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WILLIAM CLIFFORD MORSE, Ph.D.
Director

BULLETIN 75

WEBSTER COUNTY GEOLOGY

by

FRANKLIN EARL VESTAL, M. S.

UNIVERSITY, MISSISSIPPI

1952

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LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi

May 31, 1952

To His Excellency,
Governor Hugh Lawson White, Chairman, and
Members of the Geological Commission

Gentlemen:

Herewith is Bulletin 75, Webster County Geology, by Franklin Earl Vestal. It constitutes one of the county reports which deal primarily with the sequence of the beds and the economic products. To meet the urgent requests for up-to-date information on the iron ore deposits, Bulletin 73, Webster County Iron Ores, was published in advance of the complete report.

Very sincerely yours,

William Clifford Morse
Director and State Geologist

CONTENTS

ILLUSTRATIONS

FIGURES

PLATE

WEBSTER COUNTY GEOLOGY

FRANKLIN EARL VESTAL, M. S.

INTRODUCTION

Webster County, an area of 416 square miles,[1] is in the north central part of the state, a little east of the central meridian (Figure 1). Approximately, it lies between the meridians of 89° and 89°30′ west longitude, and the parallels of 33°27′30″ and 33°43′ north latitude. It is bounded on the north by Calhoun and Chicka-

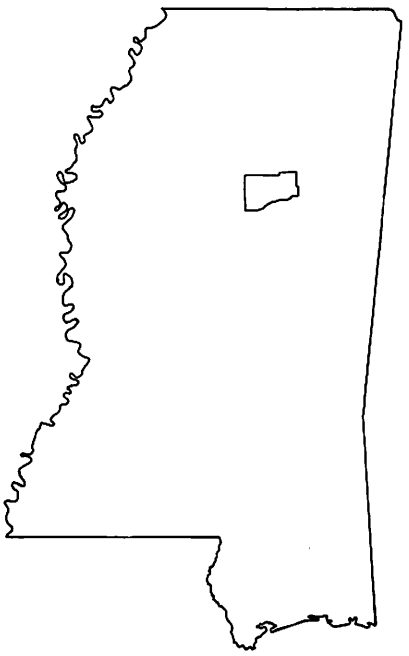

Figure 1.—Location of Webster County.

saw Counties, on the east by Clay County, on the south by Oktibbeha, Choctaw and Montgomery Counties, and on the west by Montgomery and Grenada. The northern boundary is 27 miles long, the southern, 28, in a straight line; the eastern boundary is 12 miles in length, the western, 18 miles. The western is the only boundary that is not offset. The eastern third of the northern boundary-line is offset 1⅛ miles to the north; the southern five

sections of the eastern boundary-line are offset almost a mile to the east; the southern line, near its eastern end. is offset 2 miles toward the north (Plate 1). For three-sevenths of its straight-line length, the southern boundary of the county is the Big Black River, which accounts for most of the 6-mile difference in length between the eastern and western boundaries. Except for this difference, the county as a whole would be of a roughly oblong shape.

The population of Webster County numbered 11,607 at the time the 1950 census was taken. This total is smaller by 18 percent than the 1940 population total of 14,160.[2] The population is entirely rural, by the definitions of "urban" and "rural" adopted by the U. S. Department of Commerce Bureau of the Census for the 1950 census, according to which population is classed as urban only if it lives in groups of 2,500 or more.[3] Eupora, the largest town of Webster County, had a population of 1,338 in 1950. Other towns and villages are scattered over the county: Maben, of which part is in Oktibbeha County, population, 616; Mathiston, part of which is in Choctaw County, population 584; Mantee, population, 189; Walthall, the county seat, population, 149;[4] Cumberland, Clarkson, Hohenlinden, Montevista, Bellefontaine, Tomnolen, Embry, and Cadaretta. In places, commonly at crossroads, are other small groupings of population, where a general store, a church, a school, and a few dwellings, mark a community center. The population is distributed somewhat unevenly, the greater number being east of Highway 9. Several areas have few if any inhabitants.

Eupora is a busy little town, the site of a considerable lumber industry and the glove factory of the Wells-Lamont Corporation. It is on the Columbus and Greenville Railway, and at the intersection of U. S. Highway 82 and Mississippi Highway 9.

The routes of travel and transportation consist of highways, railroads, and country roads. The Columbus and Greenville Railway lies along almost the entire southern border of the county, roughly parallel to Big Black River and Highway 82, and the Gulf, Mobile, and Ohio Railroad right-of-way is almost north-south across the eastern end through Mathiston, Maben, Cumberland, and Mantee. The course of U. S. Highway 82, pavement, describes a shallow arc a little inside the county's southern border,

along the northern edge of the valley of Big Black River. Mississippi Highway 15, pavement, roughly parallels the Gulf, Mobile and Ohio Railroad north-south across the eastern end of the county. Mississippi Highway 9 is along a right-of-way a little west of the central meridian, almost north from Big Black River through Eupora and Walthall to half a mile north of Walthall, thence northwest by north. Among the net of secondary roads, most of which are metaled wholly or in part, a few might properly be called highways: Mississippi Highway 10, which leads east by south from Highway 15 in the southeastern corner of the county; the Cumberland-Clarkson road; the Bellefontaine-Embry-Cadaretta road, and the Alva-Tomnolen road. Local roads provide access to almost all parts of the territory in dry weather, but many of them are impassable or practically so in rainy weather because of deep mud or washed-out bridges or submergence from stream overflow. Many sections have no roads except perhaps farm or logging roads. The road pattern was determined to a greater or lesser degree by the topography—the roads have been kept to the tops of hills and ridges as much as practicable, and crossings of the larger valleys and streams are relatively few. The usable crossings of Big Black River number only five or six in Webster County and along its border, a distance of at least 30 miles; only three roads cross Spring Creek; only two can be regularly used across Little Black Creek; two across Salt Creek; four across Sand Creek; five across Calabrella Creek; two across Wolf Creek, and one across Sabougla. Moreover, most of these roads are impassable at times of high water; even the part of Highway 9 in the Big Black River Valley is submerged during big floods.

The economy of the people is almost exclusively agricultural, although lumbering is of some importance. Much of the county is too hilly for successful farming, and considerable areas are underlain by infertile sand; naturally, then, most of the best farms are on the flood plains or "branch bottoms." Cotton and corn are the chief crops. That the lumber industry is still alive in the county is attested by lumber yards at Eupora and at a few places in the country; by portable sawmills operating here and there, and by truck-loads of logs on the roads and highways. Most of the best timber has been cut, and the relatively few

sizable trees that remain, chiefly in the jungles along the main streams, are rapidly being used.

PHYSIOGRAPHY

PROVINCES

Webster County includes parts of two physiographic regions or provinces—the Flatwoods in the east, underlain by the Porters Creek formation, and the North Central Hills, west of the Flatwoods, underlain by the Naheola, the Fearn Springs, the Ackerman, and the Meridian formations.[5] The names suggest the general character of the regions: The Flatwoods is low rolling to flat; the North Central Hills consists of hills and valleys and includes little level surface except on the valley flats.

TOPOGRAPHY AND RELIEF

As a whole, the county is a low, broad ridge, oriented east by north and west by south. The north and south slopes are cut by streams, between which are minor ridges of varying heights. In the North Central Hills district relief is considerable in a short distance in a few places, especially where sands and sandstones are predominant. A few specific examples may be noted. The elevation of the mouth of the old Henley No. 1 well, some 3.5 miles north by east of Clarkson, was given as 530 feet, and although the figure is believed to be too great, it at least suggests that the correct figure may be approximately 500 feet. The elevation of the Skelton well,[6] in a valley a little more than 3 miles northwest of the Henley well, was given as 352 feet. In this area, then, is an elevation difference of at least 148 feet. Southwest of Montevista, as is evident from the section (see Stratigraphy) a difference of elevation of 240 feet exists in a distance of half a mile or less. Furthermore, the elevation of the State of Mississippi No. 1 well,[7] in the northwestern part of the county, was given as 427 feet D.F., and the elevation of a point in the valley of Sabougla Creek less than 4 miles northeast of the well, is 265 feet; thus a relief of 162 feet in 4 miles is indicated, and this is not the maximum for the region. The Sabougla Creek elevation is the lowest recorded for the county; the greatest elevation probably is in the northeastern part of the county, on the Midway-Wilcox cuesta and the Yalobusha-Big Black divide, in the vicinity

of the Henley well. All in all, the maximum surface relief of the county probably is not less than 250 to 275 feet.

The meager elevation data available provide a skeleton picture of the larger topographic features. Elevations along the Gulf, Mobile, and Ohio Railroad[8] range from 446.5 feet at the station in Maben, to 323.7 feet at a crossing a little south of Dancy, and 340.2 feet at the Mantee station; however, the northward descent is not uniform: The altitude at Cumberland station is approximately 446 feet, as at Maben; but at the Pheba road a mile and a half north from Cumberland the altitude is 386.6 feet—that is, the track has descended northwards some 60 feet in 1.5 miles. In the next mile and a half it descends to 323.7 feet—another 63 feet, or a total of 123 feet in less than 3 miles. The relatively abrupt change in altitude is due to descent from the North Central Hills to the Flatwoods, diagonally across the steep side of the cuesta. The Columbus and Greenville Railway[9] descends from an altitude of 421 feet a little east of the Mathiston station, to 374 feet at Sapa, whence it rises to 405 feet a little west of the Eupora station. From Eupora it descends to 358.5 feet at Grady, 355 feet at Tomnolen, and 349 feet at Pellez. Thus, the railroad shows a general west by south slope of 86 feet in 20 miles, but reaches its next to highest point at Eupora, 8 miles west of Mathiston, on the Middle Ackerman cuesta. In like manner the general westward slope of the surface in the northern part of the county is interrupted by local highs.

The general slope of the surface is west-southwest. The topography is featured by cuestas developed from the sand and sandstone units of the geologic formations. Conspicuous examples are: 1) the Midway-Wilcox cuesta, represented by a north-south chain of hills towards the eastern end of the county; 2) the middle Ackerman cuesta, represented by a hill belt, including a few "mountains," across the middle part of the county; and 3) remnants of the Meridian, or basal Claiborne, cuesta, in the western part of the county. Another feature of the topography is the relatively large flood-plain area: The larger streams have wide flats, and even the smaller streams have flood plains well up toward their heads. All in all, the region is in the mature stage of the erosion cycle—hills and ridges rounded, slopes gentle to steep, but having a relatively small ratio of steep slopes to moderate and

gentle; little if any upland untouched by erosion; valleys relatively wide; flats well deveoped.

DRAINAGE

The northern third or more of Webster County, except for its eastern end, is in the Yalobusha River drainage basin, and the southern two-thirds or slightly less, except for its eastern end, is in the basin of the Big Black River. The chief tributaries of the Big Black are, in east-west order: Spring Creek, Little Black Creek, Salt Creek, Calabrella Creek, and Wolf Creek, all southward flowing. The main tributaries of the Yalobusha from Webster County are Shutispear, Sabougla, and Lindsay Creeks, which flow northwest. All the creeks named have numerous tributaries, the drainage system as a whole forming a dendritic pattern which reaches every part of the region. The larger creeks are permanent, being fed by underground water as well as surface water; although their volume fluctuates widely, it is never zero. All streams of the county are subject to floods, which do great damage to crops, destroy bridges, and carry away immense quantities of soil and subsoil.

Some of the larger water courses have been canalized; notably, 3-mile to 4-mile lengths of Big Black River and Spring Creek in the southeastern part of the county, and sections of Sabougla and Lindsay Creeks in the northwestern part.

The streams of the eastern part of the county flow east and southeast to Line Creek, part of the Tombigbee River system.

CLIMATE

No information is available relating to the climate of Webster County specifically; but data for Montgomery County[10] apply to Webster as well. Mean annual temperature is approximately 63 degrees Fahrenheit. Summers are long, and warm to hot; the average temperature for July, the hottest month, is 81 degrees more or less, but the extreme high may be more than 100 degrees. The growing season has an average length of seven months, the last killing frost in the Spring now and then being as late as early April, and the first killing frost in the Fall rarely coming till late October. Winters are short and relatively mild, the average temperature being about 45 degrees, and the temperature seldom

falling as low as 10 degrees. Winter weather is very changeable. Precipitation, almost all in the form of rain, is abundant (average annual precipitation more than 50 inches) and fairly well distributed through the year; but it may not be well distributed in a single month. The manner of precipitation is of great significance as affecting run-off and erosion. Much of the rain comes as hard downpours, and runs off rapidly and almost completely, March and April are the months of greatest precipitation, and October the month of least precipitation. Although very few winters are without snow, heavy snowfalls are very rare. Relative humidity is high.

STRATIGRAPHY

GENERALIZED SECTION

The stratigraphic units which have surface exposures in Webster County are named, classified, and briefly described below, in natural order—that is, in the order of relative age and position, the oldest at the bottom, the youngest at the top, as they are arranged in the Earth's crust.

GENERALIZED SECTION

Cenozoic group	Feet
Quaternary system	
Holocene series	
Recent formation	
Unconsolidated rock waste (mantle rock); residuum, colluvium, alluvium , a heterogeneous mixture, or assorted bodies, of sand, silt, and clay chiefly; estimated, maximum	50
Unconformity	
Pleistocene series?	
Higher stream terraces; possibly a little loess from which the Brown Loam soil was derived; possibly a little of older residuum and alluvium; all sand, silt, and clay chiefly; estimated, maximum	25
Unconformity	
Tertiary system	
Eocene series	
Claiborne sub-series	

Tallahatta (Basic City) formation

Shale, chocolate-brown, dark, and white, silty and sandy; white paper-thin silt shale; sand, chiefly brown and tan, fine; a little claystone, siltstone, sandstone, and quartzite; estimated maximum 25

Meridian formation

Sand, white and brown coarse to fine micaceous; cross-bedded; some sandstone 75

Unconformity

Wilcox sub-series

Ackerman formation

Sand, sandstone, clay shale, clay, silt, lignite, iron ore: A persistent basal sand, coarse to fine, containing locally a few cobbles and boulders; above it a succession of units of fine sand, silt, and clay, silt and fine silty sand predominating; a discontinuous middle sand similar to the basal sand; above it interbedded sand, silt, clay shale, clay, and iron ore, a little lignite; silty and sandy shale and clay predominating. Structure very irregular in many places. Thickness, from well logs and calculated from average degree of dip and width of outcrop, 600 to 700

Unconformity

Fearn Springs formation

Clay, silt, sand: Clay gray, white, pink, silty, very plastic, good pottery clay; yellow and gray somewhat lignitic silt; estimated maximum 25

Unconformity

Midway sub-series

Betheden? formation

Bauxite, kaolin, kaolinitic clay, iron ore, lignitic clay 5

Naheola formation

Clay shale, gray to black and rusty micaceous silty and sandy, interbedded with sand, laminated gray to tan fine silty micaceous; concretions of iron carbonate and oxide; ferruginous crusts; thin bedding conspicuous 100

Porters Creek formation

Clay shale, dark gray, bluish black, black, tabular or showing conchoidal fracture; weathers to a grayish-white clay, flaky when dry; contains some silt and fine sand, comminuted plant remains, and thin iron carbonate discs 500

PORTERS CREEK FORMATION

The Porters Creek is the lowest in the stratigraphic column, therefore the oldest, formation represented by outcrops in Webster County. Its surface area—that is, the area under which Porters Creek is the uppermost rock except for the mantle—comprises a narrow north-south segment bounded on the east by the eastern boundary of the county and on the west by the Naheola outcrop belt (Map, Plate 1). In this strip of territory are several good outcrops of sections of the upper part of the formation.

Figure 2.—Bluff of Porters Creek shale (NW. ¼, Sec. 25, T. 16 S., R. 2 E.) a mile southeast of Dancy.

The largest Porters Creek outcrop in Webster County, and one of the largest in Mississippi, is the face of the east wall of the valley of a tributary of Prairie Creek at a place (NW.¼, Sec.25, T.16 S., R.2 E.), half a mile east from Highway 15 and a quarter of a mile north of a local road. Here the creek, by undercutting the valley wall, has created a steep-faced scarp at least 300 yards long, and 50 feet, maximum, in height (Figure 2). The material exposed is dark-gray to bluish-black and black clay shale, which weathers to gray clay, grayish white when dry. The unweathered clay shale is dense, extremely fine grained, moderately indurated, tough when moist, brittle when dry. A promi-

nent characteristic is its tendency to curved or conchoidal fracture. Fractures develop as if along curved surfaces, splitting the clay body into spheroids, large and small; from them successive spalls or concentric shells break away in much the same manner as the layers of an onion separate from the core, leaving the clay spheroids smaller and smaller. Finally both shells and central mass crumble to a flaky meal which takes up water and becomes a tenacious mud. This conchoidal fracturing is marked, even in the fresh clay shale; it facilitates weathering, and becomes more conspicuous as weathering progresses. In fact, the manner of weathering of the Porters Creek shale might be correctly designated spheroidal weathering.

The shale contains some silt and fine sand, and comminuted plant remains. No doubt finely divided lignite has blackened it. Also thin lentils and smaller lenticular masses of iron carbonate are numerous at the outcrop along the Prairie Creek tributary; the floor of the creek channel at the foot of the scarp has at times been paved with them.

An excellent section of the upper part of the Porters Creek formation and perhaps almost the entire Naheola has been exposed by a Highway 15 cut and by Bluff Creek, which heads a little west of Highway 15 and a little north of Highway 10. Along the south headwater fork and the main branch below the junction of the two headwater forks, the walls and floor of the channel are Porters Creek clay shale, exposed uninterruptedly for a mile or more (Northern part, Sec.17, and NW.¼, Sec.16, T.20 N., R.12 E.). In places the flat creek floor is 15 to 20 feet wide, is washed clean of debris, and affords as sharply defined an outcrop as exists in the county. At several places layers more resistant than the average have caused rapids and small falls. The lowest shale of the section is noticeably light of color and rusty, possibly because it underlies almost flat land and consequently has been reached more effectively by weathering agencies. It is the lower part of an interval which is in general lighter of color and more rusty than the overlying shale, and contains many concretions of iron carbonate. The upper interval of the section is dark-gray to black and bluish-black shale, appearing as flat-lying thin beds cut by joints. The exact contact of this Porters Creek section with the

Naheola beds is hidden, but is somewhere within the 20-foot to 25-foot covered interval at the highway.

Along Highway 10 east of its intersection with Highway 15 are several cuts, most of which are in Naheola strata, but almost on the Webster County-Clay County line, a local road cut in the low south wall of the valley of Bluff Creek has exposed gray and black conchoidally fractured clay under a yellowish weathered mantle.

Road cuts and gullies and ravines north of the places described and east of Highway 15 show other Porters Creek outcrops. A short section (SW.¼ NE.¼, Sec.9, T.20 N., R.12 E.) of gray to black clay having a conchoidal fracture, has been uncovered by a local road cut in the east wall of a shallow valley some 2.5 miles east from Cumberland. Also, west of Mantee for a short distance, and along the road which leads south from Mantee sub-parallel with Highway 15 are Porters Creek outcrops.

NAHEOLA FORMATION

The Naheola formation consists in general of laminated fine sand and thin layers of dark-gray to light-gray silty shale. Commonly shale and sand are interlaminated. Concretions and thin beds of siderite and limonite are present almost everywhere, and marcasite is abundant. The formation is superjacent to the Porters Creek, and its surface area is a strip of territory which extends a little west of north, reaching westwards into the valley of Big Black River along the county's southern boundary, and westwards along the northern boundary of the county to half a mile or more west of the line between Ranges 10 and 11 East. Both eastern and western boundary lines of this outcrop belt are very irregular in detail because of stream dissection of the terrane; and the western boundary partly because of the unconformable contact of the Naheola and the overlying Ackerman formation.

The contact between the Porters Creek and Naheola formations is gradational; no exact stratigraphic position could be fixed for it. As in the Highway 15 and Bluff Creek section, so in other sections which include this contact, its position is somewhere or anywhere within an interval of several feet of strata. In fact, in most writings which concern the Midway of Mississippi,

the beds which are in this report assigned to the Naheola are included in the Porters Creek, although their difference from the typical Porters Creek is noted. Apparently the Porters Creek formation becomes more sandy and silty and more distinctly bedded towards the top, and this upper part, some 50 to 100 feet thick, is correlative, at least in part, with the Naheola formation of Alabama.

Along Highways 10 and 15 are several good outcrops of the Naheola beds. Presumably the 85 feet of strata above the uppermost Porters Creek exposure in the Bluff Creek section belong to the Naheola, except perhaps part of the covered interval which includes the contact between the two formations. The east wall of the Highway 15 cut a few rods north of the junction with Highway 10 shows a 20-foot to 25-foot succession of thin beds or laminae of gray or tan silty fine sand, dark-gray to black silty shale, all micaceous, and thin limonite ore. Some iron rust-cemented laminae and rusty joint fillings are in relief.

Naheola strata are exposed by Highway 10 cuts a little east of the junction, and by several Highway 15 cuts north and south of the junction. At all these places the bedding is sharp and well defined, and the rock material is of the same general character as that of the Bluff Creek section. The best Highway 15 sections are south of Cumberland. In one or two of them iron ore is conspicuous.

A section of Naheola beds (SW.¼, Sec.34, T.20 N., R.11 E.) along a local road in the east wall of the valley of Big Black River a mile northwest of Mathiston is typical of the formation in Webster County, except that it contains more iron ore than is present at most other outcrops observed.

SECTION OF THE EAST WALL OF BIG BLACK RIVER VALLEY A MILE NORTHWEST OF MATHISTON

	Feet	Feet
Naheola formation		56.5
Covered-sand, clayey weathered zone, to top of valley wall, level of houses. Extreme top of upland a little farther southeast, some 15 feet higer	15.0	
Sand, clayey, horizontally laminated, blocky, shaly, rusty except for lowermost two feet or so, which are gray; upper part weathered	6.5	

Clay, lignitic, or sand, fine clayey lignitic; chocolate brown to purplish brown; similar to material at the top of the Naheola in other places. Thickness uncertain because of overlying weathered rock debris; estimated 2.0

Covered, for most part, but gray sandy clay, or argillaceous shaly sand, shows here and there in roadside ditches..... 10.0

Shale, gray, brown, and black sandy and silty, rusty, contains ellipsoidal masses of iron carbonate and oxide; continuous exposure, to flood-plain level. Approximately..... 23.0

The uppermost two intervals of the section may be weathered Fearn Springs, or Ackerman, at least in part.

Several shorter stratigraphic sections in the vicinity of Mathiston and Maben show the same lithologic and structural characteristics as the sections already described—sharply defined thin beds or laminae of fine silty sand and sandy and silty shale, containing iron ore; the sand gray to tan, the clay shale dark gray to light gray; limonitic seams along joints and some bedding planes. Commonly the strata have a very low westward dip.

The features of the upper part of the Naheola are well shown by an outcrop (SW.¼, NW.¼, Sec.13, and SE.¼, NE.¼, Sec. 14, T. 20 N., R.11 E.) some two and a half miles southwest of Cumberland.

SECTION OF SOUTH WALL OF THE VALLEY OF A TRIBUTARY OF BIG BLACK RIVER, ALONG A LOCAL NORTH-SOUTH ROAD, SOME 2.5 MILES SOUTHWEST OF CUMBERLAND

	Feet	Feet
Recent formation		3.0
Soil, sandy loam, and subsoil, dark-brown clayey sand; estimated	3.0	
Ackerman formation		28.0
Sand, medium to coarse, red brown, lighter brown, yellowish, and white; pockets of purple and pink sand; sparingly micaceous; massive to poorly bedded; contains considerable ferruginous sandstone, some large masses. In the basal part, sand pisolitic, bauxite-structured (pseudobauxite), silty, white to brown and yellow and splotched with other colors	28.0	
Unconformity		
Naheola formation		28.0

Sand, thin-bedded, argillaceous; some thin layers of sandy light-colored clay shale; micaceous, especially along the bedding-planes and laminae planes; sand rusty; beds defined by rust	10.0
Iron ore (oxide) discontinuous concretions, up to	1.0
Clay shale, thin beds, and sand, thin yellowish beds and laminae; the shale is in general a darker gray than the shale of interval 4, and is somewhat sandy; fine light-gray sand along the bedding planes	9.0
Covered, to bridge in valley	8.0

The length of the section is 250 to 300 yards. The sand of Interval 5 is especially well exposed by a pit 150 yards long east-west, 180 yards (maximum) wide north-south, and some 30 feet deep, on the east side of the road.

Cuts for the Dancy-Clarkson road have cross-sectioned the Naheola beds in a few places. Approximately 2 miles west from Highway 15 at Dancy, the floor and the walls of a cut a little above the base of the west wall of a valley are black shale. Higher in the section the beds are thin, sandy, and micaceous; the rock material approaches a blocky micaceous sand. Bedding is well defined by indurated ferruginous laminae, and westward dip is conspicuous. Flattish concretions of iron oxide are included in the strata 30 to 35 feet below the top of the ridge, and at the very top of the steeper part of the slope. This section, half a mile long, is one of the best in the county of the Naheola beds, or the thin-bedded sandy upper part of the Porters Creek. It appears to include the Porters Creek-Naheola contact, at the top of the black shale.

Some 0.65 mile northeast from the Clarkson school a road cut (SW.¼, NW.¼, Sec. 34, T.21 N., R.11 E.) exposes a section of uppermost Naheola. Gray rusty sandy clay shale in the lower part of the section grades upwards into gray rust-mottled clay, which in turn grades into almost white clay towards the top. A quarter of a mile farther northeast a shallow cut near the top of a rise shows iron ore debris and gray iron-mottled clay.

Another excellent Naheola section (SW.¼, Sec.16, T.21 N., R.11 E.) is at the surface along a short almost east-west local road 3 miles north of Clarkson, in the east wall of a valley. The

section is 0.4 mile long. The lower, more prominently exposed part of it is described below:

Figure 3.—Naheola beds (SW. ¼, Sec. 16, T. 21 N., R. 11 E.) on east-west local road 3 miles north of Clarkson.

SECTION OF LOWER PART OF EAST WALL OF VALLEY ALONG A LOCAL ROAD 3 MILES NORTH OF CLARKSON

	Feet	Feet
Naheola formation		32.4
Sand, shaly fine micaceous, gray, tan, black; distinctly laminated; includes dark-gray to black paper shale laminae, also thin oxide-encrusted iron carbonate, to top of lower, steeper part of slope	10.0	
Iron ore, oxide-encrusted carbonate	0.7	
Shale, thin black leafy, chiefly, but interlaminated with fine clayey and silty tan and gray micaceous sand; some thin iron ore (Figure 3)	8.7	
Iron ore, chiefly carbonate cased in oxide	0.5	
Sand, as in interval 6, and shale	7.5	
Covered, to bridge	5.0	

Most of the part of the valley wall above the beds described, 30 to 40 feet, is covered, but shaly sand or sandy shale crops out in a place or two.

Cuts for the main road which leads westwards from Mantee are walled with Naheola strata and their weathered residue or with Naheola beds and overlying sand. The longest section between Mantee and Hohenlinden extends from a bridge 2 miles west from Highway 15 to the top of the ridge 0.35 mile farther west, perhaps 100 feet above the valley bottom. Roadside gullies and road cut walls show gray and black clay and clay shale toward the bottom of the ridge, interlaminated with gray and tan sand. The sand is more abundant at higher levels, and the uppermost beds are brown sand interlaminated with light-gray and tan silty and clayey sand containing some sandy iron ore.

Along the road on the southwest slope of the same ridge Naheola gray laminated shale or shaly sand beds are exposed almost continuously for 0.4 mile, and are at the surface in both slopes of the next ridge farther southwest. Half a mile or so still farther southwest, and a little northeast of a road junction (SW.¼, Sec.2, T.21 N., R.11 E.) is an outcrop of rusty greenish-gray to tan laminated shaly sand and clay and silt, very micaceous, especially along the lamination planes. Along the roads 2 to 4 miles south by east are a few outcrops where the lithology and structure of the Naheola may be observed. One of these (Southern part, Sec.3, T.21 N., R.11 E.) 0.35 mile northwest of a road junction, shows greenish sandy very micaceous clay and its weathered phase, a red-brown clayey sand. A little less than a mile farther northwest, 4.0 to 5.0 feet of the same kind of clay are exposed associated with a 0.5-foot layer of iron ore. The same type of material—greenish and gray rusty sandy shale and shaly sand—has been uncovered by roadside ravines some 0.35 mile farther west, at a lower level; and green clay and iron ore crop out at the road junction (Eastern part, Sec.5) three quarters of a mile west of the ravine exposure. In fact, iron ore is relatively abundant along here. Along the road which leads south by east from this junction are other outcrops of shaly sand and red micaceous sand. North of the junction, also, between it and Hohenlinden, road cuts expose gray and red sandy clay and iron ore, especially almost at the junction and about three quarters of a mile north of it.

In the southeast corner of Section 8, or the northeast corner of Section 17, Township 21 North, Range 11 East, 0.65 mile, more or less, southwest from a road junction, is a good outcrop of Naheola laminated gray micaceous clayey sand, containing a foot of iron ore. Also at the junction mentioned, and some 250 yards southwest of it, are other outcrops. Still another very good short section of the laminated light-gray and tan micaceous fine silty sand and sandy and silty clay shale of the upper Naheola has been exposed by gullying along an old road three quarters of a mile west by south from the iron ore outcrop mentioned above, and some 300 yards north of the main road.

Cuts for the northernmost of the Mantee-Hohenlinden roads have uncovered Naheola strata in several places. Three quarters of a mile northwest from the first road junction west by south of Mantee. is a good outcrop—thin layers of black to dark-gray shale interbedded with fine gray tan and rusty micaceous sand. The road is on a westward slope along here for approximately 0.8 mile, of which 0.4 mile is a gentle slope, and 0.2 mile a steeper slope. In the steeper slope the beds are well exposed by roadside walls and ravines. A curved segment of abandoned road is walled with thin-bedded shale and sand, and along the main road shale and sand are exposed almost all the way down the slope. Except in the weathered zone and where affected by slides, the bedding is sharp and well defined, partly because of the rust-cemented laminae. The terrane weathers to greenish sandy clay and clayey sand.

The three miles of road between this valley and Hohenlinden are on Naheola strata, sections of which show in at least two places. At and near Hohenlinden are some of the best outcrops in the county. The village is on a hill between northward-flowing headwater forks of Topisaw Creek, and every road to and from it leads up or down slope through cuts which expose Naheola beds. A little below the top of the slope, the west wall of a cut (NE.¼, Sec.35, T.15 S., R.1 E.) on the road which trends northeast from Hohenlinden is well-bedded shale and sand containing iron ore (Figure 4). The road north by west down the ridge is through cuts in the same beds, and makes an excellent outcrop in the lower and steeper part of the slope. Likewise, the road which leads west is flanked by well-exposed Naheola strata in

the west slope of the ridge. Another good outcrop of Naheola is approximately a mile west of Hohenlinden, on the road northwest to the common corner of Webster, Chickasaw, and Calhoun Counties.

Figure 4.—Naheola beds (NE. ¼, Sec. 35, T. 15 S., R. 1 E.) near the top of the valley wall in the northern edge of Hohenlinden.

Along the Hohenlinden-Montevista road 0.4 mile to 1.0 mile southwest from the first road junction west of Hohenlinden, beds of the same formation crop out in a northeastward facing slope. Road cuts along the southwestward facing slope of the same ridge show a well-bedded section (NW. ¼, Sec. 6, T. 21 N., R. 11 E.) a quarter of a mile in length, of black and gray sandy and silty shale and thin sand layers, including at least two layers of iron ore. This is the southwesternmost well-defined Naheola outcrop on the Hohenlinden-Montevista road; but in the ridge some 0.3 mile across the valley to the west, a section (NE. ¼, Sec. 1, T. 21 N., R. 10 E.) of light-gray red-mottled clay and gray and tan sand is exposed. Although the section appears to have been weathered almost from top to bottom, the bedding of sand and clay shale is still visible well up the slope under a structureless mantle. Some iron ore concretions were found to contain greenish sandy mater-

ial. A quarter of a mile or less farther southwest the Naheola beds grade upwards into thin beds of brown sand and gray clay. A chocolate-colored blocky conchoidal clay shale is overlain by tan sand and light-gray to white clay and a brown and white mixture.

The Porters Creek and Naheola formations are marine, as attested by marine fossils. A study of seventeen samples from several stratigraphic levels of the two formations in Winston County found arenaceous formaminifera of many genera and species.[11] Macroscopic fossils, moulds of gastropods and pelecypods, have been found in the upper part of the Naheola in Kemper County.

A well drilled in 1910 by the town of Mathiston was said to have passed through clay from the surface to a depth of 600 feet.[12] Inasmuch as Mathiston is almost on the Midway-Wilcox contact, presumably the 600-foot thickness of clay is Naheola and Porters Creek.

BETHEDEN FORMATION

Residual material which comprises the uppermost few feet of the Midway in many places was designated the Betheden formation by Mellen[13] in 1939. In Webster County a few remnants of the residuum may remain, although, where the exact Midway-Wilcox contact is concealed, distinction between true residuum subjacent to the contact, and re-worked material in the basal part of the overlying terrane, is not always easy. Theoretically, if contact zone rock under younger beds is weathered and structureless. it can with reason be assigned to the Midway residuum; if it is bedded, it has been re-worked and may be considered part of the Wilcox terrane. The Midway-Wilcox contact is exposed in several places along its strike across Webster County.

Re-worked Betheden material is present here and there in the contact zone entirely across the county, but at no outcrop was conclusive evidence found that any part of the Betheden formation in place remains at the surface. For example, although a considerable area in the vincinity of Maben and Mathiston is almost coincident with the contact, the topographic surface being slightly below or slightly above the actual contact surface, no material which could be proved to be Betheden as defined by

Mellen was found. On the contrary, in a few places the evidence is that the mantle rock which accumulated from the weathering of the Naheola beds prior to the beginning of Wilcox time, was swept away entirely and incorporated in the superimposed sands. On the Wood Jr. College road, 1.7 miles north of Highway 82 at Mathiston, a cut exposes some top strata of the Naheola in contact with overlying Ackerman sand except for 2 to 3 inches of bauxitic sandstone between. Also, the section (SW. ¼, NW. ¼, Sec. 13, T. 20 N., R. 11 E.) described in the part of the present report which concerns the Naheola formation, includes a sharp Midway-Wilcox contact, the sand resting on the Naheola beds. The pisolitic silty white to brown and yellow sand which occupies a part of the Betheden stratigraphic position here, appears to be a lens of reworked material. Likewise, in another pit or two the sand rests directly on the Naheola strata.

On the north-south local road three quarters of a mile more or less, west of Maben, a cut (NE. ¼, Sec. 26, T. 20 N,. R. 11 E.) only 0.1 mile south of an intersection, has exposed hard blocky light-gray clay overlain by fragments of bauxite in a weathered zone. The material may be true Betheden.

A little less than 2 miles southwest of Cumberland, on both sides of the southern of the two Cumberland-Walthall roads, white kaolinitic clay, possibly residual, is exposed, lying on Naheola laminated gray and brown clayey sand. The contact appears to be gradational. Brown concretionary ferruginous sandstone, and some iron ore, are associated with the clay.

An outcrop of rock material, at least part of which may be Betheden residuum in place, has been made by pits along a local road in the southeast corner of Section 27, Township 21 North, Range 11 East, some 0.35 mile northeast of a road junction. Mantle rock and other rock debris have been removed from perhaps an acre. A rough bed of very siliceous and ferruginous bauxitic rock a foot to two feet thick is uppermost, and several large masses of ferruginous quartzitic sandstone are lying about among abundant smaller fragments. Most of the floor of the pit is dull white to brown and yellow pisolitic sand, and on the southeast side of the road the pit shows little except white and brown silty sand. Pieces of the rock were found at a considerable distance north of the pit, and a quarter of a mile southwest of it.

The southeast wall of a cut (almost on the line between Secs. 33 and 34, T. 21 N., R. 11 E.) for the Dancy-Clarkson road, in the west wall of a small valley some 0.65 mile northeast of the Clarkson School, is gray rusty sandy clay shale grading upwards into gray rust-mottled clay, of which the upper part is almost white. The clay shale is upper Naheola, and the white clay could perhaps be considered part of the Betheden terrane. A little farther southwest, at a greater elevation, and only 0.2 mile northeast of the road junction at the Clarkson School, a small cut shows white and gray clay of the same character as that at the larger outcrop.

At a few other places, described in the discussion of the Naheola formation, white clay and bauxitic debris possibly are remnants of the Betheden residuum. However, in general, the Betheden terrane as described by Mellen is poorly represented in Webster County, if present at all, even though the Midway-Wilcox contact zone is exposed here and there in a north-by-west belt having a maximum width of 3 miles.

WILCOX—GENERAL

The Wilcox terrane is the most heterogeneous of the Tertiary of Mississippi, in both lithology and structure. The complexity of the lithology is not due to the presence of many different kinds of rock materials—sand, silt, and clay shale or clay comprise almost the entire mass of Wilcox sediments—but to the intricate intermingling of the materials. Almost it could be truly said that in the Wilcox terrane no sand unit is free from silt or clay, or both; no body of silt is free from sand or clay, or both; and no aggregate of clay lacks its silt and fine sand. In short, the generalization would probably be sound, that no Wilcox deposit is ever even as much as nine-tenths composed of one kind of sediment. The structural features and relationships of the units are as complex as the lithology. In Webster County at least, few of the many outcrops are of evenly bedded, conformable, parallel, normally dipping strata or laminae; and near most places where uniform bedding is exposed are outcrops which show irregular structure, indicating that the regular stratification is not continuous for any considerable distance. Numerous outcrops show clay and silt bodies of various shapes and sizes haphazardly oriented in a sand matrix. Cross-bedding or lamination in various directions, undulatory bedding, and sinuosities of all sorts, are common. Con-

temporaneous erosion surfaces may be seen in many places. In a word, it seems that units, large and small, of sand, silt, clay, lignite, iron ore, and mixtures of all these materials are intertongued, interlensed, interwedged, interwoven, in a complicated pattern which does not conform to any system. Small wonder, then, that the Wilcox terrane has long perplexed geologists who have sought some kind of order in it, and that it still puzzles them. The Midway sediments were deposited as units, each of which could be differentiated from the others, and labeled, because it had characteristics peculiar to itself, and essentially constant. The Midway is reasonably orderly. Not so the Wilcox; it seems to be constant in its heterogeneity only. In this character can be found the reasons for the difficulty geologists have had in their attempts to correlate different regions, to recognize the existence of major divisions, if any, to delimit them and to establish criteria for them. Some geologists do not recognize any subordinate unit of the surface Wilcox of sufficient size and of character sufficiently distinctive to justify a name; they refer to the entire terrane as "undifferentiated Wilcox." Grim[14] states, "Any subdivision of the Wilcox is, therefore, purely arbitrary." Not so many years ago the Wilcox was ranked a series consisting, in central and northern Mississippi, of the Ackerman formation below and the Holly Springs above. Later study showed that the Holly Springs is at least in part, the equivalent of the Meridian sand, which has been held to be of Claiborne age by some geologists, and of Wilcox age by others. Although no attempt is made in this paper to make out a case for differentiation of major parts of the Wilcox terrane in Webster County, beyond recognition of the Fearn Springs and Ackerman formations, yet more or less distinct minor divisions of the Ackerman are recognized. References will be found to the basal Ackerman sand and to the middle Ackerman sand; also to the Lower Ackerman and the Upper Ackerman.

FEARN SPRINGS FORMATION

The Wilcox beds of Winston County, between the Midway-Wilcox contact and the basal Ackerman sand, were considered by Mellen[15] a distinct stratigraphic unit, and named the Fearn Springs formation. Prior to his work these strata had been included in the Ackerman formation. He found the Fearn Springs formation to consist of sand, silt, and clay: "Throughout the

state, it contains ball-type clays, good stoneware clays, silty clays, silt, sand, lignite, and siderite."[16] In one section which he describes the 25 feet of Fearn Springs strata were:[17]

	Feet
"Silty material, probably originally same as below, but highly ferruginous and structureless because of weathering	4.8
Clay, evenly bedded micaceous very silty laminated	12.0
Silty material, micaceous, ferruginous (limonitic)	0.2
Sand, cross-bedded and lenticular fine-grained to medium-grained, and large flakes of muscovite; thin and irregular lenses of stoneware clay and reworked bauxite	8.0."

Mellen's description of another Fearn Springs section of Winston County is quoted below:[18]

	Feet	Feet
"Fearn Springs formation		45
Soil, yellowish residual	10	
Siltstone, thin ferruginous at unconformity; medium- to fine-grained argillaceous sand, cross-bedded, containing a few clay balls and streaks of clay; thin beds of laminated silty clay in lower part; upper half of interval dominantly fine-grained sandy finely laminated sparingly micaceous clay containing comminuted lignitic material; argillaceous fine-grained sand lenses subordinate	35	

Disconformity."

The same geologist found the Fearn Springs formation of Winston County to have a maximum thickness of 50 feet or more.[19]

Vestal[20] did not differentiate the Fearn Springs formation in Choctaw County, although he recognized the presence in the county of strata of Fearn Springs age. Some of these Fearn Springs beds are described in test-hole records and descriptions of the outcrops in Bulletin 52, Mississippi State Geological Survey.

As was true of the Betheden terrane, so of the Fearn Springs —in few places, if at any place, is it present at the surface in Webster County, at least as well-defined strata of the character just described. Here and there at exposed sections which lie across the Midway-Wilcox contact the beds that overlie the contact resemble some of the Fearn Springs beds of the type locality.

Some of the clay interval of the larger pit section at Mathiston may be Fearn Springs material. It consists of light-gray, dove-

colored, chocolate and black clay, the lowermost interval of the section. The overlying yellowish micaceous sand also may be Fearn Springs. Furthermore, some other clay which crops out in the vicinity of Mathiston and Maben may be Fearn Springs clay.

A probable Fearn Springs outcrop is 4 miles west of Mathiston, on the Sapa road 0.1 mile south of Highway 82, at the north edge of the flood plain of Big Black River. The section here (Northern part, Sec. 1, T. 19 N., R. 10 E.) consists of light-gray and pinkish clay at the base, grading upwards into yellow, gray-streaked sandy silt, which in turn grades into a clay and sand conglomerate. The conglomerate is overlain, above a well-defined contact. by brown, coarse sand, gritty towards the base, containing some small gravel and fragments of silicified wood. The sand is believed to be of Ackerman age.

Approximately 2.5 miles northeast from the Sapa road junction, a little above the foot of the east slope of a ridge, a road cut (SE. ¼, NW. ¼, Sec. 32, T. 20 N., R. 11 E.) exposes a sharp irregular contact between dense light-gray to pinkish laminated clay below, and current-bedded coarse brown sand, containing stringers of lighter colored sandy clay, above. The contact line strikes westwards diagonally across the face of the wall of the cut. The clay is here assigned to the Fearn Springs formation, the sand to the Ackerman.

The third and fourth intervals of the section (SW. ¼, Sec. 34, T. 20 N., R. 11 E.), described in the Naheola part of the present report, may be Fearn Springs material.

In the northern part of the county, where relief is considerable, road cuts have exposed segments of the Midway-Wilcox contact in a few places, but no well-defined section of Fearn Springs beds. The Hohenlinden-Montevista road is across the contact some 2 miles northeast by east from Montevista. In the west wall of a small valley, a quarter of a mile west of a prominent outcrop of Naheola strata in the east wall of the same valley, road cuts (NE. ¼, Sec. 1, T. 21 N., R. 10 E.) show a section of sand and sandy clay shale chiefly. The lowermost interval, a light-gray to dark-gray blocky sandy micaceous clay shale, is overlain by a foot or so of compact yellowish rust-cemented shaly

sandy clay, and this in turn by red-mottled clay. A few iron ore concretions containing greenish sand are included. The rusty clay is thought to be uppermost Midway. No typical Fearn Springs material is present, but in the upper part of the valley wall some 200 yards farther west, beds of blocky mottled sandy clay shale alternate with beds of brown sand which contain some thin layers of white sandy and silty clay, probably eroded from Fearn Springs clay. Thicker overlying sand beds contain thin white clay laminae. In the upper part of the west slope of the rise, dark-gray and chocolate-brown hard leaf-bearing clay shale, blocky and showing some conchoidal fracture, crops out in the north wall of the road cut. It is overlain by tan sand and light-gray to white clay, and seems to be part of a body of clay which extends some distance westwards, as indicated by another outcrop a little below the top of the next rise some 0.2 mile farther west, where rusty mixed-up sandy clay abuts against and interfingers with brown cross-laminated non-micaceous sand along a diagonal contact. It seems possible that the entire section from the top of the Naheola to the clay-sand contact just referred to, might be properly classified as Fearn Springs. It occupies the Fearn Springs stratigraphic position, but its lithology suggests Ackerman clay shale.

The Hohenlinden-Montevista road section is probably the thickest visible section in the county across the Midway-Wilcox contact, but, as is true of other outcrops, it does not show the kind of material described as typical of the Fearn Springs formation. Light-colored clay stringers and irregular bodies in the sand suggest that Fearn Springs material has been eroded from its original position and worked into overlying sand. In fact, the Fearn Springs formation may be absent from its stratigraphic position in more places than it is present. Also, as Mellen[21] notes, the clay tends to be very slippery when wet, and to cause land-slips which result in burial of the clay under sand. Probably, then, Fearn Springs beds are present in places in the outcrop belt, but not visible because masked by sand.

A ravine (SW. ¼, Sec. 13, T. 21 N., R. 10 E.) along the Savannah Lake-Montevista road 0.4 mile northwest from an intersection, exposes lignitic clay at the bottom, above it light-gray sandy clay, and still higher a yellowish mixture of weathered sand and clay. These beds are believed to be either uppermost Naheola, or

Fearn Springs. Half a mile northwest, similar, perhaps the same, clays are exposed, and slightly farther down slope, light-gray and rusty bedded fine silty sand. At the road junction (NW. ¼, Sec. 14, T. 21 N., R. 10 E.) a mile and a half southeast from Montevista, gray and rusty somewhat lignitic bedded fine silty sand grades upward into light-gray clay which is yellowish at the top. The uppermost material is brown and red-brown sand. The clay-sand contact is believed to be correlative with that north of Montevista.

ACKERMAN FORMATION

Inasmuch as a stratigraphic section of the entire Wilcox of northern Choctaw County is almost completely exposed, and the sequence and lithology of its beds are similar to the sequence and lithology of the Webster County Wilcox, it is described briefly herein. The LaGrange road, along the top of the south wall of the valley of Big Black River, at distances from the river ranging from 2 miles to less than a quarter of a mile, trends a little south of west, almost down dip, across the outcrop belt of the Wilcox strata. Topographic relief varies from slight to relatively great; the over-all direction of slope of the surface is roughly parallel to the direction of dip, but the general degree of slope is somewhat less than the average degree of dip. Road cuts, ravines, and gullies have provided numerous outcrops. Some intervals of the section are described below, in the order of stratigraphic position, lowest to highest, which is also the order of age, oldest to youngest; and the chief lithologic features of each are stated, insofar as they could be ascertained from outcrops.

Although the section lies across the Midway-Wilcox contact, no Fearn Springs material like that of Winston County, described by Mellen, is present; seemingly, Ackerman beds lie on the Naheola.

On the LaGrange road, a little more than half a mile west from its junction (almost on the line between Secs. 10 and 15, T. 19 N., R. 11 E.) with Highway 15, a 50-foot to 60-foot section of lowermost Ackerman strata is exposed in the east slope of a ridge. The basal interval consists of brown and red-brown coarse to medium finely cross-laminated sand which contains stringers of light-gray clay. It is overlain by interbedded silt, clay, and fine sand, which, near the top, include light-gray and lignitic clay and

pillow-shaped masses of iron ore. Half a mile farther west, a short distance west of a road fork (NE. ¼, NW. ¼, Sec. 16, T. 19 N., R. 11 E.) a cut in the east slope of a 25-foot to 30-foot rise reveals higher thin-bedded silt, fine sand, and light-gray clay. The top of this rise is, roughly, 1.5 miles west of the highway and at least 75 to 80 feet above it.

A good section of the east wall of a valley half a mile or a little less west of the forks has been uncovered by cuts and roadside gullies:

SECTION OF WESTWARD FACING HILL SLOPE ABOUT 1.7 MILES WEST OF HIGHWAY 15, NORTHERN CHOCTAW COUNTY, ON THE LAGRANGE ROAD (NW. COR., SEC. 16, OR NE. COR., SEC. 17, T. 19 N., R. 11 E.)

	Feet	Feet
Ackerman formation		60.2
Clay, sandy and silty, red brown, weathered, to top of ridge in road	6.0	
Clay, light-gray	3.0	
Silt, laminated irregularly, bluish gray where fresh, green on weathered surface	17.0	
Covered, presumably Ackerman	5.0	
Clay shale, gray to slate colored, dark, dense, conchoidally fractured; visible	5.0	
Iron ore, oxide, pillow-shaped masses	0.7	
Clay, bluish gray and greenish gray, blocky; interval partly covered	7.0	
Lignite	1.5	
Clay, gray, blocky; interval partly covered; some of lower part may be laminated silt	7.0	
Iron ore, as above	0.5	
Silt, laminated, bluish gray and brown	2.5	
Covered, except for foot or so of bluish-gray conchoidal clay, to the bottom of a roadside ditch at the mouth of a gully at the level of the valley flat	5.0	

The bed of lignite and the upper iron ore probably are correlative with the lignitic clay and the iron ore of the section half a mile west of the highway.

Approximately 2.4 miles west from Highway 15, and a little east of a junction, the face of the south wall of a cut shows 10 feet of black, chocolate-brown, and dark-gray to light-gray clay shale, overlain by brown to tan silty sand and laminated silt. The beds are slightly arched east-west. The west slope of the ridge exposes gray, greenish-gray, and lignitic clay containing two layers of

iron ore concretions, one of which may be correlative with the upper ore of the last section described.

Towards the foot of the steeper part of the eastward facing slope 3.3 miles west from Highway 15 is an outcrop showing very irregularly bedded brown and tan sand containing stringers of gray clay and variously oriented blocks of laminated green silt and gray clay. The same kind of material, associated with chaotic bedding, is exposed also along a farm road leading northwards.

Approximately 3.6 miles west from Highway 15, a 100-foot section of the south wall of the river valley is almost completely exposed by cuts for a road which leads north across the river to Sapa, Webster County, and by a deep ravine a little east of the road:

SECTION OF SOUTH WALL OF BIG BLACK RIVER VALLEY ALONG SAPA ROAD AND LAGRANGE ROAD (SE. ¼, SEC. 12, NE. ¼, SEC. 13, T. 19 N., R. 10 E.; NW. ¼, SEC. 18, T. 19 N., R. 11 E.)

	Feet	Feet
Ackerman formation		100.0
Clay and iron ore: Clay gray and lignitic, iron ore thin flattish concretions: silt, light gray, and silty clay shale; sand, laminated gray to tan and yellow fine, to top of cut for LaGrange road a little west from junction with Sapa road; 25.0 to	30.0	
Silt, sand, and clay, interlaminated; sand fine, dull white, light gray, tan to olive drab, and brown; clay laminae in relief, defining the bedding sharply; upper part of section especially laminated and shaly	65.0	
Clay, light gray, thin interval; sand, fine, clayey and silty, gray to black, rusty, uppermost part notably shaly and rusty; slightly consolidated, blocky, to flood plain of river	5.0	

A feature of the uppermost interval of the section is the steep dip of the beds, one rough measurement finding a dip of 5 feet in 35 feet S.30° to 35°W. The same dip shows at an outcrop 0.7 mile farther west.

The walls of a cut in the up slope 0.5 mile farther west are light-gray silty blocky clay irregularly interbedded with thin sand layers and lentils and a 0.4-foot iron ore layer. Above this outcrop, on the north side of the road, is a sand cap, and much ferruginous sandstone lying on a low slope below it. This sand and sandstone is an outlier of the sand and sandstone and silty

limonite cap at LaGrange, some 0.65 mile farther west, which is considered the Middle Ackerman sand. Lignitic clay shows west of and a little below the road-level top of the hill overlying the gray clay; and bedded silt and gray and lignitic clay are exposed almost uninterruptedly westwards to the west wall of the valley of Phillips Creek, on which the village of LaGrange stands. The lower part of the face of the west wall of the valley of Phillips Creek along the road is an excellent outcrop of light-gray to white sandy and silty clay. The clay is overlain by dense slabs of silty limonite and by ferruginous sandstone along a sharp but irregular contact which can be traced northward by float rock to the level of the valley floor. A quarter of a mile or less from the road, pieces of hard, gray, root-marked claystone or siltstone, identical with that at Flat Rock Church, Benton County, are lying about.

Outcrops of the strata in northern Choctaw County between Highway 15 and LaGrange, as described in the foregoing paragraphs, indicate, according to the writer's interpretation, that the surface trace of the Midway-Wilcox (Naheola-Ackerman) contact intersects the Highway 15-LaGrange road a short distance west of Highway 15 and extends westwards across the face of the south wall of the valley of Big Black River to the flood plain 2.5 miles or more west of the highway. The outcrops suggest also that the contact trace of the Middle Ackerman sand and the underlying Ackerman clay shows in the Highway 15-LaGrange road in the west wall of the valley of Phillips Creek at LaGrange, and extends westwards along the south wall of Big Black River Valley to and well beyond Highway 9.

The Middle Ackerman sand at LaGrange is coarse to medium, brown and red brown on the surface but almost white where fresh, and not conspicuously micaceous. Some 30 feet above its base is a 4-inch to 5-inch layer of dense silty limonite or limonitic silt, the top of which rises to 40 feet above the base of the sand where it forms a ledge across the road a few rods farther west, and to 50 feet above the base on the west side of the hill a few feet below the top. The attitude of this upper silty limonite bed seems to indicate that the bed was formed along a sloping sand-clay contact, a beveled surface of the sand bed. The silty limonite layer is overlain by 15 to 20 feet of light-gray, brown, and red-mottled clay.

Along Highway 9 between the valley of Big Black River and the LaGrange road, cuts in the lower part of the valley wall expose at least 35 to 40 feet of horizontally bedded, thin-bedded to laminated very fine micaceous silty sand, light gray to tan and yellow, grading upward into surface brown to red brown, with some bands of light-gray to white sand. It is believed that this sand is a continuation of that at LaGrange, and that both belong to a middle sand member of the Ackerman formation. The sand along the highway is overlain by dark-gray sandy clay which dries white.

Southwestward from Highway 9 along a continuation of the LaGrange road, outcrops show a succession of interbedded clays, silts, sands, and iron ore, clays predominating. A mile from the highway a deep road cut in the first considerable up slope southwest of LaGrange affords an excellent exposure of one of the chaotically structured intervals of the Wilcox: The units are interbedded and interlensed and interfingered in a complicated manner; steeply inclined diagonal lamination is a feature. Most of the material is fine silty sand or sandy silt. The basal part of the section is light-gray iron-splotched clay, dipping normally towards the west; and the upper part, above the zone of irregular structure, also, is evenly bedded and has a normal west to southwest dip. However, midway of the slope, in the chaotic zone, the general dip is eastwards at a high angle. Half a mile farther southwest, at an elevation which, allowance being made for dip, indicates that it is stratigraphically higher than the section just referred to, is an outcrop of gray, bluish, and lignitic clay containing two layers of iron ore. Farther southwest the surface has a greater relief, and the road cuts show a larger proportion of sand. Some 2.2 miles from Highway 9 and at a southward bend of the road, a deep ravine on the west side descends 50 to 75 feet in a short distance through red-brown sand, possibly correlative with the sand of the irregularly bedded interval a mile east of it.

A mile west by north of a road junction a good section (SW. ¼, Sec 19, T. 19 N.,R. 10 E.) of Ackerman strata is exposed along an old washed-out road cut in the south wall of the valley of Big Black River. Some 60 to 65 feet of evenly bedded and laminated sand, silt, and sandy and silty lignitic clay and clay shale crop out here, with several feet of red-brown sand as uppermost interval.

A road cut 0.1 mile west of the section shows gray clay and sand beds dipping strongly west. West-southwest of the section 0.4 mile to 0.5 mile, and above a very irregularly bedded interval of sand containing clay stringers, are two layers of iron ore concretions in clay. The interval of confused bedding with which the ore is associated is exposed both northeast and southwest of the iron ore.

Sand predominates at the outcrops west of the iron ore just mentioned. Half a mile or so east of the junction (Sec. 25, T. 19 N., R. 9 E.) red-brown sand begins to be conspicuous and the surface more rugged. Only a quarter of a mile southwest of the junction is a hill of red-brown sand, which is succeeded farther southwest by other hills of sand to beyond the Tomnolen road intersection (SW. ¼, Sec. 35, T. 19 N., R. 9 E.). Westward from the intersection to the river flood plain on the Tomnolen road the outcrops show red sand and re-worked clay; also some light-gray clay and thin iron ore near the base of the valley wall. North of the intersection the upper part of the valley wall is red-brown sand containing fragments of ferruginous rock, and the lower part is weathered clay with lignitic streaks and pieces of iron carbonate masses.

Along the north-south road across Big Black River Valley which joins U. S. Highway 82 at Pellez a little more than a mile southwest of Tomnolen, Webster County, the lower part of the gently sloping southeast wall of the valley is brown and yellowish weathered material, and the upper part is red-brown sand. A good section is exposed by an eroded old roadway west of the present road. Also, along the road southwest from the intersection (SW. ¼, Sec. 4, T. 18 N., R. 9 E.) red and brown sand is the only rock material visible for a mile; but a little above the flat of McCurtain Creek, in the east wall of the valley, is an outcrop of gray clay. The west wall of the creek valley, however, appears to be sand only. Approximately a mile and a quarter west of the intersection (Western part, Sec. 18, T. 18 N., R. 9 E.) is a body of gray and lignitic silty clay in the sand, possibly re-worked. A tenth of a mile farther southwest is a well-defined clay-sand contact, and a little farther on, another clay outcrop. Cuts along the route of descent of the south wall of the valley of the Big Black, south of Stewart show sand only; but southwest by south of the intersection (SE. ¼, Sec. 15, T. 18 N., R. 8 E.) of the Stewart road with

local Choctaw County roads, the surface terrane is largely gray clay. A mile from the intersection is an outcrop of gray clay and large ellipsoidal masses of iron ore which is continuous to Free Will Baptist Church (SE. ¼, Sec. 22) and beyond, half a mile east of the Montgomery County line.

This part of the Ackerman outcrop area reaches southwestwards along the river to and perhaps beyond the Montgomery County line, its extent perhaps being greater than it would normally have been, possibly because of lessening of dip due to warping on the southeast margin of the Kilmichael Dome. Furthermore, the general slope of the land surface is roughly parallel with the regional dip of the underlying strata, and not greatly less in degree.

In Webster County, scattered deposits of sand, lying on Naheola beds on the east border of the Ackerman outcrop area, are believed to be basal Ackerman sand. They are particularly prominent well toward the eastern edge of the Naheola area of outcrop, where several pits along the strike afford very good exposures. Two of these pits are on the north side of U. S. Highway 82 in the eastern edge of Mathiston. The smaller pit, at the intersection of the highway and a local road, exposes 15 to 20 feet of cross-laminated fine micaceous gray, yellow, red-brown, and white sand containing lentils and stringers of white pisolitic sandy silt or kaolinitic clay (Figure 5). The larger pit (Figure 6), some 200 yards east of the smaller, is 30 to 35 feet deep at the north end, where the lower part of the vertical wall is fine micaceous gray and white and yellow cross-laminated sand, and the upper part is brown and red-brown sand enclosing scattered inclusions of pisolitic white sandy silt or clay (Figure 7). In the center is the most conspicuous feature of the entire pit—a 15-foot ledge or bench, of which the lower 10-foot interval is fine micaceous sand, and the upper 3-foot to 5-foot interval is a sandstone, dark red and coarse grained on the surface (Figure 8).

The general level of the pit floor is about at the base of the fine sand, but a deeper excavation has exposed lignitic and gray clay which may belong to the Fearn Springs interval.

Figure 5.—Basal Ackerman sand, smaller pit, eastern edge of Mathiston, on the north side of U. S. Highway 82 at intersection of highway and a local road.

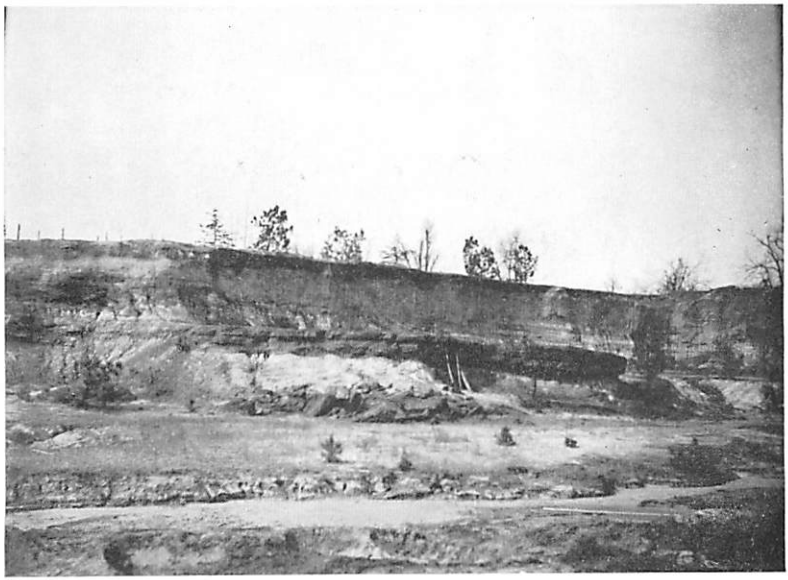

Figure 6.—Basal Ackerman sand, larger pit, on the north side of U. S. Highway 82 at Mathiston, some 200 yards east of the smaller pit.

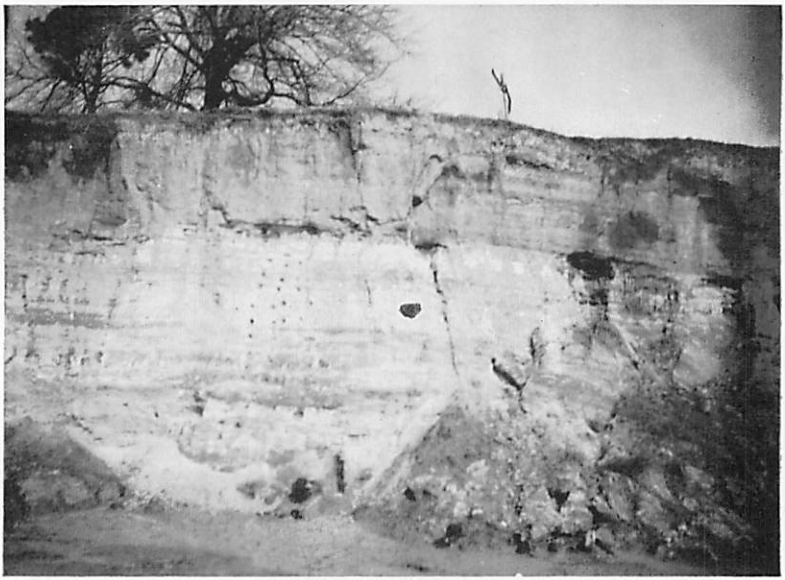

Figure 7.—Basal Ackerman sand, face of north wall of larger pit at Mathiston.

Figure 8.—Basal Ackerman sand: Sand and sandstone ledge in center of larger pit at Mathiston.

SOUTH-NORTH SECTION OF PIT (NEAR CENTER, SEC. 2, T. 19 N., R. 11 E.) A LITTLE EAST OF MATHISTON, ON THE NORTH SIDE OF U. S. HIGHWAY 82

	Feet	Feet
Ackerman formation		51.0
Soil and subsoil, to top of north wall of pit estimated	1.0	
Sand, whitish, brown, and red-brown, compact, somewhat indurated, fine to coarse; jointed; spalls off along planes parallel to the face of the wall, in blocks 2 feet or more thick; contains pellets and small pockets of light-colored sand, and lentils of pisolitic sand and clay (pseudo bauxite), especially toward the top	17.0	
Sand, bedded, horizontally and cross laminated, fine, micaceous, white, yellow, gray, pink, brown, and dark streaked, but not so much dark material as in second interval; contact with overlying sand sharp; thin ferruginous crust	15.0	
Sandstone, deep hematite red on surface, but yellow, greenish, brown, tan, or black beneath the surface; tenacious to friable; forms roof of bench or ledge in the center of the pit, and descends northward; 4 feet of it show at the base of the north wall of the pit; also shows a little in the east and west walls. (Figure 9) Maximum	5.5	
Sand, yellow, fine, micaceous; lower part of overlying interval; 1.5 to	2.0	
Sand, fine micaceous (very fine mica flakes), white, streaked with yellow and gray and dark (lignitic sand); contains black spots and pockets of comminuted lignite; laminated and cross laminated; 10.0 to	10.5	
Unconformity		
Fearn Springs (?) formation 6.0 to		8.0
Clay, light-gray, dove colored, and chocolate and black; upper surface uneven, sloping eastward from the west wall of the pit; southward the interval wedges into or dips under the sand 6.0 to	8.0	
Covered, to water level at south end of pit	4.0	4.0

The laminae of the west wall of the pit dip north at a low angle (Figure 10).

This body of sand can be traced northwards and southwards along the strike, and in places westwards to some distance. A road cut (Northern part, Sec .2, T. 19 N., R. 11 E.) 0.45 mile northeast

Figure 9.—Nearer view of sand and sandstone ledge in center of larger pit at Mathiston.

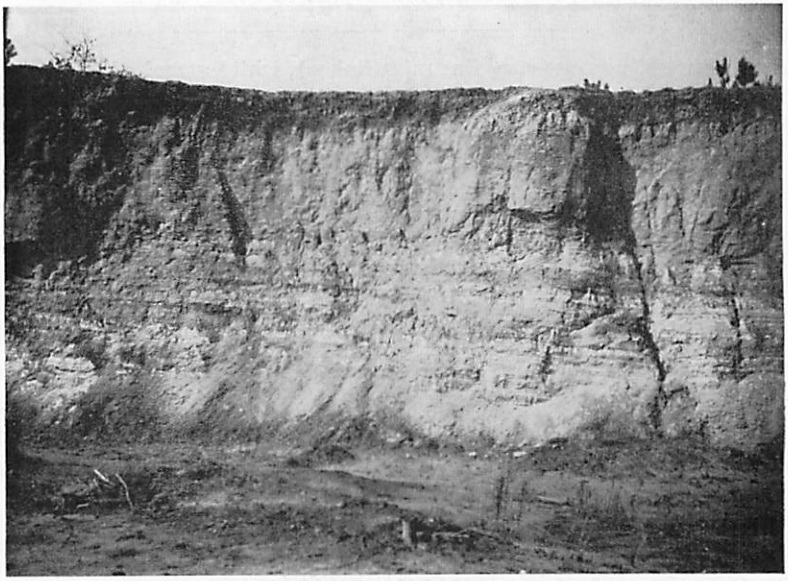

Figure 10.—Basal Ackerman sand, face of west wall of larger pit at Mathiston, showing low northward dip of beds.

from Highway 82 in eastern Mathiston, exposes brown sand containing many stringers of white and brown pisolitic sand (Figure 11), and a few rods farther northeast at almost the same level, light-gray plastic iron-stained clay (weathered Naheola or Fearn Springs) crops out. North of Highway 82, 1.7 miles, on the east side of the Wood Jr. College road, the north wall of a small valley at the spillway of an artificial lake is the same red-brown and

Figure 11.—Stringers of white and brown pisolitic sand in a matrix of brown sand in the wall of a road cut (Northern part, Sec. 2, T. 19 N., R. 11 E.) 0.45 mile northeast from Highway 82 in eastern Mathiston.

white sand containing many stringers, lentils, and smaller inclusions of white pisolitic silty sand. An outcrop of Naheola is only 0.1 mile south of this sand exposure, and about the same distance north of it, 60 yards or so east of the road, are pits 25 feet deep in the sand, which here is brown and banded brown and light colored.

The sand member of the section (SW. ¼, NW. ¼, Sec. 13, T. 20 N., R. 11 E.), described in the part of the present report which concerns the Naheola formation, is one of the most prominent outcrops of the basal Ackerman sand in the county.

On the road which trends south by west from Cumberland for a mile or more, thence west, the sand and re-worked material are well exposed by a pit (SE. cor., Sec. 12, T. 20 N., R. 11 E.) on the south side of the road 1.4 miles southwest from the railroad at Cumberland. The bottom and walls of the pit are brown sand and white clayey and silty pisolitic sand. The white components comprise a very large proportion of the exposed terrane, in the form of irregular bodies worked into the red-brown sand, which in general overlies the white material (Figure 12).

Figure 12.—Irregular bodies of white pisolitic sand in a matrix of red-brown basal Ackerman sand. Pit (SE. cor., Sec. 12, T. 20 N., R. 11 E.) on the south side of the Cumberland-Walthall road 1.4 miles southwest of Cumberland.

Two or three large pits (SE. ¼, Sec. 23, T. 21 N., R. 11 E.), the largest of which is a quarter of a mile north by west from a road junction expose sand of this same belt. The floors and lower parts of the walls of the pits are white sand, and stringers of white sand and clay are numerous in the brown sand. In general the sand is red-brown shot through with stringers of sand and clay of a lighter color; but other colors—light brown, yellow, pink, white, purple—splotch the sand body here and there.

Another pit, in the upper part of a low hill (Near center, Sec. 10, T. 21 N., R. 11 E.), 0.35 mile north of the intersection at the Cross Roads Baptist Church, has a floor of Betheden-type

bauxitic white and yellow sand, and walls of red-brown coarse to medium sand containing a considerable percentage of purple and white sand and clay inclusions. The pit is, roughly, 100 yards long, 60 yards wide, and 25 to 30 feet deep.

A short distance east of the road forks approximately a mile and a half west of Mantee, a large pit (NE. ¼, Sec. 4, T. 16 S., R. 2 E.) exposes brown to red-brown and white micaceous sand, cross laminated in different directions and at various angles, and large slabs of micaceous ferruginous sandstone.

Some 3.5 miles south of Hohenlinden, a pit (Southern part, Sec. 17, T. 21 N., R. 11 E.) on the north side of a short road and 0.35 mile east by south of a road junction, has been excavated in sparingly micaceous yellowish-brown sand containing pipe concretionary sandstone. The sand, lying on Naheola beds, is approximately 30 feet thick.

Clarkson, on the divide between Big Black River and Spring Creek, 2 to 3 miles south of their sources, stands on sand, presumably of Ackerman age, only a few feet above the Midway-Wilcox contact zone, as attested by outcrops of Naheola beds a short distance northeast. The region northwest of Clarkson, part of the divide between the Big Black River and the Yalobusha River drainage basins, is sand ridges and hills. Road cuts in the vicinity of Savannah Lake expose brown, red-brown, and whitish silty sand; and ridges extending southwards between the head branches of Spring Creek are capped with brown and red-brown sand. The sand rests on the Midway beds, which crop out in a few places along the eastern edge of the sand area, as in Sections 16 and 17, Township 21 North, Range 11 East. A little more than 2.5 miles west of Clarkson, at a road junction (NW. ¼, Sec. 6, T. 20 N., R. 11 E., and NE. ¼, Sec. 1, T. 20 N., R. 10 E.) a thickness of 15 to 20 feet of sand is exposed by gullies in the northeast wall of the valley of Spring Creek. The sand is brown and pink towards the base, and brown above, and contains stringers and smaller inclusions of sandy light-colored clay near the base. In the opposite wall of the valley, 0.6 mile farther southwest, an outcrop made by a road cut near the center of Section 1, a few rods southwest of a junction, shows 5 feet or more of white sand at the base, grading upwards into rusty sand, above which is an interval of some 10

feet of greenish jointed blocky clay shale containing a few thin discoidal concretions of iron ore.

The origin and the exact stratigraphic position of the easternmost sand interval are not readily determined from surface relationships. However, west and southwest of the road junction (almost on the line between Secs. 17 and 18, T. 21 N., R. 11 E.) and half a mile or less west of an outcrop of Betheden-type material, cuts and gullies in the west wall of a small valley expose yellowish to white shaly clay or laminated silty clay shale interbedded with brown sand, dipping westwards. Above it is weathered structureless brown and red-brown sand to the top of the ridge, some 75 to 80 feet above the valley floor. The section seemingly includes the sand of the pits and the other outcrops described in the foregoing paragraphs, and is here considered part of the Ackerman formation.

So far as was observed, this basal Ackerman sand interval does not extend eastwards beyond the Naheola belt of outcrop, along which its surface expression is a cuesta and a drainage divide. Attempts to trace it westwards were not very successful, largely because of the discontinuity of surface strata brought about by stream erosion in the development of the present drainage system. As already indicated, the patches of the sand member east of Spring Creek are the upper parts of the divides. Furthermore, the brown and red-brown color is a surface character, which becomes less noticeable with depth, and finally disappears.

West of the outcrops at and north and northwest of Mathiston is the wide flat valley of Big Black River and Spring Creek, where no bed rock shows; and the surface material of the low west wall of the valley is for the most part a brownish mixture of weathered clay and sand and silt. However, some clues to the stratigraphy may be found at the few outcrops along and near Highway 82, and obtained from well logs.

U. S. Highway 82 in southern Webster County is on a region of low relief—the northern edge of the flood plain of Big Black River and the southern edge of the low sloping north wall of the river valley. It lies across several southward-flowing tributaries of the Big Black, the larger of which have relatively wide flats that merge with the river plain and extend a considerable distance up the tributaries. Thus, the inter-stream terrane is a series

of finger-like ridges reaching southward, progressively lower in elevation southward to their ends at flood-plain level. Active weathering and erosion in this region have lowered the surface and destroyed almost all evidence of structure. Highway cuts in the low ridges between the stream plains are shallow, and most of them expose nothing except a structureless mixture of sand, silt, and clay, stained various shades of brown, yellow, and red by oxidation of iron. At a few places a more or less sharp contact is present between light-colored laminated sandy and silty clay below and brown sand above.

The westernmost showing (Northern part, Sec. 1, T. 19 N., R. 10 E.) of the Midway-Wilcox contact trace or of superjacent beds in southeastern Webster County is 4 miles west from Mathiston by Highway 82, on the Sapa road 0.1 mile south of the highway, at the north edge of the Big Black River flood plain. The uppermost interval of the section here (see Fearn Springs formation) above a well-defined contact, is brown coarse sand, gritty towards the base, containing some small gravel and fragments of silicified wood. Joints containing green clayey sand extend upwards from the base of the sand interval, and small ironstone concretions and concretionary ferruginous sandstone are strung along the contact. The sand is believed to be basal Ackerman.

In this connection, the log of a test-hole drilled by Layne Central Company on the property of Carvis Gary,[22] some 2.5 miles east from the center of Eupora, and 1.5 miles west from the Sapa road is worth attention:

LOG OF TEST HOLE NO. 3

Location: 255 feet south of Highway 82, on the property of Carvis Gary and almost due south of his residence, which is on the north side of the highway; about 2.5 miles east of the center of Eupora.
Driller: Layne Central Company, Jackson, Mississippi.

	Strata	Total depth
Top soil	15	15
Sand, medium fine, yellow	25	40
Sand, fine, yellow; clay streaks	20	60
Sand, fine, yellow; clay streaks; sand a little coarser than above	20	80
Sand, medium, yellow; clay streaks	20	100
Sand, medium, white; fairly clean	20	120
Sand, coarser, medium, with clay and shale	20	140
Mostly blue clay; a little fine sand at top	20	160
Blue clay, hard; no sand	20	180

defined by iron rust. The excavation on the north side of the highway, a short time after it was made, exposed a sharp contact between the laminated interval and the sand (Figure 13). In places the laminae can be traced across the contact into the sand, although they are much less distinct in the sand, and somewhat uneven. Such a relationship seems to be evidence that the silty brown sand is the weathered, especially oxidized, laminated sandy silt. The sand lies as a mantle on the slope, thicker towards the bottom: The 40-foot bluff some 200 yards north of the highway is all sand and sandstone, so far as can be determined from the outcrop. The sand of the bluff outcrop is fine grained to medium grained, cross laminated, current bedded, and contains scattered inclusions of light-colored clay and silt. Large slabs and masses of irregularly laminated ferruginous sandstone project from the face of the outcrop; others are lying on the talus slope below.

South of the highway the same kind of laminated rusty sandy silt is exposed by a railroad cut and by gullies in the slope south of the railroad. Reconnaissance north of the highway along the east wall of the valley of Little Black Creek found the same kinds of materials and relationships in a place or two as much as a mile north of the highway, in a region of few outcrops. Silicified wood is fairly abundant.

The region north of Highway 82, west of Spring Creek, and south of the latitude of Walthall contain a considerable number of outcrops of Ackerman sands, silts, and clays. A few of them may be described briefly, as representative of the general character of the formation, or at least of the lower part of it.

A section (NW. ¼, Sec. 32, T. 20 N., R. 11 E.) of the northwest wall of the valley of Spring Creek, approximately 2 miles east-northeast of the Sapa road junction, has features which seem to

It will be noted that, except for the "top soil" and "clay streaks," the material penetrated was fine to medium yellow sand to a depth of 100 feet, and medium white sand for another 20 feet. Probably a large part of it is alluvial fan sand, transported from the higher land to the north, but the two or three intervals next above the blue clay may be basal Ackerman. The lowermost 40 feet of "blue clay" probably are Naheola. The consistent 20-foot thickness of the intervals obviously is arbitrary. Unfortunately,

Figure 13.—Lower Ackerman laminated silt and fine sand: Excavation in the east wall of the valley of Little Black Creek, on the north side of U. S. Highway 82, a mile east of Highway 9 in Eupora.

the elevation of the mouth of the well is not stated; but probably it is not more than 25 feet greater than that of the Columbus and Greenville Railway along here (378.7 feet)[23]—that is, approximately 404 feet.

The beds of the east wall of the valley of Little Black Creek a mile or so east of Eupora are well exposed by the Highway 82 cut, the creek valley, and excavations on both sides of the highway. The highway cut walls show a thickness of 12.5 feet of

A mile northwest of the Section 32 outcrop, in the southwest wall of the valley of a Spring Creek tributary, a cut for a north-south road at a church and cemetery (SW. ¼, Sec. 30, T. 20 N., R. 11 E.) has uncovered a section of irregularly bedded terrane at a greater elevation. The lower part of the 40-foot exposure is highly cross-bedded brown sand, containing lentils and stringers, and pellets and other irregular bodies of banded light-gray sandy silt and clay and light-colored sand worked into the brown sand at various angles; the upper part, to the top of the valley wall, is more or less weathered material.

Other outcrops, along a northeast-southwest road (NW. ¼, Sec. 25, T. 20 N., R. 10 E.) a mile and more still farther west and somewhat higher stratigraphically, bring to view additional sections of Ackerman strata, the best of which is in the northeast wall of a small valley 0.3 mile to 0.45 mile southwest of a road junction and approximately 1.5 miles north of the Sapa junction on Highway 82. Light-gray, greenish-gray, and lignitic clay are exposed farther down the slope, and light-gray rusty laminated clayey and sandy silt in brown clayey and silty sand above.

Along the local road which extends due north from Eupora, east of Highway 9, laminated sand containing clay laminae is exposed in a place or two, and approximately 2 miles north of the junction of this road with Highway 9 in Eupora, shallow cuts and roadside gullies in a long gentle up slope northwards have uncovered light bluish-gray sandy laminated clay, lignitic at base. Several large blocks of ferruginous sandstone and many chips of iron oxide-cemented clay are lying about. This place may be on the contact of the Lower Ackerman silts and clays with an outlier of the Middle Ackerman sand. Farther north along this road 0.6 mile is an outcrop of whitish, yellow, and lignitic clay under red-brown sandstone and sand. The basal zone of the sand

bauxitic white and yellow sand, and walls of red-brown coarse to medium sand containing a considerable percentage of purple and white sand and clay inclusions. The pit is, roughly, 100 yards long, 60 yards wide, and 25 to 30 feet deep.

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LOG OF TEST HOLE NO. 3

Location: 255 feet south of Highway 82, on the property of Carvis Gary and almost due south of his residence, which is on the north side of the highway; about 2.5 miles east of the center of Eupora.
Driller: Layne Central Company, Jackson, Mississippi.

	Strata	Total depth
Top soil	15	15
Sand, medium fine, yellow	25	40
Sand, fine, yellow; clay streaks	20	60
Sand, fine, yellow; clay streaks; sand a little coarser than above	20	80
Sand, medium, yellow; clay streaks	20	100
Sand, medium, white; fairly clean	20	120
Sand, coarser, medium, with clay and shale	20	140
Mostly blue clay; a little fine sand at top	20	160
Blue clay, hard; no sand	20	180

of light gray to dull white or buffy pinkish buffy clay are [illegible] bedded with brown sand which is cross laminated and faintly current bedded, and contains sandstone crusts, fragments of weathered silicified wood, and thin undulating stringers of gray clay. Some of the clay bands of the outcrop are several inches wide.

It will be noted that, except for the "top soil" and "clay streaks," the material penetrated was fine to medium yellow sand to a depth of 100 feet, and medium white sand for another 20 feet. Probably a large part of it is alluvial fan sand, transported from

A mile northwest of the Section 32 outcrop, in the southwest wall of the valley of a Spring Creek tributary, a cut for a north-south road at a church and cemetery (SW. ¼, Sec. 30, T. 20 N., R. 11 E.) has uncovered a section of irregularly bedded terrane at a greater elevation. The lower part of the 40-foot exposure is highly cross-bedded brown sand, containing lentils and stringers, and pellets and other irregular bodies of banded light-gray sandy silt and clay and light-colored sand worked into the brown sand at various angles; the upper part, to the top of the valley wall, is more or less weathered material.

Other outcrops, along a northeast-southwest road (NW. ¼, Sec. 25, T. 20 N., R. 10 E.) a mile and more still farther west and somewhat higher stratigraphically, bring to view additional sections of Ackerman strata, the best of which is in the northeast wall of a small valley 0.3 mile to 0.45 mile southwest of a road junction and approximately 1.5 miles north of the Sapa junction on Highway 82. Light-gray, greenish-gray, and lignitic clay are exposed farther down the slope, and light-gray rusty laminated clayey and sandy silt in brown clayey and silty sand above.

Along the local road which extends due north from Eupora, east of Highway 9, laminated sand containing clay laminae is exposed in a place or two, and approximately 2 miles north of the junction of this road with Highway 9 in Eupora, shallow cuts and roadside gullies in a long gentle up slope northwards have uncovered light bluish-gray sandy laminated clay, lignitic at base. Several large blocks of ferruginous sandstone and many chips of iron oxide-cemented clay are lying about. This place may be on the contact of the Lower Ackerman silts and clays with an outlier of the Middle Ackerman sand. Farther north along this road 0.6 mile is an outcrop of whitish, yellow, and lignitic clay under red-brown sandstone and sand. The basal zone of the sand contains clay breccia. East of the southern of these two outcrops a mile more or less in the east wall of the valley of Little Black Creek, are two considerable sand exposures. A little north of a road junction, a cut (NW. ¼, Sec. 27, and NE. ¼, Sec. 28, T. 20 N., R. 10 E.) is entirely in sand, brown to red chiefly, but including much purple and pink sand and many stringers and lumps of purple, pink, and yellow clay. The sand is highly cross bedded in places.

bauxitic white and yellow sand, and walls of red-brown coarse to medium sand containing a considerable percentage of purple and white sand and clay inclusions. The pit is, roughly, 100 yards long, 60 yards wide, and 25 to 30 feet deep.

A short distance east of the road forks approximately a mile and a half west of Mantee, a large pit (NE. ¼, Sec. 4, T. 16 S., R. 2 E.) exposes brown to red-brown and white micaceous sand, cross laminated in different directions and at various angles, and large slabs of micaceous ferruginous sandstone.

Some 3.5 miles south of Hohenlinden, a pit (Southern part, Sec. 17, T. 21 N., R. 11 E.) on the north side of a short road and 0.35 mile east by south of a road junction, has been excavated in sparingly micaceous yellowish-brown sand containing pipe concretionary sandstone. The sand, lying on Naheola beds, is approximately 30 feet thick.

Clarkson, on the divide between Big Black River and Spring Creek, 2 to 3 miles south of their sources, stands on sand, presumably of Ackerman age, only a few feet above the Midway-Wilcox contact zone, as attested by outcrops of Naheola beds a short distance northeast. The region northwest of Clarkson, part of the divide between the Big Black River and the Yalobusha River drainage basins, is sand ridges and hills. Road cuts in the vicinity of Savannah Lake expose brown, red-brown, and whitish silty sand; and ridges extending southwards between the head branches of Spring Creek are capped with brown and red-brown sand. The sand rests on the Midway beds, which crop out in a few places along the eastern edge of the sand area, as in Sections 16 and 17, Township 21 North, Range 11 East. A little more than 2.5 miles west of Clarkson, at a road junction (NW. ¼, Sec. 6, T. 20 N., R. 11 E., and NE. ¼, Sec. 1, T. 20 N., R. 10 E.) a thickness of 15 to 20 feet of sand is exposed by gullies in the northeast wall of the valley of Spring Creek. The sand is brown and pink towards the base, and brown above, and contains stringers and smaller inclusions of sandy light-colored clay near the base. In the opposite wall of the valley, 0.6 mile farther southwest, an outcrop made by a road cut near the center of Section 1, a few rods southwest of a junction, shows 5 feet or more of white sand at the base, grading upwards into rusty sand, above which is an interval of some 10

feet of greenish jointed blocky clay shale containing a few thin discoidal concretions of iron ore.

The origin and the exact stratigraphic position of the easternmost sand interval are not readily determined from surface relationships. However, west and southwest of the road junction (almost on the line between Secs. 17 and 18, T. 21 N., R. 11 E.) and half a mile or less west of an outcrop of Betheden-type material, cuts and gullies in the west wall of a small valley expose yellowish to white shaly clay or laminated silty clay shale interbedded with brown sand, dipping westwards. Above it is weathered structureless brown and red-brown sand to the top of the ridge, some 75 to 80 feet above the valley floor. The section seemingly includes the sand of the pits and the other outcrops described in the foregoing paragraphs, and is here considered part of the Ackerman formation.

So far as was observed, this basal Ackerman sand interval does not extend eastwards beyond the Naheola belt of outcrop, along which its surface expression is a cuesta and a drainage divide. Attempts to trace it westwards were not very successful, largely because of the discontinuity of surface strata brought about by stream erosion in the development of the present drainage system. As already indicated, the patches of the sand member east of Spring Creek are the upper parts of the divides. Furthermore, the brown and red-brown color is a surface character, which becomes less noticeable with depth, and finally disappears.

West of the outcrops at and north and northwest of Mathiston is the wide flat valley of Big Black River and Spring Creek, where no bed rock shows; and the surface material of the low west wall of the valley is for the most part a brownish mixture of weathered clay and sand and silt. However, some clues to the stratigraphy may be found at the few outcrops along and near Highway 82, and obtained from well logs.

U. S. Highway 82 in southern Webster County is on a region of low relief—the northern edge of the flood plain of Big Black River and the southern edge of the low sloping north wall of the river valley. It lies across several southward-flowing tributaries of the Big Black, the larger of which have relatively wide flats that merge with the river plain and extend a considerable distance up the tributaries. Thus, the inter-stream terrane is a series

of finger-like ridges reaching southward, progressively lower in elevation southward to their ends at flood-plain level. Active weathering and erosion in this region have lowered the surface and destroyed almost all evidence of structure. Highway cuts in the low ridges between the stream plains are shallow, and most of them expose nothing except a structureless mixture of sand, silt, and clay, stained various shades of brown, yellow, and red by oxidation of iron. At a few places a more or less sharp contact is present between light-colored laminated sandy and silty clay below and brown sand above.

The westernmost showing (Northern part, Sec. 1, T. 19 N., R. 10 E.) of the Midway-Wilcox contact trace or of superjacent beds in southeastern Webster County is 4 miles west from Mathiston by Highway 82, on the Sapa road 0.1 mile south of the highway, at the north edge of the Big Black River flood plain. The uppermost interval of the section here (see Fearn Springs formation) above a well-defined contact, is brown coarse sand, gritty towards the base, containing some small gravel and fragments of silicified wood. Joints containing green clayey sand extend upwards from the base of the sand interval, and small ironstone concretions and concretionary ferruginous sandstone are strung along the contact. The sand is believed to be basal Ackerman.

In this connection, the log of a test-hole drilled by Layne Central Company on the property of Carvis Gary,[22] some 2.5 miles east from the center of Eupora, and 1.5 miles west from the Sapa road is worth attention:

LOG OF TEST HOLE NO. 3

Location: 255 feet south of Highway 82, on the property of Carvis Gary and almost due south of his residence, which is on the north side of the highway; about 2.5 miles east of the center of Eupora.
Driller: Layne Central Company, Jackson, Mississippi.

	Strata	Total depth
Top soil	15	15
Sand, medium fine, yellow	25	40
Sand, fine, yellow; clay streaks	20	60
Sand, fine, yellow; clay streaks; sand a little coarser than above	20	80
Sand, medium, yellow; clay streaks	20	100
Sand, medium, white; fairly clean	20	120
Sand, coarser, medium, with clay and shale	20	140
Mostly blue clay; a little fine sand at top	20	160
Blue clay, hard; no sand	20	180

It will be noted that, except for the "top soil" and "clay streaks," the material penetrated was fine to medium yellow sand to a depth of 100 feet, and medium white sand for another 20 feet. Probably a large part of it is alluvial fan sand, transported from the higher land to the north, but the two or three intervals next above the blue clay may be basal Ackerman. The lowermost 40 feet of "blue clay" probably are Naheola. The consistent 20-foot thickness of the intervals obviously is arbitrary. Unfortunately,

Figure 13.—Lower Ackerman laminated silt and fine sand: Excavation in the east wall of the valley of Little Black Creek, on the north side of U. S. Highway 82, a mile east of Highway 9 in Eupora.

the elevation of the mouth of the well is not stated; but probably it is not more than 25 feet greater than that of the Columbus and Greenville Railway along here (378.7 feet)[23]—that is, approximately 404 feet.

The beds of the east wall of the valley of Little Black Creek a mile or so east of Eupora are well exposed by the Highway 82 cut, the creek valley, and excavations on both sides of the highway. The highway cut walls show a thickness of 12.5 feet of laminated silt. A west face south of the highway shows about 8.0 feet of jointed, tan to light-yellow conspicuously laminated silt

and fine sand, overlain by brown silty sand. The laminae are defined by iron rust. The excavation on the north side of the highway, a short time after it was made, exposed a sharp contact between the laminated interval and the sand (Figure 13). In places the laminae can be traced across the contact into the sand, although they are much less distinct in the sand, and somewhat uneven. Such a relationship seems to be evidence that the silty brown sand is the weathered, especially oxidized, laminated sandy silt. The sand lies as a mantle on the slope, thicker towards the bottom: The 40-foot bluff some 200 yards north of the highway is all sand and sandstone, so far as can be determined from the outcrop. The sand of the bluff outcrop is fine grained to medium grained, cross laminated, current bedded, and contains scattered inclusions of light-colored clay and silt. Large slabs and masses of irregularly laminated ferruginous sandstone project from the face of the outcrop; others are lying on the talus slope below.

South of the highway the same kind of laminated rusty sandy silt is exposed by a railroad cut and by gullies in the slope south of the railroad. Reconnaissance north of the highway along the east wall of the valley of Little Black Creek found the same kinds of materials and relationships in a place or two as much as a mile north of the highway, in a region of few outcrops. Silicified wood is fairly abundant.

The region north of Highway 82, west of Spring Creek, and south of the latitude of Walthall contain a considerable number of outcrops of Ackerman sands, silts, and clays. A few of them may be described briefly, as representative of the general character of the formation, or at least of the lower part of it.

A section (NW. ¼, Sec. 32, T. 20 N., R. 11 E.) of the northwest wall of the valley of Spring Creek, approximately 2 miles east-northeast of the Sapa road junction, has features which seem to place it in the basal part of the Ackerman formation. The road cut at this place has exposed 20 to 25 feet of sand and clay: Layers of light-gray to dull white or faintly pinkish sandy clay are interbedded with brown sand which is cross laminated and faintly current bedded, and contains sandstone crusts, fragments of weathered silicified wood, and thin undulating stringers of gray clay. Some of the clay bands of the outcrop are several inches wide.

A mile northwest of the Section 32 outcrop, in the southwest wall of the valley of a Spring Creek tributary, a cut for a north-south road at a church and cemetery (SW. ¼, Sec. 30, T. 20 N., R. 11 E.) has uncovered a section of irregularly bedded terrane at a greater elevation. The lower part of the 40-foot exposure is highly cross-bedded brown sand, containing lentils and stringers, and pellets and other irregular bodies of banded light-gray sandy silt and clay and light-colored sand worked into the brown sand at various angles; the upper part, to the top of the valley wall, is more or less weathered material.

Other outcrops, along a northeast-southwest road (NW. ¼, Sec. 25, T. 20 N., R. 10 E.) a mile and more still farther west and somewhat higher stratigraphically, bring to view additional sections of Ackerman strata, the best of which is in the northeast wall of a small valley 0.3 mile to 0.45 mile southwest of a road junction and approximately 1.5 miles north of the Sapa junction on Highway 82. Light-gray, greenish-gray, and lignitic clay are exposed farther down the slope, and light-gray rusty laminated clayey and sandy silt in brown clayey and silty sand above.

Along the local road which extends due north from Eupora, east of Highway 9, laminated sand containing clay laminae is exposed in a place or two, and approximately 2 miles north of the junction of this road with Highway 9 in Eupora, shallow cuts and roadside gullies in a long gentle up slope northwards have uncovered light bluish-gray sandy laminated clay, lignitic at base. Several large blocks of ferruginous sandstone and many chips of iron oxide-cemented clay are lying about. This place may be on the contact of the Lower Ackerman silts and clays with an outlier of the Middle Ackerman sand. Farther north along this road 0.6 mile is an outcrop of whitish, yellow, and lignitic clay under red-brown sandstone and sand. The basal zone of the sand contains clay breccia. East of the southern of these two outcrops a mile more or less in the east wall of the valley of Little Black Creek, are two considerable sand exposures. A little north of a road junction, a cut (NW. ¼, Sec. 27, and NE. ¼, Sec. 28, T. 20 N., R. 10 E.) is entirely in sand, brown to red chiefly, but including much purple and pink sand and many stringers and lumps of purple, pink, and yellow clay. The sand is highly cross bedded in places.

Road cuts northwest, west, southwest, and south of the junction (SE. ¼, Sec. 1, T. 20 N., R. 10 E.) expose much clay—greenish, bluish, gray, and lignitic, some of it compact, blocky, and somewhat indurated, approaching clay shale. Almost everywhere gray, greenish, or tan laminated silt and fine sand are interbedded with the clay. A feature is the abundance of silicified wood. Two or three of the outcrops are of some prominence:

Road cuts in both flanks of a ridge (SE. ¼, Sec. 3, T. 20 N., R. 10 E.) two and a quarter miles west from the valley of Spring Creek, have uncovered greenish-gray very plastic clay below and above lignitic clay. Outcrops of the same beds are along the road south of this ridge exposure—a road which trends south by east from the intersection on the southern boundary of Section 3. Three quarters of a mile south of the intersection, in front of an abandoned cabin, a thickness of some 30 feet of strata is visible, consisting of micaceous selenitic sandy gray clay towards the base, and above it laminated gray, tan, and rusty silty sand, and some clay shale. The south wall of the small valley, 0.4 mile farther south, is greenish, tan, gray, black, and rusty fine silty sand, interlaminated with thin clay. Towards the top of the rise these strata are overlain by lignitic clay. The uppermost 20-foot interval is lignitic and light-gray, bluish and greenish-gray clay under a little tan sand. The entire section is perhaps 50 feet. Fragments of silicified wood are numerous along this road.

A road cut (NE. ¼, Sec. 9, T. 20 N., R. 10 E.) a mile east of Walthall, has exposed a section of very irregularly bedded fine sand, clay, and silt, a section very similar to many other sections in the county. Sand is dominant—laminated, gray where fresh, brown on the weathered surface; laminae, conspicuous because defined by iron oxide, are curved or diagonal. The surface appearance of much of the material is that of the structure of partly decayed wood. Joint breaks, and unit contacts, are defined by harder cemented seams. In short, the face of either wall of the cut is that of a cross-section of chaotically bedded sands and clays, seeming to reflect the work of vigorous and shifting currents. Another feature of the outcrop is the dark patches and dark laminae. The upper 5 to 7 feet of the exposure is the kind of featureless red-brown clayey and silty sand that constitutes the mantle rock of a large part of the territory. The general dip is westwards.

At Walthall strata of the same general character are exposed by Highway 9 cuts, and by a ravine some 0.4 mile east from the highway. On both sides of the highway south of its intersection with a local road leading into Walthall, are outcrops of a laminated very sandy and silty tan and light-gray clay, or a clayey and silty fine sand, which contains two beds of iron ore. The laminae are defined by iron rust, and the entire surface is streaked and spotted with rust. The same kind of material crops out along the local road between the highway and the courthouse in Walthall.

Highway cuts, and ditches on both sides of the highway north of the intersection at Walthall afford other good outcrops through a vertical interval of 50 feet. The lowermost beds, light-gray sandy clay, grade upward into lignitic clay, which, in turn, is overlain, above a sharp line of contact, by intricately interbedded sand and clay and iron ore, well exposed by a cut through the upper part of the ridge 0.2 mile north of the intersection.

Because the section of upper Midway and lower Wilcox beds along the Hohenlinden-Montevista-Bellefontaine road is more nearly continuously exposed than is any other section of the same age in Webster County, it is described herein in some detail.

The Midway-Wilcox transition zone is described under "Fearn Springs Formation." A few feet above the transition beds, and a little below the top of a rise (NW. ¼, Sec. 1, T. 21 N., R. 10 E.) a rusty, mixed-up sandy clay abuts against and interfingers brown cross-laminated non-micaceous sand along a diagonal contact. Fingers of gray clay extend into the sand from the main clay body, and clay pellets are scattered through the sand. The entire structure suggests an origin by both aggradation and degradation—deposition of sand, subsequent channeling of the sand, and still later deposition of clay, silt, and fine sand in the erosion depressions. The relationships of the units here testify that disturbed conditions prevailed in this region in early Wilcox time. Here and there along the road for a mile farther west are outcrops of the same character, along with some probably residual red-brown sand and sandstone.

Vertical faces of the walls of cuts in the 55-foot west wall of the valley of Buck Creek (Sec. 2, T. 21 N., R. 10 E.) afford an excellent showing of the same unit. By far the greater part of the Buck Creek section is tan, olive-drab, light-gray, and rusty

fine sand, diagonally and otherwise irregularly laminated; but it includes many irregular stringers, lentils, pellets, and other bodies of light-gray clay shale and wood-textured laminated silt and sand, the clay content increasing towards the top. The outcrop as a whole resembles a mosaic. Such extremely irregular, almost chaotic, structures prevail through a thick interval of the Lower Ackerman terrane—in fact, it is present in places through the entire formation.

A tenth of a mile or a little farther northeast from the northern of the two road junctions at Montevista, a section (SW. ¼, SE. ¼, Sec. 3, T. 21 N., R. 10 E.) is exposed by a ravine and a road cut:

SECTION OF RAVINE AND ROAD CUT WALLS IN NORTH EDGE OF MONTEVISTA

	Feet	Feet
Ackerman formation		63.0
Sand, white to red brown, coarse to fine, but chiefly fine; sparingly micaceous; contains flakes of white clay; clay ball at base, encased by 2 inches to 3 inches of limonite; some ferruginous sandstone; sharp contact with underlying clay shale; to top of ridge	20.0	
Clay shale and sand: Light-gray silty clay shale interbedded with tan to olive-drab cross-laminated micaceous fine sand; clay shale dominant	39.0	
Covered, to flat at bottom of steeper gradient of ravine	4.0	

At least the upper half of this section is higher stratigraphically than the Buck Creek section, but the lower (39-foot) interval probably is part of the Buck Creek section. The 20-foot sand interval is part of a sand belt which extends uninterruptedly north into Calhoun County, south to a mile or more south of Montevista, and west to the valley of Shutispear Creek. It may be the oxidized upper part of the interbedded sand and silt terrane.

A little northwest of the road junction (NE. ¼, Sec. 9, T. 21 N., R. 10 E.) a confused mosaic of sand and clay similar to that at Buck Creek is displayed by the road cut walls. It is on the same level as some of the red sand, suggesting that much red sand is a weathered phase of the gray and tan sand of the irregular interval. Road cuts (NE. ¼, Sec. 8, T. 21 N., R. 10 E.) in the west wall of the valley of Shutispear Creek a mile west of the Section 9 outcrop, show the same kinds of materials and the same structure —that is, tumultuously bedded tan sand containing shale stringers

at the base, the southwest wall, the foot of which is only a quarter of a mile farther southwest, shows 85 feet of cream-colored or light-yellow rusty shale or clay interspersed with thin beds and laminae of very fine silty sand. Alternating laminae of silty clay and silty fine sand are conspicuous because of iron rust along the lamination planes (Figure 14). In the lower part of the outcrop, almost uniform northeastward dipping bedding prevails; in the upper part, irregular and strong cross bedding, dipping northeastwards for the most part. Cuts in the opposite (southwest) wall of the ridge expose the same kinds of materials, dipping both northeast and southwest.

Southwest of a west headward tributary of Shutispear Creek, the road is on an ascent 0.6 mile long, which reaches more than 165 feet above the water of the tributary. The top of the "mountain" on the northwest side of the road is 75 feet still higher. The stratigraphic section of this elevation, as exposed along the Montevista-Bellefontaine road, is described below:

SECTION OF "MOUNTAIN" (NE. ¼, SEC. 17, T. 21 N., R. 10, E.) ALONG THE MONTEVISTA-BELLEFONTAINE ROAD 2.5 MILES SOUTHWEST FROM MONTEVISTA

	Feet	Feet
Ackerman formation		241.5
Sand and sandstone: Sand coarse to fine, red brown and white and a little purple and pink; much ferruginous sandstone, including pipe sandstone; large masses of sandstone cap the "mountain." Some reworked clay in the basal part of the interval; to top of "mountain"	110.0	
Clay, light gray to dark gray lignitic, greenish; 0.5-foot band of lignitic clay at top, under the sand; clay plastic; contains five beds of iron ore, of a total thickness of 3.5 to 4.0 feet	25.0	

and blocks of laminated shale tossed about haphazardly. This interval is succeeded upwards topographically by a brown sand and sandy clay mantle. Half a mile farther west is an outcrop (NW. ¼, Sec. 8) of decayed-wood textured dull-white rusty laminated sandy and silty clay shale, or sandy and clayey silt, incorporated in brown fine sand which probably is residual from

Figure 14.—Lower Ackerman laminated silty clay and fine sand: Road cut SW. ¼, Sec. 9, T. 21 N., R. 10 E.) in the southwest wall of the valley of Shutispear Creek, 1.5 miles southwest from Montevista.

weathering of the laminated beds. This kind of material is abundant in the lower part of the Ackerman formation of Webster County.

The succession noted above is repeated along the Montevista-

laminated light-gray to white lumpy sandy clay, sand, and silt, a confused mosaic on the outcrop. Some 25 to 30 feet above the base of the interval, considerable bodies of light-gray clay in the sand finger into brown sand which contains bands and pellets of gray clay 35.0

Sand, light gray clayey, grading upwards into alternating gray and brown sand weathered beds, and these into a weathered, structureless interval 22.0

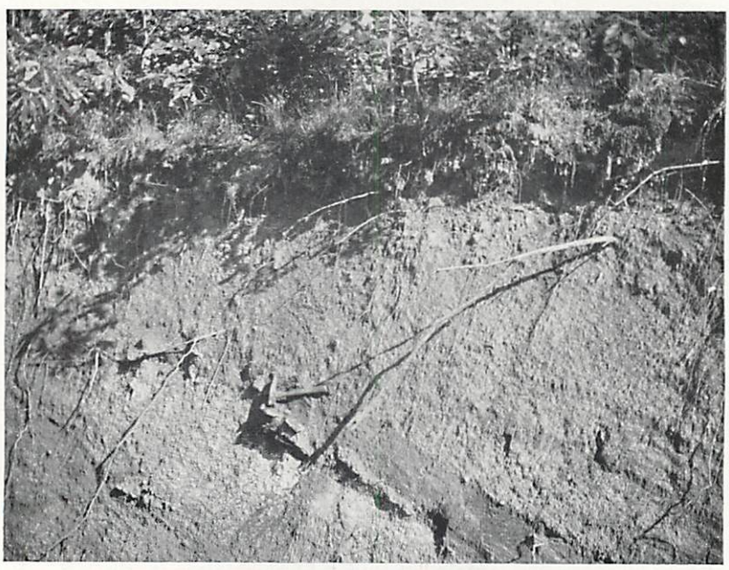

Figure 15.—Steeply dipping Lower Ackerman beds: Wall of road cut (NE. ¼, Sec. 17, T. 21 N., R. 10 E.) in southeast slope of "mountain" 2.5 miles southwest from Montevista.

Sand, fine bluish to bluish gray; weathers green on the surface; contains angular fragments of hard laminated shaly sand and small pieces of lignitized wood; rust

and fine sand, overlain by brown silty sand. The laminae are defined by iron rust. The excavation on the north side of the highway, a short time after it was made, exposed a sharp contact between the laminated interval and the sand (Figure 13). In places the laminae can be traced across the contact into the sand, although they are much less distinct in the sand, and somewhat uneven. Such a relationship seems to be evidence that the silty brown sand is the weathered, especially oxidized, laminated sandy silt. The sand lies as a mantle on the slope, thicker towards the bottom: The 40-foot bluff some 200 yards north of the highway is all sand and sandstone, so far as can be determined from the outcrop. The sand of the bluff outcrop is fine grained to medium grained, cross laminated, current bedded, and contains scattered inclusions of light-colored clay and silt. Large slabs and masses of irregularly laminated ferruginous sandstone project from the face of the outcrop; others are lying on the talus slope below.

South of the highway the same kind of laminated rusty sandy silt is exposed by a railroad cut and by gullies in the slope south of the railroad. Reconnaissance north of the highway along the east wall of the valley of Little Black Creek found the same kinds of materials and relationships in a place or two as much as a mile north of the highway, in a region of few outcrops. Silicified wood is fairly abundant.

The region north of Highway 82, west of Spring Creek, and south of the latitude of Walthall contain a considerable number of outcrops of Ackerman sands, silts, and clays. A few of them may be described briefly, as representative of the general character of the formation, or at least of the lower part of it.

A section (NW. ¼, Sec. 32, T. 20 N., R. 11 E.) of the northwest wall of the valley of Spring Creek, approximately 2 miles east-northeast of the Sapa road junction, has features which seem to place it in the basal part of the Ackerman formation. The road cut at this place has exposed 20 to 25 feet of sand and clay: Layers of light-gray to dull white or faintly pinkish sandy clay are interbedded with brown sand which is cross laminated and faintly current bedded, and contains sandstone crusts, fragments of weathered silicified wood, and thin undulating stringers of gray clay. Some of the clay bands of the outcrop are several inches wide.

A mile northwest of the Section 32 outcrop, in the southwest wall of the valley of a Spring Creek tributary, a cut for a north-south road at a church and cemetery (SW. ¼, Sec. 30, T. 20 N., R. 11 E.) has uncovered a section of irregularly bedded terrane at a greater elevation. The lower part of the 40-foot exposure is highly cross-bedded brown sand, containing lentils and stringers, and pellets and other irregular bodies of banded light-gray sandy silt and clay and light-colored sand worked into the brown sand at various angles; the upper part, to the top of the valley wall, is more or less weathered material.

Other outcrops, along a northeast-southwest road (NW. ¼, Sec. 25, T. 20 N., R. 10 E.) a mile and more still farther west and somewhat higher stratigraphically, bring to view additional sections of Ackerman strata, the best of which is in the northeast wall of a small valley 0.3 mile to 0.45 mile southwest of a road junction and approximately 1.5 miles north of the Sapa junction on Highway 82. Light-gray, greenish-gray, and lignitic clay are exposed farther down the slope, and light-gray rusty laminated clayey and sandy silt in brown clayey and silty sand above.

Along the local road which extends due north from Eupora, east of Highway 9, laminated sand containing clay laminae is exposed in a place or two, and approximately 2 miles north of the junction of this road with Highway 9 in Eupora, shallow cuts and roadside gullies in a long gentle up slope northwards have uncovered light bluish-gray sandy laminated clay, lignitic at base. Several large blocks of ferruginous sandstone and many chips of iron oxide-cemented clay are lying about. This place may be on the contact of the Lower Ackerman silts and clays with an outlier of the Middle Ackerman sand. Farther north along this road 0.6 mile is an outcrop of whitish, yellow, and lignitic clay under red-brown sandstone and sand. The basal zone of the sand contains clay breccia. East of the southern of these two outcrops a mile more or less in the east wall of the valley of Little Black Creek, are two considerable sand exposures. A little north of a road junction, a cut (NW. ¼, Sec. 27, and NE. ¼, Sec. 28, T. 20 N., R. 10 E.) is entirely in sand, brown to red chiefly, but including much purple and pink sand and many stringers and lumps of purple, pink, and yellow clay. The sand is highly cross bedded in places.

Road cuts northwest, west, southwest, and south of the junction (SE. ¼, Sec. 1, T. 20 N., R. 10 E.) expose much clay—greenish, bluish, gray, and lignitic, some of it compact, blocky, and somewhat indurated, approaching clay shale. Almost everywhere gray, greenish, or tan laminated silt and fine sand are interbedded with the clay. A feature is the abundance of silicified wood. Two or three of the outcrops are of some prominence:

Road cuts in both flanks of a ridge (SE. ¼, Sec. 3, T. 20 N., R. 10 E.) two and a quarter miles west from the valley of Spring Creek, have uncovered greenish-gray very plastic clay below and above lignitic clay. Outcrops of the same beds are along the road south of this ridge exposure—a road which trends south by east from the intersection on the southern boundary of Section 3. Three quarters of a mile south of the intersection, in front of an abandoned cabin, a thickness of some 30 feet of strata is visible, consisting of micaceous selenitic sandy gray clay towards the base, and above it laminated gray, tan, and rusty silty sand, and some clay shale. The south wall of the small valley, 0.4 mile farther south, is greenish, tan, gray, black, and rusty fine silty sand, interlaminated with thin clay. Towards the top of the rise these strata are overlain by lignitic clay. The uppermost 20-foot interval is lignitic and light-gray, bluish and greenish-gray clay under a little tan sand. The entire section is perhaps 50 feet. Fragments of silicified wood are numerous along this road.

A road cut (NE. ¼, Sec. 9, T. 20 N., R. 10 E.) a mile east of Walthall, has exposed a section of very irregularly bedded fine sand, clay, and silt, a section very similar to many other sections in the county. Sand is dominant—laminated, gray where fresh, brown on the weathered surface; laminae, conspicuous because defined by iron oxide, are curved or diagonal. The surface appearance of much of the material is that of the structure of partly decayed wood. Joint breaks, and unit contacts, are defined by harder cemented seams. In short, the face of either wall of the cut is that of a cross-section of chaotically bedded sands and clays, seeming to reflect the work of vigorous and shifting currents. Another feature of the outcrop is the dark patches and dark laminae. The upper 5 to 7 feet of the exposure is the kind of featureless red-brown clayey and silty sand that constitutes the mantle rock of a large part of the territory. The general dip is westwards.

At Walthall strata of the same general character are exposed by Highway 9 cuts, and by a ravine some 0.4 mile east from the highway. On both sides of the highway south of its intersection with a local road leading into Walthall, are outcrops of a laminated very sandy and silty tan and light-gray clay, or a clayey and silty fine sand, which contains two beds of iron ore. The laminae are defined by iron rust, and the entire surface is streaked and spotted with rust. The same kind of material crops out along the local road between the highway and the courthouse in Walthall.

Highway cuts, and ditches on both sides of the highway north of the intersection at Walthall afford other good outcrops through a vertical interval of 50 feet. The lowermost beds, light-gray sandy clay, grade upward into lignitic clay, which, in turn, is overlain, above a sharp line of contact, by intricately interbedded sand and clay and iron ore, well exposed by a cut through the upper part of the ridge 0.2 mile north of the intersection.

Because the section of upper Midway and lower Wilcox beds along the Hohenlinden-Montevista-Bellefontaine road is more nearly continuously exposed than is any other section of the same age in Webster County, it is described herein in some detail.

The Midway-Wilcox transition zone is described under "Fearn Springs Formation." A few feet above the transition beds, and a little below the top of a rise (NW. ¼, Sec. 1, T. 21 N., R. 10 E.) a rusty, mixed-up sandy clay abuts against and interfingers brown cross-laminated non-micaceous sand along a diagonal contact. Fingers of gray clay extend into the sand from the main clay body, and clay pellets are scattered through the sand. The entire structure suggests an origin by both aggradation and degradation—deposition of sand, subsequent channeling of the sand, and still later deposition of clay, silt, and fine sand in the erosion depressions. The relationships of the units here testify that disturbed conditions prevailed in this region in early Wilcox time. Here and there along the road for a mile farther west are outcrops of the same character, along with some probably residual red-brown sand and sandstone.

Vertical faces of the walls of cuts in the 55-foot west wall of the valley of Buck Creek (Sec. 2, T. 21 N., R. 10 E.) afford an excellent showing of the same unit. By far the greater part of the Buck Creek section is tan, olive-drab, light-gray, and rusty

and fine sand, overlain by brown silty sand. The laminae are defined by iron rust. The excavation on the north side of the highway, a short time after it was made, exposed a sharp contact between the laminated interval and the sand (Figure 13). In places the laminae can be traced across the contact into the sand, although they are much less distinct in the sand, and somewhat uneven. Such a relationship seems to be evidence that the silty brown sand is the weathered, especially oxidized, laminated sandy silt. The sand lies as a mantle on the slope, thicker towards the bottom: The 40-foot bluff some 200 yards north of the highway is all sand and sandstone, so far as can be determined from the outcrop. The sand of the bluff outcrop is fine grained to medium grained, cross laminated, current bedded, and contains scattered inclusions of light-colored clay and silt. Large slabs and masses of irregularly laminated ferruginous sandstone project from the face of the outcrop; others are lying on the talus slope below.

South of the highway the same kind of laminated rusty sandy silt is exposed by a railroad cut and by gullies in the slope south of the railroad. Reconnaissance north of the highway along the east wall of the valley of Little Black Creek found the same kinds of materials and relationships in a place or two as much as a mile north of the highway, in a region of few outcrops. Silicified wood is fairly abundant.

The region north of Highway 82, west of Spring Creek, and south of the latitude of Walthall contain a considerable number of outcrops of Ackerman sands, silts, and clays. A few of them may be described briefly, as representative of the general character of the formation, or at least of the lower part of it.

A section (NW. ¼, Sec. 32, T. 20 N., R. 11 E.) of the northwest wall of the valley of Spring Creek, approximately 2 miles east-northeast of the Sapa road junction, has features which seem to place it in the basal part of the Ackerman formation. The road cut at this place has exposed 20 to 25 feet of sand and clay: Layers of light-gray to dull white or faintly pinkish sandy clay are interbedded with brown sand which is cross laminated and faintly current bedded, and contains sandstone crusts, fragments of weathered silicified wood, and thin undulating stringers of gray clay. Some of the clay bands of the outcrop are several inches wide.

A mile northwest of the Section 32 outcrop, in the southwest wall of the valley of a Spring Creek tributary, a cut for a north-south road at a church and cemetery (SW. ¼, Sec. 30, T. 20 N., R. 11 E.) has uncovered a section of irregularly bedded terrane at a greater elevation. The lower part of the 40-foot exposure is highly cross-bedded brown sand, containing lentils and stringers, and pellets and other irregular bodies of banded light-gray sandy silt and clay and light-colored sand worked into the brown sand at various angles; the upper part, to the top of the valley wall, is more or less weathered material.

Other outcrops, along a northeast-southwest road (NW. ¼, Sec. 25, T. 20 N., R. 10 E.) a mile and more still farther west and somewhat higher stratigraphically, bring to view additional sections of Ackerman strata, the best of which is in the northeast wall of a small valley 0.3 mile to 0.45 mile southwest of a road junction and approximately 1.5 miles north of the Sapa junction on Highway 82. Light-gray, greenish-gray, and lignitic clay are exposed farther down the slope, and light-gray rusty laminated clayey and sandy silt in brown clayey and silty sand above.

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Vertical faces of the walls of cuts in the 55-foot west wall of the valley of Buck Creek (Sec. 2, T. 21 N., R. 10 E.) afford an excellent showing of the same unit. By far the greater part of the Buck Creek section is tan, olive-drab, light-gray, and rusty

fine sand, diagonally and otherwise irregularly laminated; but it includes many irregular stringers, lentils, pellets, and other bodies of light-gray clay shale and wood-textured laminated silt and sand, the clay content increasing towards the top. The outcrop as a whole resembles a mosaic. Such extremely irregular, almost chaotic, structures prevail through a thick interval of the Lower Ackerman terrane—in fact, it is present in places through the entire formation.

A tenth of a mile or a little farther northeast from the northern of the two road junctions at Montevista, a section (SW. ¼, SE. ¼, Sec. 3, T. 21 N., R. 10 E.) is exposed by a ravine and a road cut:

SECTION OF RAVINE AND ROAD CUT WALLS IN NORTH EDGE OF MONTEVISTA

	Feet	Feet
Ackerman formation		63.0
Sand, white to red brown, coarse to fine, but chiefly fine; sparingly micaceous; contains flakes of white clay; clay ball at base, encased by 2 inches to 3 inches of limonite; some ferruginous sandstone; sharp contact with underlying clay shale; to top of ridge	20.0	
Clay shale and sand: Light-gray silty clay shale interbedded with tan to olive-drab cross-laminated micaceous fine sand; clay shale dominant	39.0	
Covered, to flat at bottom of steeper gradient of ravine	4.0	

At least the upper half of this section is higher stratigraphically than the Buck Creek section, but the lower (39-foot) interval probably is part of the Buck Creek section. The 20-foot sand interval is part of a sand belt which extends uninterruptedly north into Calhoun County, south to a mile or more south of Montevista, and west to the valley of Shutispear Creek. It may be the oxidized upper part of the interbedded sand and silt terrane.

A little northwest of the road junction (NE. ¼, Sec. 9, T. 21 N., R. 10 E.) a confused mosaic of sand and clay similar to that at Buck Creek is displayed by the road cut walls. It is on the same level as some of the red sand, suggesting that much red sand is a weathered phase of the gray and tan sand of the irregular interval. Road cuts (NE. ¼, Sec. 8, T. 21 N., R. 10 E.) in the west wall of the valley of Shutispear Creek a mile west of the Section 9 outcrop, show the same kinds of materials and the same structure —that is, tumultuously bedded tan sand containing shale stringers

and blocks of laminated shale tossed about haphazardly. This interval is succeeded upwards topographically by a brown sand and sandy clay mantle. Half a mile farther west is an outcrop (NW. ¼, Sec. 8) of decayed-wood textured dull-white rusty laminated sandy and silty clay shale, or sandy and clayey silt, incorporated in brown fine sand which probably is residual from

Figure 14.—Lower Ackerman laminated silty clay and fine sand: Road cut SW. ¼, Sec. 9, T. 21 N., R. 10 E.) in the southwest wall of the valley of Shutispear Creek, 1.5 miles southwest from Montevista.

weathering of the laminated beds. This kind of material is abundant in the lower part of the Ackerman formation of Webster County.

The succession noted above is repeated along the Montevista-Bellefontaine road, a mile or more farther south. Although the northeast wall of the valley of Shutispear Creek shows cross-

laminated red sand only except for a little light-colored material at the base, the southwest wall, the foot of which is only a quarter of a mile farther southwest, shows 85 feet of cream-colored or light-yellow rusty shale or clay interspersed with thin beds and laminae of very fine silty sand. Alternating laminae of silty clay and silty fine sand are conspicuous because of iron rust along the lamination planes (Figure 14). In the lower part of the outcrop, almost uniform northeastward dipping bedding prevails; in the upper part, irregular and strong cross bedding, dipping northeastwards for the most part. Cuts in the opposite (southwest) wall of the ridge expose the same kinds of materials, dipping both northeast and southwest.

Southwest of a west headward tributary of Shutispear Creek, the road is on an ascent 0.6 mile long, which reaches more than 165 feet above the water of the tributary. The top of the "mountain" on the northwest side of the road is 75 feet still higher. The stratigraphic section of this elevation, as exposed along the Montevista-Bellefontaine road, is described below:

SECTION OF "MOUNTAIN" (NE. ¼, SEC. 17, T. 21 N., R. 10, E.) ALONG THE MONTEVISTA-BELLEFONTAINE ROAD 2.5 MILES SOUTHWEST FROM MONTEVISTA

	Feet	Feet
Ackerman formation		241.5
Sand and sandstone: Sand coarse to fine, red brown and white and a little purple and pink; much ferruginous sandstone, including pipe sandstone; large masses of sandstone cap the "mountain." Some reworked clay in the basal part of the interval; to top of "mountain"	110.0	
Clay, light gray to dark gray lignitic, greenish; 0.5-foot band of lignitic clay at top, under the sand; clay plastic; contains five beds of iron ore, of a total thickness of 3.5 to 4.0 feet	25.0	
Sand, clay, silt: Sand fine, shows bands of rust-brown and gray thin laminated layers, very distinct. The proportion of clay increases upwards, and crusts and seams of iron rust separate the units. The interval as a whole is interbedded silty brown and tan sand and silty gray clay. Relatively steep southwest dip (Figure 15)	42.0	
Sand, clay, silt: Sand fine, silty, gray, tan and brown, with bluish and greenish bodies; tumultuously cross bedded, ripple marked, etc.; encloses irregular angular blocks of		

laminated light-gray to white lumpy sandy clay, sand, and silt, a confused mosaic on the outcrop. Some 25 to 30 feet above the base of the interval, considerable bodies of light-gray clay in the sand finger into brown sand which contains bands and pellets of gray clay 35.0

Sand, light gray clayey, grading upwards into alternating gray and brown sand weathered beds, and these into a weathered, structureless interval 22.0

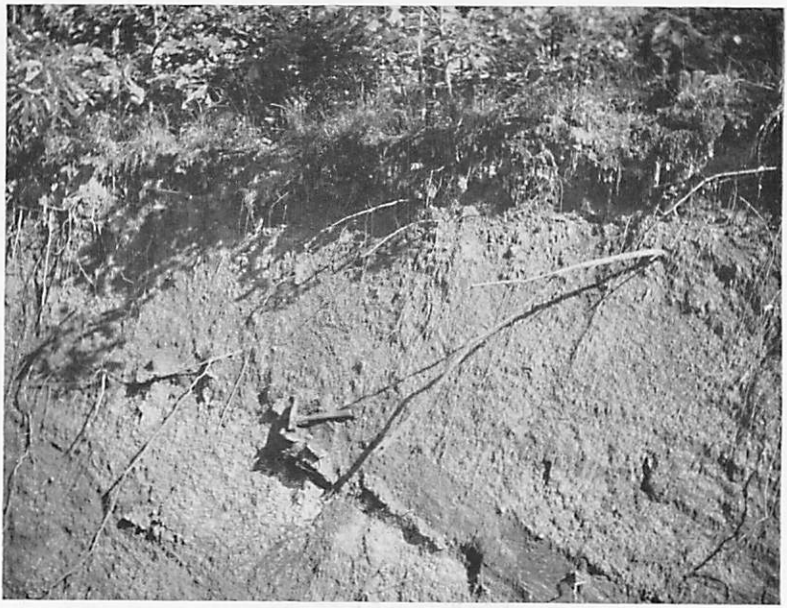

Figure 15.—Steeply dipping Lower Ackerman beds: Wall of road cut (NE. ¼, Sec. 17, T. 21 N., R. 10 E.) in southeast slope of "mountain" 2.5 miles southwest from Montevista.

Sand, fine bluish to bluish gray; weathers green on the surface; contains angular fragments of hard laminated shaly sand and small pieces of lignitized wood; rust splotched on the surface; grades upwards into gray and purplish clayey sand 6.5

Sand, fine grayish blue; hard layer, thin bedded, laminated; forms a rapid in the small branch, to floor of branch a foot below water level at bridge 1.0

Road cuts in the southwest slope of the "mountain" expose sand and clay bodies in irregular relationships, as in the north-

east slope. The lignitic band at the top of the section shows 0.5 mile farther southwest and 15.0 feet lower than the section outcrop. The relative locations and elevations of these two outcrops of the same band of lignitic clay thus indicate a dip of approximately 30 feet to the mile southwest, which direction is a little south of normal to the strike.

Figure 16.—Irregular bedding of sand, silt, and clay: Road cut (SW. ¼, Sec. 19, T. 21 N., R. 10 E.), Montevista-Bellefontaine road.

Along the segment of the Montevista-Bellefontaine road between the junction (NE. ¼, Sec. 19, T. 21 N., R. 10 E.) and Highway 9, Ackerman strata are exposed in several places. Three quarters of a mile southwest from the junction, in the lower part of the southwest wall of a valley, an outcrop (SW. ¼, Sec. 19) shows a confused intermingling of clay bodies and sand—in general a breccia of large and small blocks and tongues and stringers of laminated light-gray to whitish silty clay in a matrix of tan and brown sand (Figure 16). A quarter of a mile farther southwest a thick section of irregularly bedded tan sand overlies lignitic clay; and a quarter of a mile still farther southwest the up slope to the highest point exposes the same succession overlain by a considerable interval of greenish clay. Down slope to the southwest the succession is, roughly:

Sand, red brown, clayey, to top of hill
Clay, lignitic, dark gray, containing silicified wood
Clay, pale green, sticky
Covered interval
Clay shale, light gray silty; weathers rusty
Covered interval may be upper part of interval below
Clay shale, evenly bedded; grades upwards into weathered material —red-brown clay and sand
Sand, fine, shaly, and clay shale, sandy; bluish black and gray; somewhat irregularly bedded; clay shale has conchoidal fracture; thickness of interval, 6 to 8 feet. Two levels of 0.25-foot to 0.3-foot iron ore, about 4 feet apart; to base of slope.

Some 250 yards farther south, and a quarter of a mile north of Highway 9, a cut has exposed dark-gray conchoidally jointed clay shale, overlain by yellowish-brown sand of which the lowermost 2 to 3 feet contain leafy clay laminae. The sand is overlain by gray and lignitic clay.

Southeast from the road junction (NE. ¼, Sec. 19, T. 21 N., R. 10 E.) a mile or more, the section of the south wall of a valley is exposed almost continuously along a road which leads southeast and south: Gray and greenish and tan fine sand, grading upwards from evenly bedded to very irregularly bedded. Some 15 to 20 feet below the top of this valley wall, in the south slope, iron ore crops out at two or three levels. It is some 2 miles almost due south of the iron ore interval on the Montevista-Bellefontaine road, and at about the same elevation; that the ore at the two places belongs to the same beds is, therefore, very probable. At the southern of the outcrops, too, as at the northern, the ore is in clay which contains a lignitic band in the upper part, and is overlain by irregularly bedded gray brown, and tan sand enclosing bodies of clay.

Road cuts (SE. ¼, Sec. 29, T. 21 N., R. 10 E.) about 2 miles north from Highway 9, in the slopes of a low ridge, expose sections which show somewhat unusual, perhaps significant, structural features. On the north side of the rise the face of the east wall of the cut displays a pattern of intertongued bodies of extremely fine sinuously laminated tan or olive drab sand and light-colored laminated silt or silty clay. On the south side of the ridge, the section is as follows:

SECTION OF EAST WALL OF ROAD CUT 2 MILES NORTH BY EAST FROM JUNCTION (0.6 MILE NORTH FROM WALTHALL) OF ROAD WITH HIGHWAY 9 (FIGURE 17)

	Feet	Feet
Ackerman formation		23.4
Sand, fine gray and red brown clayey and silty, containing stringers of light-gray silty clay toward the base; to top of rise in road	6.0	
Clay, lignitic silty dark gray	0.4	
Silt, clayey and sandy cream colored to tan and shades of yellow and brown; conspicuously laminated; texture of partially decayed wood	12.0	
Clay or clay shale, silty, blackish blue; to base of section in roadside ditch	5.0	

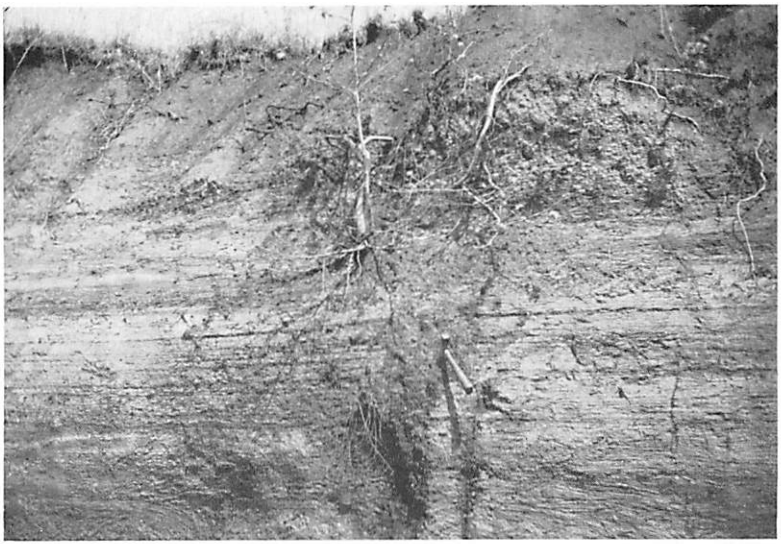

Figure 17.—Lower Ackerman dark-blue silty clay grading upward into light yellow to rusty clayey silt developed by weathering: Road cut (SE. ¼, Sec. 29, T. 21 N., R. 10 E.) some 2.5 miles north of Walthall.

The two lowermost intervals grade into each other, the upper being, seemingly, an oxidized part of the lower. Outwards from vertical joints filled with rust-cemented silt the dark-blue clay has been oxidized to a light yellow or cream color to distances up to two feet or more; that is, the lighter color of the upper of the two intervals has been extended downwards along the joints which transgress the blue clay (Figure 17). The contact is sharp, but not erosional, and does not follow the bedding closely. In fact, bedding is absent or very inconspicuous in the blue material.

The lignitic upper part of the lighter colored interval can be interpreted as a more advanced stage of weathering. The beds at this place are very similar to those at Little Black Creek east of Eupora, and probably are correlative with them.

The juxtaposition of the evenly bedded undisturbed south half and the irregularly bedded north half of the low rise suggests channeling, the undisturbed strata being one of the channel banks, and the mixed-up material, the filled channel.

The lower 40 feet or so of the south wall of the valley a short distance farther south is the same kind of wood-textured cream-colored to brown, light-yellow and tan laminated rusty silty clay as the second interval of the section just described. A lignitic band occupies a position a little above the middle level of the interval. The upper part of the valley wall (35 feet plus or minus) is light-gray and greenish-gray clay, containing three or four layers of iron ore. The section of the south slope of the ridge is as follows:

SECTION (SE. ¼, NW. ¼, SEC. 32, T. 21 N., R. 10 E.) OF THE SOUTH SLOPE OF A RISE 1.5 MILES NORTH OF HIGHWAY 9 ON A ROAD WHICH JOINS THE HIGHWAY 0.6 MILE NORTH FROM WALTHALL

	Feet	Feet
Ackerman formation		25.8
Clay, light gray rusty, to top of rise in road	2.0	
Clay, dark lignitic	2.5	
Clay, dark gray towards base of interval; lignitic, lumpy, having conchoidal fracture; grades upwards into lighter gray, and above into pale greenish-gray; contains 0.3-foot iron ore concretions some 7.0 feet above base of interval	13.0	
Sand, fine light-gray to tan and rusty; more clayey towards top	2.0	
Iron ore	0.8	
Clay, greenish rusty silty	2.5	
Covered, to culvert in valley	3.0	

The same kinds of strata show almost continuously from a distance of 1.3 miles from Highway 9 to within 0.65 mile from the highway. The light-gray and lignitic clay is interbedded with greenish-gray clay and greenish rusty sand, and contains iron ore. The weathered part of these strata is much like the rusty light-yellow silty clay of the section farther north.

The Montevista-Walthall road is across a considerable part of the Lower Ackerman belt of outcrop. A mile or so southeast from Montevista, headward erosion by a head tributary of Shutispear Creek has cut into the divide and is undermining the road. The section (NW. ¼, Sec. 14, T. 21 N., R. 10 E.) exposed by the ravine is gray sandy clay and clayey sand below and red-brown sand above; the contact is sharp.

Both north and southwest of the junction (SE. ¼, Sec. 27, T. 21 N., R. 10 E.) cuts expose shale and laminated sand, or sand and shale interbedded very irregularly, for a distance of almost three-eighths of a mile and through a vertical interval of 75 feet. From the top of the ridge 0.1 mile southwest of the junction, the surface slopes southwest by south, in the same direction as the trend of the Walthall road, for a mile. The wood-textured laminated silt or clayey silt, interfingered with tan and brown sand, is exposed here and there in this slope for at least 0.6 mile from the junction. Near the top of the west wall of the main valley crossed by this Walthall road is a rather extensive outcrop of light-gray and lignitic clay containing some masses of concretionary iron ore. Some 15 feet below the iron ore is a 0.7-foot to 0.8-foot bed of ferruginous silt, which may mark the contact of the clay with underlying silt and sand. North and northwest of the road lignitic and light-gray clay crop out in the flanks of the ridges in a few places. The same type of clay is at the surface along the Walthall road farther southwest, interbedded with gray or tan fine silty sand or sandy silt. A layer of impure hematite (NE. ¼, Sec. 4, T. 20 N., R. 10 E.) a short distance southwest of a road junction, may be correlative with the bed of ferruginous silt referred to above. Three quarters of a mile southwest from it are cuts exposing a chaotic pattern of tan silty sand and paper-thin clay or silt, similar to, and probably correlative with, interwoven units on another road half a mile farther south. The same sort of materials and structure shows in the east wall of the valley a quarter of a mile farther southwest. The west wall of the valley, along the Walthall road, is deep red-brown sand, probably residual from weathering of the sand-clay terrane.

The sand member of the Ackerman which is so well exposed at LaGrange, in northern Choctaw County, seems to be represented in Webster County here and there west of Highway 9.

Cuts for the road leading west from Eupora show clay-sand contact features. At a bend (NW. ¼, Sec. 6, T. 19 N., R. 10 E.), 0.5 mile west of a junction at the northwest corner of the corporate area of Eupora, a thickness of several feet of sand containing clay breccia, and underlain by gray and pinkish iron-stained sandy and silty clay, is exposed by a cut in a low ridge under a heavy accumulation of ferruginous sandstone which may be a remnant of sandstone at the base of the Middle Ackerman sand. Some 2 miles farther west, a few rods east of a road junction, red-brown sand and sandstone cap a ridge overlying clay. A little farther west, the west wall of a small valley shows a fair section—a bottom interval of light-gray rusty bedded sand, clayey towards the top; above it a 0.5-foot to 0.7-foot lignitic band, which is overlain, in turn, by light-gray clay. The clay grades upwards into a rusty, shaly clay. Higher in the section are masses of iron ore in the clay. A mile still farther west, in the west wall of the valley of Salt Creek, is another outcrop of ore, in gray clay, overlain by brown sandstone. Silicified wood is present at all these contact exposures.

The east wall of the valley of Sand Creek (SW. ¼, Sec. 33, T. 20 N., R. 9 E.) contains a great quantity of ferruginous sandstone and silty limonite. At the top of the westward facing slope, under a power line, are numerous large blocks and irregular masses of the rock, lying flat or tilted at various angles. A little less than half a mile down the slope to the west is a sand pit, showing brown, yellow, and white sand and many masses of ferruginous sandstone. The writer believes that the sand and sandstone of this valley wall should be assigned to the upper part of the basal sand member of the Middle Ackerman as defined herein, and are correlative with the same kinds of rock at LaGrange, northern Choctaw County.

The road which leads northwest from Eupora is on a sand terrane for 3.5 miles, except for two or three small showings of light-gray silty clay. The sand is well exposed at several places along this road, particularly well by a ravine (SE. ¼, Sec. 26, T. 20 N., R. 9 E.) a few rods west of the junction with an old road which leads west by south 0.1 mile west of Mt. Zion Baptist Church. The ravine, some 50 feet wide and 30 feet deep, is cut in red-brown and white sand. Half a mile or so farther north,

a cut and roadside gullies in a westward facing slope (Northern part, Section 26) expose 30 feet of gray and bluish clay, lignitic towards the top, below, and 20 feet of iron-red sand above. Heavy ferruginous sandstone, associated with silicified wood, marks the approximate contact. The outcrop seems to be that of an inlier of Lower Ackerman clay surrounded by Middle Ackerman sand.

Cuts along the east-west road which intersects Highway 9 about 1.3 miles south of Walthall have exposed parts of this Middle Ackerman sand and the underlying clay. At the intersection (Center of line between Secs. 19 and 20, T. 20 N., R. 10 E.) gray sandy clay is overlain by red-brown sand above a well-defined contact line. Some 0.35 mile west from the intersection, at the base of an eastward facing slope, is an outcrop of lignitic and light-gray clay containing iron ore. A quarter of a mile farther west, near the base of a slope (Western part, Sec. 19, T. 20 N., R. 10 E.), dark-gray lignitic and light-gray shaly structured clay is exposed. Many pieces of silicified wood and slabs of siliceous limonite are lying about. The strata at the surface here are overlain by a hill of red-brown and light-gray sand containing some grit and ferruginous sandstone, all which is thought to be part of the Middle Ackerman sand member. A mile farther west is a north-south ridge of red-brown and light-gray sand, part of which is a "mountain" consisting of an elongated flat-topped segment of the ridge, capped with thick slabs of ferruginous sandstone. The same kind of rock crops out in the flanks of the ridge. This "mountain" of sand and sandstone probably is of Middle Ackerman age, and the clay beneath it Lower Ackerman.

Along the road which trends due west from Walthall are other exposures of the clay-sand contact. Near the foot of a westward facing slope 0.45 mile west of Highway 9, a 1-foot layer of black lignitic clay, of which the upper part is leached white, crops out, and in the upper part of the same slope, large angular inclusions of white silty clay or clay shale are conspicuous in the red-brown sand. In an eastward facing slope 0.3 mile long (Eastern part, Sec. 11, T. 20 N., R. 9 E.) a little more than 2 miles west from the highway, an interval of several feet of blue red-mottled plastic clay is overlain by sand, the contact being marked by a steepening of the slope. The rise is capped by hard, thick ferruginous sandstone, some of which approaches a quartzite. The

westward facing slope is shorter and steeper, due in part, no doubt, to the hard sandstone ridge cap. East of this ridge, relief is slight; west of it for at least a mile the topography is more rugged and the hills are red and brown sand and sandstone. The contact between the clay below and the sand above is believed to mark the base of a Middle Ackerman sand member.

A little northwest of the junction of Highway 9 and a south-north road, a mile north of the Walthall intersection, deep highway cuts have exposed sections of intricately cross-laminated gray, greenish-gray, and tan fine silty sand including laminae and stringers of gray silty clay. The general dip is northwestwards. Quartz boulders were found in the sand east of the highway.

The core of the ridge at and near the entrance from Highway 9 to the American Legion Lake grounds is chiefly sandy shale, as indicated by the description of the section:

SECTION OF THE SOUTHWEST WALL OF HIGHWAY 9 CUT NORTHWEST OF THE ENTRANCE TO AMERICAN LEGION LAKE (NORTHERN PART, SEC. 6, T. 20 N., R. 9 E.)

	Feet	Feet
Ackerman formation		100.5
Subsoil and soil (mantle rock)		
Shale and sand and clay: Shale dense, blocky, thin-bedded and laminated, light gray to dark gray, and slate blue, light blue, and black; iron stained along joints and bedding-planes and other partings and on surfaces of blocks; some thin layers indurated by iron rust cementation; light gray and tan where slightly oxidized, blue to black where fresh; includes lentils and laminae and stringers of fine tan to white sand, and two 3-inch layers of soft white iron carbonate. Length of interval, 0.1 mile	45.0	
Sand, tan or olive drab or light yellow where fresh or only slightly weathered; red-brown and clayey where weathering is farther advanced. Contains lentils and other inclusions of bright blue or white shale, and, near the base of the slope, on the opposite side of the highway, clay breccia. Length of interval, 0.15 mile	45.0	
Shale, dark gray to black laminated; possibly a lens in the sand	0.5	
Covered, to the top of the concrete floor of the culvert in the creek 100 yards northwest of the base of the ridge	10.0	

The section shows some interesting structural features. The top of the third interval slopes southeastwards under the fourth interval, the contact being well defined across the face of the wall. The ill-defined bedding planes of the sand dip in the same direction, but only slightly. At the lower (northwest) end of its outcrop, the shale is almost horizontal, but descends slightly in the same direction as the sand to about the middle of its 500-foot length of outcrop, from where it rises at a very low angle towards the southeast to the top of the ridge. At the top of the ridge sand of the same character as Interval 3, presumably the same sand, appears under the shale, its bedding dipping northwest. Ravines on the northeast side of the highway, across from the lake entrance, expose good sections of bedded sand and sandy and silty shale, much of the shale being at the same level as the sand along the highway. In fact, the structural relationships of the strata, including clay stringers in the sand, suggest that much of the sand is residual from weathered sandy shale and interbedded thin sands such as the fourth interval of the section.

The stratigraphic section described below may include the Lower Ackerman-Middle Ackerman contact:

SECTION (SE. ¼, SEC. 26, T. 21 N., R. 9 E.) OF WEST WALL OF VALLEY OF A HEADWATER BRANCH OF SABOUGLA CREEK, ALONG THE BELLEFONTAINE-EMBRY ROAD 0.65 MILE WEST FROM HIGHWAY 9 AT BELLEFONTAINE

	Feet	Feet
Recent formation		
Subsoil and soil sandy loam, to the top of the valley wall		
Ackerman formation		50.5
Sand, gray to tan and brown and yellow, fine, somewhat silty and clayey; bedded; some laminae loosely cemented to yellow and brown crusts; some irregular lamination, defined by iron rust. Contains stringers and nodules of gray compact clay	25.0	
Shale, compact sandy and silty, gray to blue and black; large piece of silicified wood at shale-sand contact	3.0	
Lignite, black, pure, blocky, jointed; contains pieces of lignitized wood	1.5	
Clay, lignitic, and sand, fine blue to tan silty	1.0	
Shale, blocky, gray to tan, light brown, red and black; grades into gray iron-stained very plastic clay where weathered. To level of flat	20.0	

The clay shale which comprises the lowermost interval is in general gray and blocky, and splits into thin plates; the blocks

are filmed with carbonaceous material, and fine sand is along the bedding-planes. A little above the base some of the shale is a deep hematite red, but most of the whole interval is tan or light-brown on the weathered surface, and where broken down by the weather leaves chip-like fragments or flakes. This shale is very much like that shown by the road cut (NW. ¼, Sec. 25, T. 21 N., R. 9 E.) a little north of Bellefontaine, and probably is correlative with it. Also, the sand at the top of the section is very similar to, and probably is correlative with the sand of the Section 25 outcrop.

The up slope southwest from a road junction 1.6 miles west of Bellefontaine exposes the section:

SECTION ALONG ROAD SOUTHWEST FROM JUNCTION (SE. ¼, SEC. 27, T. 21 N., R. 9 E.) 1.6 MILES WEST OF BELLEFONTAINE

	Feet	Feet
Ackerman formation		50.0
Sand, shaly, gray where fresh, tan or olive drab to red brown where weathered; silty and clayey; bedded and cross bedded; contains clay bodies and stringers towards base; to house at top of slope	32.0	
Clay shale, blocky, gray where fresh, tan to brown on weathered surface, sandy and silty; much jointed near the surface; to the Bellefontaine-Embry road at the junction	18.0	

From 0.7 mile south of the junction to 1.3 miles farther south the elevation increases by about 140 feet. Along the road up the slope is a good section of the usual laminated tan rusty, silty sand tan and light-gray clay, lignitic bands, silt, and iron ore. The hill is capped with sand. The thickest iron ore is a little below the clay-sand contact.

Northwest from Bellefontaine many Highway 9 cuts expose laminated sand and sandy and silty black, blue, and gray clay shale, as well as overlying brown clayey sand of the weathered zone. Approximately 3.7 miles northwest from the Bellefontaine junction, the faces of the walls of a highway cut (Eastern part, Sec. 15, T. 21 N., R. 9 E.) display a rather complicated pattern of sands (Figure 18). Below is very irregularly bedded tan to greenish and rusty fine silty sand, which may be, in part at least, the residue from weathered sandy shale; above, and separated from the sand below by a definite contact, is a coarser red-brown sand. At the southeast end of the cut, on the northeast side, the lower

Figure 18.—Complicated bedding, Middle Ackerman sand, Highway 9 cut 3.7 miles northwest from Bellefontaine.

Figure 19.—Cross-section of body of ferriferous silty sand, Highway 9 cut 3.7 miles northwest from Bellefontaine.

sand contains a mass of sandy iron ore, and ferriferous sand, which has a roughly elliptical cross-section 3.0 and 2.5 feet in diameter (Figure 19). Near the northwestern end of the cut, also, the lower sand contains iron ore, which never forms in pure sand.

From the lithologic characteristics of the strata, as observed at the outcrops, and the sequence and structure, it appears that the Lower Ackerman outcrop belt through Webster County and in northern Choctaw is 4.0 to 9.0 miles wide. Its eastern boundary, except for outliers, is the westernmost outcrops of Naheola beds; its western margin is marked in northern Choctaw and in some places in Webster by ferruginous sandstone and slabs of silty limonite, remnants of a Middle Ackerman sand; elsewhere in Webster County by light-colored and lignitic clay, in places yellow at the top, underneath sand. Another feature of the western (upper) contact is silicified wood. The geographical positions of the boundary lines are indicated by lines on the map (Plate 1).

The Lower Ackerman-Middle Ackerman contact trace, as has been indicated, trends roughly a little west of north from Big Black River to half a mile west of Eupora, thence in the same direction along a course roughly 2 miles west of Highway 9 to a mile or so north of Walthall, across the Bellefontaine-Embry road half a mile or so west from Highway 9 at Bellefontaine, and north by west to the highway some 2 miles south of the Calhoun County line.

Clay crops out pretty generally in the walls of the headwater valleys of the Sand Creek system, but patches of sand have been left here and there, especially along the Big Black-Yalobusha divide. Some remnants occupy the uppermost interval of the divide; others, the thicker sections, seemingly have been deposited in old valleys or other depressions. From the junction (NE. ¼, Sec. 3, T. 20 N., R. 9 E.) in the eastern part of the headwater area, along the roads to the south and southwest for 2 miles, brown and red-brown sand only is exposed; likewise, in the western part of the headwater area sand is the surface rock of the minor divides. However, along the main Big Black-Yalobusha divide in the northwestern part of Township 20 North, Range 9 East, both sand and clay crop out. Clay, containing some iron ore, is conspicuous along the road which leads east by north from the junction (On

the line between Secs. 5 and 8, T. 20 N., R. 9 E.); west by south of the junction the road is on both sand and clay. Much of the sand seems to have been removed from the dividing ridge and shifted southwards or northwards. Approximately a mile and a half west by south of the junction referred to above, and east of an intersection (NW. ¼, Sec. 7, T. 20 N., R. 9 E.) a quarter of a mile, is a road cut in the slopes and the upper part of a ridge. The walls of the cut on the east slope are clay below and sand above, although no sharp contact shows; on the west slope, which is not so steep as the east slope, coarse red-brown to dull-white sand is underlain by lignitic and very light-gray to white clay which seems to grade downward into light-gray and brown sand interbedded with thin clay. The light-gray to white clay subjacent to the sand is indurated and blocky, very similar to a clay at Flat Rock Church in Benton County, at LaGrange in northern Choctaw County, and at other places.

In the southeast corner of Section 1, and the northeast corner of Section 12, Township 20 North, Range 8 East, some 0.4 mile northwest of an intersection, is one of the thickest sand sections in the county:

SECTION OF VALLEY WALL ALONG A NORTH-SOUTH ROAD, 0.5 TO 0.6 MILE NORTHWEST FROM ROAD INTERSECTION (NE. COR., SEC. 12, AND SE. COR., SEC. 1, T. 20 N., R. 8 E.)

	Feet	Feet
Recent formation		1.5
Soil, sandy loam, to top of hill at farm house	1.5	
Ackerman formation		116.0
Sand, tan to olive drab, streaked and spotted with iron rust on the surface; fine; not conspicuously micaceous; tumultuously or complexly cross laminated and curved laminated; laminae at various angles to each other, and commonly defined by rust	105.0	
Sand, tan to gray, fine indurated, undulating, blocky, chopped up; cracked into blocks of various angular shapes; conspicuous in the wall, because of light color	5.0	
Sand, tan to light yellowish brown; fine	2.0	
Clay, lignitic, brown to black; approaches lignite towards the base; lumpy and indurated in the upper part; lens-shaped; thickest in the middle and tapers towards the ends; maximum	3.0	
Clay, light gray to darker gray, lumpy, hackly, somewhat indurated, to level of valley floor at entrance to field at a cotton house	1.0	

The length of this section along the road is about 500 yards.

About half a mile south by east of Embry, a cut a few yards northwest of a sharp turn of the road has given an excellent section of 25 feet of greenish-gray clay overlain by 15 feet of red-brown clayey sand. A sand cut is farther down the slope. Half a mile northeast of this place, on the Embry-Bellefontaine road, is a short cut showing a diagonal shale-sand contact, probably a westward continuation of the irregular structure of the east wall of the valley of one of the head branches of Sabougla Creek half a mile farther east. The sand below the sharp diagonal contact is horizontally laminated tan and rust brown, and fine. The laminated shale higher up is lensed into the sand, the individual blocks or fragments being variously oriented and mixed up.

Northwest of the big red sand cut at Embry, on the Cadaretta road, bedded sand crops out in two or three places, and red sand is prominent a little northwest of the road forks (SW ¼, Sec. 18, T. 21 N., R. 9 E.).

In southern Webster County, along the road due west from Grady, the many outcrops, in east-west sequence, expose an almost continuous section of Ackerman strata.

SECTION (ON LINE BETWEEN SW. ¼, SEC. 11 AND NW. ¼, SEC. 14, T. 19 N., R. 9 E.) ALONG THE GRADY ROAD WEST FROM ITS INTERSECTION WITH HIGHWAY 82, 0.7 MILE TO 0.85 MILE

	Feet	Feet
Ackerman formation		30.0
Sand, brown and yellow and red brown, generally coarse, containing some grit and small pebbles and a few small pieces of silicified wood. The lower part contains lenses and masses of light-colored to pinkish sandy clay. The contact with the underlying clay is sharp; to the top of the low rise	15.0	
Clay, light gray, mottled reddish by iron rust, to valley flat	15.0	

The sand body and the clay-sand contact are exposed farther west in two or three places. A description of the section of the west wall of a valley 1.5 miles west from Highway 82 is given below:

SECTION (ON LINE BETWEEN SE. ¼, SEC. 10, AND NE. ¼, SEC. 15, T. 19 N., R. 10 E.) ALONG THE GRADY ROAD 1.5 MILES WEST FROM U. S. HIGHWAY 82

	Feet	Feet
Recent formation		2.0
Soil and subsoil, brown sandy loam, black spotted, to top of ridge a little south of a road junction	2.0	
Ackerman formation		59.2
Sand, brown clayey and silty, probably residual from shale which was once part of the underlying shale	15.0	
Shale, dark gray to slate blue where fresh; bedded, blocky; iron rust along the joints, and seams of rust-cemented material along the bedding planes; contains two thin seams of iron ore. The shale weathers to lighter gray and tan and dull white sticky clay; most of it is a rusty laminated gray and brown mixture, containing iron ore; 15 to	18.0	
Sand, brown, interlaminated with light-gray clayey streaks	2.0	
Shale, sandy, tan to light gray, horizontally laminated; contains sand laminae	0.7	
Sand, gray, streaked with brown; cross laminated	3.5	
Shale and sand, light colored, thin layers	3.5	
Shale, blue where fresh, with some fine sand, and some nodules of impure white iron carbonate	7.0	
Sand, iron brown, interlaminated with gray clayey sand; pinches out down dip (west)	1.0	
Shale and clay, light gray, tan, and brown; blocky; where fresh it grades into light-blue and slate-blue shale; laminae rusty; sand along joint planes and laminae planes; weathered to a structureless mass towards the foot of the slope; to the creek flat	8.5	

The dip of the strata of the section is slightly undulating, and steeper than normal, although it conforms with the regional dip in direction (west by south). However, in the west slope of the ridge, the dip is east.

In an east-facing slope a quarter of a mile long some 2 miles west of the intersection of Highway 82 and the Grady road, gray clay shale, rusty along the bedding planes, overlain by laminated weathered material, is exposed. The dip is almost zero, or slightly west. The west-facing slope of the same rise shows gray shale, tan sand, and iron-mottled gray clay through an interval of 25 feet more or less. Part of the outcrop resembles the uppermost shale interval of the section a mile and a half west of the highway.

One of the best outcrops in the county is at the intersection (Northern part, Sec. 16, T. 19 N., R. 9 E.) of the Grady road with a north-south road. The intersection is near the top of a ridge which has an elevation of 40 feet above the valley bottom east of it, and 59 feet above the valley bottom west of it.

Figure 20.—Middle Ackerman strata: Section of north wall of road cut (Northern part, Sec. 16, T. 19 N., R. 9 E.) two miles north of Tomnolen.

SECTION (NORTHERN PART, SEC. 16, T. 19 N., R. 9 E.) OF THE NORTH WALL OF A CUT FOR THE GRADY ROAD 2.6 MILES WEST FROM HIGHWAY 82, AND EAST OF THE INTERSECTION OF THE GRADY ROAD WITH A LOCAL ROAD, 2.0 MILES NORTH OF TOMNOLEN (FIGURE 20)

	Feet	Feet
Recent formation		1.5
Subsoil, clayey sand, and soil, sandy loam, to top of wall of cut; estimated	1.5	
Meridian formation		10.5
Sand, bedded, red brown to tan and yellow, coarse to medium; contains grit and scattered small pebbles and small white clay inclusions, as well as some iron oxide-cemented crusts; also two layers of ferruginous sandstone 1 inch to 3 inches thick, one at the base of the interval, the other 8 to 10 inches above it	10.5	
Contact sharp and conspicuous		

Ackerman formation		22.5
Clay shale, dense, blocky; appears light gray and slate blue on exposed surface, but where fresh varies from light blue to shades of tan and gray and chocolate; lignitic towards the base, and bright yellow at the top just under the sand contact; rusty in places	8.5	
Clay, lignitic, gray to chocolate to black; thickens westwards to 0.5 foot within 20 feet or so, and approaches a pure lignite. It forms a conspicuous band across the face of the outcrop; 0.3 to	0.5	
Clay, light gray iron oxide stained; contains some fine sand	1.0	
Sand, fine silty and clayey, light gray to tan, rust spotted and streaked; rust-cemented 1-inch to 2-inch layer at bottom, and a 2-inch to 3-inch rusty interval at the top; some rust-filled cracks	3.5	
Clay shale and clay: Light-gray rust-mottled and rust-streaked clay, weathered from gray jointed and blocky clay shale; to bottom of roadside ditch slightly above the valley floor	9.0	

The contact trace between the uppermost clay shale interval and the sand above it descends slightly eastwards, but the dip of the strata below this contact is almost zero, perhaps slightly westwards.

Road cuts in the west flank of the ridge expose the section described below:

SECTION OF THE NORTH WALL OF A GRADY ROAD CUT 2.7 MILES WEST FROM HIGHWAY 82, AND WEST OF THE INTERSECTION (NORTHERN PART, SEC. 16, T. 19 N., R. 9 E.)

	Feet	Feet
Meridian formation		3.0
Sand, coarse to medium red brown; some 3 inches of ferruginous sandstone at base	3.0	
Sharp contact		
Ackerman formation		49.1
Clay shale and clay, light gray iron stained, blocky where fresh; contains silt and fine sand	11.0	
Covered by slumped sand and sandstone	10.0	
Clay, light gray iron stained	3.0	
Silt, light gray to tan, iron stained	2.8	
Silt and clay, lignitic, up to	0.8	
Silt and fine sand chiefly, gray and rust stained to tan; clayey, blocky in places; approximately	10.0	
Rust-cemented interval	1.0	
Sand, fine silty gray to tan rust streaked	5.5	
Covered, to bridge west of section	5.0	

The outcrops in the west wall of the valley show a weathered sand-clay mixture chiefly, although a rather sharp contact between light-gray clayey material below and brown sand above is exposed at a height of 25 feet above the bridge, and the gray sandy clay is exposed on the south side of the road at a lower level.

Sand is the surface material, except as noted above, westwards more than 2 miles, to the floor of the valley of Calabrella Creek. The section of the east wall of the creek valley is described below:

SECTION (SE. ¼, SEC. 7 AND SW. ¼, SEC. 8, T. 19 N., R. 9 E.) OF THE EAST WALL OF THE VALLEY OF CALABRELLA CREEK ALONG THE GRADY-STEWART ROAD, AND THE WALLS OF NEARBY RAVINES

	Feet	Feet
Recent formation		1.5
Soil and subsoil, to road forks; estimated	1.5	
Meridian formation		115.0
Sand, red brown to brown in upper part, grading downwards to light gray and dull white; very compact; mottled in places from leaching or incipient oxidation; structureless except for indistinct bedding at depth	115.0	
Ackerman formation		5.0
Clay, light gray, and interbedded brown sand; 4.0 to	5.0	

A mile or less farther north by east, the southeast wall of the valley of Sand Creek along the main Tomnolen-Alva road is brown, red-brown, whitish, and yellow sand throughout its height. It seems to be a northward extension of the Meridian sand belt represented in the Calabrella Creek section.

The low sloping west wall of the valley of Calabrella Creek along the Grady-Stewart road shows only brown sand and weathered material through a vertical interval of 100 feet or more and a surface distance of half a mile. The southwest slope of the ridge shows sand only through a vertical interval of some 75 feet. The sand here is brown to tan where weathered, especially the upper 45 to 50 feet; but in the lower part of the interval, where it has been gullied, it is dull white to white, and micaceous. A feature is abundant thin crusts of sandstone of various shapes, some tubular, at several levels in the sand. The sand is cross laminated and horizontally laminated.

Farther southwest, shale, bedded fine sand, and iron ore, are exposed almost without a break for 1.3 miles. The section is described below:

SECTION OF THE NORTHEAST FACING WALL OF A VALLEY SOUTHWEST OF THE BOATMAN STORE (SEC. 14, T. 19 N., R. 8 E.) ALONG THE GRADY-STEWART ROAD

	Feet	Feet
Meridian formation		13.5
Sand, red brown and brown to dull white and yellow, coarse to medium; includes a few inches of sandy loam at the top; to the top of the highest point of the hill northwest of the road	13.0	
Sandstone, ferruginous, hard; maximum	0.5	
Ackerman formation		117.3
Clay, yellow in the upper part, light gray beneath, streaked and mottled with yellow, brown, and red iron rust; grades downward into light-gray to tan and greenish-gray silty clay shale, at least one interval in the lower part of which is a dense, blocky clay shale which weathers to a conchoidally fractured shale. Two thin lignitic zones in the interval. Much of the interval is covered, but several feet of clay are exposed in each of the upper and lower parts; the weathered clay is light gray to white. The basal 2 to 3 feet of the interval are a light-gray to tan or olive-drab rusty laminated silt which contains 0.5-foot iron ore concretions	60.0	
Shale, sandy and silty tan and rusty laminated, or shaly and sandy silt, containing iron ore: Two beds of ore separated by a few inches of shale	2.0	
Shale, or shaly sand and silt: Tan to olive-drab and light-gray distinctly laminated clayey and sandy silt and layers of fine brown sand; laminae defined by iron rust; sand layers more numerous toward the top of the interval; a 1-foot layer of blocky weathered iron ore about 30 feet above the base, another layer of ore at 35 feet. The weathered mantle of this interval, on the slope of the hill, is a silty and sandy white clay	42.0	
Shale, as below, very sandy and silty, dark, rusty, laminated; some sand laminae, rusty towards top	8.0	
Iron ore, concretionary	0.3	
Shale, sandy, or sand, shaly, tan and dark gray and light gray, silty, micaceous, rusty; at least one lignitic band	3.0	
Covered, to valley flat	2.0	

Southwest and west of the section just described, along the local roads in Township 19 North, Range 8 East, in the southwestern corner of the county, Ackerman clays, sands, and iron ore crop out in many places.

Along an abandoned road which leads southwest from its junction with the Grady-Stewart road, a section is partly exposed:

SECTION (SEC. 22, T. 19 N., R. 8 E.) OF THE WEST WALL OF A VALLEY ALONG AN ABANDONED NORTHEAST-SOUTHWEST ROAD APPROXIMATELY 3.0 MILES NORTH FROM HIGHWAY 82 AT STEWART

	Feet	Feet
Meridian formation		28.4
Sand, red-brown at surface, coarse to medium, to top of valley wall	28.0	
Sandstone, ferruginous slabs; sharp contact, maximum about	0.4	
Ackerman formation		91.0
Clay shale, clay, sand, and silt, interbedded, interlaminated; bluish-gray clay towards the top. Most of the interval is concealed by sand which has crept down over it from above or has been deposited in erosion depressions in the clay and shale, but the laminated shale and silt and clay are exposed here and there—at 50.0 to 55.0 feet above the base; also at 80.0 feet to 85.0 feet, and at 90.0 feet, for examples	91.0	
Covered, to old broken bridge		4.0

Some 0.15 mile from the old bridge, cuts for an abandoned farm road expose bluish, bluish-gray and lignitic clay here and there to a height of 40 feet or so above the bridge.

The elevation to the top of the section, as indicated, is approximately 123 feet, but some 0.3 mile farther southwest, the elevation increases to 140 feet or more above datum.

In the southwestern corner of the county and adjacent borders of Montgomery County, in the drainage area of the head forks of several small tributaries of Big Black River, most of the once overlying Meridian sand has been removed by erosion, exposing Ackerman clay shale and clay and silt in many places. During the survey of Montgomery County a few test holes were drilled in this region, in Montgomery County near the borders of Webster, and the logs of these holes are good descriptions of the Upper Ackerman strata.

Test hole L 242[24] (SW. ¼, NE. ¼, NW. ¼, Sec. 1, T. 18 N., R. 8 E.) located at an exposure of carbonaceous clay on the north side of U. S. Highway 82, 1.5 miles northeast from Stewart, showed 27.6 feet of interbedded dark-colored carbonaceous silts and reworked lignites. The log is quoted below:

HIGHWAY PROPERTY

TEST HOLE RECORD L 242

LOCATION: T. 18 N., R. 8 E., SEC. 1, SW. ¼, NE. ¼, NW. ¼; BENEATH SMALL GUM, ABOVE CLAY OUTCROP, NORTH SIDE OF ROAD, 25 FEET EAST OF ROAD FORK (ELEVATION: 360 FEET)

No.	Depth	Thick	Description of strata and designations of samples
1	3.7	3.7	Soil—silt, clayey yellow-buff
2	12.2	8.5	Silt, clayey brownish-buff; laminae of brownish-black limonitic claystone
3	15.3	3.1	Silt, clayey grayish-white with yellow mottling
4	18.1	2.8	Clay, slightly silty dark-gray fairly plastic
5	21.2	3.1	Clay, slightly silty dark-brown carbonaceous fairly plastic; thin laminae of black lignitic clay-shale
6	31.3	10.1	Clay, slightly silty dark-gray fairly plastic

The location is only a quarter of a mile or so southwest of a pit in Meridian sand.

Test hole L 239,[25] on the north side of Highway 82 some 2 miles west of Stewart, was logged as quoted below:

WILLIE JOHNSON PROPERTY

TEST HOLE RECORD L 239

LOCATION: T. 18 N., R. 8 E., SEC. 4, S. ½, SW. ¼, SW. ¼; BENEATH SMALL OAK IN DITCH AT NORTH SIDE OF ROAD, BENEATH ROADCUT EXPOSURE OF DARK PLASTIC CLAY (ELEVATION: 348 FEET)

No.	Depth	Thick	Description of strata and designations of samples
			Holly Springs formation
1	5.2	5.2	Clay, slightly silty light-greenish-gray red mottled
2	15.4	10.2	Clay, slightly silty dark-greenish-gray; laminae of brownish-black carbonaceous or lignitic clay; P2
3	19.2	3.8	Clay, slightly silty dark-gray fairly plastic; P3

In brief, Hole L 239 passed through 19.2 feet of greenish-gray silty clay and thinly bedded brownish-black carbonaceous clay, overlying beds of the same character as those encountered by Test hole L 242.

Test hole L 243,[26] 2 miles due west of Stewart, started beneath a breccia, encountered light-gray and greenish-buff silts and silty clays to a depth of 32.2 feet. The log is as follows:

W. W. RIVERS PROPERTY
TEST HOLE RECORD L 243

LOCATION: T. 18 N., R. 8 E., SEC. 5, NE. ¼, NE. ¼, SE. ¼; BENEATH SMALL POST OAK, NORTHEAST SIDE OF ROAD ABOVE BLACK AND WHITE CLAY, WEST CORNER OF FARM YARD (ELEVATION: 388 FEET)

No.	Depth	Thick	Description of strata and designations of samples
			Holly Springs formation
1	5.6	5.6	Soil—clay, sandy yellow-buff
2	10.6	5.0	Clay, fairly silty light-gray dark-gray mottled; laminae of dark-gray plastic clay; P2
3	14.8	4.2	Clay, silty light-gray fairly plastic; P3
4	19.0	4.2	Silt, light-buff; thin laminae of light-gray silty clay
5	26.7	7.7	Silt, clayey light-greenish-buff; P5
6	32.2	5.5	Silt, light-gray

Priddy mentions also a road cut[27] (SW. ¼, SE. ¼, NE. ¼, Sec. 36, T. 19 N., R. 7 E.) just west of the Webster County line, where 15 feet of dark-gray fairly plastic clay are exposed. His test hole L 235, drilled above the outcrop, "penetrated 33.6 feet of light-gray and dark-gray silty clays and silts overlying 12.2 feet of re-worked lignite and thinly laminated dark-brown carbonaceous clay." The log is quoted below:

W. E. ARMSTRONG PROPERTY
TEST HOLE RECORD L 235

LOCATION: T. 19 N., R. 7 E., SEC. 36, SW. ¼, SE. ¼, NE. ¼; NORTH SIDE OF ROAD BENEATH SMALL PINE, ABOVE OUTCROP OF DARK PLASTIC CLAY, OPPOSITE JUNCTURE OF FARM ROAD (ELEVATION: 370 FEET)

No.	Depth	Thick	Description of strata and designations of samples
			Holly Springs formation
1	3.0	3.0	Clay, silty light-gray buff mottled; P1
2	8.6	5.6	Clay, fairly silty light-gray yellow mottled; P2
3	13.6	5.0	Silt, fairly clayey gray-tan; P3
4	18.4	4.8	Silt, light-gray
5	30.6	12.2	Lignite, black; reworked; laminae of dark-brown carbonaceous clay; P5
6	33.6	3.0	Silt, fairly clayey dark-greenish-gray; slightly micaceous laminae; P6

Priddy includes all these beds in the old Holly Springs formation.

A few of the outcrops in southwestern Webster County and the adjacent part of Montgomery merit at least a brief description:

SECTION OF THE SOUTHEAST WALL OF A SMALL VALLEY NORTHWEST OF A ROAD FORKS (NW. ¼, SEC. 6, T. 18 N., R. 8 E., MONTGOMERY COUNTY), 1.4 MILES NORTH FROM U. S. HIGHWAY 82

	Feet	Feet
Recent formation		1.0
Soil and subsoil, to road junction, estimated	1.0	
Meridian formation		10.0
Sand and colluvial ferruginous sandstone: Sand coarse to medium, red brown and mottled, cemented to irregular crusts at base	10.0	
Ackerman formation		30.2
Clay, iron rust mottled with gray, and yellow iron stained; compact	1.0	
Siltstone, limonitic, dense	0.2	
Clay, light gray to darker gray, containing lignitic intervals; somewhat lignitic towards the top	24.0	
Covered, to road above culvert, in bottom of valley	5.0	

Half a mile northeast of the road forks section, a cut (SE. ¼. Sec. 31, T. 19 N., R. 8 E., Webster County) in the south wall of a small valley, has exposed 12 feet of light-gray rust-stained lignitic clay, black in the uppermost part except where leached, and above the clay, between it and the overlying brown clayey sand or sandy clay, a discontinuous thin layer of ferruginous sandstone. The brown clay-sand interval above the sandstone grades upwards into red-brown sand, probably Meridian.

Probably the sharpest, most clearly defined clay-sand contact (Figure 21) in this part of Webster County is in the north wall of a road cut (NW. ¼, Sec. 31, T. 19 N., R. 8 E.,) a few rods east of a junction, approximately a quarter of a mile east of the western boundary of the county and three quarters of a mile north from the southern boundary. Priddy[28] describes the strata here as "interbedded dark-colored silts and light-colored fairly plastic clays . . overlain by a breccia composed of gray clay cobbles in a matrix of buff-colored clayey silt," and assigns them to the Holly Springs formation.

The clay of this region is for the most part gray of different shades, lignitic in many places, and commonly iron stained; it contains much scattered iron ore belonging to three or four distinct layers. At the road junction (NE. ¼. SE. ¼, Sec. 30, T. 19 N., R. 8 E.) a 10-foot interval of very plastic light-gray to dark-gray clay, splotched with red, and bluish to somewhat lignitic in places,

is exposed. Some 0.4 mile farther east, a 20-foot section of gray iron-stained clay, including two horizons of iron ore, crops out; and a quarter of a mile farther east, a little south of an intersection, the same general type of clay shows from the bottom to well up towards the top of a considerable hill. These three outcrops are typical of the clay terrane of southwestern Webster County.

Figure 21.—Ackerman-Meridian contact, north wall of road cut (NW. 1.4, Sec. 31, T. 19 N., R. 8 E.) in southwestern corner of Webster County.

A significant feature of this territory is pieces of quartzite and ferruginous sandstone scattered thinly over it, even where no sand formation is present. Probably this rock is uppermost Ackerman, and was originally subjacent to the Ackerman-Meridian (Wilcox-Claiborne) contact. Quartzite is present in considerable thickness at the Wilcox-Claiborne contact farther north. It is the writer's belief that the clay of southwestern Webster County is a part of the Ackerman formation, and the overlying sand, part of the Meridian.

North of the eroded southwesternmost township of Webster County the divides are capped by Meridian sand. The lower zones of the valley walls of the upper reaches of Sand Creek and its

tributaries expose Ackerman clay shale and clay and thin beds of fine silty sand. Good clay, silt, and sand sections, including the clay-sand contact, are well exposed in many places: 1) The southeast wall of Sand Creek Valley along the Eupora road half a mile southeast of a community center (Near center, Sec. 21, T. 20 N., R. 9 E.); 2) Along a road up the northeast wall of the valley of a northern tributary of Sand Creek (NW. ¼ Sec. 29, T. 20 N., R. 9 E.), and in the west wall of the same valley; 3) at the western

Figure 22.—Clay breccia in sand: Road cut at junction (NE. ¼, Sec. 36, T. 20 N., R. 8 E.) Tomnolen-Alva road.

of the two road junctions in the northern part of Section 31, Township 20 North, Range 9 East, where a silicified log is lying along the clay-sand contact; 4) along the northeast-southwest road in Section 31, where inclusions of laminated light-colored clay or sand in deep red-brown sand are conspicuous; and 5) a little northwest of the road junction (NE. ¼, Sec. 36, T. 20 N., R. 8 E.) where clay breccia in the sand is excellently shown (Figure 22).

The north-south road almost along the line between Ranges 8 East and 9 East, Township 20 North, is on sand for 0.8 mile from its south end, but at its crossing of a small valley a good clay and sand section has been laid open by a ravine in the south wall of the valley:

SECTION (NW. ¼, SEC. 19, T. 20 N., R. 9 E) OF THE SOUTH WALL OF A VALLEY A QUARTER OF A MILE SOUTH OF ONE ROAD JUNCTION AND 2.0 MILES NORTH OF ANOTHER

	Feet	Feet
Ackerman formation		32.0
Weathered mantle, brown clayey and sandy, to level of house; a few concretions of iron ore at the top suggest a layer	7.0	
Iron ore concretions	0.3	
Silt, shaly structured, horizontally laminated, green on the surface, bluish where fresh; somewhat rust stained; weathers to a greenish-gray silty clay	7.5	
Iron ore concretions	0.2	
Silt, horizontally bedded and laminated, greenish on weathered surface, bluish where fresh; rusty; a rust-cemented crust at base, and similar crusts above	4.0	
Covered for the most part, but the shaly rusty silt, like that in Intervals 1 and 3, is exposed at the bottom and the top; contains thin rust-cemented brown to black crusts. The texture of the shaly silt of this interval and of Intervals 1 and 3 resembles that of partially decayed wood	6.0	
Sand, fine rusty brown, like Interval 2	1.0	
Silt, shaly laminated light gray rusty well bedded, like Interval 1	3.0	
Sand, fine brown, with black stains, especially along the laminae; diagonally and horizontally laminated; contains inclusions of silt, probably from subjacent bed	2.0	
Silt, light gray rusty horizontally laminated; contains very fine sand; to base of section	1.0	

Approximately three quarters of a mile north by east of the section just described, a section of the strata of the east wall of the valley of the west fork of Sand Creek is exposed by shallow road cuts and by gullies. Towards the base of the slope is laminated sand, which is succeeded above by bedded wood-structured silt, and greenish-gray and light-gray and lignitic clay containing four layers of iron ore.

A mile and a half, more or less, north by west of the Section 18 area, and a little less than half a mile in the same direction from an intersection (NW. ¼, Sec. 7, T. 20 N.. R. 9 E.) is the 105-foot sand interval described on a foregoing page. Cuts for the road which leads southwest from the intersection expose clay, silt, and sand, but chiefly red-brown sand, to the main Tomnolen-Alva road.

At the junction (Southern part, Sec. 15, T. 20 N., R. 8 E.) and a short distance northwest and northeast of it, a stratigraphic section at least a quarter of a mile long is exposed by road cuts and gullies:

SECTION (SOUTHERN PART, SEC. 15, T. 20 N., R. 8 E.) AT THE JUNCTION OF THE TOMNOLEN-ALVA ROAD AND A LOCAL ROAD

	Feet	Feet
Meridian formation		30.3
Sand, brown and red brown, including a little soil and subsoil, to the top of the hill northeast of the road junction	30.0	
Sandstone, superjacent to sharp contact	0.3	
Ackerman formation		74.7
Shale, or slightly indurated gray clay, sandy and silty, much jointed, rusty along bedding planes and joint planes; light colored on dry surface; some lentils and stringers of sandy silt; at 6.5 to 7.0 feet above the base of the interval, a layer of iron ore concretions 0.6 foot thick	30.0	
Iron ore layer, above sharp contact	0.5	
Shale, clay, sand, well bedded and laminated: Shaly clay, gray of various shades, greenish and black and brown lignitic; a few thin sand layers; all sandy and silty; a 0.5-foot bed of iron ore 10.0 feet above the base	44.2	

The Ackerman beds dip rather strongly southwards, hence the true thicknesses are somewhat greater than the thicknesses given in the description of the section.

Ranges 8 and 9 East, Township 21 North, northwestern Webster County, are part of the Sabougla Creek drainage basin. Outcrops of both sand and clay are many, sand commonly comprising the upper parts of the elevations and clay or clay shale the lower parts, although such a distribution is not invariable. The areal geology pattern is somewhat complicated, due to shifting of materials.

Northwest of Embry, cuts along the Embry-Cadaretta road show sand (Middle Ackerman?) almost exclusively for some four miles. The large cut through red-brown sand at Embry has been referred to. Approximately a mile and a half to two miles southeast of Cadaretta, in the vicinity of the C. H. Woods home (Western part Sec. 12, T. 21 N., R. 8 E.) interbedded clay and sand and iron ore are prominent. Also, along the road which leads west,

southwest, and west from the junction (SW. cor., Sec. 18, T. 21 N., R. 9 E.) are many outcrops of gray clay shale, gray and lignitic clay, laminated silt and fine sand, and iron ore. Approximately 2.3 miles southwest from the road forks (NE. cor., Sec. 22, T. 21 N., R. 8 E.) the west wall of a valley exposes 65 feet of bedded and horizontally laminated gray and light-brown fine sand containing gray clay laminae, and two layers of sandy iron ore masses. Farther southwest, at the junction near the center of Section 30, Township 21 North, Range 8 East, is a 20-foot to 25-foot section of light-gray well bedded blocky compact clayey and silty very fine sand; and half a mile or more farther south, the relatively steep south wall of a valley is chiefly bedded greenish rusty sand containing clay laminae, through a height of 100 feet above the valley floor. The section includes a 1-foot lignitic layer and two or three thin beds of iron ore.

Ackerman strata are exposed in several places in the northwestern corner of Webster County. Northwest of the road junction (NE. cor., Sec. 22, T. 21 N., R. 8 E.) gray clay and iron ore are at the surface along the local road for a mile and three quarters and through a vertical interval of 45 to 50 feet. Distant 1.75 miles from the junction referred to, and half a mile southeast from another junction, is "Point Lookout," a relatively high part of a steep valley wall, the top of which is 40 feet above the road and probably at least 100 feet above the valley bottom. The "Point Lookout" hill is capped with sand and ferruginous sandstone which may be of Meridian age. Northwest of Point Lookout half a mile or so, cropping out in the walls of the valley of a tributary of Sabougla Creek, are beds of gray clay, interbedded with sand. The west wall is made up of two or three benches or terraces, the lowermost of which is tumultuously cross bedded tan and brown sand containing clay and silt stringers and inclusions. Farther up, clay is exposed. Little if any red-brown sand shows, even near the extreme top. In fact, the surface materials of this entire region, so far as can be determined by road outcrops, are clay and tan sand; red-brown sand is conspicuously absent, even at high points. Clay and tan to gray silt and fine sand crop out in many places: At Bradford Chapel Baptist Church and west of it, for example; and northwest and south of Cadaretta. Roadside gullies a little northwest of Cadaretta in an up slope 0.3 mile long expose clay shale and tan sand, interbedded.

Along a local road 3 to 4 miles northeast of Lodi, quartzite blocks and irregular masses are scattered over a sizable area at a distance of from three quarters of a mile to a mile west from the Alva-Tomnolen road. The quartzite is believed to be fragments of a quartzite which was developed in places from silts in the upper part of the Ackerman subjacent to the Wilcox-Claiborne contact, and to be correlative with quartzite near New Liberty Church (Eastern part, Sec. 13, T. 20 N., R. 7 E., Montgomery County, a short distance west of the Webster County line) and with fragments in the southwestern corner of Webster County.

A quarter of a mile or so north of the New Liberty Baptist Church (NE. ¼, Sec. 13, T. 20 N., R. 7 E.) almost on the Montgomery County-Webster County line, hundreds of irregular masses of quartzite, ranging in weight from less than a pound to a ton or two, are scattered over the top and the east slope of the ridge. A little below the top of the ridge is a 3-foot to 4-foot ledge of quartzite in an essentially horizontal position—probably a remnant of a once much more extensive bed from which the loose blocks were broken, no doubt by their own weight after their support of sand, silt, and clay had been removed by sapping processes. The quartzite is underlain by compact silt which may be the kind of material from which the quartzite was formed; below the silt is a gradation into fine sand, and downwards into white and bluish-gray clay. The quartzite is overlain by Meridian sand. It is believed to mark the Ackerman-Meridian contact, just as, at higher stratigraphic levels, quartzite exists in places approximately at the Meridian-Tallahatta (Basic City) contact, the Tallahatta-Winona contact, and the Zilpha-Kosciusko contact. And, as stated hereinbefore, the quartzite float in places in western and southwestern Webster County probably is from the same horizon as that of eastern Montgomery County.

MERIDIAN AND TALLAHATTA FORMATIONS

The Meridian formation is considered by some geologists to be the lowermost member of the Claiborne, and by others to be the uppermost member of the Wilcox. Foster[29] and Thomas[30] accorded the Meridian sand formation rank, but other geologists have included it in the Tallahatta formation, as a member.[31] In this report the Meridian will be considered a formation, the lower-

most of the Claiborne sub-series, and the Tallahatta will be confined to the Basic City shales and sands.

A little west of a road junction (SW. ¼, Sec. 27, T. 20 N., R. 8 E.) and approximately 4 miles east by north of Lodi, the upper part of the divide between the Calabrella Creek basin on the east and the basin of Wolf Creek on the west is sand, capped by white silt shale and dark reddish-brown ferruginous sandstone. Description of the section follows:

SECTION OF VALLEY WALL NEAR HEAD OF VALLEY AND WEST OF ROAD JUNCTION (SW. ¼, SEC. 27, T. 20 N., R. 8 E.) SOME 4 MILES EAST BY NORTH OF LODI

	Feet	Feet
Tallahatta (Basic City) formation		22.0
Sand, brown, and silt shale, white, alternating layers and stringers; sandstone, ferruginous, brown, slabs 0.5 foot to 1.0 foot thick capping the ridge, to top of ridge	17.0	
Silt shale, white, thickness extremely variable, 3.0 to	5.0	
Meridian formation		60.0
Sand, brown, micaceous, coarse to fine, white where fresh; contains abundant crusts of rust-cemented sand, especially along laminae; cross-bedded zones; to floor of valley	60.0	

A mile and a half south of the section, and a few rods south of another road junction (NE. ¼, Sec. 3, T. 19 N., R. 8 E.) is a second outcrop of the Tallahatta white silt shale and underlying Meridian sand. The silt shale is typical Tallahatta (Basic City) paper shale—white, light of weight, laminated, splitting into thin leaves, jointed, blocky. The better exposure is in the west wall of the road cut; the east wall is dominantly red sand, although the white shale shows near the base. A pocket of green sand was found immediately above the shale.

An exposure of well-bedded white silt and silty and sandy clay (NW. ¼, Sec. 4, T. 19 N., R. 8 E.) a little more than a mile west by south of the Section 3 Basic City outcrop, and a short distance west of a road junction, is thought to show Basic City beds.

Below and south and southwest of the Section 3 outcrop of Tallahatta white shale, brown and red-brown sand comprises the upper part of the divide for at least 3 miles, and patches of it cap some high hills still farther south—for example, the hills (Sec. 14, T. 19 N., R. 8 E.) on and near the Grady-Stewart road, where the 131-foot section was measured. Also, this belt of Meridian sand,

which forms a cuesta almost south-north across the western part of the county, is well represented north of the two Meridian and Tallahatta outcrops described, especially in the more considerable elevations. A few examples may be referred to:

On the Alva-Tomnolen road some 2.5 miles southeast from Alva, one of the most prominent hills (NE. ¼, Sec. 8, and NW. ¼, Sec. 9, T. 20 N., R. 8 E.) of the region is capped with 30 to 40 feet of brown and dull white sand, probably of Meridian age. Sand of presumably the same formation caps the rises along a local road a mile and a half south of the hill just referred to.

Also, an outcrop at the road junction (SW. ¼, Sec. 31, T. 21 N., R. 8 E.) a quarter of a mile or less east of the Montgomery County line in Alva, exposes a complicated pattern of materials which probably are part of the basal zone of the Meridian. Angular fragments of laminated silt or silty clay in a matrix of brown sand; laminae and bedding at many different angles; pebbles and pieces of silicified wood embedded in the terrane, especially along contacts—all suggest active stream erosion, probably much undercutting of channel banks, associated with landslides which overloaded and choked streams and forced them to cut new channels—conditions which would be accentuated at the beginning of a new cycle. It seems pertinent to note, too, that fragments of quartzite were found on the hill slope just above the outcrop.

The terrane of the northern part of Township 20 North and the southern part of Township 21 North, northeast of the Alva-Tomnolen road, probably is largely Meridian sand, at least the more western block of it and the higher ridges and hills. This region was not explored during the present survey, mainly because it has no roads.

The red-brown and white sand above well-defined contacts, exposed by Highway 9 cuts northwest from Bellefontaine, might be assigned to the Meridian formation. In the walls of one of these cuts 1.7 miles to 1.9 miles southeast from the Calhoun County line, the red-brown sand which overlies the Ackerman clay shale has fragments and stringers of clay worked into its basal part, and for a distance of a mile and a quarter northwest from there the highway cuts show sand only. Less than half a mile south of the county line, on the southwest side of the highway, is a V-shaped

Figure 23.—North wall of pit in Meridian sand: Highway 9, 0.5 mile southeast from Calhoun County line.

Figure 24.—North wall of pit in Meridian sand: Highway 9, 0.5 mile southeast from Calhoun County line, and a few yards east of the section shown by Figure 23.

sand pit about 500 feet long and 34 to 35 feet (maximum) deep. The sand is red-brown to brown and white, micaceous, chiefly fine, and highly cross bedded. The Meridian type of alternate cross bedding and horizontal bedding is conspicuous (Figures 23 and 24). The sand in which the pit has been excavated is believed to be a Meridian outlier, probably a remnant of the filling of an old valley or other depression in the Ackerman terrane. Such an inference seems warranted by the absence of clay in the walls of

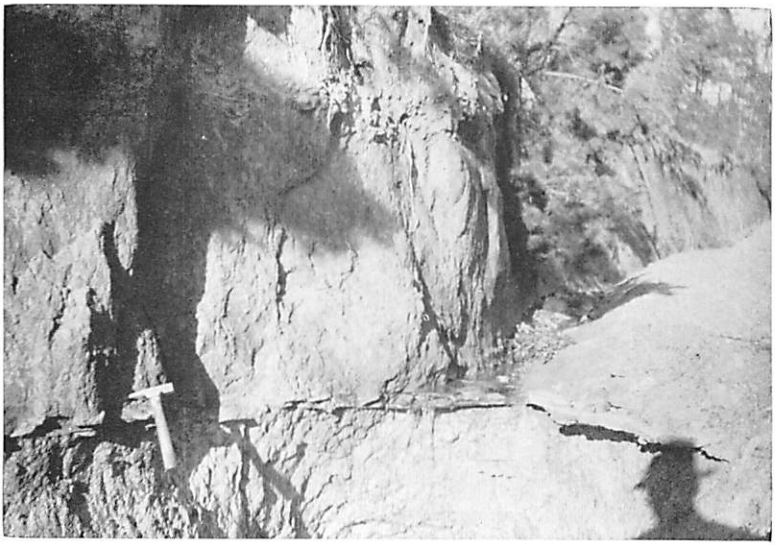

Figure 25.—Clay-sand contact (NE. ¼, Sec. 25, T. 21 N., R. 8 E.) in a wall of road cut 2 miles west from Embry.

the pit, although the ridge in which the pit has been made is approximately the same height as the rising ground at the county line, where light-gray shaly clay containing iron ore crops out.

Meridian sand is well exposed by road cuts north and west of Embry. The road trending west from the village is in a valley between sand hills for half a mile or a little more, beyond which it leads up a hill through a cut in 50 feet or more of red-brown sand. At the top of the sand hill is a prominent clay lens in the sand—the light-gray plastic clay, mottled with pale red, is separated from the sand by a 3-inch to 4-inch layer of sandstone. The west slope of the hill or ridge, 0.3 mile long, exposes sand only, some showing alternating brown and light-colored bands. Cuts

in the next hill to the west reveal red-brown sand containing a little clay breccia towards the base. The elevation here is relatively great. Near the foot of the west slope of this hill or ridge is a very good contact between light-colored irregularly bedded sandy clay below, and red-brown sand above (Figure 25).

Figure 26.—Meridian sand exposed by ravine (SE. ¼, Sec. 21, T. 19 N., R. 8 E.) 3 miles north of Stewart.

The eastern border zone of the Meridian formation is represented by the uppermost interval of the section (Southern part, Sec. 15, T. 20 N., R. 8 E.) northeast and northwest of the junction of the Alva-Tomnolen road and a local road. The 30-foot interval is brown and red-brown sand underlain by a thin sandstone. It extends a considerable distance along the local road towards the northeast, and also to some distance along the road to the southwest, in both east and west walls of the valley of Calabrella Creek.

At the junction (Western part, Sec. 35, T. 20 N., R. 8 E.) is an exposure of a thick section of white, yellow, and brown sand which almost certainly is correlative in part with the Meridian sand of the Meridian-Tallahatta sections (Sec. 3, T. 19 N., R. 8 E., and Sec. 27, T. 20 N., R. 8 E.) a mile more or less southwest and northeast of it, respectively.

The greatest elevations in the southwesternmost township are capped with sand which is thought to be Meridian. 1) a few rods northwest of the road junction (SE. ¼, Sec. 21, T. 19 N., R. 8 E.) a deep ravine has been cut in micaceous brown and white sand (Figure 26). From the base of the exposure to its top at the head of the ravine near the summit of the hill, is 45 feet, of which the upper 25 feet are included in a vertical-faced wall. 2) In the extreme southwestern corner of the county most of the once overlying sand has been removed by erosion, but remnants remain as caps for the higher hills and ridges. A few rods east of a road junction (NW. ¼, Sec. 31, T. 19 N., R. 8 E.) approximately a quarter of a mile east of the western boundary of the county, and three quarters of a mile north of the southern boundary, is a relatively high hill, the top 25 to 30 feet of which is whitish to brown and red-brown sand, probably Meridian. The contact of the sand with the underlying clay is sharp (Figure 21).

The uppermost interval of a section (Sec. 22, T. 19 N., R. 8 E.) some three quarters of a mile east of the Section 21 ravine already referred to, in the west wall of a valley, and along an old road, is 28.0 feet of coarse to medium brown and red-brown sand, underlain by ferruginous sandstone 0.4 foot thick. The sand and sandstone probably are of Meridian age.

Meridian sand is prominent in places in the northwestern quarter of Township 19 North, Range 8 East—indeed, the road cuts show little of any kind of rock material except sand. West by south from the intersection (SW. ¼, Sec. 9) are several outcrops of deep red sand, and on the north-south road across Sections 18, 19, and 30 are steep descents through deep cuts in the sand. The road is on the slope of the north wall of one valley for 0.6 mile, and in a cut in the steep north wall of the main valley for more than 200 feet and through a vertical interval of 50 to 75 feet. Nothing except red-brown sand is exposed by these road cuts.

In the extreme western part of Webster County, and in eastern Montgomery, the Meridian sand is present pretty generally. Along and near the Sibleyton-Lodi-Alva road, eastern Montgomery County, are several good outcrops. Approximately 1.6 miles north from U. S. Highway 82 at Sibleyton, steep dips of the brown sand are noticeable. A short distance farther north, at the junc-

some 2 miles, exposed by several cuts. North of Lodi sandy clay shale crops out in the nearby valley and low rises; and the ridge on the west side of the Lodi-Alva road a quarter of a mile, more or less, west of the Hart Property iron ore pits (Sec. 25, T. 20 N., R. 7 E.) is chiefly brown sand, lying on greenish-gray clay which grades upwards into white. The clay-sand contact (Ackerman-Meridian; Wilcox-Claiborne) is approximately at road level. The same contact is exposed a short distance farther north, a little west of the road.

Because the Lodi-Alva road lies across the regional strike of the strata at a low angle, both Wilcox and Claiborne (Ackerman and Meridian) beds crop out in the walls of the road cuts. South of

tion (NW. ¼, Sec. 2, T. 18 N., R. 7 E.) of the Lodi road with a road which leads southwest to Kilmichael, a cut for the southwest road is in brown and red-brown sand. Included in the coarse sand of the cut walls is a large block of Tallahatta (Basic City) white shale, the bedding of which dips southwest at a steep angle. The sand matrix is cemented at its contact with the shale. Just over the rise to the south is a large pit excavated in medium to coarse red-brown sand which is streaked and spotted with white sand; the shale is not exposed in the pit. Less than a quarter of a mile north of the road junction, and 150 to 200 yards north of a church and school, is another showing of white silt shale under and in the

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A mile northwest of Alva, a deep road cut (NE. ¼, Sec. 35, T. 21 N., R. 7 E., Montgomery County) in the west wall of the valley of a small creek, has exposed a section of well-bedded sands. Priddy[36] states that a thickness of 112 feet of sand is shown here, underlain by dark silty clays. The sand is red-brown, brown, yellow, whitish, pink, and purple. At the base of the sand, a little above the creek bridge, is a small outcrop of dark-blue bedded clay.

PLEISTOCENE AND RECENT

Deposits of rock material which may have accumulated in Webster County during the Pleistocene epoch can not be differentiated from younger deposits, or in some cases from older deposits. Perhaps the sand and silt and clay of older and higher stream terraces, none of which is of any considerable extent, accumulated during Pleistocene time, or even earlier. Possibly, too, a part of the alluvium which underlies the flood plain of the Big Black was deposited as long ago as the Pleistocene epoch, and very probably the deeper part of the residual mantle in some places originated prior to the rather indefinite beginning of the time commonly referred to as "Recent." Loessial material, too, from the thick body of Pleistocene loess farther west, has entered extensively into the composition of the soils of Webster County. The brown loam soil, derived from the loess, covers a fifth of Choctaw County, and probably as great a part of Webster County.

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Except for the two small showings of Tallahatta shale near the road junction, the surface material along this part of the Lodi road is brown and red-brown sand. A short distance east of the road is an artificial lake in the valley of a small tributary of Wolf Creek, and cuts even below lake-level showed sand only. However, a little less than a mile farther north, a short road which leads east from the Lodi road lies across a belt of gray and bluish clay at a distance of 0.9 mile from the Lodi road. Lower in the Wolf Creek Valley wall, also, gray clay is exposed at two or three places. The clay-sand contact may be the Wilcox-Claiborne contact. The presence of Tallahatta beds at the surface (SE. ¼, Sec. 2, T. 18 N., R. 7 E.);[32] and in the east wall of Big Mulberry Creek half a mile southwest of the junction, all three Tallahatta exposures being at elevations little if at all greater than the elevation of the Wilcox clay outcrop, is the result of severe faulting incident to the Kilmichael uplift. According to Priddy,[33] Tallahatta sands have been dropped down on the east flank of the dome, forming a graben. He describes and figures[34] a Wilcox clay outcrop (NE. ¼, Sec. 36, T. 19 N., R. 7 E.) not more than a mile east by north of his Section 35 showing of tilted Tallahatta beds.

North from Highway 82 approximately 3.3 miles the red sand walls of a Lodi road cut contain grit and small gravel. The gritty sand can be traced eastwards and northwards for considerable distances: a mile farther north by road, are outcrops of coarse red-brown sand containing much small chert gravel, on the slopes east of the road. At this place, too, thin beds of clay and yellow and white sand, ferruginous sandstone crusts, and a thin seam of iron ore show in the road bed and are exposed by a roadside gully. The top of the Kilmichael Dome (common corner, Secs, 22, 23, 26, 27, T. 19 N., R. 7 E.)[95] is only half a mile west of this segment of the Lodi road.

Lodi stands at a road intersection on a sand hill which is part of the west wall of the valley of a Wolf Creek tributary. The roads are in deep sand cuts north, east, south, and west of the village, and small valleys on the north and south have been cut in the sand. Banding of the sand is well exhibited by these exposures, especially by the walls of the road cut a few rods west of the intersection. East of Lodi the west wall of the flat-bottomed valley is weathered sand, but the east wall includes beds of clay shale, iron ore, and bluish-gray clay below, and 25 to 30 feet of tan and red-brown sand above. The contact zone of the light-colored clayey material below and the brown sand above is very irregular, showing evidence of strong cross currents. The sand cap on which Lodi stands is believed to belong to the Meridian formation, and the underlying clay and iron ore, to the Ackerman (Wilcox). From Lodi the sand body, showing conspicuous banding, extends southwestwards along the Winona road for some 2 miles, exposed by several cuts. North of Lodi sandy clay shale crops out in the nearby valley and low rises; and the ridge on the west side of the Lodi-Alva road a quarter of a mile, more or less, west of the Hart Property iron ore pits (Sec. 25, T. 20 N., R. 7 E.) is chiefly brown sand, lying on greenish-gray clay which grades upwards into white. The clay-sand contact (Ackerman-Meridian; Wilcox-Claiborne) is approximately at road level. The same contact is exposed a short distance farther north, a little west of the road.

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Commonly the so-called "Recent" epoch is understood to mean the time which has elapsed since the close of the Pleistocene epoch, and the Recent series is thought of as the entire body of rock which has been transported and deposited or has accumulated

in situ since the end of Pleistocene time. Of course no exact definition of the epochs is possible. The Recent series, then, includes most of the blanket of rock debris which lies over the more or less consolidated Tertiary strata of the county. It consists of residual soil, sub-soil, and other loose rock material, also rock waste which has been moved from its original position—talus, colluvium, and alluvium. The alluvium of the flood plains is the most important part of the Recent series, at least in Webster County. It is made up of sand, clay, and silt chiefly, intermingled or aggregated as lenses or discontinuous beds or irregular bodies, each of which may consist of one kind of material almost entirely, but commonly consists of one dominant kind mixed with smaller proportions of one or more of other kinds of materials. Thus a cross-section of the rock materials which underlie any flood plain of Webster County would show bodies of sand, silt, and clay interwedged and interfingered in a complicated manner. In general, however, the alluvium is more sandy nearer the stream (the front lands) and more silty and clayey back towards the valley walls (the back lands).

STRUCTURE

The structure of the Webster County strata is in general monoclinal, the beds dipping west by south at 25 to 30 feet to the mile. In a few places rough determinations can be made of the degree of dip. As stated in the discussion of stratigraphy, a lignitic clay interval at the top of the Lower Ackerman section in the "mountain" southwest of Montevista was found to dip southwest at the rate of 30 feet to the mile. Dip determined on iron ore beds along the Embry-Alva road in Sections 21 and 22, Township 21 North, Range 8 East, was approximately the same. A few local evidences of departure from the normal regional structure were noted, as mentioned in the part of this paper which relates to stratigraphy, but they may not be significant. It seems pertinent, however, to refer again to the more prominent of them.

In the northeast slope of the "mountain" southwest of Montevista, the beds dip steeply toward the southwest through a distance of perhaps 200 yards or more; but this apparent steep dip may be due partly to creep of the surface and near surface parts of the beds down the rather steep slope.

Several zones of breccia and very irregular bedding suggest larger structures, but almost certainly are due to current action—erosion, particularly undercutting, by strong streams, and redeposition of the eroded material.

In northern Choctaw County, Ackerman outcrops show slight flexures, reverse dips, and dips steeper than normal in a few places, but none of these structural irregularities seems to extend over a considerable distance, hence all probably are due to variation of original deposition, and to expansion, contraction, compacting and shrinkage after deposition. The same kind of phenomena is present in Webster County.

The southwesternmost township of Webster County is not far from the center of the Kilmichael uplift, but no surface evidences of disturbance of the strata were noted by the present survey.

Lowe[37] describes stratigraphy and structure exposed by a Gulf, Mobile and Northern Railroad [now Gulf, Mobile and Ohio] cut 3.5 miles north of Maben. He states that the upper beds, composed of laminated micaceous gray clay and sand, dip 4 degrees toward the north, and the lower beds, composed of laminated dark greenish-gray highly micaceous lignitic sandy clay which weathers almost black, dip at a lower angle in the same direction. Thus the exposed strata seem to constitute the north limb of an anticline. The possibility that they are indeed part of a low flexure is strengthened by the fact that in a cut a little less than a mile farther south very similar, probably identical beds dip South twenty degrees East at an angle of 4 degrees. Moreover, Naheola beds exposed by some Highway 15 cuts a mile or less east of the railroad show higher than normal dips. All in all, field evidence suggests structural conditions here of a type favorable for the accumulation of oil and gas; but the flexure may not affect the rock to great depth; besides, the uppermost Paleozoic beds this far south probably are very thick Pennsylvanian (Pottsville) conglomerates, shales, and sandstones, chiefly non-marine, which have not yielded very encouraging results to oil prospectors in Mississippi and Alabama. The Mississippian strata, which have produced a little gas and oil farther north, probably could not be reached above a depth of 7,000 to 8,000 feet, unless the folding or doming of the rocks is much more pronounced at depth than it is at the surface.

Geologists for oil companies have examined Webster County territory from time to time. A report[38] by one of them, written in 1926 or 1927, states the results of a study of Townships 20 and 21 North, Ranges 11 and 12 East. It describes specifically evidence of structure in the vicinity of Cumberland: A south dip of 3 to 5 degrees for a distance of 3 miles from a point half a mile south of Cumberland, shown by G. M. and N. Railroad cuts, and a North 20 degrees West dip of 5 degrees along the railroad some three quarters of a mile north of Cumberland. From this evidence the inference was drawn that the village of Cumberland is standing on the axis of a small anticlinal fold. Furthermore, the author of the report expressed the opinion that the fold probably becomes more prominent with depth. Also, he speculated that the small fold at Cumberland might be the southwest end of a much larger fold 3 to 4 miles northwest of the village, and mentioned some suggestions of a larger structure in the area centered in Section 15, Township 21 North, Range 11 East—specifically, local northeast dips in the area between Dancy and Hohenlinden, and pronounced west and northwest dips immediately west of Hohenlinden.

It is pertinent to mention, in this connection, that the author of the report rather discouraged a drilling venture, stating that 1) the evidence of structure was indefinite and inconclusive, because the relationship between surface indications and subsurface structure was unknown; and 2) the Cretaceous formations, wherever drilled, did not appear to contain favorable source material. However, his lack of enthusiasm for northeastern Webster County as likely oil-producing territory did not deter a local organization, the Cumberland Oil and Gas Company, from drilling a well (Henley No. 1)[39] at the place he had referred to as the top of a possible relatively large structure—Section 15, Township 21 North, Range 11 East. The well probably did not reach the Paleozoic. The writer of the present report has seen the railroad cut outcrops north and south of Cumberland, also the road cuts around Hohenlinden, and has noted the structural irregularities at both places. He doubts, however, that they are evidences of folding or warping of the strata on a large scale. It will be noted that the structures alluded to are on or near the surface trace of the Midway-Wilcox contact, a contact of great unconformity, along and above which structural anomaly is the rule rather than the exception. Possibly

a more intensive study of the region would provide a sound basis for a decision on the question of whether or not the surface expression of structure is an index to subsurface structural conditions.

At least two, probably three, major unconformities are included in the strata which crop out in Webster County: The Midway-Wilcox, the Fearn Springs-Ackerman, and the Wilcox-Claiborne. Of these, the Midway-Wilcox represents the greatest time interval and the most radical change of geological conditions. However, the relief of the old Midway surface is in general slight, whereas the relief of the old Fearn Springs surface is very considerable—in fact, in places, according to Mellen,[40] the Fearn Springs strata have been entirely eroded, so that Ackerman beds rest on the Midway. This relationship seems to be general in Webster County. In parts of Webster County basal Ackerman sand fills old valleys cut in Naheola materials, and here and there the Meridian sand has a similar relationship to the underlying Ackerman beds.

By way of summary, it may be said that the strata which crop out in Webster County have a regional dip of approximately 30 feet to the mile west by south, and strike north by west and south by east; that the stratigraphic column includes at least two major unconformities; that both regular and irregular bedding and lamination are common; that minor structural features, such as joints, contemporaneous erosion surfaces, slickensides, old landslip surfaces, brecciated zones, local arching of strata, etc., are many; and that probably relatively extensive and deep-seated flexures, which may be of economic significance, have affected the terrane in places.

CONDITIONS OF SEDIMENTATION; GEOLOGIC HISTORY

During the Midway epoch in the region which is now Webster County, Mississippi, the shallow margin of the sea lay over a gently sloping surface, on which fine sediment from the low land to the northeast was accumulating. Numerous small streams and a few large ones from the north and northeast discharged into the marine waters. Most of these streams built deltas,[41] because the tide and the waves and the shore currents were not sufficiently strong to distribute the sediments uniformly over the

sea floor as rapidly as they were brought in. The extreme fineness of the Porters Creek sediment indicates that the drainage from the Cretaceous peneplain was sluggish, the streams of low gradient, and the sediment available, the residuum from long weathering, approaching the end product.[42] The absence of bedding suggests also that the sediment settled in quiet water which was deep enough to prevent any shifting about of the detritus. Grim expresses the opinion that the Porters Creek material of north east-central Mississippi is a "delta deposit built out to the southwest by a larger river entering the embayment at this place," and states that the delta explains the lithology and distribution of the Midway series,[43] and also its great thickness in central Mississippi can be explained by irregular deposition along the old shore line: As the deltas grew and merged laterally, the terrigenous sediments spread seaward and along the coast, masking the calcareous deposits; intermittent coalescing of the deltas was reflected in alternating marine and deltaic conditions, which are testified to today by the sequence of lenticular beds of 1) marine glauconitic partly fossiliferous limy sand, and 2) essentially non-fossiliferous non-calcareous clay. The successive marine beds were smaller and smaller toward the top of the Midway as the size of the deltas increased."

The fineness of the Porters Creek sediment, its uniformity of lithology and structure, and the absence of breaks in the formation, indicate uninterrupted deposition, and testify to uniform old age conditions in the source region. Streams flowing from such a territory would carry silt, clay, and fine sand only.[45] However, the great quantity of sediment transported seems to point to gradual uplift of the source region, beginning in early Eocene time. Quickened erosion, or more sand available for the streams, is reflected in the relative increase of sand in the upper Midway.[46] Following the retirement of the Gulf southward the Midway terrane was subjected to long-continued weathering and erosion. A thick residuum was developed in places, and much of it was later removed by streams rejuvenated by gradual uplift which inaugurated Wilcox time. The Midway surface, upon which the lowermost Wilcox sediments were laid, was very much like the surface which received the Midway sediments, but the Wilcox which is now at and near the surface in Mississippi was deposited on low

land, as indicated by lignite and plant fossils rather than marine fossils.[47]

Lithology and structure of the surface and near-surface Wilcox terrane, described under "Stratigraphy," are evidence of the conditions of deposition. As Grim puts it, "The Wilcox in Mississippi is an extremely varied assemblage of beds of sand and clay . . . "[48] These beds, composed almost wholly of fine materials, and in many places including angular blocks of clay and silt, could hardly have been deposited by water of high velocity. However, the very irregular structure, especially the complicated cross-bedding, testifies to shifting currents of meandering, probably braided streams. The evidence seems to point to deposition on a coastal plain, as stream alluvium, alluvial fans and cones, lake fillings, and lagoon deposits. Grim's summary is, "The characteristics of the Wilcox sediments in Mississippi point strongly to water as the chief agent of deposition and to a somewhat variable non-marine environment adjacent to the sea. Such requirements are met by littoral, deltaic, lagoonal, or palludial conditions in a flat region. Under such conditions wind could have played the minor part suggested for it by the few examples of eolian cross-bedding."[49]

The same writer states that his interpretations of Wilcox samples "Suggest that the Wilcox material in central Mississippi was deposited as a huge delta built out to the southwest from the northeast-central part of the state. The littoral deposits in eastern Mississippi may have been local on the delta, but more probably mark the general limit of the delta in that direction."[50] He expresses the opinion that the delta referred to was built by the ancestral Tennessee, the "Appalachian River," in Midway and Wilcox time.[51] He states also, "The thickness of the Wilcox sediments indicates a gradually subsiding area during Wilcox deposition. Throughout this interval the crustal movement in the region of the present Wilcox outcrop in Mississippi did not usually keep pace with deposition, so that the area became filled and general non-marine conditions were maintained."[52]

Grim explains the difference in lithology between the Midway and the Wilcox terranes as due to variations in lithology of the source region. Lithologic differences within the Wilcox are explained in the same way.[53]

According to Grim, towards the close of Wilcox time and the beginning of Claiborne time, the Gulf began a gradual northward migration, causing a change from the non-marine conditions of the Wilcox to littoral conditions at the beginning of Meridian time, and later to neritic conditions. However, it is probable that subsidence failed to keep ahead of deposition, and the shore line was pushed southward by accumulation of sediment. This fluctuation of the shore line continued far into Claiborne time.[54]

ECONOMIC GEOLOGY

SOILS

Inasmuch as the average soil is a mixture of mineral substances chiefly, soils may properly be classed as a mineral resource. Indeed, the soil of any agricultural region is its most valuable mineral resource. Obviously the mineral matter is derived from pre-existing country rock, but it has undergone many changes in its long history. Both mechanical and chemical processes are involved in weathering, in any climate; but in a humid subtropical climate, such as that of Webster County, chemical weathering is dominant. Rock waste becomes the mineral components of soil through disintegration and decomposition. Chemical processes, especially oxidation, hydration, and carbonation, bring about decomposition and the formation of new minerals; and if the rock waste remains long enough in the place where it originated, it becomes residual soil. Ultimately the soluble substances, including the most valuable plant foods, are leached out, and the final product is composed, in the main, of the relatively infertile insoluble or difficultly soluble mineral matter, notably silica and alumina.

Both residual and transported soils are present in Webster County. The residual soils were formed in situ by weathering of rock which once occupied the area where the soil now is; but of course the thickness of the derivative soil is much less than was that of the parent rock, because of the leaching of soluble matter from the rock. Transported soils are, as the name indicates, soils which were once residual, but have been removed by the agents of erosion from their places of origin, and carried a lesser or greater distance. Transported soils occupy a wide range of positions, then, topographically as well as geographically—that is,

they may be found near the crests of ridges, or farther down the slopes, or underlying the flood plains of the streams, according as they may be in an early stage of transportation, or a late stage, or a stage somewhere in between. They may be the soils of flood plains or of alluvial fans or of terraces.

In Webster County the transported soils are more important than the residual soils. The best farm land is the flood plains of the many streams, not only because a flood plain is level and thus more easily worked by farming implements, but because its soil is thicker and more fertile. A flood plain soil is more fertile because it is composed of rock material of many different kinds, transported from every part of the region and from every rock unit which the stream system concerned has reached. Also, some alluvial soils contain more humus, and the humus is more thoroughly distributed through the soils than is commonly the case with residual soils.

Inasmuch as the mineral content of the soils of Webster County was derived from sands, silts, and clays similar to those which now underlie the surface of the county, the soils are in general mixtures of sand, silt, clay, and humus. The relative proportions of the three leading types of mineral matter in the residual soils vary from place to place, of course, according as the underlying parent rock varied; and in transported soils they vary according to the kind of rock material carried and deposited by the streams. The residual soils of the extreme eastern part of the county, underlain by the Porters Creek formation, are heavy, clayey, acid soils; those of the Naheola belt are more sandy and silty; the residual soils of the Ackerman outcrop area are sandy, clayey, and silty above the strata of the same character, and sandy on the sand belts. The transported soils are mixtures almost everywhere, because almost every stream system carries several kinds of rock material.

The U. S. Department of Agriculture Bureau of Soils has issued reports on the soils of many Mississippi counties, but, unfortunately, Webster County was not among the number. However, a soil survey was made of Choctaw County and a report published in 1920, and inasmuch as the geology and climate of Webster County are very similar to those of Choctaw, the soils also of the two counties are much alike. A summary of the leading

features of the Choctaw County report will be given here, therefore, as equally applicable to the soils of Webster County.[55]

The authors of the report recognize "three well-defined soil divisions: 1) Upland, or old sedimentary and loessial soils; 2) old stream alluvium, the terrace or second bottom soils lying above normal overflow; 3) recent stream alluvium or bottoms subject to overflow." The soil types of any one division are similar to each other. That is, the areal distribution of soil types is controlled by topography rather than by geography. The map which accompanies the report shows that the soil types are scattered widely in a jigsaw puzzle pattern as patches of various sizes and irregular shapes. Sixteen soil classes are named, composed of six types of soil—fine sand, fine sandy loam, very fine sandy loam, silt loam, silty clay loam, and clay. Of the sixteen classes, nine are upland soils, one is a terrace or second bottom soil, and six are bottom land or flood-plain soils. The Collins series, consisting of the Collins silt loam, the Collins silty clay loam, and the Collins fine sandy loam, are the chief flood-plain soils, occupying more than a fifth of the area of the county. Of the three soils of the Collins series, the silt loam occupies an area almost six times as great as the combined areas of the other two, and is "the most important first-bottom soil in the county." Commonly it is a light-brown silt loam 8 to 10 inches thick.

The terrace or second-bottom soil, the Olivier silt loam, is grayish-brown to pale yellow, and 8 to 10 inches thick. Surface drainage is sufficient except in some low spots; subsurface drainage is not so good, because of the high water table, or because of the impervious hardpan in the lower subsoil, or perhaps because of both factors.

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water rose to within 40 feet of the surface. Most of the water probably came from beds between depths of 250 and 360 feet, that may be in the Clayton formation.

MINERAL ANALYSIS OF WATER FROM PUBLIC WELL 700 FEET DEEP AT EUPORA, WEBSTER COUNTY[58]

	Parts per million
Silica (SiO_2)	33
Iron (Fe)	1.4
Calcium (Ca)	46
Magnesium (Mg)	10
Sodium and Potassium (Na-K)	42
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	215
Sulphate radicle (SO_4)	42
Chloride radicle (Cl)	22
Nitrate radicle (NO_3)	.40
Total dissolved solids at 180° C	300
Total hardness as $CaCO_3$ (calculated)	156

Analyst: Dr. W. L. Kennon, University of Mississippi

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The table of the results of mechanical analyses shows the lithologic character of this soil type:

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Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Soil	0.4	0.4	0.4	2.3	7.6	73.9	14.0
Subsurface	0.0	0.1	0.1	2.7	8.2	64.1	24.5
Subsoil	0.0	0.2	0.9	4.4	9.1	63.4	21.9
Lower Subsoil	0.0	0.0	1.2	5.7	8.5	64.0	20.5

Very probably the soil classes of Choctaw County are present in Webster County. The considerable proportion of Webster County which is flood plain, is, no doubt, underlain by the Collins soils, as in Choctaw County; and the upland soils also are almost certainly of the same general nature in the two counties.

Because all soils tend to be reduced by weathering to a mixture of mineral matter consisting chiefly of insoluble silica and alumina minerals, measures designed to retard weathering processes and to restore the soluble mineral plant foods which may have been leached out, become necessary. Because, too, running water carries away loose soil and subsoil and other mantle rock, measures designed to prevent or retard and counteract erosion become necessary. In other words, the soil, the mineral resource which is the basis of life itself, must be guarded constantly, and fostered, if it is to remain with men and continue to provide food, clothing, and shelter for them. Such care has been neglected in many places to such a degree that the soil, if any remain, is so thin and poor that it will yield nothing worth the labor of tilling it. And of all desolate corners of the earth, none is more melancholy than a land ruined by the forces of Nature which, understood, cooperated with, and in a measure controlled and directed, will enrich rather than despoil, preserve rather than destroy.

No doubt many factors operated jointly to bring about Webster County's 18 percent loss of population during the 1940-1950 decade; but very probably one of the leading factors was unfavorable agricultural conditions, among which loss or depletion of soil was by no means of least importance. Yet the scars of soil erosion are fewer and smaller and less prominent in Webster County than in some other parts of Mississippi.

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Nitrate radicle (NO_3)	.40
Total dissolved solids at 180° C	300
Total hardness as $CaCO_3$ (calculated)	156

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Sent by: Layne Central Company
Date received: 9/18/47
Laboratory number: 850
Date analyzed: 9//25/47
Physical characteristics: Turbidity, 5 p.p.m.
Chemical characteristics: (p.p.m.)

Total solids	200.00
Total hardness as $CaCO_3$	23.23
SiO_2	24.40
Alkalinity (P)	0.00
Alkalinity (M)	148.00
Calcium (as Ca)	7.15
Magnesium (as Mg)	1.31
Sulfate	0.98
Total iron	0.30*
Free carbon dioxide	0.00
pH	8.40
Fluorides	0.00
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An old survey of part of eastern Montgomery County and western Webster (see the section of this report on ceramic clay) found six seams of iron carbonate, in two distinct zones, separated by an interval of approximately 40 feet of white and bluish-gray to black clay. The upper zone contained three thin layers of ore 1.0 foot to 1.5 feet apart; the total ore thickness was only a little more than a foot. The lower zone included three layers, each 1.0 foot to 1.5 feet thick, separated by iron-stained clay. The ore of both intervals was concretionary, the lower pillow-shaped, discoidal, or ellipsoidal masses being so close together as to form almost solid seams. Individual masses ranged from 2 feet to 20 feet in width, and consisted chiefly of whitish material carrying 30 percent to 42 percent metallic iron; but their oxidized outer parts, to a depth of 1 to 3 inches beneath the surface, contained a much greater percentage of iron. Records of analyses of the carbonate by the Birmingham Testing Laboratory are quoted below:

Raw ore	Percent
Metallic iron	40.05
Silica	7.78
Alumina	3.37
Carbon dioxide	27.21
Sulphur and phosphorus	Trace

MISSISSIPPI STATE BOARD OF HEALTH
DIVISION OF SANITARY ENGINEERING

REPORT OF PHYSICAL AND CHEMICAL WATER ANALYSIS

City: Eupora
Source: Well, 174 feet deep
Point of sampling: New well at Test hole No. 1, on Highway 9
Sent by: Layne Central Company
Date received: 9/18/47
Laboratory number: 850
Date analyzed: 9//25/47
Physical characteristics: Turbidity, 5 p.p.m.
Chemical characteristics: (p.p.m.)

Total solids	200.00
Total hardness as $CaCO_3$	23.23
SiO_2	24.40
Alkalinity (P)	0.00
Alkalinity (M)	148.00
Calcium (as Ca)	7.15
Magnesium (as Mg)	1.31
Sulfate	0.98
Total iron	0.30*
Free carbon dioxide	0.00
pH	8.40
Fluorides	0.00
Chlorides	12.00
Nitrogen as nitrites	0.00
Nitrogen as Nitrates	0.00
Na and K as Na	65.91

This well was installed and completed in October, 1947, for the City of Eupora.

Springs are many in Webster County, because of the heavy rainfall and the interbedded sands, clays, and silts. Polly Spring (SE. ¼, Sec. 33, T. 20 N., R. 9 E. or NE. ¼, Sec. 4, T. 19 N., R. 9 E.) consists of a main spring and several smaller springs. According to measurements and calculations made by Professor A. B. Hargis of the School of Engineering of the University of Mississippi, on June 25, 1947, below the junction of the flow from all the springs, the combined flow was approximately 200 gallons a minute. On September 9, after some two and a half months of hot and almost rainless weather, the flow appeared to be as strong as when measured in June, and people who lived near by said that it is essentially the same at all times.[60]

A remarkable example of the extent to which water may be mineralized in the Midway beds was provided many years ago by the "Lewis Mineral Well," owned by J. A. Lewis, 1.5 miles northwest of Mantee. The well was said to be only 14 feet deep, and to overflow a strong stream. Records of analyses of water from the Lewis well are quoted below, as reported by Dr. W. F. Hand, State Chemist:[61]

	Parts per million
Silicon Dioxide	411.531
Iron Oxide	78.848
Aluminum Oxide	8.570
Calcium Oxide	601.614
Magnesium Oxide	1091.150
Sulphur Trioxide	1674.098
Chlorine	247.895
Potassium Oxide	29.584
Sodium Oxide	916.819
Carbon Dioxide	3138.831
Total	8198.940
Combined as Salts,	
Potassium Sulphate	54.762
Sodium Sulphate	1603.396
Calcium Sulphate	1267.709
Sodium Chloride	408.738
Calcium Bicarbonate	230.310
Magnesium Bicarbonate	3982.685
Iron Bicarbonate	175.428
Alluminum Oxide	8.570
Silicon Dioxide	411.531
Oxygen	55.807
Total	8198.936

IRON ORE

Outcrops of iron ore are many in Webster County. They are not restricted to any one part of the county, nor to any one formation, nor to any one stratigraphic level. On the contrary, iron ore is exposed in almost every part of the county, in three of the formations which show at the surface, and at several horizons in each formation. Commonly, it is in the form of discrete masses bounded by curved surfaces, but it may appear as discrete masses defined by roughly flat surfaces, or as beds. Thus the individual mass may

be ellipsoidal, or pillow-shaped, or sub-spherical, or roughly oblong or cubical, or any other among the variations of these shapes. However, by far the greater number of the separate masses are roughly ellipsoidal or sub-spherical. The size may range from several feet in length and width to only a few inches: One pillow-shaped bowlder measured approximately 6 by 4 by 2 feet, and others even larger were seen. Continuous beds of ore are not so

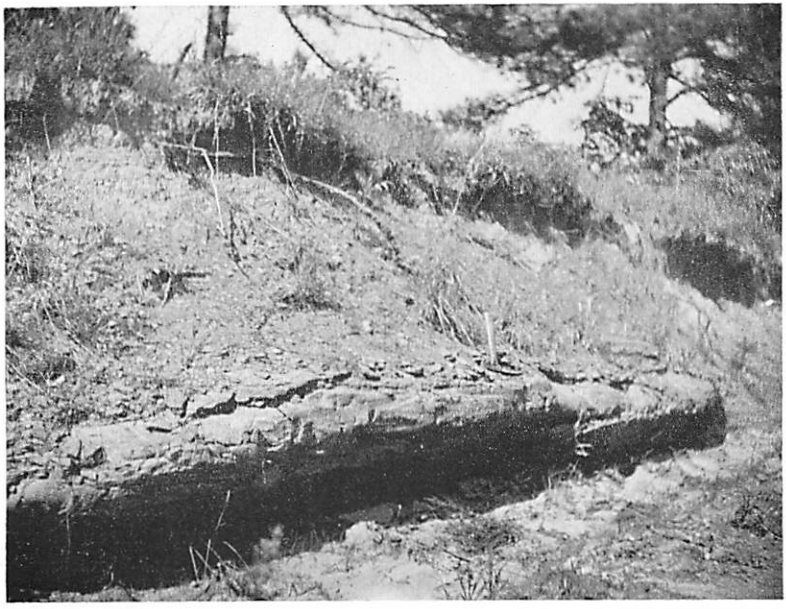

Figure 27.—Bed of iron ore (SW. ¼, Sec. 22, T. 19 N., R. 8 E.) 3 miles north from Stewart.

common, and few are of considerable extent, so far as can be judged from outcrops. The thickest bed noted (Figure 27) is exposed by a shallow road cut about 3 miles north from Stewart.

The ore is carbonate (siderite, $FeCO_3$) and the oxides limonite ($2Fe_2O_3.3H_2O$) and hematite (Fe_2O_3). At and near the surface at least, oxide ore is much more abundant than carbonate. Field evidence indicates that a large part, if not most, of the oxide originated by oxidation of the carbonate.

Rather thorough prospecting, especially along all roads, found ore at the surface here and there throughout the county. It seems to be developed best in lignitic clay, but is associated also with

silty and sandy clay and clayey and sandy silt, and even with silty sand.

The total mineable tonnage is relatively large, not because of enormous concentration of ore in any one small area, although 3,000 long tons or more were taken from an acre in eastern Montgomery County, but chiefly because of the great extent of ore territory, the considerable number of beds, and the favorable mining conditions. The distribution of the ore, especially the locations of outcrops, and features of the outcrops, are described in some detail in Mississippi State Geological Survey Bulletin 73, "Webster County Iron Ores," [62] which contains some tonnage estimates also. The estimates, totaling 16,379,826 long tons of mineable ore are based on only 25 square miles in Webster County, northern Choctaw, and eastern Montgomery. "Mineable ore" is defined as ore under 25 feet or less of overburden.

A very large proportion of the oxide ore of Webster County is high grade, containing as much as 50 percent or more of metallic iron, little or no phosphorus, and low moisture.

An old survey of part of eastern Montgomery County and western Webster (see the section of this report on ceramic clay) found six seams of iron carbonate, in two distinct zones, separated by an interval of approximately 40 feet of white and bluish-gray to black clay. The upper zone contained three thin layers of ore 1.0 foot to 1.5 feet apart; the total ore thickness was only a little more than a foot. The lower zone included three layers, each 1.0 foot to 1.5 feet thick, separated by iron-stained clay. The ore of both intervals was concretionary, the lower pillow-shaped, discoidal, or ellipsoidal masses being so close together as to form almost solid seams. Individual masses ranged from 2 feet to 20 feet in width, and consisted chiefly of whitish material carrying 30 percent to 42 percent metallic iron; but their oxidized outer parts, to a depth of 1 to 3 inches beneath the surface, contained a much greater percentage of iron. Records of analyses of the carbonate by the Birmingham Testing Laboratory are quoted below:

Raw ore	Percent
Metallic iron	40.05
Silica	7.78
Alumina	3.37
Carbon dioxide	27.21
Sulphur and phosphorus	Trace

Calcined ore

Metallic iron	57.55
Silica	10.21
Alumina	4.25

Ore partially roasted in open air on the ground

Metallic iron	44.90
Silica	7.98
Alumina	3.43
Carbon dioxide	20.14

The record of an analysis of completely roasted ore, by Robert W. Hunt & Company, Chicago, follows:

Metallic iron	56.57
Silica	4.96
Alumina	1.56
Lime	2.10
Magnesia	1.11
Sulphur	.06
Phosphorus	.087
Carbonic acid	33.41

It is stated in the report that good outcrops of ore show in Sections 4, 8, and 33; that at places the ore lies close to the surface under several acres; and that the fact that it was struck in all the drill holes and was shown in cuttings and in wells at widely separated places leaves little room for doubt that the deposits are very extensive and the total tonnage many millions.

CERAMIC CLAY

The strata of Webster County contain much clay. The Porters Creek formation is almost entirely clay shale and clay; the Naheola is sandy and silty clay, silt, and sand; most of the Fearn Springs is silty clay; and clay is very abundant in the Ackerman. Considerable bodies of good ceramic clay are included.

Clay from the Porters Creek formation is not suitable for general ceramic purposes. The reasons for its unsuitability are obvious from a consideration of its properties, as determined by laboratory study and tests of samples from Tippah County, where the middle phase of the formation is very similar in general appearance to the Porters Creek of Webster County:

About 40 percent of the weight of the freshly mined clay is water, and the water is retained so tenaciously that samples which

have been air dried at room temperature for months are still 7 percent to 8 percent water at 100° C. Water of plasticity ranged from 64 percent to 86 percent; moduli of rupture were 170 pounds per square inch when the clay was dried at 25° C. and 219 pounds per square inch when it was dried at 110° C. In spite of the high water content, the clay dried without warping or cracking, and with normal shrinkage. In slow burning (20° C. per hour) it was not appreciably changed up to the temperature of Cone 7 (2,210° F.). As the temperature was increased, porosity decreased, average linear shrinkage and bulk specific gravity increased, and the clay melted to a vitreous chocolate-brown glob at Cone 15 (2,570° F.). The fired modulus of rupture ranged from 505 pounds per square inch at Cone 4 (2,129° F.) to 737 pounds per square inch at Cone 12 (2,390° F.).

Mr. T. E. McCutcheon, the ceramic engineer who made the tests referred to in the preceding paragraph, summed up the possibilities of the clay for industrial use in the statement quoted herein:

"The possibilities of the middle phase of the Porters Creek clay are obviously in the field of light-weight materials; however, the limitations of the clay must be realized for successful utilization. . . . "Even though the clay has fair working properties in the raw state and can be made into light weight building units of good insulating quality, such products would have a limited use due to structural weakness and their high porosity would preclude exterior use . . . "It is the opinion of the writer that the Porters Creek clay is not suitable for making brick by either the plastic or dry-press process . . .

"The high porosity of the burned clay is attributed to microscopic pores which are characteristic of efficient high temperature insulation products. The application of brick in this field is limited to use as back up brick on account of structural weakness as heretofore described.

"Possibilities for making burned light-weight aggregate from the clay appears to be its most promising ceramic use for as such, undesirable weakness developed during burning is obviated and desirable light-weight qualities are preserved. Two types of aggregate, hard and soft, can be produced by burning in rotary kilns."

One sample from Winston County[5] was found to have excessive drying shrinkage. Test pieces, biscuited to 1,700° F. in twelve hours under ideal oxidizing conditions, cracked; and on reburning to higher temperatures, bloated. Exceptionally high dry strength, and tendency to bloat or swell at relatively low temperatures are the two outstanding characteristics of the clay. "High dry strength implies good bonding strength, or the ability of the clay to bond together particles of non-plastic materials. This property . . . can be used to advantage in improving the dry strength of clays deficient in strength, permitting the utilization of otherwise good clays for a variety of clay products. The low sintering temperature . . . would be advantageous in producing common clay products such as building brick and hollow tile, but would render the clays unsatisfactory for bond in refractory products such as fire brick, saggers, and crucibles."

Porters Creek clays have an oily or waxy plasticity, cohesive rather than adhesive, which is a desirable property of the bonding substance in molding sand. Their fusion points, although they vary considerably, are in general below the pouring temperatures of molten iron and steel; however, the refractoriness of the molding mixture which uses the Porters Creek clays as bond should be satisfactory, because of the small percentage of clay necessary to give desired strength to the molding sand. At least one industrialist has pointed out that as little as 5 percent of the Porters Creek clay added to clean silica sand increases strength from 75 percent to 175 percent over known mold compositions without the usual decrease in permeability when using ordinary clay. He claimed also an increase in refractoriness of 200° F. to 300° F. when Porters Creek clay from Southern Illinois was used.

"The tendency of the clays to swell or bloat, thereby developing a vesicular structure suggests the possibility of utilization in the manufacture of light-weight aggregate for concrete."

The Webster County Porters Creek clay, judged by a few samples, is not so light of weight as the Tippah County samples used by McCutcheon; probably, then, it would not be so satisfactory for use as light-weight aggregate. It will be noted, also, that other differences in properties exist between the Tippah County Porters Creek and the Winston County Porters Creek. The Win-

ston County clay probably is more nearly like that from Webster County.

Of the clays of the "upper phase" of the Porters Creek formation of Tippah County, which is the equivalent of the Naheola formation of Webster County, McCutcheon says:[66]

"The typical range of properties of the clays in this group are: water of plasticity, 37-39 percent, linear drying shrinkage, 4-5 percent; porosity at cone 1, 36-37 percent, at cone 7, 11-20 percent, linear shrinkage at cone 1, 3-4 percent, at cone 7, 8-9 percent.

"These clays are more characteristic of the middle or typical phase than clays from the lower phase of the formation. Other than the difference in physical states between the upper and middle phases, the silt content of the upper phase is the most distinguishing characteristic. The silt increases the bulk specific gravity from 1.0-1.2 of the middle phase to 1.49-1.51 for the upper phase.

"The clays in the upper phase of the Porters Creek formation possess fair working properties and dry without difficulty. Their burning properties are undesirable because they have a very short maturing range before overburning. They could be used in the manufacture of common brick but since common brick are also used as face brick, brick made from these clays would have a limited market. They are suitable for making fire proofing (hollow tile) and farm drain tile but are not suitable for use in products that must resist frost such as face brick or those requiring structural strength such as load bearing hollow tile. The clay is not suitable for blending with tight bodied clays such as those of the pottery group, for when present in appreciable amounts they cause bloating."

The Winston County sample from the upper silty phase of the Porters Creek (Naheola) did not show such excessive drying shrinkage and warpage as did the sample from the underlying Porters Creek (middle phase).

The Betheden-type clay is not abundant in Webster County. As has been stated in the description of the stratigraphy, a few small deposits may remain, but no accumulation of commercial consequence was noted from outcrops. However, McCutcheon's

summation of the physical characteristics, the properties, and the possible uses of the Betheden-type materials is quoted herein, for reference, because of the possibility that larger deposits may be found some time.

Betheden-type materials, consisting of bauxite and kaolin and bauxitic and kaolinitic clays, were studied and tested rather thoroughly at the clay-testing laboratory of the Mississippi State Geological Survey several years ago. The samples tested were from Tippah, Benton, Union, Pontotoc, and Winston Counties, but the results of the analyses and tests could apply to materials from the same stratigraphic position and of the same general character from Webster County. The samples of kaolinitic clays from Tippah and Benton Counties were of two classes:[17]

1. "Refractory coarse-grained, white to light burning, containing hard non-slaking kaolin nodules and pisolites. Not overburned at cone 18. Less than 5 percent accessory mineral aggregates.

2. "Refractory fine-grained soft, white to light burning completely slaking kaolins. Not overburned at cone 18. Less than 5 percent accessory mineral aggregates."

It was found that the clays of the first group were well suited for making refractory grog when calcined between cones 11 and 15 (2,345°-2,570° F.)—a grog suitable for use in No. 1 first quality fire brick, refractory shapes, and saggers. Of the clays of the second group, McCutcheon states:

. . . "The typical clays are of such purity in their natural state that it is well worth while that they be washed, as such beneficiation would place them in a rank equal to the better grades of domestic and foreign kaolins . . .

"High grade soft fine-grained kaolins are usually washed before being placed on the market. The clays in this group, having quality ratings of one and two, when washed free of the small amounts of impurities would be especially suitable for compounding into bodies of ceramic white ware which includes electrical, chemical, and table porcelain, hotel china and dinner ware, ceramic floor and wall tile, dust pressed wall tile, pottery shapes and art ware. They are well suited for use in compounding glazes and

enamels. For non-ceramic purposes, they are suited for use as a filler in paper, rubber, oil cloth and linoleum, and as a pigment for paint."

The Fearn Springs formation according to Mellen,[69] contains ball-type clays, good stoneware clays, and silty clays. The Fearn Springs clays of Webster County, cropping out in a few places only, have been briefly described under "Stratigraphy" in the present report. Most of them are the silty clays mentioned by Mellen. He states of the Fearn Springs clays of Winston County: "In visible quality they range from extremely fine grained plastic ball type clay through various intergrades to good stoneware clay, and through various other intergrades to almost non-argillaceous silt. It is possible that these clays offer greater industrial promise than other similar clays of the South . . . They are very plastic, easily shaped with the hand, and appear generally to contain relatively little organic, gypsiferous, or pyritiferous matter."[70]

The ceramic engineer who directed and supervised the tests of samples of Fearn Springs clays from Winston County, states: "These clays are of the ball, or bond, type; they are fine grained, plastic, colloidal, and have moderate to excellent strength in both the dried and fired state and have a wide burning range. Their plastic dry and fired properties are comparable when taking into consideration the influence of accessory minerals which vary with the individual clays."[71]

The same authority continues: "Individual clays are suitable for use in many clay products as the sole constituent and in a still wider variety of products as a principal to minor constituent." He lists a considerable number of objects which could be manufactured from clays of the Fearn Springs type: Fire brick and refractory shapes, in which the clay could be used as a bond; face brick; enameled and salt glaze brick; electric conduit, silo tile, facing and partition tile; stoneware; earthenware; art pottery; ferro-enamels; and ceramic glazes.[72]

The Ackerman formation contains much clay shale and clay interbedded with sand and silt. Outcrops are numerous, indicating inexhaustible quantities of clay without overburden or under very thin and easily removable overburden. Samples of Ackerman clays from Tippah, Union, Pontotoc, Choctaw, Winston, and

Lauderdale Counties have been tested in the laboratory, and the results of the tests have been published. Inasmuch as the Ackerman clays of Choctaw County, which bounds Webster County on the south, are very similar to clays from the same formation in Webster County, some test records of Choctaw County samples will be repeated herein.[7a]

The ceramic engineer found that three general types of clay were represented by the Choctaw County samples tested: The clear burning buff and salmon group, which he classified as pottery, brick, and tile clays; the red burning group, classified as brick and tile clays; and a group which had undesirable ceramic properties—clays which he classified as miscellaneous. The first class named—pottery, brick, and tile clays—was found to have excellent plastic properties; linear drying shrinkage ranging from medium to high, but not excessive; and dry strength or modulus of rupture ranging from medium to high. On burning, the clays became steel hard at low temperatures; firing shrinkage was low and fairly constant over a wide temperature range; clays were not overburned at Cone 11 (2,345° - 2,417° F.). Absorption and porosity values decreased very slowly above Cone 3 (2,093° - 2,138° F.). Modulus of rupture values of 3,000 to 4,000 pounds per square inch were common, and some samples at certain temperatures were in the range of 6 000 to 7,000 pounds per square inch. A number of the samples were definitely bond clays. Mr. McCutcheon stated, in regard to possibilities for untilization:

"Those clays . . . free from gypsum and those in which the calcium salts may be rendered insoluble by addition of barium salts are suited for making various kinds of pottery such as art pottery, yellow ware, and kitchen ware. They are suitable for use in stone ware, and as the major ingredient in chemical stone ware. The clays highest in alumina and free from gypsum are suited for use as a medium-duty refractory bond clay for use in retorts, crucibles, and saggers.

"Clays high in silica and free of gypsum are suited for the manufacture of wall tile and natural, salt glazed, and enameled facing tile and brick. Flower pots and garden pottery are possibilities."

Of the clays classified as red burning brick and tile clays, those "which have a high drying shrinkage and a normal to low burning shrinkage may be successfully untilized in making various kinds of brick and tile . . . Samples having normal drying and burning shrinkages . . . are well suited for the manufacture of face brick and common brick, hollow tile, partition tile, drain tile, and possibly sewer pipe. They burn steel hard at low temperatures and do not overburn below Cone 11. The firing shrinkage is low and changes only slightly over a firing range of several cones. The fired colors are somewhat dull and some of the samples are stained with calcium salts." The clays of this group which have a higher average drying shrinkage may be utilized by controlling the water content and the grinding. In general, they are suitable for the products named above. The clays which have a high average drying shrinkage "could better be used after a pre-heating treatment to reduce drying shrinkage or by adding non-plastic material such as sand or grog. The firing shrinkage is generally low, and the firing range is more than adequate for most heavy clay products."

Linear drying shrinkage may be reduced by coarse grinding and by limiting the water used to develop plasticity, to the minimum.

The clays classified as miscellaneous had high drying shrinkage and high modulus of rupture values in the unburned state; they were steel hard at Cone 02 (2,003° - 2,057° F.) and had a short firing range; modulus of rupture values for the burned clay were high for the samples that could be tested, but most of the test pieces either cracked or bloated and could not be tested. The possibilities for utilization of the miscellaneous clays are few. Such clays could serve as a bonding material in less plastic clays and as a flux in refractory clays. Some of them, which bloat at low temperatures, forming a light-weight vesicular mass, could be crushed for use as a vitrified light-weight aggregate in concrete, after burning under conditions most favorable to the development of the vesicular structure.

The samples tested were from different parts of the county and from different stratigraphic levels: the classification was

based on the properties and possible economic uses of the clays rather than on their stratigraphic positions.

Of course, suitability of the clay for industrial use, and the quantity available, must be the controlling factors in determining the location of the pits; but where these factors vary little if at all over a large area, the most favorable deposits for working are those which are situated on or near main highways or railroads and not too distant from centers of population. A few such Webster County locations may be mentioned:

1) In the southwestern corner of the county, 1.5 to 2.0 miles north of U. S. Highway 82 and the Columbus and Greenville Railway (Ackerman clays);

2) North and northeast of Stewart, along the Grady road (Ackerman clays);

3) Along the Grady road north of Tomnolen (Ackerman clays);

4) The west valley wall half a mile or more west of Bellefontaine; also the Bellefontaine-Montevista road half a mile or so north of Bellefontaine (Ackerman clays). Both these locations are within half a mile from Highway 9.

5) The Sapa road, a few rods south of Highway 82 (Fearn Springs clays, possibly).

Many other locations, less favorable than those named above, are mentioned in the description of the stratigraphy.

Almost half a century ago the J. P. Thomas hand pottery at Cumberland manufactured a general line of stoneware.[74] The clay used was a mixture of a gray clay from the B. F. Sanders farm some 3 miles north of Mathiston, with a lighter-colored clay from near Clarkson. The output was 2,000 gallons, more or less, per year, of jugs jars, and churns. The ware had a good strong body, but showed small spots of iron which probably appeared because the clay was not ground before mixing. The brown slip glaze was used.

The record of the chemical and rational analyses of the gray clay is quoted below:

ANALYSIS OF GRAY CLAY FROM THE B. F. SANDERS FARM SOME 3 MILES NORTH OF MATHISTON

	Percent
Moisture (H_2O)	1.47
Volatile matter (CO_2 etc.)	9.24
Silica (SiO_2)	59.82
Iron oxide (Fe_2O_3)	1.26
Aluminum Oxide (Al_2O_3)	27.19
Calcium oxide (CaO)	0.49
Magnesium oxide (MgO)	0.37
Sulphur trioxide (SO_3)	0.31
Total	100.15

RATIONAL ANALYSIS

Clay substance	68.80
Free silica	18.21
Impurities	2.43

Some of the physical properties of this clay in the unburned state were: Specific gravity, 2.51; tensile strength, 68 pounds average, 81 pounds maximum; water of plasticity, 25 percent; air shrinkage, 6 percent; in water the raw clay slaked very slowly to fine grain. In burning, at Cone 20 the clay vitrified and turned dark gray. It had no absorption.

The Maben Brick Manufacturing Company, which began operations in 1905, used two kinds of clay, one of which was the same as that used by the Thomas pottery, and the other a gray clay from a 6-foot bed overlain by 2 feet of gray to yellow sandy loam. Brick made from the Sanders clay burned white; those from the surface clay varied from red to chocolate.[75]

White clay from an outcrop in the public road 3.5 miles north of Mathiston had the following named properties: Plasticity of sub-surface clay poor, but plasticity increased with fineness of grain; specific gravity, 2.31; average tensile strength of air-dried brickettes, 25 pounds per square inch; water of plasticity, 35 percent; air drying shrinkage, 4 percent; in water the clay slaked slowly to fine grain. In burning, at the temperature (2,174° F., slow burning) necessary to fuse Cone 6, the clay showed no further shrinkage but vitrified and had a firm white body, without spots, crazing, or checks.[76]

Logan mentions pottery clays in the western part of the county, in the vicinity of Dabney and Lerma.[77] Also, a rather en-

thusiastic report, dated October 11, 1904, by a Colonel A. J. Montgomery, "Mining Expert and Engineer," of Birmingham, Alabama, deals at some length with the mineral resources, chiefly clays, of the same region.[78] The report relates specifically to Sections 12 and 13, Township 20 North, Range 7 East, Montgomery County; and Sections 2, 3, 4, 7 8, 9, 10, 11, 16, 17, and 18, Township 20 North, Range 8 East, and Section 33, Township 21 North, Range 8 East, Webster County. In the course of the survey on which the report was based, four holes, totaling a depth of 625 feet, were drilled, and cores taken. According to the report, clay strata were passed through to a depth of 440 feet. In addition to well cores, many cuttings or cores were taken with a hand punch to depths of 6 to 13 feet from the walls of fourteen openings ranging in length from 30 to 100 feet, made on the outcrop.

The general stratigraphic sequence, as determined by the Montgomery survey, is indicated by the composite section which follows:

COMPOSITE SECTION OF STRATA, WESTERN WEBSTER COUNTY

Sand, covering approximately one-fifth of the area (the so-called Orange Sand) in the upper parts of the elevations
Quartzite, 3 feet to 4 feet thick
Sand, yellow, 13 inches to 2 feet thick
Clay, silty, or silt, clayey ("stone"), upper 2 feet or more yellow, merging into pure white downwards; total thickness, 8 feet
Clay ("silicate of alumina"), granular
Clays, blue-gray to black and white, 12 feet to 50 feet
Clay, white, with three seams of iron carbonate 1 foot to 1.5 feet apart; total thickness of iron carbonate, 1 foot or a little more
Clay, dark; decomposed lignite
Iron carbonate, three seams, each 1.0 to 1.5 foot thick, separated by iron-stained clay
Clay, fine white plastic, 9 to 12 feet thick
Sand, fine white (reached in Hole 3 at a depth of 74 feet); 57 feet thick
Clay strata and two seams of lignite
Sand, several beds
Shale, 7 feet
Lignite and clay, alternate seams
Lignite, 5-foot seam, carrying pyrite; reached at 314 feet
Lignite and clay, 19 feet
Lignite and sand, alternate seams, 10 feet
Sandstone, hard gray.

The author of the report discusses in some detail the possibilities for utilization of the various rock materials listed above. The uppermost sand (Interval 1) he says can be mixed with the white clays of the underlying formation to make common and re-pressed brick. The quartzite, also, if crushed and mixed with the dark clay which underlies it, may serve as a chief component of a mixture from which exceedingly refractory fire brick may be made. The quartzite itself is very refractory: Samples heated to 2,600 degrees Fahrenheit showed no apparent change, but the rock could be crushed more easily after burning. The clay of Interval 5 is said to be very plastic, easily moulded, to burn to a cream color, and to be suitable for making refractory brick. The writer of the report suggests that some of the uppermost sand can be mixed with any of this clay which is too "fat," and that any color from cream to red can be obtained by the use of the iron carbonate near by. Also, he asserts that by drying and blowing, almost any grade of polishing powder can be obtained.

The clays of Interval 6 he classifies as very refractory, and very plastic. He mentions a 4-foot to 6-foot bed of pure white clay which, he states, burns from a light cream to pink, and is suitable for pottery and terra cotta ware. Further, he refers to a yellow ochre, in workable quantities, in Section 8, asserting that it is extremely plastic and "burns to a beautiful shade of red, without mixture of coloring matter." It is pointed out also that the blue clay is very plastic and refractory, and that tests show it to be suitable raw material for the manufacture of coke-oven brick or furnace brick, with the usual mixture of calcined clay or rock. In short, its chief value is as a base for building brick or fire brick. Under 2,600 degrees Fahrenheit this blue clay burns a light cream, of pleasing appearance. The report states further that inasmuch as tests by the Birmingham Testing Laboratory show that best brick are obtained by liberal use of calcined clay or calcined flint rock, for both refractoriness and shrinkage, it would seem that from a mixture of the blue clay with from 40 percent to 60 percent sand from the beds above, a good vitrified or paving brick can be made. Analysis of the blue clay, for impurities alone, was made by the Birmingham Testing Laboratory: Calcium sulphate, 0.73; calcium oxide, 0.30; sulphur trioxide, 0.43; remainder, silica, alumina, and water.

The white clay below the blue might be used as an adulterant for soap. Tests made by J. H. Walden, of the Birmingham Paint and Glass Company, prove that the white and blue clay makes a good base for paints. By mixing with the iron carbonate, any color of red can be obtained.

The white clay (Interval 7), in which is the uppermost iron carbonate, is suitable for a component of a mixture with calcined clay to be used for the manufacture of common building brick. It should be weathered and ground before being mixed with the calcined clay, and can be colored with calcined iron carbonate to any shade desired. The analysis of the white clay, quoted below, was made by Regis Channennet and Brother, St. Louis:

	Percent
Water	6.00
Silica	72.00
Alumina	16.28
Iron oxide	1.60
Calcium oxide	0.00
Magnesia	0.059
Alkalies	3.44
Total	99.379

The analysis stated that the impurities were too low to affect the fusibility of the clay for uses such as for fire brick, especially in the presence of so much silica; that the clay would prove very infusible, of good color, and sufficiently high in alumina to form a bond and to pug well; and that it could be used for fire brick or building brick and other ware.

SAND, SANDSTONE, QUARTZITE

It has been pointed out that in the Ackerman and Meridian formations are many beds of coarse to fine sand. In fact, immense quantities of sand are at or near the surface in Webster County. It has been mentioned also, in the discussion of stratigraphy, that pits have been dug in the sand beds in almost all parts of the county, in obtaining sand for use on the roads, and possibly for local building. Sand suitable for all the common uses such as for building and paving, is available in unlimited quantities. It was used in the blacktop for Highways 15 and 9; also on many graveled and earth and sand roads. Lowe[7v] states, with reference to the sand of the old Holly Springs formation, which is now considered

Meridian, at least in large part: "The sand of this formation furnishes excellent building material along most of the outcrop, the coarse sand especially being admirably adapted to the making of mortar and concrete. In some localities the sand is useful in road making. In many places where it contains a proper admixture of clay and iron it makes an excellent molding sand." The same could be said of some of the Ackerman sands. In fact, in several industries which use sand, specifications are, commonly, not very rigid, but are adjusted to fit supplies of sand available in the locality concerned. This is particularly true of structural sand. Possibly, too, certain sands could by proper processing be made to serve purposes which require material having special properties, but in few cases would such a processing be economically feasible. No Webster County sand suitable for the making of fine glass was found; all contains too large a percentage of impurities, such as iron, mica, clay, and carbonaceous material. Possibly some could be used for making low-grade green or amber glass.

In short, no considerable industrial development based on the use of sand can be reasonably hoped for. At best, a small-scale, more or less local, utilization as structural sand can be anticipated.

Sandstone is scattered pretty generally over the county, but in only a few places is aggregated in relatively large deposits. Most of the higher hills and ridges are capped by masses of ferruginous sandstone of various shapes and sizes. This rock was formed by cementation of sand by iron and silica precipitated from solution in water which seeped through the sand. As would be expected from such a mode of origin, the rock is very irregular, although the most common shape of the individual mass is roughly tabular. Masses range in size from very small to several feet in length and width and many tons weight. The largest accumulations observed by the present survey were: 1) At the top of the "mountain" (Northern part, Sec. 17, T. 21 N., R. 10 E.) 2.5 miles southwest from Montevista; 2) in a ridge (NW.¼, Sec. 24, T. 20 N., R. 9 E.) some 2 miles southwest of Walthall; 3) in the upper part of the east wall of the valley of Sand Creek. north and south from the road junction (SE. ¼, Sec. 33, T. 20 N., R. 9 E.) 4.5 miles west of Eupora. Other places are referred to in the description of the stratigraphy.

Although, as stated, this sandstone is commonly in the form of large and small masses of more or less irregular shape, and although it is variable in its degree of cementation, yet it can be used as building material, at least on a small scale. It is used locally to some extent for the construction of chimneys, well-curbs and linings, retaining walls, bridge supports, and walks, and as foundation stones for frame houses. A few houses have been built of it, and many more should be, especially in view of the growing scarcity and increasing cost of lumber, and the poor quality of much of the lumber sold. Besides, a stone house has many obvious advantages over a frame house: It can not burn; it is everlasting, if its durability is reckoned in terms of the span of human life; it is almost tornado proof, if sturdily built; insects and rodents can make no impression on it; it requires no painting or other treatment to protect it from the weather; it shuts out both heat and cold more efficiently than wood does, and requires few or no repairs. Moreover, its initial cost need not be much greater than the cost of a first-class frame house. The sandstone of Webster County is not particularly beautiful, but its brown and yellow harmonize very well with a rural landscape. It should be more widely used for general building.

Some stretches of country road have been metaled with crushed sandstone, which is excellent road metal. Good examples are, part of the road which extends northeast from Clarkson, and the road which leads over the "mountain" southwest of Montevista.

The Midway-Wilcox contact zone, including the Betheden materials, in original place or re-worked, commonly is featured by white or at least light colored silty and clayey pisolitic sand, or white to pinkish non-pisolitic sand, and in places white kaolinitic clay, siliceous and ferruginous bauxite, bauxitic sandstone and siltstone, ferruginous sandstone, and iron ore. The iron ore is nodular and concretionary, and the other hard rock may be very irregular, ragged, and pitted as if it had been subjected to long and intensive weathering, or as if it were itself the product of weathering processes such as differential cementation and solution. Because this mixture of sand, sandstone, quartzite, iron ore, clay, and bauxite rock has been found to be very good road metal, many pits have been opened in it and in the overlying sand,

the largest of which are indicated on the map (Plate 1). It will be seen that their distribution pattern, almost south-north across the county, coincides roughly with the strike of the Midway-Wilcox contact trace. The four or five of these pits north of Mathiston and Maben and southwest of Cumberland expose little or no hard rock; but a few of the pits farther north have uncovered it. The pits which expose more hard rock than any other in the eastern part of the county are on both sides of the Dancy-Clarkson road, in the southeast corner of Section 27, Township 21 North, Range 11 East, some 0.35 mile northeast from a road junction. Here mantle rock and other rock debris have been removed from perhaps an acre. A rough bed of very siliceous and ferruginous bauxitic rock a foot to two feet thick, is uppermost, and several large masses of ferruginous quartzitic sandstone are lying about, among abundant smaller fragments. This kind of material has been used on many stretches of country road.

Quartzite is present in a few localities of western Webster County. Lowe[80] mentions an accumulation occupying a ridge 3 miles long and 0.5 mile wide between two creeks 8 to 10 miles southwest of Walthall. The writer of this report did not find any such deposit at the place referred to, but quartzite is mingled with ferruginous sandstone near a road junction (SE. ¼, Sec. 33, T. 20 N., R. 9 E.) 4.5 miles west of Eupora, and can be traced some distance north and south from the road, along the divide between the valleys of Salt Creek and Sand Creek. Probably this is the place Lowe had in mind.

Another deposit of quartzite (SE. ¼ Sec. 8, SW. ¼, Sec. 9, NW. ¼, Sec. 16, and NE. ¼, Sec. 17, T. 20 N., R. 8 E.) consists of blocks of various sizes and shapes scattered over a considerable area. A larger accumulation is in the vicinity of New Liberty Church (Eastern part, Sec. 13, T. 20 N., R. 7 E.) in eastern Montgomery County, a little west of the Webster County line. Here hundreds of blocks of quartzite, some of them several feet in length and width and 3 to 4 feet in thickness, are scattered over the slopes, their positions seeming to indicate that they have broken from a once solid bed, of which small patches remain essentially in place a little below the crest of the ridge. The quartzite at the last two locations mentioned seems to have been formed by cementation of silts in the top of the Ackerman formation,

probably by silica carried in solution by water seeping through the overlying Meridian sand.

The tonnage of quartzite at the New Liberty Church location has been estimated as 200,000, and that in the vicinity of the common corner, Sections 8, 9, 16. and 17, Township 20 North, Range 8 East, Webster County, as 100,000.[81] The rock could be used for building stone, although it would be difficult to shape because of its extreme hardness. It would be excellent railroad ballast if crushed to the proper size, being hard, free from dust and smalls, tough to brittle, and insoluble; also the angular fragments pack and bind together well. As has been mentioned in the discussion of clays, a very refractory fire brick can be made from a mixture of the quartzite with the underlying clay. At present it is used on a small scale locally for the same purpose as the ferruginous sandstone, except that it is not used for road metal. It could be used for riprap on dams or along streams to prevent erosion.

MISCELLANEOUS MINERAL SUBSTANCES

Although the bauxite zone of Mississippi, which is included in the Midway-Wilcox contact zone, extends across Webster County, no bauxite of importance has been found. The most considerable outcrop of bauxitic rock in the county so far as the writer has discovered is some 2 miles northeast of Clarkson and 3 miles northwest of Cumberland, in a shallow pit (SE. cor., Sec. 27. T. 21 N., R. 11 E.) on both sides of the Clarkson-Dancy road approximately 0.35 mile northeast from a road junction. A rough bed of siliceous and ferruginous bauxitic rock a foot to two feet thick is uppermost. It is associated with much ferruginous and quartzitic sandstone. Pieces of the bauxitic rock were found at a considerable distance north and southwest of the pit. Most of the floor of the pit is dull white to brown and yellow pisolitic sand. Several other pits have been made along the strike of the Midway-Wilcox contact by the removal of bauxitic rock and associated sandstone and iron ore for road metal.

As mentioned in the sections of this report which relate to stratigraphy, re-worked pisolitic sand and clay are exposed in many places, especially in the vicinity of Maben, Mathiston, and Cumberland. Morse[82] refers to only two localities:

"Some bauxitic clay has been found at two places in the county: 1) in the vicinity of Cumberland and 2) in the vicinity of Mathiston. The deposits three miles northwest of Cumberland are small and of little importance. Those one mile east of Mathiston and those three miles north of the same town are pisolitic clays which are only slightly bauxitic."

The analysis record of a surface sample of pisolitic clay from a cut on the old Maben road a mile from Mathiston is quoted below:

Aluminum oxide (Al_2O_3)	32.20
Ferric oxide (Fe_2O_3)	0.00
Silicon dioxide (SiO_2)	34.76
Titanium dioxide (TiO_2)	1.80
Loss on ignition	10.03
Non-volatile with HF	21.18
Moisture	0.20
	100.17

Lignite crops out in a few places, but the maximum thickness found was 1.5 feet, in the section west of Bellefontaine (see Stratigraphy). Brown[83] states that a sample from the bed west of Bellefontaine contained very little sulphur, and gave a good welding heat when burned. He mentions other places in the vicinity of Bellefontaine, and in the western part of the county, where lignite was reported to be present. It is used locally, on a small scale. In general, the lignite beds near the surface are thin and poor, but much thicker beds have been encountered in wells according to reports. If such bodies of lignite exist, they must be of relatively small extent, because they do not crop out up dip.

Other mineral substances disseminated through the strata in very small quantities are of no value, and are mentioned here only because people believe them to be valuable, and make inquiries concerning them. Perhaps the commonest of these are marcasite and selenite, which are present in the clays and sands and silts in many places, especially in the lignitic clays and lignites. Marcasite (FeS_2) is a compound of iron and sulphur which when fresh has a whitish metallic luster, but rusts and decomposes to a white powder in a relatively short time when exposed to the air. Pyrite has the same composition, but is golden yellow. Mar-

casite and pyrite may appear as concretions or veins or coatings, or replacements, or small grains. They have been referred to as "fool's silver" and "fool's gold" because of their superficial resemblance to silver and gold. Selenite ($CaSO_4.2H_2O$) is a compound of calcium, sulphur, oxygen, and water; a form of glassy crystallized gypsum.

OIL AND GAS PROSPECTING

In the discussion of structure certain stratigraphic relationships were described which suggest that a structure or structures favorable for the trapping of oil or gas or both, exists in the subsurface rocks of Webster County. Discovery of these structural irregularities led to the drilling of three wells in search of oil or gas. The first of these, Cumberland Oil and Gas Company's Henley No. 1[54] (SE. ¼, NW. ¼, Sec. 15 T. 21 N., R. 11 E.) was drilled in 1927. It aroused considerable interest because of persistent reports of oil and gas showings, but its total depth 1,865 feet, failed to reach Paleozoic rock.

Webster County Oil Development Tr. Company's State of Mississippi No. 1[55] (330 feet south and east of the NW. corner, SW. ¼, SE. ¼, Sec. 15, T. 21 N., R. 8 E.) was begun on November 10, 1944, and completed February 2, 1945, at a depth of 3,545 feet. The sample tops were given: Sandy Midway (Naheola?) 740 feet; Midway Shale, 1,140 feet; Clayton, 1,170 feet. The elevation was 427 feet D. F. No oil or gas shows were reported.

P. M. Barton and Joe E. Skelton's No. 1 Joe E. Skelton[56] (200 feet south and 660 feet west of NE. cor., NE. ¼, NE. ¼, Sec. 6, T. 21 N. R. 11 E.) was begun March 5, 1945, and completed April 19, 1945, at a depth of 2,910 feet, in Paleozoic rock. The elevation was 352 feet, D. F. The tops were published: Ripley, 460 feet; Selma, 568 feet; Eutaw, 1,290 feet; Tuscaloosa, 1, 595 feet, Comanchean, 2,020 feet. No oil or gas shows were reported.

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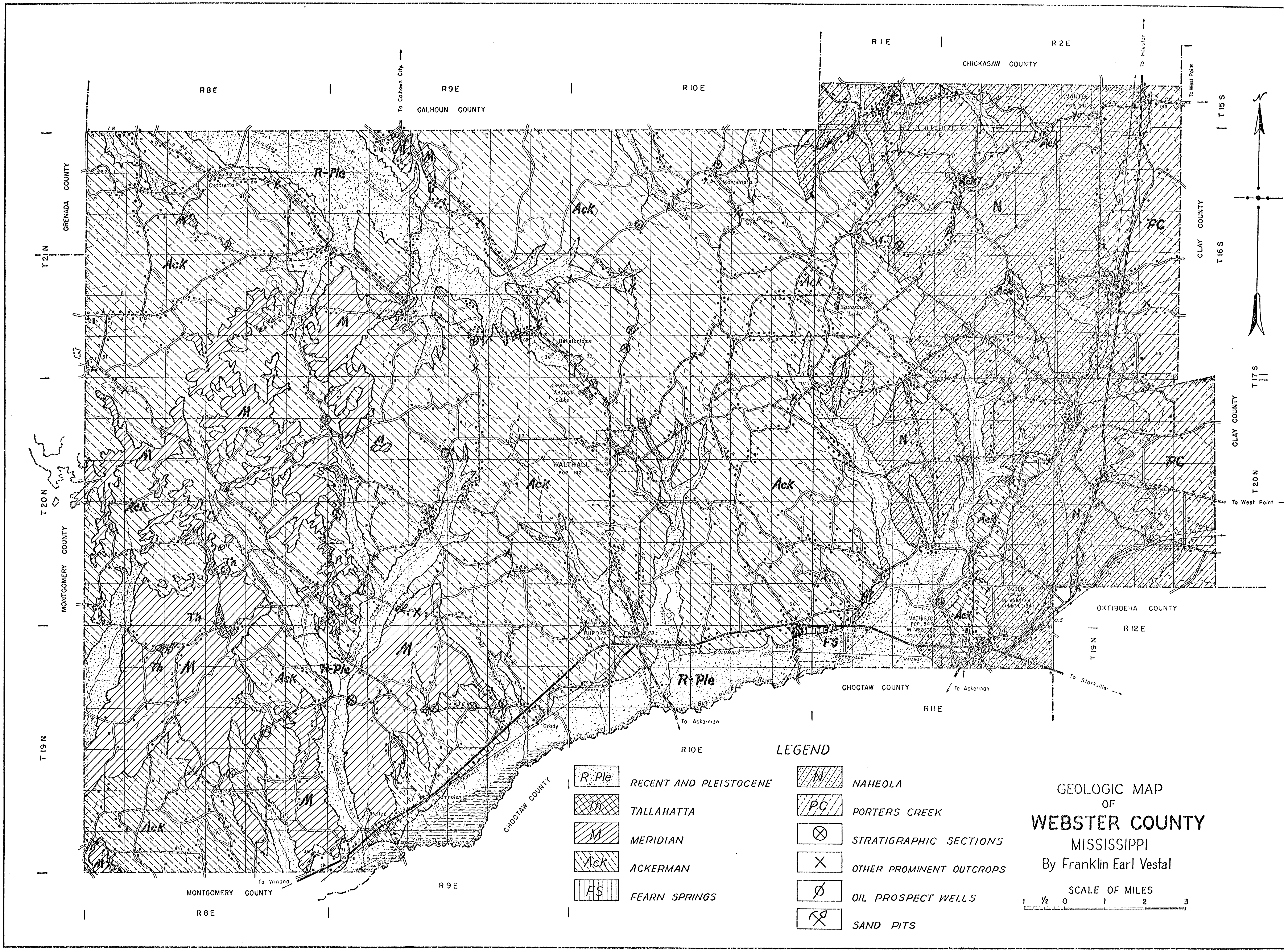
INDEX


GEOLOGIC MAP
OF
WEBSTER COUNTY
MISSISSIPPI
By Franklin Earl Vestal
SCALE OF MILES
1 ½ 0 1 2 3
LEGEND
R-Ple RECENT AND PLEISTOCENE
Th TALLAHATTA
M MERIDIAN
AcK ACKERMAN
FS FEARN SPRINGS
N NAHEOLA
PC PORTERS CREEK
STRATIGRAPHIC SECTIONS
OTHER PROMINENT OUTCROPS
OIL PROSPECT WELLS
SAND PITS
R8E
R9E
R10E
R1E
R2E
R11E
R12E
T21N
T20N
T19N
T15S
T16S
T17S
CALHOUN COUNTY
CHICKASAW COUNTY
GRENADA COUNTY
MONTGOMERY COUNTY
CLAY COUNTY
OKTIBBEHA COUNTY
CHOCTAW COUNTY
To Calhoun City
To Houston
To West Point
To Winona
To Ackerman
To Starkville
Cadaretta
Embry
Bellefontaine
Montevista
American Legion Lake
Savannah Lake
WALTHALL POP. 142
EUPORA POP. 1,377
MATHISTON POP. 549 IN WEBSTER COUNTY 484
MABEN POP. 675 IN WEBSTER COUNTY 134
MANTEE POP. 241
Hohenlinden
Dancy
Cumberland
Grady
Tomnolen
Peller
Lindsay
Sabougla
Calabrella Creek
Big Black River
COLUMBUS AND GREENVILLE RAILWAY
TVA TRANS. LINE