horizons and seams of lignite are numbered from oldest to youngest. Core holes (A) and (C) were drilled and described by the Office of Geology. (B) represents a water well logged by the Office of Geology. Samples from the water well were examined. Lignite placement for (B) is based upon sample examination combined with nearby subsurface data of the same interval.

The Oak Hill lignite, near the top of the Oak Hill Member in the Naheola Formation (seam 1 in Figure 3), is recognized as a useful correlative marker in the Alabama Paleocene. In 1982, Meissner and Heermann suggested a reasonable correlation between the Oak Hill Lignite in Alabama and that in the Fearn Springs Formation of Lauderdale County, Mississippi, as mapped by Foster (1940). This appears to be a valid assumption and, when applied to the Mississippi Paleocene farther north, allows for consistent recognition of the Oak Hill lignite stratigraphic marker when present.

Lignite seams of the Coal Bluff Member in the Naheola Formation typically occur in the upper portion of the predominantly sandy unit. These lignites can be discriminated from the Oak Hill horizon by recognizing that Oak Hill lignites occur below the lowest Coal Bluff sand marker and massive bauxitic/kaolinitic clays. The Coal Bluff lignite horizon is labeled in Figure 3 as (2).

Throughout most of east-central Mississippi, the Gravel Creek Sand Member is not a very consistent lignite-bearing unit; the lignites that do occur are typically in the upper, less sandy portion. In the Ackerman area, the Gravel Creek is much less sandy, and the upper two thirds or more of the unit is argillaceous with multiple lignite seams. The lignites of this interval are correlatable in the Ackerman area, but do not occur consistently on a larger, regional scale, particularly to the southeast. Goddard, Echols, and Comet (1992) cited an analogy regarding the depositional environment of lignitic intervals. They asserted that "the organic material that forms the initial peat accumulates either in coastal marshes, as blanket deposits, or in interdistributary basins as interchannel peats. The former is of a more regional extent, whereas the latter tends to be of limited distribution." Due to the relative limited distribution of the Gravel Creek lignitic interval, it seems possible that these lignites were formed in interdistributary basins. Lignite horizons above and below the Gravel Creek, with a more regional extent, were deposited in coastal marshes. There has been research, based on identification of wood in lignite samples, that indicates a marsh environment for several lignite horizons above the Gravel Creek Sand Member (Dueitt, Froelicher, and Rosso, 1985). In Figure 3, lignite seams of the Gravel Creek are denoted as (3), (4), (5), and (6).

The lignite of the Grampian Hills Member in Mississippi is generally widespread and correlatable. From the initial core hole completed for this project in Lauderdale County, Mississippi, to later core holes in the Ackerman area, this typically lignitic interval has become an important correlation tool. Once again, proper recognition of the lower Wilcox sands and sands of the upper Midway allows for general alignment of the section. Subsequent consideration of lignite seams in the Grampian Hills, when well developed, allows for precise correlation of the section. Lignite seams of the Grampian Hills are numbered (7), (8), (9), (10), and (11) in Figure 3. Considerable attention has been given to the lignites of this interval for possible economic development as a fuel for electric power generation.

Lower Tuscahoma lignites have also been considered for economic development. Some of the best prospects involve lignite deposits of the lower Tuscahoma and Grampian Hills in combination. This appears to be the scenario involving the economic lignite deposits of the Ackerman area, known as the Chester Prospect. In 1982, Consolidation Coal Company proposed a lignite mine for electric power generation in Lauderdale and Kemper counties. A generalized geologic column presented in a project report, McMahill and Koerpel (1982), depicts the stratigraphic placement of the ore body in the upper Nanafalia (Grampian Hills) and lower Tuscahoma formations. Interestingly, the stratigraphic framework is analogous to that utilized in this report, and the individual lignite seams appear directly correlative to those of the Ackerman area. Lower Tuscahoma lignite seams are numbered (12) and (13) in Figure 3.

Intervals of lignite occur in the middle to upper Tuscahoma and Hatchetigbee formations. That portion of the section has not been studied in detail; however, it is expected that those lignitic intervals too have widespread correlatable features.

CONCLUSION

A comprehensive surface geologic mapping venture of the Paleocene section in Mississippi demands a uniform stratigraphic framework. County bulletin coverage in the state does not provide a consistent stratigraphic foundation from which to operate. An appropriate stratigraphic base for the Paleocene of Mississippi involves careful correlation to the well understood, classic section of Alabama.

Lignite seams are a valuable correlative aspect of the Mississippi Paleocene and occur in specific horizons over broad areas. Lignite occurrence, when combined with other related lithologic characteristics, depositional system thicknesses, and geophysical log correlations, can provide support for a successful subdivision of the section.

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POST-OLIGOCENE STRATIGRAPHY AND MAPPING OF SOUTHERN MISSISSIPPI—COMMENTS WITH UPDATE

Ervin G. Otvos
Geology Section, Gulf Coast Research Laboratory
Ocean Springs, Mississippi

Recently, May and others (1995) have reiterated some of the stratigraphic problems that hamper stratigraphic subdivision and surface mapping of Mississippi's Neogene and Quaternary. Researchers are unable to distinguish between the massive gravelly subsurface Miocene and surface Citronelle Formation beds of the Jones-Forrest-Lamar County area in the northern part of southern Mississippi. As for the currently indistinguishable various Neogene alluvial units, their suggestions strongly echo recommendations for an "undifferentiated Neogene" category (Otvos, 1987, 1991).

Several conclusions of May and coauthors do not apply to the surface and Neogene subsurface geology in the coastal counties. A few comments therefore appear to be warranted.

(1) Neogene Subdivisions in Coastal Subsurface

Extensive drillcore work and correlation with adjacent southern Alabama and the nearshore in recent years have documented at least three Miocene and Pliocene transgressive-regressive cycles in several coastal Mississippi counties and the adjacent Gulf. The early Middle Miocene cycle was associated with the largest marine embayment (Otvos, 1991; 1994, figure 2). Age-diagnostic planktonic foraminifers have been utilized in dating the units and the associated sedimentary cycles.

This reappraisal resulted in the use of the term "Pensacola Formation" (Table), modified from the term "Pensacola Clay" of northwestern Florida (Marsh, 1966). A sharply expressed erosional unconformity surface between the finer-grained Pensacola Formation and the generally coarser, sandy-gravelly Citronelle forms the recommended upper formation boundary. The proposed, biostratigraphically adequately dated, lower formation boundary coincides with a major late Early Miocene gap in deposition and with the associated unconformity (Otvos, 1994).

Even if of practical use in naming local sediment intervals for hydrogeological purposes (Dockery, 1995), the "formation" designation of the "Middle Miocene" Hattiesburg deposits is stratigraphically invalid and ought to be discontinued (Otvos, 1987, 1990, 1991). The formation status of the Oligocene-Early Miocene Catahoula sands that in Mississippi interfinger both with Oligocene and Early Miocene nearshore marine units (Otvos, 1994) has already been established in other Gulf coastal areas.

The locally very thick Pensacola Formation includes the Amos and Escambia members, as originally described in and correlated from the western Florida Panhandle (Marsh, 1966; Raymond, 1985; Otvos, 1994); it includes also the Late Miocene Pascagoula and Early Pliocene Graham Ferry members, inaccurately designated earlier as "formations" in southern Mississippi. Because of difficulties in drawing and correlating both the upper <u>and</u> lower unit boundaries in the field and subsurface, the formation designation is no longer justified for them. They are now relegated to "member" status.

Based on pollen and dinocyst data from the USGS Belle Fontaine, Jackson County, drillcore (Willard and Edwards, in press), the Pliocene age of the Graham Ferry has been proven on the Mississippi coast. The alluvial and paralic Graham Ferry Member overlies the Late Miocene, *Rangia johnsoni*-bearing Pascagoula. The northern limit of the Graham Ferry Member will be very difficult to establish.

(2) Citronelle Formation

May and others (1995) express doubt about the validity of the Citronelle designation of oxidized, coarse-detrital upland units. They appear to merge Citronelle deposits into the rather ill-defined "Upland Complex." It should also be noted that in southeastern Alabama the raised upland Citronelle deposits locally descend to sea level. Similarly to the so-called "Prairie Complex," the Upland Complex is another "waste basket" label and not a valid stratigraphic term.

In their cursory review, May and others also question the validity of at least part of the southern Mississippi Citronelle. Outcrops of this thin formation in the coastal region very often include only muddy sands and sands, and exclude gravel layers and stringers. The frequently brilliant orange-red hues of muddy Citronelle lithofacies very often give way to weathered grayish-yellow, yellowish-brown, and other less prominent oxidized colors. Clearly defined at its Alabama type locality (Matson, 1916), over the years the Citronelle has been reliably correlated into southern Georgia and westward into southern Louisiana.

In northwestern Florida the Citronelle and its Florida-Georgia correlative, the finer-grained, predominantly also alluvial Miccosukee Formation (Huddlestun, 1988), overlie early Late Pliocene coastal marine deposits. Once carefully combined with a complex of lithologic and the very frequent paleosol features, the recent Japanese umbrella pine

EPOCHS		downdip →			
HOLOCENE		Stream and creek alluvium and terrace units.			Coastal fresh and brackish water deposits. Holocene and Recent strandplains and islands. Paralic, inshore, nearshore and neritic deposits. Transgressive-regressive sediment cycle under Mississippi Sound.
PLEISTOCENE		Stream and creek alluvium and terrace units (e.g., **NATCHEZ FM**). Eolian deposits. Several Wisconsinan loess units.			Sangamonian Interglacial: **GULFPORT FM** (barrier complex), **PRAIRIE FM** (alluvial) **BILOXI FM** (paralic-to-neritic). Pre-Sangamonian coastwise alluvial terrace remnants ("Big Ridge", etc).
PLIOCENE				**CITRONELLE FM**	
				PENSACOLA FM: **Graham Ferry Mbr**	**PERDIDO KEY FM (AL-FL)**
MIOCENE	L	**UNDIFFERENTIATED NEOGENE**	**UNDIFFERENTIATED PENSACOLA FM**	**Pascagoula Mbr**	
	M			**Escambia Mbr**	
				Amos Mbr	
	E	**CATAHOULA FM**		**HANCOCK FM**	**TAMPA FM (AL-FL)**
				Heterostegina Zone	
OLIGOCENE				**PAYNES HAMMOCK FM**	

Table 1. Suggested stratigraphic table of Mississippi Neogene and Quaternary units (see Dockery, 1981, and Otvos, 1994, figures 2 and 4).

(*Sciadopitys*) pollen find (D. A. Willard, USGS, written communication) in a Citronelle backswamp lignite sample at Vancleave, Mississippi (Otvos, in preparation), by fixing its Pliocene age offers a glimmer of hope for the formation's possible correlation into western and central Mississippi.

Dockery's suggestion (1995, p. 8) for a "common ancestral Mississippi River source in the Late Pliocene or Pleistocene" of southwestern Mississippi Citronelle gravels runs into the problem of the East Gulf (reworked Cretaceous and Tertiary Appalachian) heavy mineral suite that characterizes these deposits (Rosen, 1968; Smith and Meylan, 1983). None of the highly typical Mississippi River Province mineral spectra were reported from the Citronelle east of the river.

(3) Quaternary Units

In the coastal region, the suggested blanket designation, "Pleistocene Complex" (May and others, 1995), is unnecessary for the Pleistocene units. The upper and lower boundaries of the three designated Sangamonian Interglacial formations (Dockery, 1981) have been satisfactorily defined in the subsurface and correlated with corresponding units in other Gulf coastal sectors (partial reference list in Otvos, 1995). Use of the "Pamlico" terrace name (Dockery, 1981) is not appropriate on the Gulf. This misapplied alternate term was derived by other authors from the distant Atlantic Carolina coastal plain and does not define a lithosome, only a coastal surface.

The presented tables (Dockery, 1981, *in* May and others, 1995; present Table) are too crowded to adequately portray the western Mississippi Pleistocene loess sequences as consisting of several Wisconsinan units. With the unlikely exception of the oldest, they do not correlate with, but post-date, the three listed Sangamonian coastal formations.

An areally fairly extensive, even if erosionally reduced and fragmented, pre-Sangamonian unit is exposed in the elevated Big Ridge surface (Table) on the central Mississippi coast. It is exclusively of alluvial origin and seaward is delineated by a shore-parallel fault scarp.

While the coastal Quaternary units have long been defined and have been available for charting on a new geological map, conceptual planning, sediment and fossil analysis, and concentrated field efforts will be required to define the northern limits of the Miocene-Lower Pliocene Pensacola (or of the "undifferentiated alluvial-paralic Neogene") and the Citronelle formations on that map.

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Editors: Michael B. E. Bograd and David Dockery

In this issue:

... an article on the stratigraphic framework and lignite occurrence in the Ackerman area, by David Thompson of the Mississippi Office of Geology

... and a comment on the ongoing discussion of post-Oligocene stratigraphy and mapping in southern Mississippi, by Ervin Otvos of the Gulf Coast Research Laboratory