MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph. D.
Director

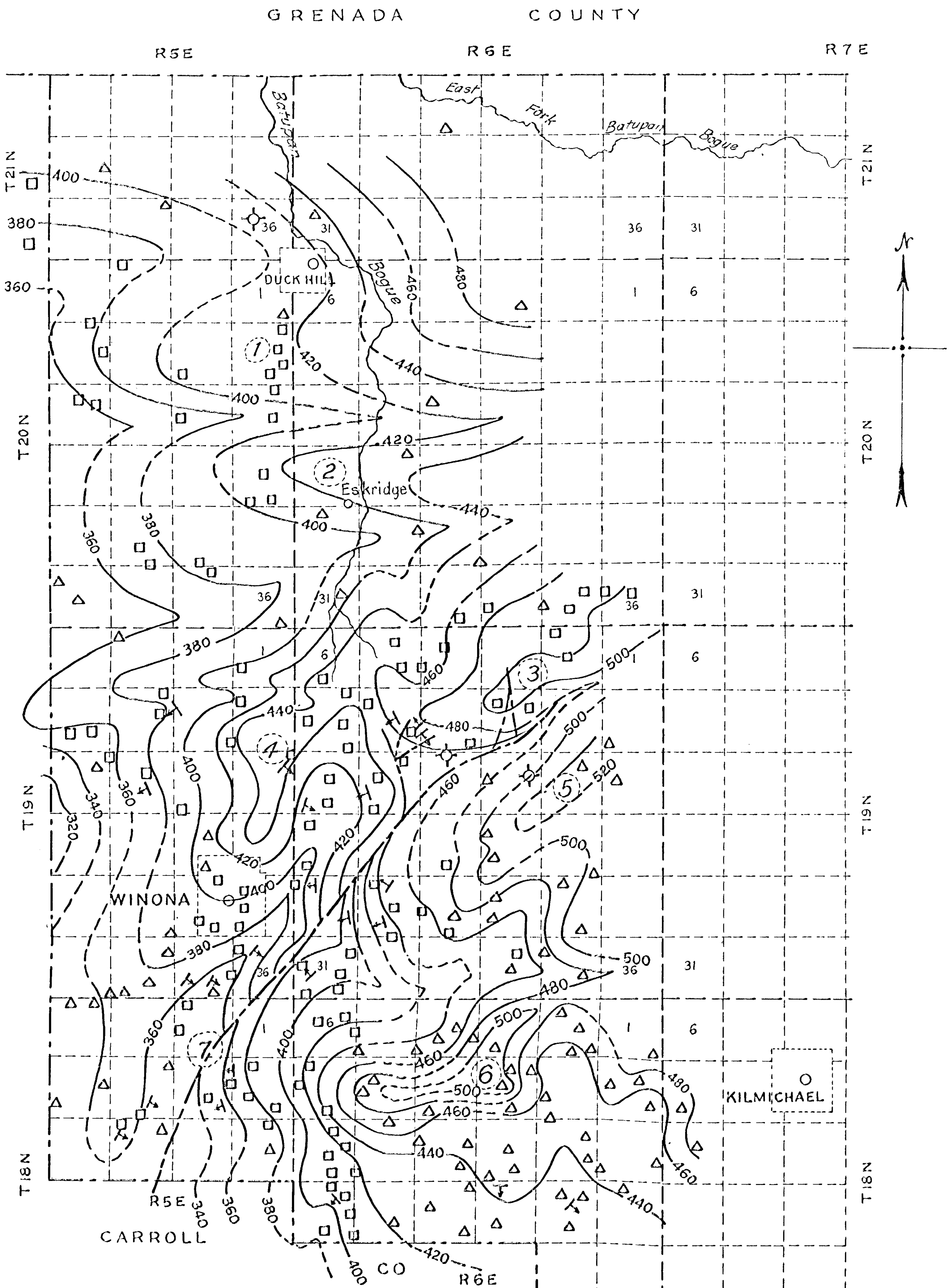
BULLETIN 51

MONTGOMERY COUNTY MINERAL RESOURCES

GEOLOGY
By
RICHARD RANDALL PRIDDY, Ph. D.

TESTS
By
THOMAS EDWIN McCUTCHEON, B. S., Cer. Engr.

UNIVERSITY, MISSISSIPPI
1943



STRUCTURAL MAP
OF
WESTERN
MONTGOMERY COUNTY
MISSISSIPPI

SCALE OF MILES
0 1 2 3 4
Contour Interval = 20 feet

LEGEND
Dip
Dry oil test
Structure
Winona-Zilpha contact
Calculated contact
Fault

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Prepared in cooperation with the Montgomery County citizens and
the WPA as a report on O. P. 65-1-62-137

UNIVERSITY, MISSISSIPPI

1943

MISSISSIPPI GEOLOGICAL SURVEY

COMMISSION

STAFF

SUPERVISORS—WPA

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* On military leave.

LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey
University, Mississippi
January 27, 1943

To His Excellency,
Governor Paul Burney Johnson, Chairman, and
Members of the Geological Commission

Gentlemen:

Herewith is Bulletin 51, Montgomery County Mineral Resources, Geology by Richard Randall Priddy, Ph.D., Tests by Thomas Edwin McCutcheon, B.S., Cer. Engr., published as a fulfillment in part of the Sponsor's pledge to secure Federal-WPA funds. As in the geological survey of all other counties, the investigation of Mineral Resources of Montgomery County would not have been possible in such detail without Federal, County, Municipal, and private aid. To the good citizens of Winona, of the county as a whole, and especially to Mr. M. K. Horne, Secretary of the Winona Chamber of Commerce, the State Geological Survey is, consequently, under special obligation.

Inasmuch as no adequate survey can be made of any area without first determining the nature and sequence of the formations, the stratigraphy, in which training in historical and paleontological geology are absolute prerequisites, and then determining the distribution of the formations, the mapping, the Director has instructed the geologist of each county survey to proceed in this order—a procedure that has resulted in splendid stratigraphic and areal surveys and reports of the state in but a trifle longer time than that required for incomplete, unsatisfactory, reconnaissance surveys, in short a complete survey in approximately the same time as an incomplete one.

In following out these instructions, perhaps Dr. Priddy has had the most difficult county thus far assigned, for the reason that the Kilmichael area in the eastern part of the county has no doubt undergone more folding and faulting of its beds than any other county or area in the State—deformation greater than any geologist up to a few years ago would have considered probable. Whereas the present survey has not shown all the minor faults and folds as revealed in the details of plane table surveys supplemented by data from core drilling and seismograph work of various oil companies, nevertheless, it does show the major features of this uplifted structure. Furthermore the detailed structural work in the western half of the county seems to explain why the wells drilled thus far on the Kilmichael structure have failed to produce oil.

The geologic work of the county is of still further importance, for, like that on "The Claiborne," Bulletin 48, by Dr. Paul E. Thomas, it has materially aided in determining and defining the limits of the Winona, in the original description of which other stratigraphic units were included. Thus not only county by county are surveys being completed, but stratigraphic problems are being solved. Accordingly, all future surveys, and especially those for favorable oil and gas structures, should proceed on a safer sounder basis.

As in the mineral investigations of all other counties, many samples, mostly of clays, were tested in the laboratories of the Mississippi State Geological Survey. The wealth of information condensed in a few tables under "Tests" by Ceramist McCutcheon reveals clays suitable for the manufacture of buff face brick, flue lining, chimney block, and various types of hollow tile and building block—as well as for facing tile, faience, garden pottery, terra cotta, art pottery, and flower pots, not to mention salt glaze silo tile, drain tile, common brick, and insulating products.

Very sincerely and respectfully,

William Clifford Morse,

State Geologist and Director

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MONTGOMERY COUNTY MINERAL RESOURCES

GEOLOGY

RICHARD RANDALL PRIDDY, Ph.D.

INTRODUCTION

Montgomery County lies in north-central Mississippi (Figure 1). It is bounded on the north by Grenada County, on the east by Webster and Choctaw Counties, on the south by Attala and Carroll Counties, and on the west by Carroll County. The county has an area

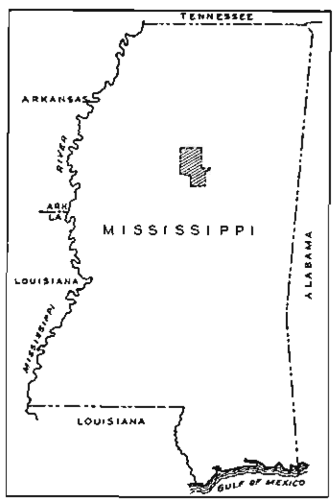

Figure 1.—Location of Montgomery County in the State and in the North Central Hills.

of 398 square miles and had a population in 1940 of 15,703. The incorporated towns are Winona, the county seat, Kilmichael, and Duck Hill with populations of 2,532, 556, and 537 respectively. Small villages are Alva, Stewart, Lodi, Sweatman, Poplar Creek, and Sibleyton. Crossroad settlements referred to in this discussion are Foltz, Sawyer, Eskridge, Fox, Hendrix, Minerva, and Cedar Hill.

PHYSIOGRAPHY

Montgomery County lies wholly within the North-Central Hills[1] (Figure 1). Approximately two-thirds of the county is hilly, the hill tops and ridge tops being 100 to 200 feet above the general level of the broad alluvial lowlands which are drained by comparatively small meandering streams. The hills are most rugged in the west part of the county where they are upheld by ferruginous sandstones in the Winona and Kosciusko sand members, or by colluvial sandstones derived from both the Winona and the lower Kosciusko. In the central and east parts of the county most of the hills are broader, but lower.

The highest elevations, 500 to 555 feet, are attained near the Carroll County line, in an area of sharp divides underlain by Kosciusko sand (Secs. 21, 22, and 28, T.20 N., R.5 E.), 3 to 4 miles west of Eskridge. In the south part of the county, broader but lower

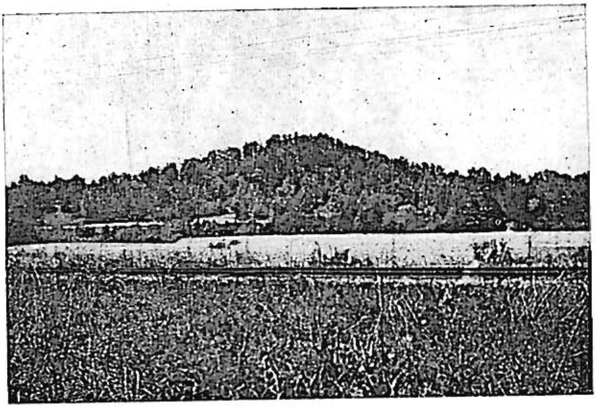

Figure 2.—Duck Hill "Mountain" northeast from the Jackson Creek bridge of U. S. Highway 51, SW. 1/4, SE. 1/4, NE. 1/4, Sec. 36, T.21 N., R.5 E. April 1941.

ridges, having elevations of 400 to 475 feet, are held up by ferruginous upper Winona sandstones in the "Palmertree Hills" area near the Attala County line (Secs. 20, 29, 30, 31, and 32, T.17 N., R.7 E.). Similar sandstones cap divides at the same elevations a few miles to the north (Secs. 6, 7, and 8, T.17 N., R.7 E.), 2 miles west of Poplar Creek. In the region to the east and southeast of Duck Hill (T.20 N., R.7 E., and in the lower tier of sections in T.21 N., R.7 E.), broad hills held up by Winona sands and upper Tallahatta clay-shales attain elevations of 450 to 480 feet. However, the greatest relief is shown at Duck Hill "Mountain" (Figure 2), at the northeast edge of the village of that name. Its crest which is 201 feet above the level (253 feet) of the town (Figure 3), is capped by 13 feet of cross-bedded ferruginous intact or colluvial Kosciusko sandstone (Figure 4), overlying nearly 80 feet of Winona sand.

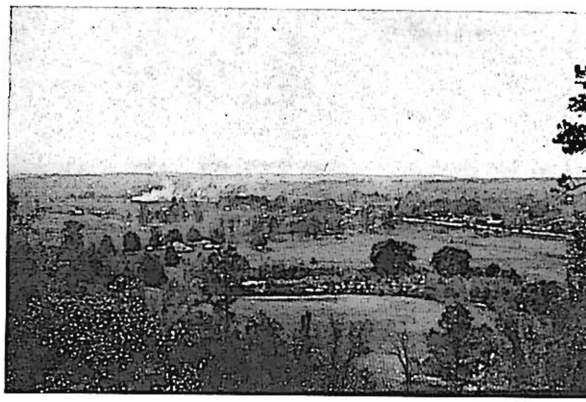

Figure 3.—Batupan Bogue Valley and the Village of Duck Hill, south-southeast from the summit of Duck Hill "Mountain," S. 1/2, SE. 1/4, NW. 1/4, Sec. 31, T.21 N., R.6 E. April 1941.

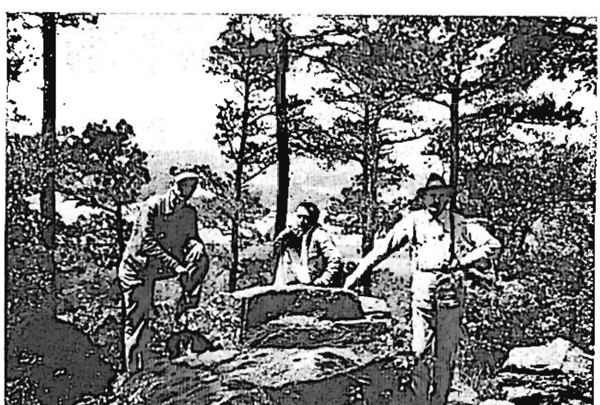

Figure 4.—Colluvial sandstone capping Duck Hill "Mountain," S. 1/2, SE. 1/4, NW. 1/4, Sec. 31, T.21 N., R.6 E. April 1941.

Montgomery County is drained by the Big Black River, Batupan Bogue, and Big Sandy Creek (Map 2). The Big Black River flows southwesterly through the southeast part of the county and joins the Mississippi River south of Vicksburg. Batupan Bogue drains the north part of the county and flows north to Grenada where it joins the Yalobusha River. Big Sandy Creek rises in the west part of the county and flows west to Greenwood where it empties into the Yazoo River.

The area drained by the Big Black River is much the largest of the three. Its chief tributaries from the north are, from east to west, Weir, Mulberry, Reed, Flowers, Lewis, and Hays Creeks. Those from the south are Grape and Poplar Creeks. The streams in the northeast part of the county which flow west into Batupan Bogue are Mouse and Worsham Creeks, and those in the northwest part of the county that flow north are Jackson and Wilkins Creeks. Although the valley walls are steep, the valleys are broad and nearly level, suggesting that they have been partly filled with alluvium. In fact, there is evidence that the deposition is rather recent, since dredging of some channels shows 5 to 15 feet of loosely consolidated debris, containing axe-marked logs, overlying typical hard-packed alluvium.

CULTURE AND INDUSTRY

Montgomery County is served by two paved highways which traverse the state. U. S. Highway 51, through the west part of the county, connects with Grenada and Memphis to the north and with Vaiden and Jackson to the south. U. S. Highway 82 crosses the middle of the county, connecting with Eupora and Columbus to the east and with Greenwood and Greenville to the west. Approximately 50 percent of the rural roads are graveled, except in the less populated areas. Although the two paved highways have been constructed indiscriminately over hills and valleys, the other roads follow either ridge crests or the bases of the valley walls. The county is served by two railroads: the Columbus and Greenville Railway, paralleled by U. S. Highway 82, and the Illinois Central Railway, by U. S. Highway 51.

Winona, Duck Hill, and Kilmichael have long been provided electric current by the Mississippi Power and Light Company, and recently the Rural Electrification Administration has been extending service to the smaller communities and to some rural districts.

The chief industry of the county is farming, and the chief crop is cotton. However within the last few years, dairying has been undertaken on an extensive scale, originally to supply a cheese factory and more lately to provide milk for canning. At present the

Poplar Creek area, in the southeast portion of the county, leads all others in milk production. Stimulated by the war industries, lumbering has been revived despite the fact that little mature timber is available. Portable sawmills are to be found in operation along many of the back roads, and permanent planing mills are located at Kilmichael, Winona, and Duck Hill.

Except for the making of brick, Montgomery County has never profited from mining or its kindred industries. Building brick was formerly made in the northeast part of Winona from weathered Zilpha clay and colluvium, but the industry was abandoned because of the lack of a market. Unfortunately, Montgomery County contains no gravel in workable quantities, since the Citronelle gravels which thickly mantle the hills bordering the delta do not extend far enough east. In the only small area in which gravel has been found, a few miles north of Kilmichael, the beds proved to be of such poor quality that they have never been extensively worked.

STRATIGRAPHY AND AREAL GEOLOGY

The greater part of Montgomery County is underlain by sands, clays, clay-shales, silts, and quartzitic sandstones of the Eocene system. These beds are unconformably overlain by Citronelle (Pliocene or Pleistocene) gravels and sands in a small area north of Kilmichael, and by a thin mantle of loess (Pleistocene) in the west part of the county, west of U. S. Highway 51.

Strata of two divisions of the Eocene are exposed, the Wilcox series and the overlying Claiborne series. A third, the Midway which underlies the Wilcox, is provisionally identified in an uplifted and intensely faulted area north of Kilmichael—the Kilmichael structural area. In this discussion, the Wilcox beds are undifferentiated, for although most of them are recognized as the Holly Springs formation, some of the underlying Ackerman sand may be exposed near the crest of the Kilmichael uplift. On a lithologic basis, the overlying Claiborne beds are divided into the Meridian, Tallahatta, and Lisbon formations; and the Lisbon, into the Winona, Zilpha, and Kosciusko members. According to the latest classification, the stratigraphic column for Montgomery County is as follows:

Recent			Terrace Sands and alluvium
		—Erosional unconformity—	
Pleistocene		Loess	
		—Erosional unconformity—	
		Citronelle formation	
Pliocene or Pleistocene			
		—Erosional unconformity—	
			Kosciusko sand member
			—Erosional unconformity—
		Lisbon formation	Zilpha clay member
			Winona sand member
	Claiborne series	Tallahatta formation	
		—Erosional unconformity—	
		Meridian formation	
		—Erosional unconformity—	
Eocene			
		Holly Springs formation	
	Wilcox series	Ackerman formation (?)	
	Midway	Porters Creek	

MIDWAY SERIES

As noted above, the Midway, the lower series of the Eocene system, is probably represented by the Porters Creek formation in the central uplift of the Kilmichael structure. Black carbonaceous clays of typical Porters Creek lithology are recognized in roadside exposures and in nearby test hole L100 (W. 1/2, SE. 1/4, NW. 1/4, Sec. 28, T.19 N., R.7 E.) and in a water well recently dug in a farmyard (SE. 1/4, NE. 1/4, SW. 1/4, Sec. 23, T.19 N., R.7 E.) to the east of the crest of the uplift. In the test, an interval of 36.6 feet of clay was measured, and in the well a thickness of 32.3 feet of black clay-shale was encountered beneath 19 feet of interbedded coarse-grained sand, silt, and siltstone. The clay weathers dark-gray and develops a conchoidal fracture similar to samples taken from exposures 30 miles to the east and from samples taken from oil tests recently drilled in Montgomery County and in adjacent counties. That this actually is the Porters Creek clay is in part substantiated by data obtained from the nearby Gulf-Parker oil test which reached the Selma chalk at 450 feet, 50 to 100 feet stratigraphically below the base of the clay.

WILCOX SERIES

As indicated, the Wilcox series is undifferentiated in this discussion. Although not recognized in exposures or test holes, the lower division, the Ackerman formation, is probably present near the crest of the Kilmichael structure. However, the upper part of the upper division, the non-marine Holly Springs formation, has a broad belt of outcrop east of a line extending N. 20° W. from the southeast corner of the county.

It should be noted before discussing the Holly Springs formation and the successively overlying units, that no beds of the upper Wilcox Grenada formation are present in the county, as previously mapped[2]. Recent investigations[3] show that the unit does not exist, and that beds formerly referred to it belong in part to the upper Holly Springs formation, to the Meridian formation, to the Tallahatta formation and to the Winona and Zilpha members of the Lisbon formation.

HOLLY SPRINGS FORMATION

According to correlations based on outcrops and test hole records, an interval of approximately 400 feet of the Holly Springs formation is normally exposed in the county, and presumably its full thickness of 550 feet might crop out in the Kilmichael structural area. In some places it is unconformably overlain by the Meridian sand, the basal formation of the Claiborne series, and at other localities by the Tallahatta formation where the Meridian sand has been eroded or where it was never deposited. The upper Holly Springs contact is very irregular as evidenced locally by the erosion of 25 to 40 feet of sand and 25 to 100 feet of subjacent dark silts and silty clays which are normally next to the highest recognizable beds of the unit.

The Holly Springs formation is composed of non-marine well-bedded fine-grained to medium-grained micaceous sand and thinner beds of dark lignitic silts, light and dark plastic clays, light-colored silts and sandy silts, and re-worked lignites, named in the order of their relative abundance. In its normal outcrop belt exclusive of exposures in the Kilmichael structural area, the Holly Springs has the following generalized section where Wilcox-Claiborne erosion has not cut too deeply into the upper beds:

Composite section of the Holly Springs formation

		Feet
8.	Sand, fine-grained to medium-grained light-buff fairly micaceous From 25 to	40
7.	Interfingering lenses of gray laminated clayey silt, light and dark-gray plastic clay, and nearly black carbonaceous and lignitic clay, overlying bluish or grayish-green silty clay From 25 to	100
6.	Sand, fine-grained to medium-grained yellow-buff fairly micaceous well-bedded From 100 to	150
5.	Silt, light-gray; interbedded with light-gray clayey silt and dark-gray to brown to black carbonaceous or lignitic silty clay; locally overlain by or containing thin beds of limonite-coated quartzitic siltstone From 40 to	80
4.	Sand, fine-grained to medium-grained gray-white fairly micaceous From 25 to	50
3.	Interbedded dark-colored silt and light-colored plastic clay, overlain by a breccia composed of gray clay pebbles or cobbles enclosed in a matrix of buff-colored clayey silt From 20 to	40
2.	Sand, fine-grained to medium-grained gray-buff slightly micaceous; thin beds of light-colored silty clay From 50 to	80
1.	Greenish-gray silty clay interbedded with brownish-black carbonaceous clay, overlying thick beds of carbonaceous clay, dark carbonaceous silt, and re-worked lignite (no base) From 50 to	60

The lowest beds of the Holly Springs formation recognized in Montgomery County, division 1 of the above section, crop out almost exclusively in the eastward extending panhandle which is bounded on the north by Webster County and on the south by Choctaw County. Test hole L242 (SW. 1/4, NE. 1/4, NW. 1/4, Sec. 1, T.18 N., R.8 E.), drilled at an exposure of carbonaceous clay on the north side of U. S. Highway 82, 1 1/2 miles northeast of Stewart, showed 27.6 feet of interbedded dark-colored carbonaceous silts and re-worked lignites. Another test, L239, drilled along the same highway 2 miles west of Stewart (S. 1/2, SW. 1/4, SW. 1/4, Sec. 4, T.18 N., R.8 E.) encountered 19.2 feet of greenish-gray silty clay and thinly bedded brownish-black carbonaceous clay, overlying beds of the same character as those tested east of Stewart. A roadcut (SW. 1/4, SE. 1/4, NE. 1/4, Sec. 36, T.19 N., R.7 E.), 2 1/2 miles to the north-west, just west of the Webster County line, exposes 15 feet of dark-gray fairly plastic clay (Figure 5). Test L235, drilled beneath the

Figure 5.—Weathered plastic clays of division 1, Holly Springs formation, in a roadcut near the Webster County line, 4 miles east-northeast of Kilmichael, SW. 1/4, SE. 1/4, NE. 1/4, Sec. 36, T.19 N., R.7 E. June 1941.

exposure, 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.

An interval of 50 to 80 feet of sands and thin silty clays, comprising division 2, crops out in Montgomery County. These beds form the hill slopes to the north of U. S. Highway 82 in the panhandle area, but are best seen in cuts above and to the east of the roadside clay exposure noted above, at the site of test L235.

On the same hillside, beds of division 3 are exposed above the sands of division 2 near the hill crest to the east, in a road fork (SW. 1/4, SE. 1/4, NW. 1/4, Sec. 31, T.19 N., R.8 E.) a short distance east of the Montgomery County line. Here, interbedded dark-colored silts and light-colored fairly plastic clays are overlain by a breccia composed of gray clay cobbles in a matrix of buff-colored clayey silt. Similar silts and clays are capped by a finer breccia to the southeast, 2 miles due west of Stewart (NE. 1/4, NE. 1/4, SE. 1/4, Sec. 5, T.18 N., R.8 E.). Test L243, drilled beneath this breccia, encountered light-gray and greenish-buff silts and silty clays to a depth of 32.2 feet. An excellent exposure of an even coarser breccia (Figure 6) whose fragments are poorly rounded, variously oriented, little weathered, and of obvious Holly Springs derivation, may be seen 12 miles to the north in a roadcut 200 feet west of the road

Figure 6.—Coarse breccia at the top of division 3, Holly Springs formation, in a roadcut at Alva, NE. 1/4, NW. 1/4, SE. 1/4, Sec. 36, T.21 N., R.7 E. June 1941.

fork in Alva (NE. 1/4, NW. 1/4, SE. 1/4, Sec. 36, T.21 N., R.7 E.). Finer breccias are common in beds of this division, in a faulted area half a mile east of Sweatman (SW. 1/4, Sec. 33, T.21 N., R.7 E.).

Fine-grained to medium-grained gray-white fairly micaceous sands, comprising division 4, overlie the breccia-capped silty clays. The sands crop out on the higher hills near the Webster County line in the panhandle area and low on the hill slopes to the west and to the east of the Lodi-Alva road which follows a ridge through Sections 12, 13, 24, 25, and 36, T.20 N., R.7 E.

The beds of division 5 crop out along this road and along the Lodi-Sibleyton road in Sections 14 and 23, T.19 N., R.7 E. to the south. In some of the cuts, the interbedded silts and clays are overlain by, or are separated by, thin limonite-coated quartzitic siltstones and sandstones, especially in Section 23, T.19 N., R.7 E. and in Sections 1 and 12, T.20 N., R.7 E. A mile to the west of Alva, in a road ditch on the west bank of a small stream (SW. 1/4, SW. 1/4, NW. 1/4, Sec. 36, T.21 N., R.7 E.), an exposure of dark silty clay is overlain uphill and to the west by 112 feet of massive sand. Test L85, drilled at this outcrop, showed 24.6 feet of dark-colored silts and slightly silty clays.

Division 6, comprising 100 to 150 feet of well-bedded sand, is the thickest phase of the Holly Springs formation recognized in Montgomery County. Reddish-buff upper beds of the division crop out in

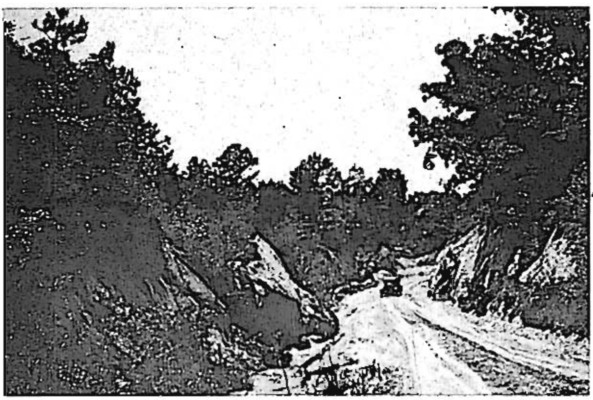

Figure 7.—Lower sands of division 6, Holly Springs formation, in deep cuts near the base of valley wall a mile west of Alva, SE. 1/4, SE. 1/4, NE. 1/4, Sec. 35, T.21 N., R.7 E. June 1941.

the hills immediately west and to the south of Lodi (Sec. 35, T.20 N., R.7 E. and Secs. 1 and 2, T.19 N., R.7 E.). Lower beds are exposed on the highest hilltops along the Lodi-Alva road and across the valley to the east, on the higher hills in adjacent Webster County. Deep cuts of a road (Figure 7) which ascends the west valley wall of a small creek above the site of test L85, (SE. 1/4, NE. 1/4, Sec. 35, T.21 N., R.7 E.) a mile west of Alva, expose well-bedded sands aggregating 112 feet in thickness, overlying dark silty clays suggestive of beds in division 5. In the Kilmichael structural area, exposures thought to be of division 6 were tested by holes L106 (W. 1/2, SW .1/4, NE. 1/4, Sec. 9, T.19 N., R.7 E.) and L101 (NE. 1/4, NW. 1/4, NE. 1/4, Sec. 20, T.19 N., R.7 E.), which were abandoned in water after failing to penetrate the massive sand at depths of 76.4 and 50.2, respectively.

Division 7 is composed of interfingering lenses of gray laminated clayey silts interbedded with light and dark-gray plastic clays and with nearly black carbonaceous and lignitic clays, which overlie bluish or grayish-green silty clays. Beds of this division underlie much of the broad valley of the East Fork of Batupan Bogue in the northeast part of the county. Here, test hole L209 (C., NW. 1/4, SW. 1/4, Sec. 21, T.21 N., R.7 E.), drilled in lower Tallahatta clay-shales in an abandoned road, showed 14.7 feet of alternately light-colored and dark-colored clays and silts. Two miles to the south, hole L124 (SW. 1/4, NW. 1/4, SW. 1/4, Sec. 34, T.21 N., R.7 E.) tested similar clays exposed at the roadside 1 1/4 miles east of Sweatman and encountered 40.2 feet of silty clays grading into the underlying sand beds of division 6. However, the full thickness was measured in the deepest hole in the county (NW. 1/4, SW. 1/4, Sec. 9, T.19 N., R.7 E.) drilled to a depth of 123.6 feet, in the stream bottom just east of Minerva. The hole penetrated 7.6 feet of alluvium, 18.2 feet of Tallahatta sands, 7.8 feet of Meridian sand, and 90.0 feet of greenish-black silty clay which grades downward into lighter-colored silts and clays. Two miles to the northeast, a study of exposures along the Minerva-Lodi road and of the record of test hole L107 (NE. 1/4, SE. 1/4, NE. 1/4, Sec. 3, T.19 N., R.7 E.) shows that the beds of the division thin updip and become more silty. In the region south of the Big Black River (Secs. 19, 20, 21, 28, and 29, T.18 N., R.8 E.) are two lenses of clay separated by silty sands. The upper lens, which is exposed near the tops of the hills, beneath the sands of division 8, has been tested by hole L193 (C., NW. 1/4, SW. 1/4, Sec. 20, T.18 N., R.8 E.), and the lower lens, which crops out at the bases of the hills, has been tested by hole L191 (SE. 1/4, SE. 1/4, SW. 1/4, Sec. 20, T.18 N., R.8 E.). At Huntsville, tests L180 and L184 show a combined thickness of 54.2 feet of dark plastic clays and lignitic clays beneath a hillside outcrop of similar clays 20 feet in thickness. A mile to the southwest, tests L185 and L186, drilled at roadside exposures at lower elevations, show that the dark plastic and carbonaceous clays are underlain by bluish or grayish-green silty clays. At a higher elevation, 2 1/2 miles southwest of Huntsville, the upper portion of the division consists of light-colored silty clays (Test L178, NE. 1/4, NW. 1/4, SW. 1/4, Sec. 20, T.17 N., R.8 E.).

The highest beds of the Holly Springs formation, which make up division 8, are at most places cut out by the Wilcox-Claiborne unconformity. They are distinguished with difficulty because of their similarity to the lower sands of the Tallahatta formation and because of their likeness to the Meridian sands, either of which may directly overlie them. Such is the case along the Kilmichael-Huntsville road where it extends up the south valley wall of Big Black River (SW. 1/4, Sec. 22, T.18 N., R.7 E.) 3 miles southeast of Kilmichael. Here, an interval of 83 feet of micaceous sands crops out above the valley bottom and beneath the lowest recognizable beds of Tallahatta clay-shale. However, to the southeast, 2 1/2 miles northwest of Huntsville, a road cut (C., SW. 1/4, SE. 1/4, Sec. 6, T.17 N., R.8 E.) shows 10 feet of buff micaceous sand and thin seams of limonite overlying blue-gray red-mottled plastic clay of division

Figure 8—Lenticular limonite concretions in the upper part of division 8, Holly Springs formation, at Grenada County line, E. 1/2, NE. 1/4, NW. 1/4, Sec. 24, T.21 N., R.6 E. June 1941.

7, beneath typical Tallahatta clay-shale. Sands of division 8 are probably recognizable in road cuts on the southeast flank of the Kilmichael structure (Secs. 2 and 3, T.18 N., R.7 E.), and farther to the northeast in Sections 35 and 36, T.19 N., R.7 E. Far to the north, similar sands crop out at several places along the east-west road in Sections 25, 26, and 27, T.21 N., R.6 E., immediately below Tallahatta clay-shale, and at some localities below gritty Meridian sand. To the northeast, at the Grenada County line, ditch banks at the roadfork (E. 1/2, NE. 1/4, NW. 1/4, Sec. 24, T.21 N., R.6 E.) expose lenticular limonite concretions in the upper part of division 8 (Figure 8).

In the highly faulted Kilmichael structural area, few exposures or test hole samples were definitely assigned to divisions of the Holly

Springs formation. In most instances, the writer was satisfied to identify strata as Holly Springs without attempting to differentiate them further. Dark plastic clays, exposed to the west of Tallahatta clay-shales, on the upthrow side of a fault, 100 feet west of the cross roads in Section 28, T.19 N., R.7 E., were tested by hole L236 which showed 41.2 feet of plastic clays and silty clays alternating with beds of brownish-black carbonaceous clay and lignitic silty clays. A mile to the north, light-colored silty clays crop out in the banks of a small stream (SW. 1/4, NE. 1/4, SE. 1/4, Sec. 20, T.19 N., R.7 E.), which when tested by hole L110, measured 50.2 feet in thickness. A similar exposure in a roadcut 1 1/2 miles northeast, when tested by hole L75 (Cen., NE. 1/4, Sec. 21, T.19 N., R.7 E.), showed 54.2 feet of clays of the same type, interbedded with silty sands.

CLAIBORNE SERIES

On the most recent map of Mississippi[4], beds of the Claiborne series are shown as a broad belt of outcrop extending from the Alabama line near Meridian northwest through Clarke, Lauderdale, Newton, Scott, Leake, Madison, Attala, and Holmes Counties and thence north through Carroll, Montgomery, and Grenada Counties. But recent studies in Tallahatchie County[5] show that Claiborne strata extend even farther north than Grenada, probably as far as the Tennessee line. Four formations are recognized, Meridian, Tallahatta, Lisbon, and Yegua. Of these, all but the Yegua crop out in Montgomery County. The few exposures of the Meridian and the wide belt of outcrop of the Tallahatta are shown as units on the areal map (Map 2), whereas the Lisbon formation is shown as three distinct belts, those of the Winona, Zilpha, and Kosciusko members.

MERIDIAN FORMATION

The Meridian sand, designated the basal formation of the Claiborne series, unconformably overlies the Holly Springs formation and is, in turn, overlain unconformably by the Tallahatta formation (Figure 9). These erosional surfaces above and below account for considerable variation in the thickness of the Meridian in adjacent exposures and for its absence on the outcrop throughout most of Montgomery County (Map 2).

At the few known exposures, the formation consists of cross-bedded fine-grained to medium-grained yellow-buff micaceous quartz sand which contains scattered grains of coarser sand. Unmistakable outcrops of the Meridian are limited to one area, along the east-west road some 4 1/2 miles northeast of Duck Hill (Secs. 25, 26, and 27, T.21 N., R.6 E.). Here the sand is highly cross-bedded (Figure 9) and has a maximum thickness of 14.9 feet. A possible area of outcrop is in the southeast part of T.18 N., R.7 E., where portions of thick sand having Meridian characteristics are assigned either to the lower Tallahatta or to division 8 of the Holly Springs formation. A few miles to the south, in the Huntsville region, in the southeast part of the county, the Meridian is absent and Tallahatta clay-shales rest directly on carbonaceous clays of division 7 of the Holly Springs. However, a grit-bearing sand, which is probably Meridian, is ex-

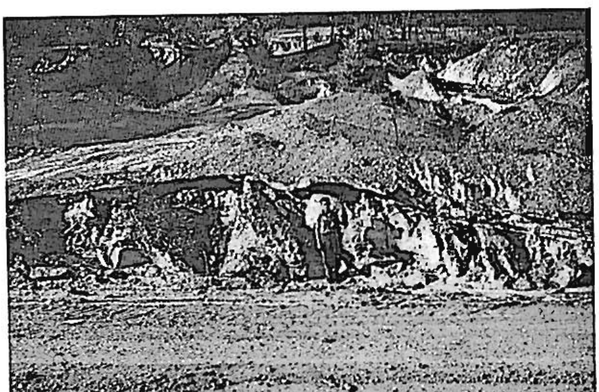

Figure 9.—Tallahatta silty shales unconformably overlying the Meridian sand 4 miles east-northeast of Duck Hill, SE. 1/4, SW. 1/4, SW. 1/4, Sec. 22, T.21 N., R.6 E. June 1941.

posed in the highly faulted southeast flank of the Kilmichael structure, in cuts of an east-west road east of the village (Secs. 2 and 3, T.18 N., R.7 E.).

The Meridian, encountered more extensively in test holes than in outcrops, has the thicknesses indicated in the following scattered tests: L108 (S. 1/2, NE. 1/4, NE. 1/4, Sec. 27, T.21 N., R.6 E.), 14.2 feet; L68 (E. 1/2, NE. 1/4, SW. 1/4, Sec. 10, T.20 N., R.6 E.), 9.3 feet; and L102 (NW. 1/4, SW. 1/4, N.W. 1/4, Sec. 9, T.19 N., R.7 E.), 7.8 feet. Further evidence of a greater extent of the formation than field work shows is suggested by the fact that the water supply of the City of Winona is obtained from a sand whose lithology and stratigraphic position is that of the Meridian.

TALLAHATTA FORMATION

The Tallahatta formation in Montgomery County is 125 to 150 feet in thickness, although it was formerly believed to thin to only 15 feet in the Duck Hill area and to wedge out near Grenada[6]. The unit rests unconformably on either the Meridian sand or on beds of the upper Wilcox formation where the Meridian was not deposited or had been eroded. The formation consists of fine-grained to medium-grained micaceous sands interbedded with thin silty micaceous clays and a few thin "buhrstones"—beds of claystone embedded in sandstone. In addition, one to five clay-shale lenses are developed locally at several horizons. This lithology differs sharply from that attributed to the Tallahatta in Lauderdale[7] and Clarke Counties to the southeast, where thick beds of diatomaceous(?) clay-shale are separated by thin beds of "buhrstone." Along the outcrop northwest of Lauderdale County, beds of micaceous sand become increasingly more numerous and the amount of clay-shale correspondingly decreases, so that in Montgomery County only about one-third of the thickness of the unit is comprised of clay-shale. Still farther to the north, in Grenada, Yalobusha, and Lafayette Counties, nearly all of the unit is well-bedded sand that contains an even lesser number of clay-shale lenses.

In Montgomery County, the Tallahatta has a broad belt of outcrop, 4 to 10 miles in width, which extends through the county from the southeast corner to the northwest corner. At places, the full thickness of the unit can be directly measured, especially in the region of the "buhrstone"-capped rugged hills in the southeast corner of the county (Secs. 30, 31, and 32, T.17 N., R.8 E.).

Although the sands of the Tallahatta formation are much like some of the thicker sands of the upper part of the Holly Springs formation, and like the lower non-glauconitic sands of the overlying Winona, the rest of the Tallahatta lithology is distinctive. The clay-shales are dark-brown or tan but weather cream-white, have a blocky fracture, and are remarkably light in weight, in sharp contrast to the dark silty or plastic clays of the upper part of the Holly Springs formation. These shale lenses are thickest and most numerous in the region of sharp hills and narrow valleys a few miles east of Duck Hill (Secs. 1, 2, 10, 11, 13, and 14, T.20 N., R.6 E.), and near the Grenada County line (Secs. 25 and 36, T.21 N., R.6 E.). Several of the clays were sampled and are described in the records of test holes L108, L67, and L209. The lowest lens (Figure 10) is exposed in an abandoned road in the north part of the county (at L209, Cen., NW. 1/4, SW. 1/4, Sec. 21, T.21 N., R.7 E.). Probably the thickest exposure of Tallahatta shales and interbedded sands is along the east-west road from the small creek just east of Minerva to the road fork at the crest of the hill (NW. 1/4, Sec. 9, T.19 N., R.7 E.), a distance of 0.35 mile.

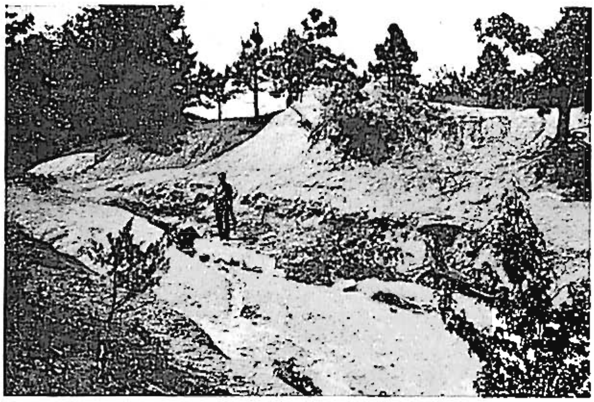

Figure 10.—Lower Tallahatta clay-shales, in a gully of an abandoned road, 2 1/2 miles north of Sweatman, Cen., NW. 1/4, SW. 1/4, Sec. 21, T.21 N., R.7 E. June 1941.

SECTION OF TALLAHATTA FORMATION (NW. 1/4, SEC. 9, T.19 N., R.7 E.) ALONG ROADWAY EAST OF MINERVA

	Feet	Feet
9. Soil—sand, clayey reddish-buff; to top of roadcut at road fork	4.1	
Tallahatta formation		58.0
8. Sand, fine-grained dark-buff fairly micaceous; thin laminae of light-buff silty clay	3.3	
7. Clay-shale, silty gray-white brittle; laminae of very silty yellow-buff very micaceous sand	3.4	
6. Sand, fine-grained to medium-grained yellow-buff well-bedded; limonitic nodules at base	15.1	
5. Clay-shale, slightly silty gray-white thinly bedded; silty and limonitic laminae; clay-shale is chocolate-brown on fresh exposure	3.9	
4. Sand, fine-grained buff fairly micaceous; thin discontinuous beds of gray-white clay-shale	4.5	
3. Clay-shale, silty gray-white irregularly bedded; several lenses of gray-buff fine-grained sand near top	8.3	

2.	Sand, fine-grained yellow-buff fairly micaceous irregularly bedded	5.3
1.	Clay-shale, slightly silty well-bedded; blocky fracture; beds on north side of roadcut are gray-white and dry; those on south side are gray-brown and wet; irregular lenses of limonitic sandy silt (no base)	14.2

These 58 feet and the underlying 25 to 30 feet of basal beds in test hole L102 on the creek bank in the NW. 1/4, SW. 1/4, NW. 1/4, Section 9, T.19 N., R.7 E. can be considered typical of the lower two-thirds of the formation. At other places, the lower one-third of the unit contains one or more "buhrstone" ledges, 0.5 to 1.8 feet in thickness. Ledges are numerous in roadcuts 2 1/2 miles northwest

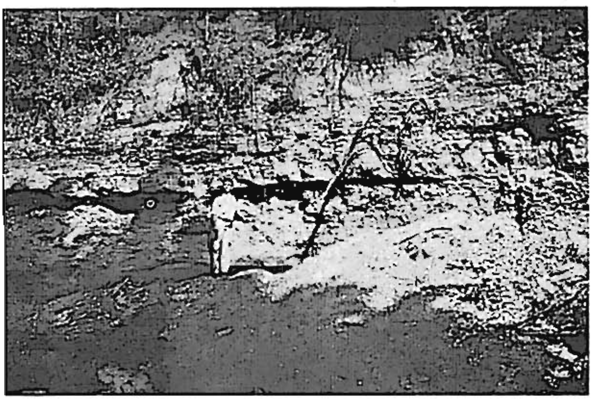

Figure 11.—Lower Tallahatta "buhrstones" and interbedded shales, bank of Jackson Creek, 1 mile west of Duck Hill, SW. 1/4, SE. 1.4, SW. 1/4, Sec. 36, T.21 N., R.5 E. May 1941.

of Duck Hill (C., Sec. 26, T.21 N., R.5 E.), in the bed of Jackson Creek (Figure 11) a mile west of Duck Hill (SE. 1/4, SW. 1/4, Sec. 36, T.21 N., R.5 E.), and in roadcuts at the bases of hills a mile west of Kilmichael (NW. 1/4, Sec. 8, T.18 N., R.7 E.).

An upper "buhrstone," the ridge-former, crops out in the streets in the southwest part of Kilmichael, 82 feet above and one-fourth mile east of the last mentioned lower ledge. Other exposures of the upper "buhrstone" are located 4 miles to the southwest, just east of a road intersection (S. 1/2, Sec. 14, T.18 N., R.6 E.), and 3 miles to the southeast along the Kilmichael-Huntsville graveled road (Secs. 26 and 27, T.18 N., R.7 E.). Roadcut exposures near the Attala

County line (Secs. 25 and 36, T.17 N., R.7 E.) show two and at places three "buhrstones," 10 to 25 feet below the Tallahatta-Winona contact. Similarly, several ledges having positions 10 and 20 feet below the contact show in roadcuts to the south and to the west of the intersection of the Hendrix road and U. S. Highway 82, (Sec. 35, T.19 N., R.6 E.) 4 miles northwest of Kilmichael. Half a mile to the north of the intersection, test hole L10 (W. 1/2, SW. 1/4, SE. 1/4, Sec. 26, T.19 N., R.6 E.), was drilled to a depth of 32.0 feet beneath a ledge which extends across the road (Figure 12).

Figure 12.—Upper Tallahatta "buhrstones" at roadside 1 mile north of Hendrix, W. 1/2, SW. 1/4, SE. 1/4, Sec. 26, T.19 N., R.6 E. May 1941.

The portion of the Tallahatta overlying the upper ledge of "buhrstone" consists of micaceous silty sand or sandy shale which is greenish-black in test holes and in fresh exposures but which weathers to a yellow-buff, much lighter than the overlying ferruginous Winona sand into which it grades. At some places, these uppermost beds are semi-indurated, but in test hole L3 (S. 1/2, NE. 1/4, NE. 1/4, Sec. 30, T.19 N., R.6 E.) a mile east of Winona, the sands are loose and poorly laminated. A petrographic study proved that both the sands and the sandy shales encountered in this test were non-glauconitic, as suggested by the light color of the weathered material. Rather, the greenish-black color of a fresh sample is due to finely comminuted particles of greenish-gray silty clay which seems to be evenly distributed throughout the beds just below the contact in the area within 4 or 5 miles to the north and to the east of Winona.

TALLAHATTA-WINONA CONTACT

The difference in color was relied on to locate the Tallahatta-Winona contact in the test holes and proved satisfactory in the Winona region. But in the Kilmichael, Duck Hill, and Minerva areas, where the greenish-black phase is absent and the Tallahatta sands grade imperceptibly into the Winona sands, the contact was arbitrarily placed at whatever depth the characteristically ferruginous non-clayey lower Winona sands gave way to lighter-colored clayey silts or to very micaceous sands containing laminae of yellow-buff silty clay. The following section illustrates the poorly marked change at the contact and is a composite of the sections of the upper outcropping beds and of the records of test holes L96, L97, L98, and L99, on the south slope of Duck Hill "Mountain" (NE. 1/4, SW. 1/4, NW. 1/4, Sec. 31, T.21 N., R.6 E.).

COMPOSITE RECORD OF OUTCROP AND OF TEST HOLES L96, L97, L98, AND L99, ON THE SOUTH SLOPE OF DUCK HILL, MAY 3, 1941

	Feet	Feet
11. Sandstone, fine-grained to coarse-grained dark-red ferruginous highly cross-bedded; probably colluvial material derived from Kosciusko and Winona sands	13.0	
Winona member		80.5
10. Sand, fine-grained to medium-grained reddish-brown ferruginous; contains badly weathered glauconite	11.8	
9. Sand, fine-grained red-buff limonitic; thin beds of gray-buff silt	2.9	
8. Sand, medium-grained brick-red very ferruginous; contains badly weathered glauconite	6.7	
7. Sand, fine-grained to silty flesh-colored	27.2	
6. Sand, fine-grained yellow-buff	6.1	
5. Sand, fine-grained to medium-grained yellow-buff	25.8	
Tallahatta formation		19.0
4. Sand, silty yellow-buff fairly micaceous; thin laminae of light-buff clay-shale	6.0	
3. Sand, fine-grained red-buff fairly micaceous	3.4	
2. Silt, clayey light-gray red-mottled fairly micaceous; thin laminae of gray-tan clay-shale	8.7	
1. Sand, silty gray-tan red-mottled; thin laminae of light-gray clay-shale	0.9	

LISBON FORMATION

The term Lisbon formation was first used by Smith[8] in 1907 to designate a number of beds called "Lisbon Bluff" or "Lisbon," which overlie the Tallahatta "buhrstone" of Clarke County, Alabama. In

Mississippi, to the Lisbon formation have been referred four members —Winona sand, Zilpha clay, Kosciusko sand, and Wautubbee marl. The Wautubbee, which appears to be the lithologic and faunal equivalent of the entire Lisbon of Alabama, is not known to crop out northwest of Newton County. The other members form a broad belt of outcrop extending from Clarke County, on the Alabama line, northwest and north at least as far as Batesville, Panola County, 35 miles beyond the Yalobusha River at Grenada at which place the unit was believed to terminate.[9] Now it seems probable that the belt of outcrop continues even beyond Batesville to the Tennessee line or even farther.

WINONA MEMBER

In 1919 Lowe[10] gave the name Winona to a "highly ferruginous, bright-red, glauconitic sand" which crops out in the vicinity of Winona, Montgomery County. He recognized its stratigraphic position above the Tallahatta "buhrstone" and beneath the Kosciusko quartzites and wisely suggested that it be considered the basal member of the Lisbon formation. However, it is now evident that the thickness of 350 feet which Lowe assigned to it is far too great, and that he was combining the lower Kosciusko sands with the Winona sand, failing to recognize the importance of the Zilpha clay which he saw near Winona[11] but which he evidently considered an insignificant bed in a great thickness of sand. Actually, the Winona sand has a thickness of only 70 to 80 feet at Winona, having thickened from 32 feet in southwest Lauderdale County[12] to 50 or 60 feet in Newton County.[13] To the north of Montgomery County, recent investigations in Tallahatchie County[14] show thicknesses of 90 to 120 feet.

In Montgomery County, the Winona sand is readily divided into three portions: (1) A basal non-glauconitic non-fossiliferous iron-stained quartz sand containing thin discontinuous clay lenses, 20 feet in thickness; (2) a middle slightly glauconitic sparingly fossiliferous ferruginous quartz sand 30 to 40 feet in thickness; and (3) an upper very glauconitic very ferruginous quartz sand containing casts of pelecypods, about 20 feet in thickness. The glauconite weathers easily, stains the upper part of the unit a brick-red, and furnishes abundant limonite for cementing the sand into numerous rough, warty sandstone ledges which mark the most upper beds. Near the top are small gray-buff claystone nodules which weather to a plastic clay and provide sufficient bonding material to support nearly vertical walls of sand. At some localities, especially at depth, the upper few feet contain gray-white calcareous claystone nodules similar to those noted in test hole L233 in the Kilmichael structural area (SW. 1/4, NE. 1/4, NE. 1/4, Sec. 17, T.19 N., R.7 E.).

The full thickness of the Winona sand can be measured on several hill sides in Montgomery County. The best continuous exposure is in road cuts along U. S. "Winona Business" Highway 82 as it extends up the east wall of Hays Creek (Sec. 25, T.19 N., R.5 E. and Secs. 30 and 29, T.19 N., R.6 E., Sec. 30 and SW 1/4, NE. 1/4, Sec. 29, T.19 N., R.6 E.) and joins the main highway at the crest of the hill. Test hole L3, a short distance to the north and above the Tallahatta-Winona contact in a cut at the base of the section, showed 22.5 feet of Winona sand overlying greenish-black silty Tallahatta clay-shale. At the top of the section, at the road intersection, test hole L5 penetrated 44.6 feet of the upper part of the unit. The thickness of the unit can also be measured in roadcuts along U. S. Highway 51, 4 1/2 miles north of Winona (SW. 1/4, Sec. 31, T.20 N., R.6 E.), from the base of the south wall of a small creek south to the hill crest; in cuts along a road which ascends a ridge 2 1/2 miles west of Duck Hill (S. 1/2, Sec. 34, T.21 N., R.5 E.); along two steep roads which extend up an outlier in the SE. 1/4, Sec. 34, T.20 N., R.6 E., to the crest of the hill just south of the juncture of the roads; and in the extreme south part of the county, along roads which extend up narrow divides in Section 34, T.17 N., R.7 E.

Exposures of the lower two-thirds of the Winona sand are common in several borrow pits (Secs. 28 and 27, T.19 N., R.6 E.) along the newly constructed U. S. Highway 82 east of Winona. Other thick sections of upper Winona are exposed in roadcuts of steep hills in Sections 3, 5, and 12, T.18 N., R.6 E.; and 2 miles east of Winona in cuts of U. S. "Winona Business" Highway 82 half way up the east wall of Hays Creek (SE. 1/4, NE. 1/4, Sec. 30, T.19 N., R.6 E.).

The upper one-third of the Winona is easily distinguished, because of its brick-red color and because of the ledges of ferruginous glauconitic sandstone alternating with silty sands. Every feature indicates that the sandstones are a product of weathering, and that they form rapidly wherever the glauconitic sands are exposed, as shown by very hard ledges (Figure 13) along U. S. Highway 82 just west of the road fork (SW. 1/4, NW. 1/4, NW. 1/4, Sec. 29, T.19 N., R.6 E.), 2 miles east of Winona. The upper part of the Winona contains similar thick ledges at the road fork (SE. 1/4, Sec. 12, T.18 N., R.5 E.), 4 miles south of Winona; in cuts on the Winona-Fox road (Secs. 16 and 17, T.19 N., R.6 E.), 4 miles northeast of Winona; in several deep cuts along the Columbus-Greenville Railway, 1 to 3 miles northwest of Winona, and at the old station of Elliott, 3 miles east of Winona; in cuts along the steep roads and on the barren hill sides (Secs. 6 and 7, T.17 N., R.7 E.) 2 1/2 miles west of Poplar Creek Village; and on both valley walls of Big Sandy Creek (Secs. 9 and 16, T.19 N., R.5 E.) 3 miles northwest of Winona.

Test holes L210, L234, and L238 were drilled in these upper beds to obtain large samples of the more glauconitic sand for laboratory analysis with a view toward using the mineral as a source of potash for fertilizer. However, these beds have been penetrated in widely scattered areas by test holes L20, L22 (Carroll County), L30, L72, L182, L211, L217, and L221 which were drilled to collect samples of the overlying Zilpha clay for laboratory examination.

The fossils in the upper ferruginous beds are poorly preserved and are identified with difficulty. Hilgard[15] reported the following from a railway cut at Vaiden, a short distance south of the county line:

Nautilus zigzag Dekayii	Voluta petrosa Conrad
Ostrea divaricata Lea	Dentalium sp.
Venericardia rotunda Lea	Turritella vetusta Lea?
Cardium nicolleti Conrad?	Terebra venusta Lea?
Avicula sp.	Solarium sp.

These upper ferruginous beds, especially where overlain by the Zilpha clay, are resistant enough to hold up many of the highest and narrowest ridges in the west-central part of the county (Map 2). The Winona-Fox-Cedar Hill road follows such a ridge (Secs. 35 and 36, T.20 N., R.6 E. and Secs 2, 10, 9, 17, and 19, T.19 N., R.6 E.) and is paralleled on the northwest by another road astride a narrow divide (Secs. 4, 5, 8, 7, 18, and 19, T.19 N., R.6 E.). Other ridges capped by resistant strata are west and southwest of Duck Hill (Secs. 3, 4, and 9 and Secs. 12, 13, and 24, T.20 N., R.5 E.), and the crests of a highland area 1 to 5 miles south of Winona are traversed by a network of roads which cuts the Winona-Zilpha and the Zilpha-Kosciusko contacts at many places.

In contrast, the middle and lower portions of the Winona sand form the gentle slopes of most of the hills in the same area and to the east and to the southeast. Those ridges which are composed entirely of Winona sand (Map 2) are almost all gently rounded for there are no resistant beds to break their even slope.

WINONA-ZILPHA CONTACT

By studying test hole records and by studying numerous exposures, the Winona-Zilpha contact has been determined to be conformable (Figure 13) although not everywhere distinct. At most places,

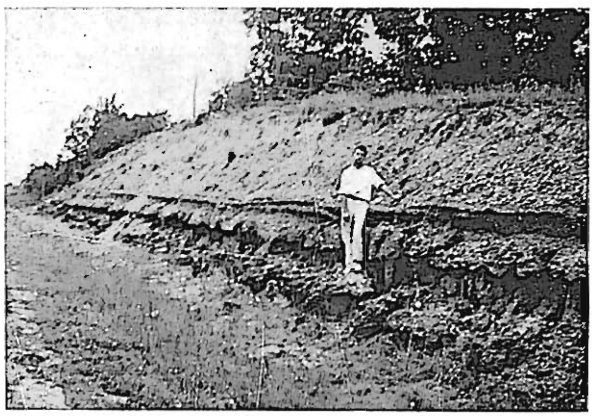

Figure 13.—Zilpha conformably overlying the Winona, just west of the intersection of old and new U. S. Highway 82, 2 miles east of Winona, SW. 1/4, NW. 1/4, NW. 1/4, Sec. 29, T.19 N., R.6 E. April 1941.

as in test holes L30, L72, L211, and L217, glauconitic sands of the upper Winona are abruptly overlain by continental Zilpha clay-shales. But at other places, and notably in holes L20, L22, and L221, similar sands are overlain by a thin zone of glauconitic clay which is the lower (marine) Zilpha, a division which thickens down dip in Carroll County and to the north-northwest along the strike to the Grenada-Tallahatchie County line. However, in a few areas, the Zilpha clay and some of the upper Winona beds have been cut out by erosion and are overlain by one to five beds of limonitic siltstone which form the basal strata of the Kosciusko member. Consequently the Winona-Kosciusko contact is valueless as a key horizon for structural mapping, whereas, the Winona-Zilpha contact has proved reliable.

ZILPHA MEMBER

At most places in Montgomery County, the Zilpha member consists of chocolate-brown clay-shale which characteristically weathers gray-white. Beds of this kind, recently identified as Zilpha, were noted by Lowe in 1929 or 1930[16] in the vicinity of Winona, but he failed to recognize their significance and evidently considered them a local clayey phase of the Winona sand, which accounts for the excessive thickness of 300 to 400 feet which he ascribed to that unit in the Montgomery County area. At approximately the same time Mr. Raymond Moore,[17] formerly with the Arkansas Fuel Oil Company, found the clay to be a good key bed and suggested the name Zilpha from Zilpha Creek in the northwest part of adjoining Attala County. Field work in 1932 by McGlothlin and Conners,[18] Gulf Refining Company, further established the clay as a mappable unit in north-central Mississippi, and their subsequent investigations to the southeast showed beds of related lithology near Hickory, Newton County.[19] In 1938 and 1939, Foster[20] identified Zilpha clays farther east in Lauderdale County; and subsurface samples from the recently discovered Tinsley oil field in Yazoo County suggest that the top of the so-called "Cane River" is probably the top of the Zilpha.[21]

LOWER (MARINE) ZILPHA

As already noted, the Zilpha member in Montgomery County is chiefly continental, although a lower marine facies is present locally in the west tier of townships. This facies, called the lower (marine) division, consists of greenish-buff fairly glauconitic blocky clay-shale, which weathers brick-red and which attains a maximum thickness of 1.5 feet in roadcuts of abandoned U. S. Highway 51, 1 to 2 miles north of Winona. In test hole L221 at Winona its thickness is 1.7 feet, but it thickens down-dip to 2.4 feet in test L22, Carroll County, 5 miles west of Winona. The division also thickens along the strike to the north-northwest, so that at the Grenada-Tallahatchie County line,[22] 10-foot to 25-foot sections of thinly laminated tan-colored clay-shales interbedded with glauconitic sands or silts are common. Similarly, along the strike to the southeast in Lauderdale County, Foster[23] reports 7.5 feet of clay-shale at the top of the Winona member, which appears to be glauconitic in the lower part.

UPPER (CONTINENTAL) ZILPHA

The upper (continental) Zilpha in Montgomery County is a jointed well-bedded tan to chocolate-brown carbonaceous slightly silty clay which contains lenses of micaceous silt at places and plant impressions at others. Whereas the beds of the lower division weather to a reddish-brown sandy clay, the clays of the upper division bleach gray-white and develop a blocky to conchoidal fracture. Gypsum, variety selenite, fills the joints in exposures and is present in quantity at depth in test holes.

Although the Zilpha rests with conformity on the upper Winona glauconitic sands and ledges of ferruginous sandstone, the contact with the overlying Kosciusko sand, as pointed out, is distinctly nonconformable (Figure 14), resulting in a great variation in thickness

Figure 14.—Kosciusko unconformably overlying the Zilpha along a contact marked by ledges of siltstones, 1 1/2 miles southwest of Winona, SE. 1/4, SW. 1/4, Sec. 35, T.19 N., R.5 E. June 1941.

of the division. The division is well developed in numerous cuts of abandoned U. S. Highway 51, from Winona north to Sawyer, a distance of 2 miles, where test holes L30 and L32 show thicknesses of 24.8 and 25.8 feet respectively. Two miles east of Winona, test hole L2 also penetrated 24.8 feet of the unit noted in roadcut exposures at the juncture of old and new U. S. Highway 82 (N. 1/2, SE. 1/4, NW. 1/4, Sec. 29, T.19 N., R.6 E.). A greater thickness of selenitic clay (32.8 feet) was drilled, (L20, N. 1/2, SW. 1/4, NE. 1/4, Sec. 6, T.18 N., R.6 E.) at the Zilpha-Kosciusko contact in a road fork 2 miles southeast of Winona, but the greatest development found in Montgomery County is in a down-dropped fault block in the Kilmichael structural area where test hole L233 (SW. 1/4, NE. 1/4, NE. 1/4, Sec. 17, T.19 N., R.7 E.) encountered the lower 38.0 feet of dipping beds. However, down-dip to the west, in adjacent Carroll County, test holes L22 and L25 drilled atop clay exposures along U. S. Highway 82, 5 and 6 miles west of Winona, show that the upper (continental) Zilpha has thickened to at least 45.2 feet and is underlain by beds of the lower (marine) division. This thickening is in keeping with observations of the upper division noted in water well and oil test records farther downdip and with the great thicknesses of 200 to 250 feet in Tallahatchie County[24] along the strike to the north-northwest.

Other good exposures of the continental division, easily accessible to Winona, are: in roadcuts near the crest of the southeast valley wall of Hays Creek, a mile southeast of town; along the Winona-Fox road (Secs. 16 and 17, T.19 N., R.6 E.); and near the crest of a hill on the Eskridge-McCarley road, 1 1/4 miles west of U. S. Highway 51. However, the upper Zilpha is so thin as to be readily overlooked in the region southwest of Duck Hill, at several points along the Columbus and Greenville Railway 1 to 3 miles northwest of Winona, and in several of the roadcuts along U. S. Highway 51 between Sawyer and Eskridge where the Winona-Zilpha and Zilpha-Kosciusko contacts are both exposed.

The division has been eroded in several widely separated areas (Map 2), so that the basal beds of the Kosciusko member rest on upper beds of the Winona, though not on strata lower than the glauconitic ferruginous semi-indurated sand. The entire Zilpha is absent: along U. S. Highway 51 near the crest of the hill (SW. 1/4, SW. 1/4, SW. 1/4, Sec. 31, T.20 N., R.6 E.) midway between Winona and Duck Hill; from its calculated position near the crest of Duck Hill "Mountain"; from the north ends of divides southwest of Duck Hill; and at places along the valley walls of Big Sandy Creek northwest of Winona.

ZILPHA-KOSCIUSKO CONTACT

In Montgomery County the Zilpha-Kosciusko contact or, where the Zilpha has been eroded, the Winona-Kosciusko contact is marked by one to five beds of buff to light-brown limonitic siltstone. Where there is but one ledge, as in roadside exposures at Fox (NW. 1/4, NE. 1/4, NE. 1/4, Sec. 16, T.19 N., R.6 E.), along the Fox-Cedar Hill road (Secs. 35 and 36, T.20 N., R.6 E.), and on the north valley wall of Big Sandy Creek (N. 1/2, NW. 1/4, SE. 1/4, Sec. 9, T.19 N., R.5 E.), the siltstone is brittle and very hard and contains large patches of fine-grained to medium-grained quartzite. The stratum varies in thickness from 0.2 to 1.2 feet and is thickest in the Fox-Cedar Hill area, where it is used as foundation stones and for chimney construction. Where there are several strata of siltstones interbedded with buff silty clay, they are softer and contain more sand and split easily along irregular bedding planes. Several thin ledges alternating with silty clays (Figure 15) are exposed in roadcuts of U. S. Highway 82, 2 1/2 to 3 miles east of Winona (Sec. 29, T.19 N., R.6 E.), at the road fork (SE. 1/4, SW. 1/4, Sec. 24, T.20 N., R.5 E.) 1 1/2 miles

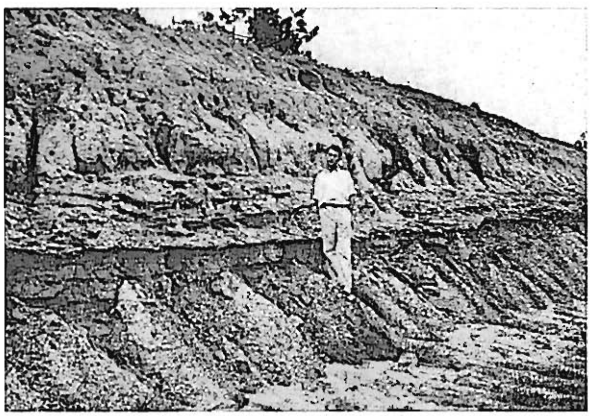

Figure 15.—Unconformable contact of Zilpha and Kosciusko members marked by thin ledges of limonitic siltstone along U. S. Highway 82, 2 3/4 miles east of Winona, NW. 1/4, SE. 1/4, NW. 1/4, Sec. 29, T.19 N., R.6 E. April 1941.

west of Eskridge, and in a roadcut (SE. 1/4, SW. 1/4, SW. 1/4, Sec. 35, T.19 N., R.5 E.) 2 miles southwest of Winona (Figure 14). Along the strike, both to the south and to the north, the limonitic zone is replaced by quartzitic sandstones or by coarse-grained sand.

KOSCIUSKO MEMBER

In 1906 Crider[25] and in 1915 Lowe[26] noted ledges of quartzitic sandstones in a thick sand interval near Kosciusko, the county seat of Attala County. Since the ledges are hard and very resistant, both men considered them Tallahatta in age, and it was not until 1925 that Cooke[27] recognized the stratigraphic position of the sand near the top of the Lisbon formation and raised it to the rank of a member. On the most recent geologic map, 1928,[28] the member is included in the undifferentiated upper Lisbon belt of outcrop. More recently the unit was recognized in Montgomery County[29] and in Lauderdale County.[30] Lowe [31] makes no reference to it in his notes of the Winona area, and it is evident that he considered the underlying Zilpha an insignificant clay lens in the Winona sand, in which member he included the overlying Kosciusko sand.

The Kosciusko formation crops out in the hilliest area of west Montgomery County, although a few outliers cap the higher hills as much as 5 or 6 miles to the east of U. S. Highway 51 (Map 2). The Kosciusko consists essentialy of fine-grained to medium-grained buff well-bedded quartz sands containing two well developed beds of silt or silty clay, 50 and 90 feet respectively above its base. Distributed throughout the entire sandy phase are numerous dark grains of an iron-bearing mineral whose weathering stains exposures brick-red or reddish-brown. These grains are not glauconitic, and, since no fossils have been found, at least in Montgomery County, the unit is considered non-marine. Down dip to the west and to the northwest, the member is definitely continental as shown by lignite fragments in subsurface samples and by beds of lignite in electrical logs of oil tests. At the Carroll County line, along U. S. Highway 82, there is evidence for a thickness of 100 to 150 feet and there is a possibility of a thickness up to 200 feet 6 miles to the north along the Eskridge-McCarley road (Road forks, SE. 1/4, Sec. 21, T.20 N., R.5 E.).

The sandy phase can best be seen in a borrow pit just east of the juncture of old and new U. S. Highways 82, (SE. 1/4, SE. 1/4, SE. 1/4, Sec. 22, T.19 N., R.5 E.) a mile west of Winona. Here, an interval of 52.7 feet of cross-bedded sand overlies 39.8 feet of well-bedded sand as measured in a test hole at the bottom of the pit. Test hole L1, (SE. 1/4, NW. 1/4, SW. 1/4, Sec. 23, T.19 N., R.5 E.) at a cross road 0.3 mile to the northeast, showed 47.3 feet of sand containing small quartz gravel near the top of the unit.

In fresh exposures the beds of silt or silty clay are grayish-white but are tinted red, orange, and purple hues where exposed to weathering. The lower silty beds crop out 2 miles north of Winona in the juncture of old and new U. S. Highways 51, and the upper silty beds are exposed above the borrow pit at the juncture of old and new U. S. Highways 82, a mile west of Winona. The upper silty strata prove rather resistant to erosion and hold up long narrow ridges in Section 9, T.20 N., R.5 E. and in adjacent sections of Carroll County to the west. In one small area (W. 1/2, SW. 1/4, NE. 1/4, Sec. 34, T.20 N., R.5 E.) the Kosciusko contains several thin lenses of breccia near its base, made up of gray-white cobbles of Zilpha clay-shale in a matrix of yellow-buff silty sand.

CITRONELLE FORMATION

The Citronelle formation (Pliocene or Pleistocene) is represented by poorly bedded micaceous sand and by gravel composed of chert and vein quartz, in the uplifted and intensely faulted area north of Kilmichael. The best exposures (Figure 16) are in cuts at either end

Figure 16.—Citronelle chert gravel and micaceous sand in a roadcut 3 miles north of Kilmichael, Cen., SW. 1/4, NE. 1/4, Sec. 28, T.19 N., R.7 E. May 1941.

of the east-west road which extends through Sections 26, 27, and 28, T.19 N., R.7 E., a short distance south of the crest of the Kilmichael structure. Test hole L225 (roadfork, Cen., SE. 1/4, SW. 1/4, Sec. 26, T.19 N., R.7 E.) encountered 40.2 feet of these gravels, and holes cored in the vicinity by the Gulf Refining Company passed through several sequences of sand and gravel ranging to 345 feet in depth.[32] At places the gravels have filtered down through some of the numerous fault planes which are so abundant near the crest of the structure.

McGlothlin,[33] who first worked out the Kilmichael structure in 1931 and 1932, considers the gravels and sands Pleistocene in age, and not Citronelle (Pliocene). However, in this study, the beds are called Citronelle, as are the gravels described in Tallahatchie County[34] at the edge of the delta 30 miles to the northwest.

The very existence of the gravel is of great importance for it proves the former eastward extent of the Citronelle formation which underlies the hills bordering the "Yazoo delta" to the west. Likewise, its presence at depths in the fault planes serves to date at least the final movements in the Kilmichael structure as post Citronelle, as late as Pliocene or even Pleistocene, depending on the age of the deposition of the gravel.

LOESS

Deposition during the Pleistocene is represented in Montgomery County by a thin mantle of loess which caps the higher hills to the west of U. S. Highway 51. The loess is thin, never exceeding 10 feet in auger holes, even on thickly wooded and well protected hilltops. In roadcuts, it is so leached and so mixed with colluvium that its original columnar structure has nearly disappeared. For convenience and for simplicity in presenting the geologic map (Map 2), it has been deemed wise to omit further reference to this inconsequential unit.

STRUCTURAL GEOLOGY

GENERAL

Structurally, northwest Mississippi lies within the great Mississippi embayment area, a now filled former arm of the Gulf of Mexico, which extended from the present Gulf Coast north as far as Cape Girardeau, Missouri. At times the bottom of this narrow seaway sank to accommodate several thousands of feet of sediments which were intermittently being deposited during the course of millions of years. Since the axis of this long depression rather closely parallels the present course of the Mississippi River, Montgomery County beds dip to the west, in keeping with the regional west dip in the northwest part of the state. Actually the normal dip in Montgomery County is southwest to west-southwest, and any departure from it was carefully noted during the course of this investigation, since a reverse dip would be suggestive of a structure favorable to the accumulation of oil or gas.

Although faults and inclined strata are common, the untested structures which can be reported with any degree of certainty are limited to the west one-third of the county, in the region where the Tallahatta-Winona and the Winona-Zilpha contact provide datum points, or in the Kilmichael structural area where nearly vertical faults displace whole stratigraphic units.

However, there are many unrelated and isolated areas of disturbed strata lacking key horizons from which their structural relations could be established. One of these areas is a mile to the west of Sweatman where faults involving clays in the Holly Springs formation are exposed at the cross roads (NE. 1/4, NE. 1/4, Sec. 6, T.20 N., R.7 E.), and another is several miles to the east along the Alva road (Secs. 33 and 34, T.21 N., R.7 E.). Other faults in beds of the same unit were observed on hillsides and in roadcuts 1 1/2 miles southwest of Huntsville (SE. 1/4, Sec. 17, T.17 N., R.8 E.) and in steep cuts 2 1/2 miles south of Huntsville (Secs. 28 and 29, T.17 N., R.8 E.).

WEST MONTGOMERY COUNTY STRUCTURES

The main structural elements of the west one-third of the county are shown on the structure map (Map 1) which is contoured at 100-foot intervals on the known or calculated elevations of the Winona-Zilpha contact. From north to south, they are:

1. A west nosing, the Duck Hill nose, whose axis extends west from a point a mile south of Duck Hill through Sections 9, 10, 11, and 12, T.20 N., R.5 E.
2. A west nosing, the Eskridge nose, whose axis extends west from a point one-half mile north of Eskridge through Sections 21, 22, 23, and 24, T.20 N., R.5 E.
3. A southwest nosing, the Fox nose, whose axis extends through Sections 1, 2, 3, and 9, T.19 N., R.6 E., northwest past the crossroads of that name.
4. A south nosing, the Sawyer nose, whose axis extends north-south through Sections 12, 13, and 24, T.19 N., R.5 E., from Sawyer toward Winona.
5. A southwest nosing whose axis extends through Sections 12, 14, and 22, T.19 N., R.6 E.
6. An irregular closure whose axis passes through Sections 3, 10, 9, and 8, T.18 N., R.6 E.
7. A syncline and longitudinal fault which extends northeast-southwest through Sections 17, 20, and 30, T.19 N., R.6 E., into

Section 36, T.19 N., R.5 E., and thence into Sections 2, 11, and 15, T.18 N., R.5 E., folowing the approximate course of Hays Creek. The structure separates nosings 3 and 4 to the northeast and 5 and 6 to the southwest.

The crest of the Duck Hill nose 1 has never been drilled for oil or gas, but the north flank was tested by the Henderson Oil Company-Columbian Mutual Life Insurance Company (400 feet from southeast corner, NW. 1/4, Sec. 36, T.21 N., R.5 E.) 1 1/2 miles northwest of Duck Hill. The hole was spudded in near the base of the Tallahatta formation July 5, 1940, and abandoned at 4458 feet January 26, 1941, after a few small shows. The drilling rig was then moved to the School land location near Fox.

Because of insufficient datum points, there is no indication of closure of noses 1, 2, and 5. But noses 3 and 4 show more promise, for, although they do not close up dip, they are situated advantageously on the down dip side of the probable Hays Creek fault. The Sawyer nose 4 appears to be a continuation of the Fox nose 3, and is partly separated from it by a branch syncline or fault which trends north from the Hays Creek structure 7.

The most favorable of the structures is element 6, for it has a probable closure of 20 to 30 feet. Although elevations of the rather unreliable Tallahatta-Winona contact were used in establishing vital northeast dip, the contacts show steep dips on the east, south, and north flanks. Yet it must be remembered that the closure is regionally situated on the up dip side of the Hays Creek structure, which, if faulted, would cut off migration of oil from the area immediately to the west.

The existence of the Hays Creek syncline is evidenced by comparative elevations of the Winona-Zilpha contact on the valley walls and by the steep dips observed in upper Winona and Zilpha beds on both valley walls, especially east and south of Winona. A longitudinal fault, breaching the syncline, is suggested by structurally high exposures of the Tallahatta-Winona contact along old Mississippi Highway 82 (SE. 1/4, NW. 1/4, NE. 1/4, Sec. 29, T.19 N., R.6 E.) 1 3/4 miles east of Winona, and by actual faulting involving Winona, Zilpha, and Kosciusko strata in the upper (northeast) end of the valley near Fox (Road fork, NE. 1/4, Sec. 17, T.19 N., R.6 E.), and a mile northeast of Fox (NE. 1/4, Sec. 10, T.19 N., R.6 E.).

Two oil tests have been drilled in or near this end of the syncline. The first, the Preston Oil Company-McLean (SW. 1/4, SE. 1/4, NE. 1/4, Sec. 15, T.19 N., R.6 E.), was drilled in late 1920 and early 1921, to a depth of 4260 feet after encountering several shows. The second, the Henderson Oil Company-School land, just west of Fox (441 feet north and 240 feet west of southeast corner, NE. 1/4, NW. 1/4, Sec. 16, T.19 N., R.6 E.) was abandoned at 3954 feet in July 1941, having had but poor shows. At this writing, the Henderson Oil Company is rumored to have made a new location just east of the old McLean test. The depths at which the more important beds were topped[36] in these holes and in the Henderson-Columbian and Gulf-Parker tests are tabulated below.

TABLE OF DEPTHS BELOW THE SURFACE AND BELOW SEA LEVEL OF THE TOPS OF IMPORTANT BEDS IN OIL TESTS

	Preston McLean	Henderson School	Henderson Columbian	Gulf Parker
Midway depth	1190	1115	900	
Midway elevation	-815	-681	-635	
Clayton depth		1775	1560	400
Clayton elevation		-1341	-1295	-6
Selma depth		1825	1620	450
Selma elevation		-1389	-1355	-56
Eutaw depth	2424	2580	2410	1263
Eutaw elevation	-2049	-2146	-2145	-869
Tuscaloosa depth	2714	2884	2650	1575
Tuscaloosa elevation	-2339	-2450	-2385	-1181
Lower Cret. depth	3460	3700	3180	
Lower Cret. elevation	-3085	-3266	-2915	
Paleozoic depth			4380	4424
Paleozoic elevation			-4115	-4030
Total depth	4260	3786	4458	5303

KILMICHAEL STRUCTURAL AREA

The Kilmichael structural area, which has been repeatedly referred to in this report, includes most of T.19 N., R.7 E., 2 to 8 miles north of the village of that name. Although the area is complicated by intense faulting and reverse dips, all of the numerous small disturbed areas are but a part of a single large structure 8 to 10 miles in diameter, centering near the common corners of Sections 22, 23, 26, and 27. This structure has a roughly circular outline; a central uplift exposing highly faulted beds of the Wilcox series and probably strata of the Midway series; and outside the uplift a sequence of marginal fault blocks consisting of first a graben, second a horst, and third a poorly defined succession of grabens and horsts involving successively younger beds. Bucher[36] describes six similar "crypto-volcanic" structures: The Wells Creek Basin, Stewart County, Tennessee; Serpent Mound, Adams County, Ohio; Jeptha Knobb, Shelby County, Kentucky; Kentland dome, Newton County, Indiana; Decaturville dome, Camden County, Missouri; and Upheaval dome, San Juan County, Utah.

Although faulting had long been noted southeast of the crest along the east-west road (SE. 1/4, Sec. 35) 3 miles northeast of Kilmichael, the structure was first detailed by Tom McGlothlin and his associates of the Gulf Refining Company in 1931 and 1932. Their surface observations were supplemented by core drilling and by seismograph work in late 1939 and early 1940, whereupon the Gulf-Parker oil test (528 feet north and 739 feet east of the southwest corner SE. 1/4, SW. 1/4, Sec. 22, T.19 N., R.7 E.) was drilled near the crest July to September 1940, to a depth of 5303 feet. Since the test encountered no shows of gas or oil, it is the opinion of many geologists, including the writer, that the location chosen was too near the crest and that any oil migrating updip from the axis of the embayment had been cut off by the marginal faults from the structurally higher areas. On the basis of field observations made in the course of this survey, a favorable site for a second test would be in Sections 18, 19, or 30, T.19 N., R.7 E., 3 to 4 miles west of the Gulf-Parker dry hole, downdip from the most western marginal faults noted.

However, the Gulf-Parker test confirmed the structure, for beneath gravels and upper Midway strata the Clayton, Selma, Eutaw, and Tuscaloosa formations were topped at the surprisingly shallow depths of 400, 450, 1263, and 1575 feet, respectively.[37] By projecting the normal dip across the crest of the structure and by adding the assumed thicknesses of the normally overlying strata, the central area has a calculated uplift of 800 to 1200 feet. Alternating Eutaw and Tuscaloosa strata at greater depths show that the faulting is deep seated. At the surface, marginal faults bounding tilted Wilcox fault-blocks are exposed at numerous places (Map 1) along the valley walls of Mulberry and Little Mulberry Creeks and in roadcuts (SE. 1/4, SW. 1/4, Sec. 21; NE. 1/4, NE. 1/4, Sec. 21; NW. 1/4, SE. 1/4, Sec. 17; SW. 1/4, NE. 1/4, Sec. 26; and SE. 1/4, NW. 1/4, Sec. 10) at higher elevations.

The southwest part of the first or graben area, the ring which immediately surrounds the central uplift, is much better developed than is the northeast part. This actual or seeming asymetry (Map 1) is due: to the component of regional west-southwest dip which provides for the exposure of thinner (younger) units on the west flank; to the scarcity of good outcrops in the northeast area; and to the confusing similarity of Holly Springs sands to the Tallahatta sands which have been down-dropped to form the inner graben ring on the east flank. In contrast, the full thicknesses of the Meridian, Tallahatta,

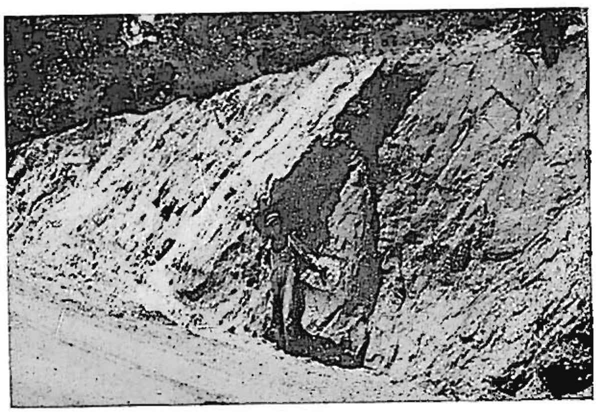

Figure 17.—Tilted Tallahatta sand and clay-shale in a roadcut 2 1/2 miles east-northeast of Kilmichael, SW. 1/4, SW. 1/4, SE. 1/4, Sec. 35, T.19 N., R.7 E. May 1941.

Winona, and Zilpha units and lower beds of the Kosciusko sand crop out in the west one-third of the ring. Some of the faults (Map 1) separating the first graben and the uplift have throws of considerable magnitude as indicated in roadcut exposures (Winona/Wilcox, north-south road, NW. 1/4, SE. 1/4, Sec. 9; Tallahatta/Wilcox, just west of the roadfork, Sec. 28; Tallahatta/Wilcox, east-west road, SE. 1/4, NE. 1/4, Sec. 9; and Tallahatta/Wilcox, east-west road SW. 1/4, Sec. 13). Faults within the graben ring are common in the southeast part of the area (Figures 17 and 18). Numerous other marginal faults of equal or greater throw are hidden in the broad valleys of Wolf, Little Mulberry, and Reed Creeks as evidenced by exposures of different units on opposite valley walls (Map 2). In contrast, the faults separating the graben ring from the surrounding horst generally show less throw than those which form the outer margin of the central uplift, for only Claiborne beds are involved (Tallahatta/Winona, north-south road, NE. 1/4, SE. 1/4, Sec. 8; and Tallahatta/Winona, east-west road, SE. 1/4, NW. 1/4, Sec. 9).

The horst area outside the graben is, at best, poorly developed, but it is recognized by several small areas of uplifted Wilcox beds surrounded by Tallahatta or Winona strata (SW. 1/4, Sec. 8; NW. 1/4, SE. 1/4, Sec. 19; SW. 1/4, Sec. 20; and NE. 1/4, Sec. 3, T.18 N., R.7 E.) on the west and south flanks of the structure. Extending fully 4 miles west of the horst are belts of slightly faulted gently

Figure 18.—Drag and fault plane, indicated by hand, in Tallahatta beds in a roadcut 3 1/4 miles east-northeast of Kilmichael, W. 1/2, NW. 1/4, SW. 1/4, Sec. 36, T.19 N., R.7 E. May 1941.

undulating Tallahatta and Lower Lisbon strata which are believed to constitute a succession of grabens and horsts of progressively diminishing intensity.

The last of the movements which produced the Kilmichael uplift is post-Citronelle, since Citronelle gravels cap the crest and have filtered down fault planes encountered in deep core holes.[35] Of course, actual dating depends on the age assigned to Citronelle deposition, whether Pliocene or Pleistocene. Probably several movements were involved in the uplift since the gravels have been found in a limited area, suggesting that they might have been deposited in a topographic low during a period of erosion following a previous upward movement. As far as known, the nature of the orogeny has not been determined, although the structure has certain characteristics of a "cryptovolcano." If gravimeter data were available, the presence or absence of a salt dome might be indicated. But a dome seems improbable, for the structure is too far up the flank of the embayment, and it is not known to be rooted in extensive salt beds.

ECONOMIC GEOLOGY

The only certain economic materials that were found in the course of this investigation are three types of clay and two types of building stone. Laboratory tests of the many samples collected may reveal other materials of importance, among them glauconite, possibly for use as a local source of potash and phosphate fertilizer.

CLAYS

The clays and some associated clayey silts selected as of probable economic value are plastic clays, carbonaceous clays, and blocky clays. They are discussed as to their relative importance, stratigraphic position, and areal distribution.

PLASTIC CLAYS

PLASTIC CLAYS OF THE UPPER HOLLY SPRINGS FORMATION

Both light and dark lenses of plastic clay interfinger with beds of clayey silt, nearly black carbonaceous and lignitic clays, and bluish or grayish-green silty clay to form division 7 of the Composite Section of the Holly Springs formation. The thicker plastic clays crop out in two widely separated areas: in the broad valley of the East Fork of Batupan Bogue in the northeast part of the county; and near Huntsville in the southeast part. In the Batupan area, the clays were penetrated in test holes L209 (C., NW. 1/4, SW. 1/4, Sec. 21, T.21 N., R.7 E.) and L124 (SW. 1/4, NW. 1/4, SW. 1/4, Sec. 34, T.21 N., R.7 E.). However, the best plastic clays are in and around Huntsville (Sec. 9, T.17 N., R.8 E.) where test holes L180 and L184 were drilled.

CARBONACEOUS CLAYS

CARBONACEOUS CLAYS OF THE LOWER AND UPPER HOLLY SPRINGS FORMATION

Equally thick lenses of carbonaceous clays crop out as parts of divisions 1 and 7 of the Composite Section of the Holly Springs formation. Accompanied by clay silts and lignitic silts, the clays of division 1 are exposed almost exclusively in the eastward extending panhandle comprising Sections 1 to 6, T.18 N., R.8 E. and were penetrated in test holes L242 (SW. 1/4, NE. 1/4, NW. 1/4, Sec. 1) and L239 (S. 1/2, SW. 1/4, SW. 1/4, Sec. 4). Those carbonaceous clays of division 7, near the top of the Holly Springs unit, are interbedded with silts, silty clays, and plastic clays. They crop out along the valley walls of the East Fork of Batupan Bogue in the northeast part of the county, along the Minerva-Lodi road in the east part, and on the valley walls of Poplar Creek in the southeast part. These clays are thickest on the north valley wall of Poplar Creek, in and near Huntsville (Sec. 9, T.17 N., R.8 E.). Here, test holes L180 and L184 show a combined thickness of 54.2 feet of dark plastic clays and carbonaceous clays beneath a hillside outcrop of similar materials 20 feet in thickness.

BLOCKY CLAYS

BLOCKY CLAYS OF THE TALLAHATTA FORMATION AND ZILPHA MEMBER OF THE LISBON FORMATION

Blocky clays, so named because of their characteristic fracture, comprise in places the whole continental part of the Zilpha member and constitute one to five thick lenses at varied horizons in the Tallahatta formation. Those of the Zilpha are readily seen in exposures along the roads in the west one-third of the county, north nearly to Duck Hill. The less silty phases were penetrated in L2 (N. 1/2, SE. 1/4, NW. 1/4, Sec. 29, T. 19 N., R.6 E.), 2 miles east of Winona, and in L20 (N. 1/2, SW. 1/4, NE. 1/4, Sec. 6, T.18 N., R.6 E.), 2 miles southeast of Winona. Lenses of Tallahatta blocky clay crop out at many places in a broad belt extending northwest-southeast across the center of the county, but they are thickest and most numerous in the region of sharp hills and valleys just east of Duck Hill. Unfortunately the lenses contain thin laminae of sand or micaceous silt so that hand-picking the samples is necessary. This means was used to obtain the outcrop materials tested as L67 (S. 1/2, NE. 1/4, NE. 1/4, Sec. 9, T.20 N., R.6 E.). Unsorted samples were collected from test hole L108 (S. 1/2, NE. 1/4, NE. 1/4, Sec. 27, T.21 N., R.6 E.) and from L209 (C., NW. 1/4, SW. 1/4, Sec. 21, T.21 N., R.7 E.).

BUILDING STONE

The two types of building stone recognized in the county as of economic value have been previously described as "buhrstone" in the discussion of the Tallahatta formation and as siltstone in the discussion of the Zilpha-Kosciusko contact. Both have been used locally for small stone buildings, for ornamental masonry, for chimneys, and for foundation stones.

ZILPHA-KOSCIUSKO SILTSTONE

The type associated with the Zilpha-Kosciusko contact is the more important because of its accessibility and its ease of quarrying. In the west one-half of Montgomery County and in adjacent parts of Carroll County, the Zilpha-Kosciusko contact is marked by one to five beds of buff to light-brown well-indurated siltstone. Where there is but one ledge, or several ledges separated by shale breaks, slabs 3 to 18 inches in thickness and 3 to 4 feet in length and width may be pried from their position and dressed on the spot. The upper and lower surfaces are smooth, usually parallel, and free of contamination from the Zilpha clays below, the Kosciusko sands above, or from the interbedded silts. The slabs thus exposed are of uniform hardness, as hard in newly exposed faces as on the crop, and as hard in their centers as on their surfaces. But despite its hardness, the rock is sufficiently brittle to be easily squared by well directed blows of a heavy hammer. Nor is its brittleness increased by heat, for slabs used in chimney construction do not split or appear to weather.

The community house in Winona has been partly constructed of this rock, obtained from the vicinity of Fox (Sec. 15, T.19 N., R.6 E.) where a hill of Winona sand is capped by a rubble of the siltstone, let down through the weathering of the underlying Zilpha clay. This rock type may be found at numerous exposures of the Zilpha-Kosciusko contact, as indicated on the geologic map (Map 2). Detailed descriptions of exposures suitable for quarrying are cited in the stratigraphic part of this report, under the title "Zilpha-Kosciusko contact."

TALLAHATTA "BUHRSTONES"

The second economic type of building stone, "buhrstone," is derived from the Tallahatta formation. It is found in durable ledges, but the ledges are rough, coarse textured, and of varying hardness, due to the inclusions of claystone and glauconitic silt in a matrix of resistant siliceous fine-grained to coarse-grained sandstone. When freshly quarried, the fragments are smooth, but they quickly roughen through differential weathering. This rock is hard to quarry, for it must be loosened along weathered joint cracks; and it is difficult to dress, for it is massive and fractures very irregularly. Its importance lies in that ledges in the east part of the county can serve that district since the more desirable Zilpha-Kosciusko siltstone is limited to the west part.

Buhrstone ledges are common near the base and the top of the Tallahatta formation. Detailed descriptions of exposures suitable for quarrying are cited in the stratigraphic part of this report, under the title "Tallahatta formation."

ROCKS OF DOUBTFUL IMPORTANCE

In the east part of the county, especially near Kilmichael, thin silty sandstone ledges have been quarried for road material, but experiment has shown that the rock is too soft to be durable. In fact, covered ledges were found much softer than crops, leading to the assumption that these rocks are actually semi-indurated bodies of silty sand which owe their degree of induration to weathering.

The same discouraging view should be taken toward the masses of soft ferruginous sandstone which mark old exposures of the upper glauconitic Winona sand in the west one-half of the county. Similarly, the rough cross-bedded sandstones which cap Duck Hill "Mountain" are only local evidences of the same weathering action over a longer interval of time.

GLAUCONITE

As intimated, glauconite, a minor constituent of the upper Winona sands, may prove of worth as a source of a potash fertilizer. Analyses of the samples submitted indicate that the glauconitic sand has possibilities for such use. Portions of the greener less weathered more glauconitic material can, accordingly, be applied directly to the fields. The characteristics and distribution of these beds are discussed in the stratigraphic part of this report, as the upper one-third of the "Winona member."

TEST HOLE RECORDS

W. M. Hull Property

Test Hole Record L1

Location: T.19 N., R.5 E., Sec. 23, SE. 1/4, NW. 1/4, SW. 1/4; on southeast side of road, 100 feet northeast of road fork Drilled: February 19, 1941
Elevation: Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	6.8	6.8	Soil—sand, silty buff-pink
			Kosciusko member
2	10.1	3.3	Sand, fine to medium-grained buff to tan
3	12.0	1.9	Sand, fine to medium-grained buff-red mottled; contains small quartz gravel
4	13.9	1.9	Sand, medium-grained reddish-brown; contains small quartz gravel
5	22.1	8.2	Sand, fine to medium-grained salmon-pink
6	29.2	7.1	Sand, fine to medium-grained reddish-brown slightly micaceous
7	43.4	14.2	Sand, medium-grained reddish-tan; contains small quartz gravel
8	44.4	1.0	Sandstone, fine-grained dark-brown limonitic
9	46.7	2.3	Sand, fine to medium-grained brownish-tan very slightly micaceous
10	54.1	7.4	Sand, medium-grained light-buff

W. H. Mortimer Property

Test Hole Record L2

Location: T.19 N., R.6 E., Sec. 29, N. 1/2, SE. 1/4, NW. 1/4; atop hill, 70 feet north of U. S. Highway 82, 275 feet east of road fork

Drilled: June 22, 1941

Elevation:

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	4.2	4.2	Soil—silt, clayey gray-buff; admixture of loess
			Upper (continental) Zilpha
2	4.9	0.7	Silt, clayey light-gray buff mottled; nodules of white caliche in joints
3	7.9	3.0	Clay, slightly silty grayish-tan yellow mottled
4	11.2	3.3	Clay, slightly silty grayish-tan waxy
5	16.8	5.6	Clay, silty gray-buff
6	17.6	0.8	Silt, fairly clayey yellow ochreous
7	21.3	3.7	Silt, very fine buff-tan
8	23.7	2.4	Clay, slightly silty tan and gray mottled; micaceous partings
9	27.0	3.3	Clay, slightly silty light-brown; micaceous partings
10	29.0	2.0	Silt, clayey buff-tan
			Winona member
11	41.2	12.2	Sand, medium to coarse-grained greenish-buff; very glauconitic silty layers

WALTER WITTY EST. PROPERTY

TEST HOLE RECORD L3

Location: T.19 N., R.6 E., Sec. 30, S. 1/2, NE. 1/4, NE. 1/4; 100 feet north of old U. S. Highway 82, above roadcut showing Tallahatta-Winona contact

Drilled: January 22, 1941

Elevation: 403 feet

Water level: 22 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	6.3	6.3	Soil—sand, medium-grained yelowish-tan
			Winona member
2	9.7	3.4	Sand, fine-grained bright red micaceous; thin laminae of yellowish-gray silty clay
3	12.2	2.5	Sand, fine-grained yellowish-brown slightly micaceous
4	15.7	3.5	Sand, medium-grained salmon-pink fairly micaceous
5	26.8	11.1	Sand, silty yellowish-buff
			Tallahatta formation
6	44.3	17.5	Sand, silty greenish-black very micaceous very lignitic; tiny greenish-black clay fragments which may be weathered glauconite
7	48.9	4.6	Clay-shale, dark-gray fairly micaceous; laminae of medium-grained dark gray sand
8	66.8	17.9	Sand, medium to coarse-grained greenish-black lignitic; laminae of fine white sand

WILL HOLMES PROPERTY

TEST HOLE RECORD L5

Location: T.19 N., R.6 E., Sec. 29, S. 1/2, NW. 1/4, NW. 1/4; in road fork of new and old U. S. Highway 82 Drilled: January 27, 1941

Elevation: 460 feet Water level: 21 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Winona member
1	7.6	7.6	Sand, medium to coarse-grained dark-red; several thin ferruginous sandstone ledges; pockets of weathered claystone
2	16.0	8.4	Sand, medium-grained dark-greenish-brown glauconitic
3	21.6	5.6	Sand, medium to coarse-grained light-greenish-brown slightly glauconitic; pockets of weathered claystone
4	22.0	0.4	Sand, medium to coarse-grained buff
5	23.0	1.0	Clay, slightly silty light-gray yellow mottled
6	26.6	3.6	Sand, medium to coarse-grained gray buff
7	44.6	18.0	Sand, medium-grained gray-buff yellow mottled

H. H. Kent Property

Test Hole Record L10

Location: T.19 N., R.6 E., Sec. 26, W. 1/2, SW. 1/4, SE. 1/4; below buhrstone ledge, 15 feet east of road
Drilled: January 30, 1941

Elevation: 412 feet
Water level: 13.5 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Tallahatta formation
1	0.8	0.8	Buhrstone, fine-grained white-yellow mottled; embedded fragments of light-gray claystone
2	7.0	6.2	Sand, fine to medium-grained yellowish-brown; very large flakes of mica
3	9.2	2.2	Sand, silty buff-yellow mottled fairly micaceous
4	11.0	1.8	Sand, fine-grained white; large flakes of mica
5	14.9	3.9	Sand, fine-grained light-yellow fairly micaceous
6	15.1	0.2	Claystone, limonitic bright-yellow
7	16.5	1.4	Sand, fine-grained buff-yellow mottled; large flakes of mica
8	18.6	2.1	Clay, dark-gray; laminae of yellowish-brown limonitic claystone
9	27.3	8.7	Sand, fine to medium-grained white-buff mottled; large flakes of mica
10	32.0	4.7	Clay, slightly silty yellowish-tan

C. E. THOMPSON PROPERTY

TEST HOLE RECORD L20

Location: T.18 N., R.6 E., Sec. 6, N. 1/2, SW. 1/4, NE. 1/4; in abandoned road bed 50 feet southeast of road fork at outcrop of limonitic siltstone

Drilled: February 5, 1941

Elevation: 455 feet

Water level: 33 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Kosciusko member
1	0.3	0.3	Claystone, yellowish-brown limonitic (marks unconformity)
			Upper (continental) Zilpha
2	2.8	2.5	Silt, buff-red mottled
3	6.0	3.2	Silt, grayish-white
4	14.3	8.3	Clay, fairly silty light-tan; yellow mottled along sandy laminae
5	16.0	1.7	Clay, slightly silty grayish-tan yellow mottled selenitic
6	18.1	2.1	Clay, slightly silty grayish-tan
7	23.9	5.8	Clay, slightly silty dark-gray very selenitic
8	32.0	8.1	Silt, clayey dark-greenish-gray; P8
			Lower (marine) Zilpha
9	33.1	1.1	Clay, slightly silty tan selenitic; glauconitic at base
			Winona member
10	38.6	5.5	Sand, clayey yellowish-brown; flecks of green glauconite

LOWE WHITEHEAD PROPERTY

TEST HOLE RECORD L22

Location: T.19 N., R.5 E., Sec. 30, NE. 1/4, NW. 1/4, NW. 1/4 (Carroll County); beneath big pine above clay cut, south side of U. S. Highway 82

Drilled: February 15, 1941

Elevation: 361 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.0	3.0	Soil—silt, clayey buff
			Upper (continental) Zilpha
2	5.4	2.4	Clay, silty, yellowish-gray weathered
3	10.1	4.7	Clay, fairly silty light-gray; P3
4	13.1	3.0	Clay, fairly silty light-gray; yellow limonitic stains along laminae
5	18.3	5.2	Silt, grayish-white
6	22.0	3.7	Silt, clayey gray-yellow stained; thin breaks of limonitic sandstone
7	22.8	0.8	Sand, fine-grained buff fairly micaceous
8	28.6	5.8	Clay, fairly silty light-gray yellow mottled
9	28.9	0.3	Silt, sandy grayish-white
10	30.9	2.0	Clay, fairly silty grayish-tan
11	36.6	5.7	Clay, fairly silty dark-gray; dries light-greenish-gray
			Lower (marine) Zilpha
12	39.0	2.4	Clay, fairly silty greenish-gray; contains large very glauconitic gray claystone nodules and glauconite as bedded sand
			Winona member
13	43.2	4.2	Silt, slightly clayey dark-grayish-green slightly glauconitic; large and small non-glauconitic claystones

T. F. McCormick Property

Test Hole Record L25

Location: T.19 N., R.4 E., Sec. 24, SW. 1/4, SE. 1/4, SE. 1/4, (Carroll County); beneath persimmon tree atop clay cut, 25 feet south of U. S. Highway 82

Drilled: February 17, 1941

Elevation: 372 feet

Water level: 48 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	8.9	8.9	Soil—clay, silty; weathered
			Upper (continental) Zilpha
2	12.0	3.1	Clay, slightly silty light-gray
3	24.8	12.8	Clay, fairly silty light-tannish-gray; P3
4	25.6	0.8	Clay, silty light-gray yellow stained; thin breaks of limonitic claystone
5	38.6	13.0	Clay, slightly silty grayish-tan; P5
6	42.7	4.1	Clay, slightly silty very dark-gray
7	42.9	0.2	Clay, silty yellow ochreous; thin breaks of yellowish-brown limonite along laminae
8	44.7	1.8	Clay, slightly silty dark-tannish-gray; pyritiferous
9	46.1	1.4	Clay, silty light-gray; laminae of fine-grained buff sand
10	48.3	2.2	Clay, fairly silty dark-gray; dries medium gray
11	54.1	5.8	Sand, slightly light-gray slightly micaceous

J. W. Dunlap Property

Test Hole Record L30

Location: T.19 N., R.5 E., Sec. 14, SE. 1/4, SE. 1/4, SE. 1/4; 35 feet west of old U. S. Highway 51 and 15 feet north of driveway leading to homesite

Drilled: February 21, 1941

Elevation: 430 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Upper (continental) Zilpha
1	7.2	7.2	Clay, silty buff-tan yellow mottled; P1
2	14.0	6.8	Clay, slightly silty light-tan yellow mottled; P2
3	18.3	4.3	Clay, slightly silty chocolate-tan yellow mottled; P3
4	24.8	6.5	Clay, silty light-tan; P4
			Winona member
5	28.4	3.6	Sand, clayey greenish-brown slightly glauconitic

P. J. HIGHTOWER PROPERTY

TEST HOLE RECORD L32

Location: T.19 N., R.5 E., Sec. 11, C., SE. 1/4, SE. 1/4; on hill above and to the west of road cut of old U. S. Highway 51 Drilled: February 26, 1941

Elevation: 454 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	5.9	5.9	Soil—silt, clayey light-buff
			Kosciusko member
2	7.7	1.8	Silt, sandy reddish-brown
3	10.0	2.3	Silt, yellowish-brown; thin breaks of limonitic claystone (marks unconformity)
			Upper (continental) Zilpha
4	11.9	1.9	Clay, silty buff-yellow and brown mottled
5	17.3	5.4	Clay, silty grayish-white red mottled; P5
6	22.0	4.7	Clay, slightly silty alternately gray and light-tan; P6
7	33.9	11.9	Clay, very slightly dark-gray; dries medium-gray; P7
8	35.8	1.9	Clay, slightly silty chocolate-brown; dries tan; P8

CHARLES GRANT PROPERTY

TEST HOLE RECORD L67

Location: T.20 N., R.6 E., Sec. 9, S. 1/2, NE. 1/4, NE. 1/4; beneath small pine, top of shale cut, southwest side of road, 300 feet south of farm home, 0.4 mile southeast of road fork
Drilled: April 2, 1941

Elevation: 322 feet
Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	2.1	2.1	Soil—silt, clayey gray-buff
			Tallahatta formation
2	4.9	2.8	Clay-shale, very slightly silty gray-tan; partings of fine white sand; P2
3	5.3	0.4	Sand, silty white-buff mottled
4	8.4	3.1	Clay-shale, slightly silty tan; fine-grained white sand in partings and joint cracks; P4
5	8.7	0.3	Sand, silty semi-indurated buff-yellow and red mottled
6	12.9	4.2	Clay-shale, chocolate-brown; dries gray-tan; fine-grained buff sand in jointing; P6
7	13.4	0.5	Siltstone, sandy gray-buff nodular
8	16.8	3.4	Clay-shale, chocolate-brown; dries tan; fine-grained white sand in jointing; P8
9	17.9	1.1	Clay-shale, silty gray-tan

MRS. MATTHEW BRITT PROPERTY

TEST HOLE RECORD L68

Location: T.20 N., R.6 E., Sec. 10, E. 1/2, NE. 1/4, SW. 1/4; at base of sand cut, southwest side of road, 0.1 mile northeast of road fork

Drilled: April 15, 1941

Elevation: 345 feet
Water level: 22.4 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	3.8	3.8	Soil—sand, silty yellowish-brown
			Tallahatta formation
2	10.4	6.6	Sand, fine to medium-grained buff; numerous large flakes of mica
3	15.6	5.2	Silt, clayey buff-tan; thin laminae of gray-tan clay-shale
4	18.4	2.8	Clay-shale, silty medium-gray micaceous laminae
5	22.4	4.0	Clay-shale, silty dark-gray; micaceous laminae
			Meridian formation
6	31.7	9.3	Sand, medium to coarse-grained light-buff

MRS. TOM TOWNSEND PROPERTY

TEST HOLE RECORD L72

Location: T.19 N., R.7 E., Sec. 33, SW. 1/4, NE. 1/4, NW. 1/4; on west side of road, atop roadcut showing north dipping beds, 500 feet north of creek, 100 feet south of farm home Drilled: March 17, 1940

Elevation: 368 feet Water level: 12 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	4.2	4.2	Soil—clay, silty yellow-buff
			Kosciusko formation
2	5.0	0.8	Siltstone, limonitic reddish-black (base of Kosciusko)
			Zilpha member
3	7.9	2.9	Clay, fairly silty buff slightly micaceous
4	12.6	4.7	Clay, slightly silty gray-tan
5	13.4	0.8	Clay, silty brownish-buff yellow mottled
			Winona member
6	15.9	2.5	Silt, sandy greenish-buff fairly glauconitic; thin breaks of yellowish-brown limonitic sandstone
7	24.9	9.0	Sand, silty greenish-black glauconitic; weathered
8	27.3	2.4	Sand, fine to medium-grained light-buff
9	29.9	2.6	Sand, fine-grained greenish-black fairly glauconitic
10	37.5	7.6	Clay, slightly silty dark-buff

Allen Perry Property

Test Hole Record L75

Location: T.19 N., R.7 E., Sec. 21, C. NE. 1/4, NE. 1/4; on east side of road, beneath large pine, 506 feet northeast of farm home

Drilled: March 20, 1941

Elevation: 420 feet

Water level: 44 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	2.1	2.1	Soil—clay, sandy yellow-buff
			Holly Springs formation
2	2.9	0.8	Silt, sandy gray-buff mottled slightly micaceous
3	3.9	1.0	Sand, silty reddish-buff
4	6.3	2.4	Clay, silty gray-buff; laminae of dark-buff sandy silt
5	8.9	2.6	Clay-shale, silty gray slightly micaceous
6	15.9	7.0	Silt, slightly clayey gray-buff
7	19.5	3.6	Sand, silty gray-buff
8	22.9	3.4	Silt, slightly clayey grayish-white
9	31.4	8.5	Sand, silty gray-buff
10	33.2	1.8	Silt, sandy greenish-buff
11	38.7	5.5	Silt, sandy light-greenish-gray
12	40.7	2.0	Silt, yellowish-buff mottled
13	51.7	11.0	Silt, light-greenish-gray
14	52.9	1.2	Silt, slightly sandy yellowish-buff red mottled
15	55.2	2.3	Silt, slightly sandy light-greenish-gray buff mottled

S. M. Parker Property

Test Hole Record L85

Location: T.21 N., R.7 E., Sec. 36, SW. 1/4, SW. 1/4, NW. 1/4; in outcrop of black clay, north road ditch, 75 feet west of creek bridge

Drilled: June 23, 1941

Elevation: 305 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	5.4	5.4	Soil—clay-shale, light-buff yellow mottled
			Holly Springs formation
2	10.9	5.5	Silt, gray-white
3	12.4	1.5	Silt, clayey gray-blue
4	15.3	2.9	Clay, slightly silty grayish-black; P4
5	19.8	4.5	Clay, slightly silty blue-gray; P5
6	23.6	3.8	Clay, slightly silty very dark-gray; P6
7	31.0	7.4	Silt, fairly clayey blue-gray

Pleassie Seale Property

Test Hole Record L100

Location: T.19 N., R.7 E., Sec. 28, W. 1/2, SE. 1/4, NW. 1/4; north side of road, 300 feet east of farm home, above bed of gravel in road cut

Drilled: March 20, 1941

Elevation: 399 feet

Water level: 14 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	5.8	5.8	Soil—silt, sandy buff-red mottled slightly micaceous
			Porters Creek formation
2	8.9	3.1	Clay, slightly silty gray-tan and buff mottled waxy; bentonitic (?)
3	13.7	4.8	Silt, clayey white-gray and tan mottled
4	17.9	4.2	Clay, silty gray-buff to light-brown; conchoidal fracture
5	19.4	1.5	Clay, slightly silty brownish-black white flecked
6	20.9	1.5	Silt, clayey brownish-black; conchoidal fracture
7	26.2	5.3	Clay, slightly silty very dark-gray
8	42.4	16.2	Silt, clayey gray and black mottled

Caleb Townsend Property

Test Hole Record L101

Location: T.19 N., R.7 E., Sec. 20, NE. 1/4, NW. 1/4, NE. 1/4; on east side of road beneath large pine

Drilled: March 20, 1941

Elevation: 440 feet

Water level: 49 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Holly Springs formation
1	16.9	16.9	Sand, fine to medium-grained salmon-pink
2	23.7	6.8	Sand, fine-grained flesh-pink
3	26.9	3.2	Sand, very fine-grained flesh-pink slightly micaceous
4	27.3	0.4	Sand, fine-grained pinkish-white
5	32.4	5.1	Sand, fine-grained cream-colored
6	40.8	8.4	Sand, fine-grained slightly silty buff-pink slightly micaceous
7	49.2	8.4	Sand, fine-grained white salmon-pink mottled
8	50.2	1.0	Sand, fine-grained flesh-colored

C. A. Townsend Property

Test Hole Record L102

Location: T.19 N., R.7 E., Sec. 9, NW. 1/4, SW. 1/4, NW. 1/4; north side of road, 75 feet east of small stream, 800 feet east of Minerva road fork

Drilled: April 4, 1941

Elevation: 402 feet Water level: 4 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	7.6	7.6	Soil—clay, sandy light-gray yellowish-brown mottled
			Tallahatta formation
2	25.8	18.2	Sand, fine-grained medium-gray fairly micaceous
			Meridian formation
3	33.6	7.8	Sand, fine-grained dark-gray slightly micaceous; thin laminae of gray silty clay; a few coarse quartz sand grains
			Holly Springs formation
4	35.6	2.0	Clay, silty greenish-black; dries dark-gray
5	65.1	29.5	Clay, slightly silty dark-gray
6	79.6	14.5	Clay, slightly silty medium-gray; dries light-gray
7	97.6	18.0	Clay, silty dark-gray; dries medium-gray
8	100.7	3.1	Silt, sandy light-buff; laminae of medium-gray silty clay
9	106.9	6.2	Clay, fairly silty medium-gray; dries light-gray
10	114.6	7.7	Silt, clayey medium-gray lignitic
11	123.6	9.0	Clay, fairly silty medium-gray

Remarks: Artesian flow at 123.6.

Deepest hole drilled in Montgomery County.

EUBI RUSSELL PROPERTY

TEST HOLE RECORD L106

Location: T.19 N., R.7 E., Sec. 9, W. 1/2, SW. 1/4, NE. 1/4; beneath large pine, southwest side of road, 400 feet northwest of road fork

Drilled: March 26, 1941

Elevation: 461 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.3	3.3	Soil—clay, sandy brownish-red
			Holly Springs formation
2	6.2	2.9	Silt, clayey yellowish-brown red mottled
3	7.1	0.9	Sand, silty salmon-yellow
4	7.3	0.2	Sandstone, coarse-grained reddish-black ferruginous
5	8.3	1.0	Sand, fine-grained salmon-yellow
6	9.7	1.4	Clay, fairly silty white-buff and yellow mottled
7	11.3	1.6	Clay-shale, silty gray-white yellow mottled; micaceous laminae
8	14.1	2.8	Sand, fine to coarse-grained buff-yellow and red mottled
9	18.5	4.4	Sand, fine to coarse-grained, mulberry-red slightly micaceous
10	25.4	6.9	Sand, silty buff slightly micaceous
11	25.5	0.1	Sandstone, fine-grained reddish-brown ferruginous
12	29.7	4.2	Sand, silty salmon-red
13	31.9	2.2	Sand, silty mulberry-red
14	33.6	1.7	Sand, fine to medium-grained reddish-yellow; a few very irregular coarse sand grains
15	35.9	2.3	Sand, silty orchid-colored
16	37.6	1.7	Silt, sandy cream-colored slightly micaceous
17	37.7	0.1	Sandstone, fine-grained yellowish-brown ferruginous
18	39.9	2.2	Silt, sandy grayish-yellow; clayey laminae
19	40.2	0.3	Sand, fine-grained salmon-pink slightly micaceous
20	42.1	1.9	Sand, fine-grained light-buff fairly micaceous
21	43.2	1.1	Sand, silty buff-tan
22	47.6	4.4	Sand, slightly silty brownish-yellow slightly micaceous
23	64.9	17.3	Sand, fine-grained salmon-red
24	66.0	1.1	Clay-shale, gray-white; laminae of buff silty sand
25	72.5	6.5	Sand, fine-grained flesh-pink slightly micaceous
26	79.7	7.2	Sand, fine-grained red-buff fairly micaceous

DR. J. P. SYNNOTT PROPERTY

TEST HOLE RECORD L107

Location: T.19 N., R.7 E., Sec. 3, NE. 1/4, SE. 1/4, NE. 1/4; on north side of road beneath large tree, above road cut showing clay

Drilled: March 14, 1941

Elevation: 405 feet

Water level: 7 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	3.7	3.7	Soil—clay, sandy yellowish-red
			Holly Springs formation (?)
2	4.7	1.0	Clay, slightly silty gray-red mottled
3	7.9	3.2	Clay, slightly silty medium-gray; dries light-gray
4	8.2	0.3	Clay, fairly silty grayish-white yellow mottled
5	13.2	5.0	Silt, slightly clayey light-greenish-gray
6	13.9	0.7	Silt, grayish-yellow
7	16.3	2.4	Silt, slightly clayey greenish-buff red mottled
8	17.5	1.2	Silt, light-greenish-gray thinly laminated slightly micaceous
9	22.4	4.9	Silt, clayey medium-gray
10	23.3	0.9	Silt, slightly clayey gray-tan red mottled
11	24.2	0.9	Sand, fine-grained semi-indurated yellowish-brown
12	38.6	14.4	Silt, sandy light-greenish-gray
13	41.3	2.7	Silt, clayey grayish-brown

MISS LILLIE DALE PROPERTY

TEST HOLE RECORD L108

Location: T.21 N., R.6 E., Sec. 27, S. 1/2, NE. 1/4, NE. 1/4; north side road atop clay-shale outcrop, 250 feet west of Dale home

Drilled: April 17, 1941

Elevation: 317 feet

Water level: 35 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	4.9	4.9	Soil—sand, silty brick-red
			Tallahatta formation
2	5.6	0.7	Clay-shale, slightly silty dirty-white buff mottled
3	9.9	4.3	Clay-shale, slightly silty light-tan; micaceous laminae
4	12.9	3.0	Clay-shale, slightly silty brownish-black; P4
5	20.8	7.9	Clay-shale, slightly silty dark-gray; P5
			Meridian formation
6	35.0	14.2	Sand, fine to medium-grained; stained gray-tan by water from above; a few large sand grains

Caleb Townsend Property

Test Hole Record L110

Location: T.19 N., R.7 E., Sec. 20, SW. 1/4, NE. 1/4, SE. 1/4; southwest bank of small creek exposing white clay, 400 feet southwest of farm home

Drilled: March 26, 1941

Elevation: 390 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	2.3	2.3	Soil—clay, sandy reddish-brown
			Holly Springs formation (?)
2	4.1	1.8	Clay, fairly silty; grayish-white red mottled
3	6.6	2.5	Clay, silty grayish-white
4	16.6	10.0	Silt, slightly clayey grayish-tan slightly micaceous
5	20.7	4.1	Silt, slightly clayey grayish-white yellow mottled
6	23.5	2.8	Silt, slightly clayey grayish-tan
7	38.3	4.8	Silt, slightly clayey greenish-gray
8	50.2	11.9	Silt, sandy greenish-gray

J. A. Dunn Property

Test Hole Record L124

Location: T.21 N., R.7 E., Sec. 34, SW. 1/4, NW. 1/4, SW. 1/4; 25 feet north of road, 300 feet west of farm home Drilled: March 12, 1941

Elevation: 411 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	5.6	5.6	Soil—silt, clayey yellow-buff
			Holly Springs formation
2	8.6	3.0	Sand, silty buff to tan
3	10.2	1.6	Clay, silty yellow-buff
4	13.9	3.7	Clay, slightly silty gray-white buff and red mottled; P4
5	16.9	3.0	Silt, clayey white pink mottled
6	18.3	1.4	Sand, silty salmon-pink
7	25.6	7.3	Silt, clayey cream-colored
8	34.6	9.0	Silt, clayey medium-gray; dries light-gray; P8
9	40.2	5.6	Silt, clayey dark-gray; dries medium-gray
10	44.9	4.7	Silt, sandy red-buff; tan clay laminae
11	45.8	0.9	Silt, clayey dark-gray; dries medium-gray

ANDREW OLIVER PROPERTY

TEST HOLE RECORD L133

Location: T.20 N., R.7 E., Sec. 6, S. 1/2, NE. 1/4, NE. 1/4; beneath large post oak, west side of road, 575 feet south of road intersection

Drilled: April 22, 1941

Elevation: 362 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	6.0	6.0	Soil—clay, silty yellowish-brown
			Holly Springs formation
2	10.4	4.4	Clay, slightly silty light-gray yellow and red mottled; P2
3	11.8	1.4	Clay, slightly silty grayish-white yellow and red mottled
4	18.5	6.7	Silt, sandy grayish-white buff mottled
5	24.5	6.0	Clay, fairly silty yellow-buff
6	25.6	1.1	Clay, slightly silty brownish-black very lignitic waxy; peculiar red mottling; P6
7	28.3	2.7	Clay, fairly silty chocolate-brown very lignitic slightly micaceous; P7
8	33.4	5.1	Silt, fairly clayey medium-gray; dries light-gray
9	36.5	3.1	Silt, slightly clayey gray-buff
10	48.2	11.7	Silt, fairly clayey medium-gray; dries light-gray
11	50.4	2.2	Silt, slightly clayey gray-buff
12	58.9	8.5	Silt, sandy greenish-gray

L. C. RAY PROPERTY

TEST HOLE RECORD L178

Location: T.17 N., R.8 E., Sec. 20, NE. 1/4, NW. 1/4, SW. 1/4; beneath tall pine southeast side of road, above clay outcrop, 0.15 mile northeast of road fork

Drilled: May 15, 1941

Elevation: 395 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	2.5	2.5	Soil—clay, slightly silty gray-buff
			Holly Springs formation
2	9.3	6.8	Clay, slightly silty light-gray gray-tan mottled; P2
3	12.4	3.1	Clay, slightly silty cream-colored; P3
4	27.4	15.0	Clay, slightly silty gray-white red mottled; P4
5	29.3	1.9	Clay, fairly silty dark-gray slightly lignitic slightly micaceous; P5
6	35.6	6.3	Clay, fairly silty light-gray slightly lignitic; P6

MRS. C. D. WHITE PROPERTY

TEST HOLE RECORD L180

Location: T.17 N., R.8 E., Sec. 9, NW. 1/4, NW. 1/4, SE. 1/4; beneath post oak above clay outcrop 60 feet north of road, 0.1 mile west of Huntsville

Drilled: May 15, 1941

Elevation: 420 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.4	3.4	Soil—clay, slightly silty gray-buff yellow mottled
			Holly Springs formation
2	4.1	0.7	Silt, slightly clayey gray-buff
3	8.9	4.8	Clay, fairly silty yellow-buff
4	10.3	1.4	Silt, clayey gray-white; light and fluffy texture; P4
5	12.4	2.1	Clay, slightly silty gray-white fairly plastic; P5
6	14.7	2.3	Silt, bright-yellow ochreous
7	16.5	1.8	Clay, slightly silty gray-tan dark-gray mottled; P7
8	18.8	2.3	Clay, slightly silty white; P8
9	21.5	2.7	Clay, silty medium-gray; dries light-gray; P9
10	22.9	1.4	Silt, clayey gray-white
11	24.2	1.3	Silt, white
12	29.2	5.0	Silt, clayey gray-buff; dries light-gray
13	31.4	2.2	Clay, fairly silty yellow-buff
14	36.7	5.3	Clay, very slightly silty brownish-black carbonaceous; P14
15	41.9	5.2	Clay, very slightly silty very dark-gray; P15
16	44.3	2.4	Clay, fairly silty medium-gray; dries light-gray; P16
17	45.9	1.6	Clay, slightly silty dark-gray carbonaceous

J. S. Sullivan Property

Test Hole Record L182

Location: T.18 N., R.5 E., Sec. 15, N. 1/2, NW. 1/4, NW. 1/4; beneath pine, north side of road, top of hill above creek bottom Drilled: June 19, 1941

Elevation: 381 feet Water level: 19 feet

No	Depth	Thick.	Description of strata and designations of samples
1	4.6	4.6	Soil—clay, slightly silty brownish-buff
			Upper (continental) Zilpha
2	6.4	1.8	Clay, silty reddish-brown red mottled
3	11.3	4.9	Clay-shale, slightly silty tan red mottled; P3
4	15.5	4.2	Clay-shale, slightly silty brown; laminae of red-buff; slightly clayey silt; P4
			Winona member
5	19.3	3.8	Sand, fine to medium-grained greenish-buff fairly glauconitic
6	23.2	3.9	Sand, clayey brownish-buff slightly glauconitic; glauconite grains are very coarse

H. C. Aust Property

Test Hole Record L184

Location: T.17 N., R.8 E., Sec. 9, E. 1/2, NW. 1/4, SE. 1/4; beneath large oak, east corner of road fork, opposite store at Huntsville

Drilled: May 15, 1941

Elevation: 407 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	1.4	1.4	Soil—clay, silty gray-tan
			Holly Springs formation
2	4.0	2.6	Clay, silty gray-buff; P2
3	7.1	3.1	Clay, fairly silty gray red mottled; much gypsum
4	14.6	7.5	Silt, fairly clayey gray-buff and yellow mottled
5	17.0	2.4	Silt, slightly clayey gray-buff
6	20.4	3.4	Clay, fairly silty gray-tan
7	26.6	6.2	Clay, slightly silty gray-black slightly micaceous; P7
8	33.7	7.1	Silt, slightly clayey gray; several layers of pyritiferous fine-grained sandstone near base

J. E. LANE PROPERTY

TEST HOLE RECORD L185

Location: T.17 N., R.8 E., Sec. 17, SW. 1/4, NW. 1/4, NE. 1/4; at log stable, north side of road, 0.4 mile northwest of road fork Drilled: May 19, 1941

Elevation: 400 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.6	3.6	Soil—silt, clayey yellow-buff
			Tallahatta formation
2	6.4	2.8	Sand, clayey yellowish-red
3	8.5	2.1	Clay-shale, silty gray-tan red mottled micaceous; P3
4	13.6	5.1	Clay, slightly silty light-gray bright-yellow mottled ochreous; a few sand grains
			Holly Springs formation
5	17.6	4.0	Clay, slightly silty light-gray yellow mottled; P5
6	20.2	2.6	Clay slightly silty dark-gray red mottled; some selenite; P6
7	23.3	3.1	Clay, fairly silty bright-grayish-green; P7
8	26.3	3.0	Clay, silty blue-gray; P8
9	31.6	5.3	Silt, clayey blue-gray
10	38.7	7.1	Clay, silty light-bluish-green; dries gray-green; P10
11	39.4	0.7	Clay, slightly silty grayish-green
12	41.2	1.8	Clay, slightly silty dark-gray fairly plastic

J. E. LANE PROPERTY

TEST HOLE RECORD L186

Location: T.17 N., R.8 E., Sec. 17, SE. 1/4, NE. 1/4, NW. 1/4; beneath large pine, north side of road, in yard of farm home, 0.5 mile northwest of road fork Drilled: May 19, 1941

Elevation: 370 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.0	3.0	Soil—clay, silty gray-buff
			Holly Springs formation
2	6.4	3.4	Clay, very slightly silty dark-gray red mottled; P2
3	10.3	3.9	Clay, slightly silty light-gray fairly plastic; P3
4	21.6	11.3	Clay, very slightly silty dark-gray; P4
5	25.8	4.2	Clay, slightly silty very lignitic very carbonaceous; alternate dark-brown and black laminae; P5
6	39.3	13.5	Clay, slightly silty blue-gray fairly plastic; P6

Harry Summers Property

Test Hole Record L191

Location: T.18 N., R.8 E., Sec. 20, SE. 1/4, SE. 1/4, SW. 1/4; beneath pine, northeast side of road, 0.3 mile northwest of road fork

Drilled: May 21, 1941

Elevation: 382 feet — Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	4.6	4.6	Soil—silt, clayey light-buff
			Holly Springs formation
2	8.1	3.5	Silt, fairly clayey gray-white red mottled slightly micaceous
3	14.8	6.7	Silt, slightly clayey gray-white slightly micaceous
4	18.9	4.1	Silt, gray-white
5	20.9	2.0	Clay, fairly silty gray-white; P5
6	33.8	12.9	Clay, silty light-greenish-gray; P6

Preston Brooks Property

Test Hole Record L193

Location: T.18 N., R.8 E., Sec. 20, C., NW. 1/4, SW. 1/4; beneath small pine, east side of road, 0.3 mile south of road fork — Drilled: May 2, 1941

Elevation: 435 feet — Water level: Dry

No.	Depth	Thick.	Description of strata and designations of samples
1	6.6	6.6	Soil—clay, silty yellow-buff
			Holly Springs formation
2	9.8	3.2	Clay, slightly silty light-gray fairly plastic; dries light-gray; P2
3	13.6	3.8	Clay, slightly silty light-gray gray-brown mottled fairly plastic; P3
4	17.6	4.0	Clay, slightly silty gray-white yellow mottled fairly plastic; P4
5	29.9	12.3	Clay, slightly silty light-gray red mottled slightly plastic; P5
6	31.8	1.9	Clay, silty light-gray slightly plastic; P6

HOOPER CAFFEY PROPERTY

TEST HOLE RECORD L209

Location: T.21 N., R.7 E., Sec. 21, C., NW. 1/4, SW. 1/4; in old road bed showing clay, 125 feet southwest of farm home, 150 feet north of present road Drilled: June 25, 1941

Elevation: 307 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Tallahatta formation
1	3.7	3.7	Clay-shale, fairly silty tan to chocolate-brown; selenite in laminae; P1
2	5.8	2.1	Clay-shale, fairly silty light-brown; P2
3	9.4	3.6	Clay-shale, silty light-brown; small marcasite nodules; selenite in laminae; P3
4	10.6	1.2	Sand, silty brownish-buff fairly micaceous (marks unconformity)
			Holly Springs formation
5	13.0	2.4	Clay-shale, fairly silty tan yellow mottled
6	14.2	1.2	Clay-shale, slightly silty very dark-gray waxy; P6
7	18.1	3.9	Clay-shale, fairly silty medium-gray; laminae of light-gray silt
8	25.3	7.2	Silt, slightly clayey medium-gray; laminae of dark-gray clay-shale

MRS. KATIE GREEN PROPERTY

TEST HOLE RECORD L210

Location: T.19 N., R.5 E., Sec. 9, C., NE. 1/4, SW. 1/4; roadcut in frontof home, north valley wall of Big Sandy Creek Drilled: June 25, 1941

Elevation: 357 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	2.9	2.0	Sample from 2 feet of glauconitic sand at top of Winona sand member; P1

Mrs. L. L. Latham Property

Test Hole Record L211

Location: T.19 N., R.5 E., Sec. 35, S. 1/2, SW. 1/4, SW. 1/4; at rock and clay contact, north side of road, 200 feet east of farm home

Drilled: June 17, 1941

Elevation: 373 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Kosciusko member
1	2.3	2.3	Siltstone, yellow-brown brittle thinly laminated; weathers into several separate ledges
			Upper (continental) Zilpha
2	5.9	3.6	Clay-shale, silty brownish-tan; partings of gray-white yellow mottled silt; P2
3	11.6	5.7	Clay-shale, slightly silty light-brown; P3
			Winona member
4	13.9	2.3	Sand, silty gray-buff slightly glauconitic; weathered gray-tan clay nodules
5	14.6	0.7	Sand, fine to medium-grained greenish-brown fairly glauconitic; irregular layers of brownish-black limonitic semi-indurated sand

Mrs. Sallie Greenlee Property

Test Hole Record L217

Location: T.17 N., R.7 E., Sec. 8, NW. 1/4, NW. 1/4, SW. 1/4; beneath oak, 100 feet southwest of road, atop highest point of ridge, 300 feet northwest of road fork

Drilled: May 24, 1941

Elevation: 479 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
			Upper (continental) Zilpha
1	2.6	2.6	Soil—clay, sandy red-buff
2	4.6	2.0	Clay, silty buff-red mottled
3	16.9	12.3	Clay-shale, slightly silty buff-yellow mottled; P3
4	18.4	1.5	Clay-shale, slightly silty light-brown yellow mottled; P4
			Winona member
5	22.1	3.7	Sand, clayey greenish-brown; thin beds of glauconitic silt alternating with reddish-brown glauconitic clay-shale
6	25.2	3.1	Sand, medium-grained semi-indurated greenish-buff very glauconitic; internal casts of pelecypods

CITY OF WINONA PROPERTY

TEST HOLE RECORD L221

Location: T.19 N., R.5 E., Sec. 26, NE. 1/4, SE. 1/4, SW. 1/4; beneath small elm, south side of street (in southwest Winona), above Zilpha clay outcrop, opposite house
Drilled: May 24, 1941
Elevation: 416 feet
Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.5	3.5	Soil—loess (?), gray-white
			Kosciusko member
2	10.6	7.1	Clay, silty buff-yellow; thin beds of limonitic siltstone marking unconformity
			Upper (continental) Zilpha
3	12.2	1.6	Clay-shale, fairly silty gray-white red mottled
4	13.4	1.2	Clay-shale, fairly silty gray-white buff mottled
5	15.1	1.7	Clay-shale, fairly silty white
6	18.4	3.3	Clay-shale, fairly silty gray-tan white mottled; P6
7	26.1	7.7	Clay, silty light-tan buff and gray mottled; P7
8	31.1	5.0	Clay-shale, slightly silty tan; laminae of gray-tan silty clay; P8
			Lower (marine) Zilpha
9	32.8	1.7	Clay-shale, gray-buff yellowish-brown mottled limonitic; numerous glauconitic claystone nodules
			Winona member
10	38.6	5.8	Sand, medium-grained semi-indurated greenish-buff fairly glauconitic

ANDREW THOMPSON PROPERTY

TEST HOLE RECORD L225

Location: T.19 N., R.7 E., Sec. 26, C., SE. 1/4, SW. 1/4; beneath large red oak southwest corner of road fork
Drilled: June 6, 1941
Elevation: 427 feet
Water level: 25 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Citronelle formation
1	9.4	9.4	Sand, fine to coarse-grained light-buff; small gray chert pebbles
2	14.3	4.9	Sand, fine to medium-grained cream-colored; small white chert pebbles
3	22.4	8.1	Sand, fine to coarse-grained buff-pink; small pebbles of gray chert and of pink quartz
4	40.2	17.8	Sand, fine to coarse-grained salmon-yellow; pebbles of white chert and yellow quartzite

C. A. Townsend Property

Test Hole Record L233

Location: T.19 N., R.7 E., Sec. 17, SW. 1/4, NE. 1/4, NE. 1/4; juncture of road and driveway to farm home, east side of road, 100 feet west of farm home

Drilled: June 12, 1941

Elevation: 407 feet

Water level: 15 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	2.4	2.4	Soil—clay, fairly silty red-buff
			Zilpha member
2	15.4	13.0	Silt, clayey gray-white red mottled
3	19.6	4.2	Clay, fairly silty pinkish-tan
4	24.1	4.5	Clay, fairly silty brownish-black fairly plastic
5	27.6	3.5	Clay, slightly silty very dark-gray fairly carbonaceous
6	40.4	12.8	Clay, fairly silty dark-brownish-gray
			Winona member
7	50.0	9.6	Silt, clayey greenish-black slightly glauconitic, slightly micaceous, slightly calcareous; gray-buff claystone pellets

J. S. Sullivan Property

Test Hole Record L234

Location: T.18 N., R.5 E., Sec. 10, S. 1/2, SW. 1/4, SW. 1/4; roadcut near top of hill, 500 feet west of creek bridge

Drilled: June 25, 1941

Elevation: 381 feet

Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.2	1.4	Sample from 1.4 feet of glauconitic sand at top of Winona sand member; P1

W. E. ARMSTRONG PROPERTY

TEST HOLE RECORD L235

Location: T.19 N., R.7 E., Sec. 36, SW. 1/4, SE. 1/4, NE. 1/4; north side of road beneath small pine, above outcrop of dark plastic clay, opposite juncture of farm road Drilled: June 17, 1941

Elevation: 370 feet Water level: dry

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

MISS LIZZIE HAMAR PROPERTY

TEST HOLE RECORD L236

Location: T.19 N., R.7 E., Sec. 28, SE. 1/4, SW. 1/4, NW. 1/4; north side of road, 100 feet west of road fork, above outcrop of black clay

Drilled: June 17, 1941

Elevation: 384 feet Water level: 40 feet

No.	Depth	Thick.	Description of strata and designations of samples
			Holly Springs formation
1	5.4	5.4	Sand, fine to medium-grained red-buff fairly micaceous; semi-indurated layers
2	7.3	1.9	Clay, slightly silty gray-white fairly plastic; P2
3	15.8	8.5	Clay, slightly silty brownish-black fairly carbonaceous fairly plastic; P3
4	20.3	4.5	Clay, slightly silty gray dark-gray mottled fairly plastic; P4
5	38.9	18.6	Clay, very silty light-greenish-gray; P5
6	41.5	2.6	Silt, sandy bluish-gray; laminae of dark-gray silty clay
7	49.6	8.1	Clay, silty dark-gray; laminae of blue-gray sandy silt

J. W. Bamberg Property

Test Hole Record L238

Location: T.19 N., R.5 E., Sec. 16, NE. 1/4, SW. 1/4, NE. 1/4; roadcut in front of home, south valley wall of Big Sandy Creek Drilled: June 25, 1941

Elevation: 347 feet Water level: dry

No.	Depth	Thick.	Description of strata and designations of samples
1	3.7	1.5	Sample from 1.5 feet glauconitic sand at top of Winona sand member; P1

Willie Johnson Property

Test Hole Record L239

Location: T.18 N., R.8 E., Sec. 4, S. 1/2, SW. 1/4, SW. 1/4; beneath small oak in ditch at north side of road, beneath roadcut exposure of dark plastic clay Drilled: June 11, 1941

Elevation: 348 feet Water level: 8 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

Highway Property

Test Hole Record L242

Location: T.18 N., R.8 E., Sec. 1, SW. 1/4, NE. 1/4, NW. 1/4; beneath small gum, above clay outcrop, north side of road, 25 feet east of road fork

Drilled: June 11, 1941

Elevation: 360 feet

Water level: 14 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

W. W. Rivers Property

Test Hole Record L243

Location: T.18 N., R.8 E., Sec. 5, NE. 1/4, NE. 1/4, SE. 1/4; beneath small post oak, northeast side of road above black and white clay, west corner of farm yard

Drilled: June 11, 1941

Elevation: 388 feet

Water level: 30 feet

No.	Depth	Thick.	Description of strata and designations of samples
1	5.6	5.6	Soil—clay, sandy yellow-buff
			Holly Springs formation
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

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MONTGOMERY COUNTY MINERAL RESOURCES TESTS

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INTRODUCTION

The materials submitted for testing consist of clays and glauconitic sands. The clays are described by Priddy as 1, plastic, 2, carbonaceous, and 3, blocky. The plastic and carbonaceous clays are from the Holly Springs and Zilpha formations. Since all of the carbonaceous clays are plastic and most of the plastic clays are carbonaceous, the designation by Priddy is not adhered to in the test part of this report. Rather, these clays are classified according to their economic uses and their ceramic properties.

A number of clays from the Holly Springs formation have clear-burning buff colors and other common properties. These clays are classified as Pottery, Brick, and Tile Clays. Other clays from the Holly Springs and Zilpha formations burn to shades of salmon buff, light red, red, and brown. Some of these materials are clear burning, and others are stained with calcium salts as scum. Other than the scum the general characteristics of the clays are comparable. These materials have been classified as: Brick and Tile Clays—Clear; and Brick and Tile Clays—Dull.

The clays described by Priddy as blocky have some unusual physical properties. Clays from test hole L67 are less contaminated with sand and silt and are probably more representative of this type. The clay has a shale-like texture but is very porous in the dried and burned states. The slight alterations in burning over a long firing range permit the manufacture of a uniform product. These clays are classified, Blocky Clays—Light-Weight, as such a designation embodies the outstanding geologic and ceramic characteristics.

Certain silty but tight bodied clays from the Zilpha and Holly Springs formations possess undesirable ceramic properties in the raw and burned states. They are classified as Clays of Doubtful Economic Value.

Glauconitic sands from the upper Winona were tested for possible use as a fertilizer. The analyses and discussion are given under Glauconitic Sands.

POTTERY, BRICK, AND TILE CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
L178	2–3–4	32.55	39.37	15.38	389	Gray
L178	5–6	38.32	39.45	15.42	344	Gray
L180	4–5	25.18	27.19	10.04	279	Lt. gray
L180	7–8–9	34.39	42.25	16.75	302	Gray
L180	14–15–16	32.91	39.11	14.28	343	Gray
L184	7	32.13	31.24	11.76	279	Dk. gray
L186	2–3–4	32.50	35.75	13.73	279	Gray
L186	5	35.85	32.74	12.41	298	Dk. gray
L186	6	32.55	40.01	15.70	378	Gray
L193	2–3–4	31.65	40.37	15.84	398	Lt. gray

SCREEN ANALYSES

SAMPLE L180 4-5

Retained on screen	Percent	Character of residue
60	1.64	Abundance of limonitic silt nodules; considerable quantity of gypsum.
100	0.49	Abundance of limonitic silt nodules; considerable quantity of gypsum; small amount of quartz.
250	1.93	Abundance of quartz; considerable quantity of limonitic clay nodules.
Cloth	95.94	Clay substance including residue from above.

SAMPLE L180 7-8-9

Retained on screen	Percent	Character of residue
60	3.32	Abundance of waxy lignitic clay nodules; small amounts of pyrite and gypsum.
100	2.55	Abundance of waxy lignitic clay nodules; traces of pyrite and gypsum.
250	5.33	Abundance of clay nodules; considerable quantity of quartz; trace of pyrite.
Cloth	88.60	Clay substance including residue from above.

SAMPLE L180 14-15-16

Retained on screen	Percent	Character of residue
60	12.12	Abundance of lignitic arenaceous clay nodules; small amount of pyrite.
100	5.90	Abundance of lignitic arenaceous clay nodules; considerable quantity of white clay nodules; small amount of lignite.
250	7.24	Abundance of dark clay nodules; small amounts of muscovite and quartz.
Cloth	74.74	Clay substance including residue from above.

SAMPLE L186 2-3-4

Retained on screen	Percent	Character of residue
60	5.06	Abundance of gray clay nodules; small amounts of limonitic nodules, quartz, pyrite, and gypsum.
100	8.69	Abundance of gray clay nodules; considerable quantity of quartz; small amount of pyrite and limonitic nodules.
250	18.35	Abundance of white and gray clay nodules; considerable quantities of muscovite and quartz; trace of pyrite.
Cloth	67.90	Clay substance including residue from above.

SAMPLE L186 5

Retained on screen	Percent	Character of residue
60	7.82	Abundance of lignitic clay nodules; considerable quantity of lignite; small amount of gypsum; trace of limonite.
100	7.51	Abundance of lignitic clay nodules; considerable quantity of lignite; small amount of gray clay nodules.
250	11.92	Abundance of lignitic clay nodules; considerable quantity of gray clay nodules.
Cloth	72.75	Clay substance including residue from above.

SAMPLE L186 6

Retained on screen	Percent	Character of residue
60	1.03	Abundance of lignitic waxy clay nodules; small amount of pyrite.
100	1.09	Abundance of lignitic waxy clay nodules; small amounts of pyrite, quartz, and lignite.
250	2.40	Abundance of quartz; small amounts of clay nodules, muscovite, and lignite
Cloth	95.48	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES*

SAMPLE L180 4-5

Ignition loss 5.28
Silica, SiO_2 ....74.14
Alumina, Al_2O_3 .....14.67
Iron oxide, Fe_2O_3 ... 2.16
Titania, TiO_2 .... 0.97
Lime, CaO 0.35
Magnesia, MgO 0.23
Manganese, MnO_2 None
Alkalies, (K_2O, Na_2O) 0.61
Sulfur, SO_3 .... 1.01

SAMPLE L180 7-8-9

Ignition loss 7.34
Silica, SiO_2 .... 64.53
Alumina, Al_2O_3 .....22.27
Iron oxide, Fe_2O_3 ... 2.18
Titania, TiO_2 .... 1.22
Lime, CaO 0.16
Magnesia, MgO 0.43
Manganese MnO_2 None
Alkalies, (K_2O, Na_2O) 0.44
Sulfur, SO_3 .... 0.92

SAMPLE L180 14-15-16

Ignition loss 7.79
Silica, SiO_2 .... 64.29
Alumina, Al_2O_3 .....20.54
Iron oxide, Fe_2O_3 ... 3.27
Titania, TiO_2 .... 1.11
Lime, CaO ....Trace
Magnesia, MgO 0.37
Manganese MnO_2 None
Alkalies, (K_2O, Na_2O) 0.13
Sulfur SO_3 .... 1.20

SAMPLE L186 2-3-4

Ignition loss 6.58
Silica, SiO_2 .... 66.65
Alumina, Al_2O_3 .....21.63
Iron oxide, Fe_2O_3 ... 2.25
Titania, TiO_2 .... 1.07
Lime, CaO 0.27
Magnesia, MgO 0.50
Manganese MnO_2 None
Alkalies, (K_2O, Na_2O) 0.46

SAMPLE L186 5

Ignition loss 12.72
Silica, SiO_2 ....63.55
Alumina, Al_2O_3 .....18.70
Iron oxide, Fe_2O_3 ... 2.53
Titania, TiO_2 .... 0.77
Lime, CaO 0.45
Magnesia, MgO ... 0.76
Manganese MnO_2 None
Alkalies, (K_2O, Na_2O) 0.40

SAMPLE L186 6

Ignition loss 8.48
Silica, SiO_2 .... 63.56
Alumina, Al_2O_3 .....22.86
Iron oxide, Fe_2O_3 ... 2.56
Titania, TiO_2 .... 0.74
Lime, CaO 0.25
Magnesia, MgO 0.56
Manganese, MnO_2 None
Alkalies, (K_2O, Na_2O) 0.34

* Samples ground to pass 100-mesh screen.
B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes L178, L180, L184

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
L178 2-3-4	03	19.96	10.36	1.93	2.41	8.61	2.99	2726	Cream	
	01	13.72	6.79	2.05	2.38	13.46	4.72	2869	Lt. buff	St. H.
	2	13.08	6.36	2.06	2.37	14.19	4.98	3030	Lt. buff	
	4	12.03	5.78	2.08	2.37	14.95	5.27	2857	Lt. buff	
	6	6.79	3.13	2.17	2.34	18.44	6.59	2665	Buff	
	8	4.57	2.43	2.18	2.29	18.88	6.74	3300	Grayish buff	
	10	.74	.33	2.20	2.22	20.09	7.21	4010	Gray	
L178 5-6	03	26.35	14.75	1.79	2.43	11.37	3.95	1741	Buff	
	01	20.54	10.94	1.88	2.36	16.17	5.72	2090	Buff	St. H.
	2	18.95	10.11	1.88	2.32	15.82	5.61	2452	Buff	
	4	16.73	8.70	1.92	2.31	17.90	6.36	2460	Buff	
	6	15.02	7.64	1.97	2.31	19.49	6.98	2747	Buff	
	8	9.16	4.57	2.01	2.21	21.27	7.67	3323	Grayish buff	
	10	5.83	3.08	1.96	2.07	19.42	6.98	3101	Gray	
L180 4-5	03	20.92	10.96	1.94	2.41	4.76	1.63	1593	Buff	
	01	19.34	9.99	1.91	2.41	6.53	2.25	2148	Buff	St. H.
	2	18.49	9.53	1.94	2.37	6.55	2.25	2730	Buff	
	4	17.16	8.73	1.96	2.37	7.32	2.53	2836	Buff	
	6	11.47	4.60	2.12	2.34	13.97	4.90	3485	Grayish buff	
	8	7.53	3.53	2.14	2.31	15.10	5.31	N.D.	Grayish buff	
	10	2.47	1.18	2.10	2.15	13.57	4.76	N.D.	Gray	
L180 7-8-9	03	23.09	11.52	1.98	2.45	13.50	4.72	2603	Buff	St. H.
	01	19.10	9.64	2.00	2.40	14.37	5.05	3274	Buff	
	2	17.73	8.88	2.00	2.43	14.37	5.05	3105	Buff	
	4	13.23	6.35	2.00	2.61	17.74	6.32	3702	Buff	
	6	12.77	6.08	2.08	2.40	18.38	6.55	4085	Buff	
	8	8.38	3.96	2.12	2.31	19.24	6.90	4648	Buff	
	10	2.82	1.31	2.14	2.20	20.10	7.21	5650	Grayish buff	
L180 14-15-16	03	15.13	7.48	2.02	2.38	15.45	5.46	3055	Buff*	St. H.
	01	13.51	6.59	2.04	2.34	16.87	5.98	3163	Buff*	
	2	12.61	6.30	2.00	2.33	16.15	5.72	3774	Buff*	
	4	12.53	6.13	2.05	2.37	17.09	6.06	4041	Buff*	
	6	5.35	2.51	2.15	2.27	20.85	7.52	3632	Grayish buff*	
	8	4.12	1.97	2.09	2.18	18.88	6.74	3638	Grayish buff*	
	10	13.16	6.76	1.95	2.25	13.28	4.65	N.D.	Grayish buff*	Bl.
L184 7	03	33.05	18.36	1.80	2.69	4.65	1.59	1125	Buff	St. H.
	01	30.06	17.27	1.74	2.49	6.16	2.11	1554	Buff	
	2	31.29	18.29	1.71	2.49	8.75	3.02	1584	Buff	
	4	27.58	15.50	1.78	2.46	9.26	3.20	1881	Buff	
	6	23.80	12.82	1.86	2.39	12.41	4.35	1952	Buff	
	8	22.02	11.74	1.87	2.40	13.75	4.83	2373	Buff	
	10	18.85	9.74	1.94	2.39	15.67	5.53	3068	Buff	

* Stained with calcium salts.

Abbreviations: Bl., bloated; St. H., steel hard.

TEST HOLES L186, L193

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
L186 2-3-4	03	20.69	10.45	1.98	2.46	14.22	5.01	2510	Buff	St. H.
	01	18.03	9.00	2.01	2.50	12.83	4.21	2533	Buff	
	2	17.74	8.88	2.00	2.43	13.57	4.76	2970	Buff	
	4	17.65	8.87	1.99	2.41	13.36	4.68	2859	Buff	
	6	10.80	5.11	2.11	2.36	18.34	6.55	2780	Buff	
	8	10.40	4.90	2.12	2.33	18.30	6.52	4927	Buff	
	10	2.26	1.07	2.13	2.18	19.95	7.17	3633	Gray	
L186 5	03	24.75	14.37	1.72	2.29	14.14	4.98	1782	Buff	St. H.
	01	22.05	12.58	1.81	2.20	15.69	5.53	1572	Buff	
	2	19.27	10.84	1.76	2.18	16.90	5.98	1941	Buff	
	4	18.57	10.26	1.75	2.25	18.12	6.48	2405	Buff	
	6	13.28	6.94	1.81	2.22	22.64	8.22	1992	Buff	
	8	8.29	4.31	1.92	2.07	23.49	8.54	3047	Buff	
	10	16.46	9.04	1.82	2.18	18.85	6.74	2912	Gray	Bl.
L186 6	03	11.27	5.31	2.19	2.36	19.00	6.78	3693	Buff*	St. H.
	01	11.15	5.18	2.22	2.36	21.44	7.75	4235	Buff*	
	2	7.29	3.37	2.22	2.39	20.04	6.82	4849	Buff*	
	4	6.02	2.72	2.26	2.43	22.70	8.22	4051	Buff*	
	6	.83	.36	2.28	2.31	24.68	9.02	3179	Grayish buff*	
	8	.21	.09	2.26	2.27	23.84	8.70	1664	Grayish buff*	Cr.
L193 2-3-4	03	11.61	5.48	2.19	2.38	14.21	5.01	3891	Dk. buff*	St. H.
	01	10.89	5.11	2.13	2.39	14.90	5.27	3906	Dk. buff*	
	2	8.23	3.77	2.20	2.31	17.53	6.25	4775	Dk. buff*	
	4	4.65	2.12	2.12	2.39	19.09	6.82	4891	Dk. buff*	
	6	1.60	.71	2.24	2.28	19.34	6.94	7590	Dk. buff*	
	8	.24	.10	2.30	2.31	21.25	7.67	4430	Gray*	
	10	.25	.11	2.23	2.24	18.60	6.63	N.D.	Gray*	Cr., Bl.

* Stained with calcium salts.

Abbreviations: Bl., bloated; Cr., cracked; St. H., steel hard.

POSSIBILITIES FOR UTILIZATION

The Pottery, Brick, and Tile Clays are the buff-burning variety from the Holly Springs formation.

Some of the clays are contaminated with gypsum and pyrite. On burning, the clays containing gypsum are stained with a white scum, and those containing pyrite are slightly specked. Samples L180 7-8-9 and L186 2-3-4 are sufficiently free of these impurities to be classed as pottery clays.

All of the clays have good plastic, drying, and burning properties. The drying shrinkage and dry strength are normal for clay of this type, and no special difficulties in processing would be expected.

On burning, the clays are steel hard at cone 03. Porosity and shrinkage are fairly low and decrease gradually with increasing heat treatment. Most of the clays vitrify without overburning and have a firing range of 6 to 10 cones within which weather-proof products could be burned. Sample L184 7 is excepted as it contains a sufficient amount of silt and sand to cause the clay to be too porous for use in products other than drain tile, and for this it is well suited.

The clays are suited for the manufacture of buff face brick, flue lining, chimney block, and various types of hollow tile and building block. Samples L180 7-8-9 and L186 2-3-4 are the better clays for face brick as they burn to brighter shades of buff. They are also suited for facing tile, faience, garden pottery, terra cotta, art pottery, and flower pots.

BRICK AND TILE CLAYS—CLEAR

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
L22	3	33.50	51.93	21.70	487	Lt. gray
L25	3	35.17	53.91	22.81	628	Lt. gray
L25	5	36.29	54.13	22.92	578	Lt. gray
L124	8	33.66	29.83	11.17	394	Lt. gray
L235	1	30.65	43.75	17.48	448	Lt. brown
L236	3–4	34.34	42.97	17.09	441	Gray
L236	5	32.13	40.46	15.89	434	Lt. gray
L243	5	39.27	55.46	23.65	429	Lt. gray

SCREEN ANALYSES

SAMPLE L25 3

Retained on screen	Percent	Character of residue
60	0.08	Abundance of gray clay nodules; small amounts of limonite and plant fragments.
100	0.63	Abundance of clay nodules; small amounts of quartz and muscovite; trace of pyrite.
250	8.10	Abundance of quartz; small amount of clay nodules.
Cloth	91.19	Clay substance including residue from above.

SAMPLE L25 5

Retained on screen	Percent	Character of residue
60	0.04	Abundance of gray silt nodules; small amounts of quartz and lignitic nodules.
100	0.56	Abundance of gray silt nodules; considerable quantity of muscovite; small amount of quartz.
250	6.83	Abundance of quartz; considerable quantity of clay nodules; small amount of muscovite.
Cloth	92.57	Clay substance including residue from above.

SAMPLE L236 3-4

Retained on screen	Percent	Character of residue
60	3.19	Abundance of lignitic clay nodules; small amount of limonitic nodules; trace of pyrite.
100	2.95	Abundance of lignitic clay nodules, considerable quantity stained with limonite; small amount of quartz; trace of pyrite.
250	8.97	Abundance of lignitic clay nodules, considerable quantity stained with limonite; considerable quantity of quartz.
Cloth	84.89	Clay substance including residue from above.

SAMPLE L236 5

Retained on screen	Percent	Character of residue
60	2.54	Abundance of pyrite; considerable quantity of arenaceous clay nodules; trace of limonite.
100	1.76	Abundance of clay nodules; considerable quantity of pyrite.
250	12.00	Abundance of clay nodules; small amounts of quartz and pyrite.
Cloth	83.70	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES*

SAMPLE L25 3

Ignition loss	6.38	Iron oxide, Fe_2O_3	3.53	Magnesia, MgO	1.32
Silica, SiO_2	68.92	Titania, TiO_2	1.20	Manganese, MnO_2	None
Alumina, A_2lO_3	16.43	Lime, CaO	1.08	Alkalies, (K_2O, Na_2O)	0.82

SAMPLE L25 5

Ignition loss	6.15	Iron oxide, Fe_2O_3	3.50	Magnesia, MgO	1.34
Silica, SiO_2	69.36	Titania, TiO_2	1.04	Manganese, MnO_2	None
Alumina, Al_2O_3	16.88	Lime, CaO	0.76	Alkalies, (K_2O, Na_2O)	0.77

SAMPLE L236 3-4

Ignition loss	6.85	Iron oxide, Fe_2O_3	3.00	Magnesia, MgO	0.33
Silica, SiO_2	67.51	Titania, TiO_2	1.06	Manganese, MnO_2	None
Alumina, Al_2O_3	19.53	Lime, CaO	0.17	Alkalies, (K_2O, Na_2O)	0.40

SAMPLE L236 5

Ignition loss	6.50	Iron oxide, Fe_2O_3	7.72	Magnesia, MgO	0.31
Silica, SiO_2	67.73	Titania, TiO_2	0.78	Manganese, MnO_2	None
Alumina, Al_2O_3	15.56	Lime, CaO	0.43	Alkalies, (K_2O, Na_2O)	0.50

* Samples ground to pass 100-mesh screen.
B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes L22, L25, L124, L235, L236

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
L22 3	03	10.71	5.12	2.09	2.34	10.64	3.70	2840	Salmon buff St. H.
	01	8.78	4.19	2.09	2.30	10.66	3.70	3270	Salmon buff
	2	8.73	4.12	2.10	2.32	11.80	4.00	3846	Salmon buff
	4	7.94	4.08	2.09	2.32	12.00	4.45	3813	Salmon buff
	6	4.32	2.01	2.17	2.27	13.95	4.90	3838	Reddish gray
	8	3.70	1.74	2.12	2.20	12.41	4.35	3996	Gray
	10	10.29	5.76	1.79	1.99	−3.54	−1.21	N.D.	Gray Cr., Bl.
L25 3	03	12.52	6.12	2.08	2.32	10.79	3.74	2784	Salmon buff St. H.
	01	10.50	5.04	2.04	2.34	8.78	3.02	3130	Salmon buff
	2	11.54	5.52	2.09	2.30	10.58	3.67	3481	Salmon buff
	4	9.31	4.48	2.09	2.36	10.85	3.77	3825	Salmon buff
	6	5.80	2.79	2.10	2.23	11.14	3.88	4086	Reddish gray
	8	5.55	2.61	2.13	2.25	12.71	4.46	2728	Reddish gray
	10	6.92	3.49	1.99	2.13	5.49	1.87	N.D.	Gray Cr., Bl.
L25 5	03	13.48	6.57	2.05	2.38	9.47	3.27	2751	Salmon buff St. H.
	01	11.67	5.79	2.01	2.28	9.29	3.20	3125	Salmon buff
	2	11.53	5.59	2.06	2.28	9.17	3.17	3510	Salmon buff
	4	12.64	6.14	2.06	2.36	9.45	3.27	3537	Salmon buff
	6	11.28	5.38	2.09	2.28	11.14	3.88	3957	Salmon buff
	8	8.43	4.04	2.10	2.36	11.86	4.14	4899	Reddish gray
	10	3.15	1.52	2.07	2.14	10.01	3.49	1243	Gray Cr.
L124 8	03	19.17	9.49	2.02	2.50	17.69	6.29	1913	Lt. red St. H.
	01	16.26	7.85	2.08	2.48	19.73	7.09	2242	Lt. red
	2	14.64	7.01	2.10	2.45	21.13	7.63	2349	Lt. red
	4	14.70	6.62	2.09	2.44	20.39	7.32	2726	Lt. red
	6	5.45	2.47	2.21	2.34	24.65	9.02	2922	Reddish brown
	8	2.56	1.08	2.22	2.27	25.07	9.18	3889	Brownish gray
	10	1.07	.51	2.07	2.09	19.78	7.09	3886	Brownish gray
L235 1	03	19.76	9.84	2.02	2.41	7.62	2.64	2246	Buff St. H.
	01	18.04	9.16	1.98	2.56	5.38	1.73	2518	Buff
	2	17.02	8.70	1.98	2.33	5.99	1.83	2702	Salmon
	4	15.05	7.60	1.96	2.36	4.56	1.56	3095	Salmon
	6	12.36	6.14	2.02	2.30	7.82	2.71	3698	Lt. red
	8	13.03	6.43	2.03	2.33	7.93	2.74	3678	Lt. red
	10	14.75	7.09	2.08	2.44	10.53	3.67	3717	Dk. buff
L236 3-4	03	17.99	9.03	1.99	2.42	11.41	3.99	2253	Buff St. H.
	01	15.92	8.05	1.98	2.35	11.93	4.17	1510	Buff
	2	15.90	7.87	1.98	2.40	12.74	4.46	2566	Buff
	4	13.50	6.38	1.97	2.41	14.01	4.94	2571	Buff
	6	10.15	4.90	2.07	2.30	15.95	5.65	3694	Buff
	8	6.31	2.94	2.14	2.29	16.00	5.65	4443	Buff
	10	1.99	.95	2.11	2.15	17.65	6.29	5535	Grayish buff

Abbreviations: Cr., cracked; Bl., bloated; St. H., steel hard.

TEST HOLES L236, L243

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
L236 5	03	21.62	11.37	1.92	2.45	6.26	2.15	2638	Buff
	01	19.34	9.82	1.93	2.52	7.92	2.74	2994	Buff
	2	18.40	8.95	1.96	2.39	8.32	2.88	2875	Buff St. H.
	4	17.84	9.10	1.95	2.42	12.07	4.21	2316	Buff
	6	13.72	6.70	2.05	2.42	11.98	4.17	N.D.	Buff Cr.
	8	11.09	5.38	2.06	2.32	12.93	4.54	3800	Grayish buff
	10	11.04	5.38	2.05	2.31	12.42	4.35	3790	Grayish buff
L243 5	03	22.14	11.01	1.98	2.47	13.38	4.68	2432	Lt. red St. H.
	01	21.11	10.76	1.97	2.49	10.07	3.49	2145	Lt. red
	2	19.80	9.96	1.99	2.48	11.39	3.95	2363	Lt. red
	4	19.06	9.68	1.97	2.43	10.70	3.70	2999	Lt. red
	6	17.57	8.63	2.03	2.46	12.87	4.40	2840	Red
	8	11.63	5.49	2.11	2.39	16.83	5.98	2962	Dk. red
	10	2.75	1.26	2.18	2.23	19.09	6.82	2377	Gray

Abbreviations: Cr., cracked; St. H., steel hard.

POSSIBILITIES FOR UTILIZATION

The Brick and Tile Clays—Clear are so designated to distinguish them from clays having generally similar properties but which are stained with calcium sulfate. The clays in this group burn to clear even shades of salmon buff, light red, red, and gray. Sample L236 5 has a slight stain of iron sulfate, but the effect is not undesirable.

The clays possess good plastic and drying properties although the drying shrinkage is rather high for certain samples. The dry strength of all samples is more than adequate for heavy clay products. On burning, porosity and absorption values decrease slightly with advancing temperatures. Linear shrinkage is low and increases only slightly within the firing range of 6 to 8 cones. The fired strength is higher than the average common clay. Modulus of rupture values are in the 2,500-3,500 pounds per square inch range at heavy clay products burning temperatures.

The clays are suitable for manufacture of face brick and common brick, building block, facing tile, salt glaze silo tile, fire proofing tile, load bearing tile, roofing tile, and drain tile. The pastel shades of salmon buff of samples L235 1, L236 3-4, and L236 5 are very desirable for facing tile and face brick.

BRICK AND TILE CLAYS—DULL

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
L124	4	29.22	33.09	12.54	450	Lt. brown
L133	2	30.81	40.13	15.75	478	Lt. brown
L184	2	29.41	39.49	15.42	404	Lt. brown
L185	3	42.29	62.48	27.89	529	Lt. brown
L185	5–6–7–8	35.72	47.02	19.12	339	Lt. gray
L185	10	34.41	43.37	17.28	373	Lt. gray
L191	5–6	35.33	43.07	17.14	416	Lt. gray
L193	5	31.32	45.17	18.17	507	Gray
L235	2	32.62	45.37	18.27	461	Lt. gray
L235	3	34.32	33.91	12.93	295	Gray
L243	2	31.17	39.44	15.42	482	Tan
L243	3	32.81	49.20	20.21	471	Lt. gray

SCREEN ANALYSES

Sample L185 3

Retained on screen	Percent	Character of residue
60	6.21	Abundance of limonitic stained clay nodules; considerable quantity of limonitic nodules; small amounts of quartz and plant fragments.
100	7.71	Abundance of limonitic stained clay nodules; small amount of quartz.
250	11.46	Abundance of limonitic stained clay nodules; considerable quantity of quartz; small amounts of muscovite and earthy hematite.
Cloth	74.62	Clay substance including residue from above.

Sample L185 5-6-7-8

Retained on screen	Percent	Character of residue
60	8.41	Abundance of carbonaceous arenaceous clay nodules.
100	4.53	Abundance of arenaceous clay nodules, some carbonaceous nodules; small amount of pyrite.
250	8.15	Abundance of clay nodules, some dark with carbonaceous material.
Cloth	78.91	Clay substance including residue from above.

SAMPLE L185 10

Retained on screen	Percent	Character of residue
60	29.01	Abundance of arenaceous gray clay nodules.
100	10.44	Abundance of arenaceous gray clay nodules.
250	11.24	Abundance of arenaceous gray clay nodules; small amount of muscovite.
Cloth	49.31	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES*

SAMPLE L185 3

Ignition loss 7.69
Silica, SiO_2 .... 61.52
Alumina, Al_2O_3 ......20.97
Iron oxide, Fe_2O_3 ... 6.38
Titania, TiO_2 .... 1.47
Lime, CaO 0.24
Magnesia, MgO 0.60
Manganese, MnO_2 None
Alkalies, (K_2O, Na_2O) 0.30
Sulfur, SO_3 .... 0.30

SAMPLE L185 5-6-7-8

Ignition loss 5.12
Silica, SiO_2 .... 69.78
Alumina, Al_2O_3 ......17.95
Iron oxide, Fe_2O_3 .. 3.37
Titania, TiO_2 .... 0.80
Lime, CaO 0.46
Magnesia, MgO 0.62
Manganese, MnO_2 None
Alkalies, (K_2O, Na_2O) 0.41
Sulfur, SO_3 .... 0.66

SAMPLE L185 10

Ignition loss 5.59
Silica, SiO_2 ....66.91
Alumina, Al_2O_3 ......17.65
Iron oxide, Fe_2O_3 .. 5.33
Titania, TiO_2 .... 0.74
Lime, CaO 0.57
Magnesia, MgO 0.62
Manganese, MnO_2 None
Alkalies, (K_2O, Na_2O) 0.42
Sulfur, SO_3 .... 1.03

* Samples ground to pass 100-mesh screen.

B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

TEST HOLES L124, L133, L184, L185

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
L124 4	03	19.19	9.69	1.99	2.45	11.23	3.92	1984	Lt. red*	St. H.
	01	17.14	9.53	2.01	2.42	10.59	3.67	2202	Lt. red*	
	2	18.35	9.37	1.96	2.40	9.14	3.17	2544	Lt. red*	
	4	18.11	9.26	1.96	2.39	9.28	3.20	2653	Lt. red*	
	6	14.98	7.22	2.05	2.40	13.36	4.68	3012	Lt. red*	
	8	11.72	5.62	2.09	2.37	15.05	5.31	N.D.	Dk. red*	
	10	6.00	2.81	2.14	2.28	17.28	6.14	N.D.	Brown*	
L133 2	03	24.03	12.43	1.94	2.55	5.93	2.04	2168	Salmon*	
	01	20.70	10.36	2.03	2.46	8.14	2.81	2125	Red*	St. H.
	2	19.62	9.88	2.00	2.52	8.86	3.06	2581	Red*	
	4	18.63	9.28	1.98	2.47	9.28	3.20	2675	Red*	
	6	18.34	9.13	2.01	2.46	9.21	3.20	2679	Red*	
	8	17.97	8.88	2.01	2.47	10.15	3.52	2990	Dk. red*	
	10	16.28	7.85	2.07	2.42	12.34	4.32	3153	Brown*	
L184 2	03	18.28	9.24	1.98	2.43	6.80	2.32	2099	Salmon*	St. H.
	01	17.98	9.18	1.96	2.39	7.95	2.74	2325	Salmon*	
	2	15.46	7.73	2.00	2.37	8.74	3.02	2588	Lt. red*	
	4	14.69	7.30	2.00	2.35	9.18	3.17	2396	Lt. red*	
	6	12.92	6.44	2.01	2.02	9.31	3.24	3150	Lt. red*	
	8	12.63	6.19	2.04	2.33	10.40	3.59	3410	Red*	
	10	14.51	6.98	2.08	2.43	12.27	4.28	4116	Lt. brown*	
L185 3	03	12.62	6.22	2.03	2.32	13.42	4.72	2011	Lt. red*	St. H.
	01	10.28	5.02	2.05	2.28	13.83	4.87	2177	Red*	
	2	10.81	5.19	2.03	2.28	13.11	4.61	2347	Red*	
	4	10.87	5.20	2.01	2.39	13.09	4.61	2527	Red*	
	6	10.00	4.88	2.05	2.28	13.97	4.90	2690	Red*	
	8	9.28	4.53	2.05	2.25	14.20	4.98	3241	Dk. red*	
	10	10.11	5.05	2.00	2.23	12.35	4.32	3296	Brown*	
L185 5-6-7-8	03	23.33	12.33	1.89	2.47	6.67	2.25	1833	Salmon*	St. H.
	01	23.42	12.21	1.97	2.42	7.65	2.64	1968	Lt. red*	
	2	22.18	11.60	1.92	2.50	7.87	2.71	2149	Lt. red*	
	4	19.19	9.81	1.91	2.46	9.62	3.34	2168	Lt. red*	
	6	18.40	9.34	1.96	2.42	10.48	3.62	2182	Lt. red*	
	8	18.13	9.21	1.97	2.41	10.37	3.59	2112	Reddish buff*	
	10	14.03	6.83	2.05	2.39	13.91	4.90	2665	Grayish brown*	
L185 10	03	14.87	7.15	2.10	2.43	15.62	5.53	2771	Lt. red*	St. H.
	01	13.57	6.46	2.08	2.44	15.04	5.31	2862	Lt. red*	
	2	12.04	5.72	2.10	2.39	15.58	5.40	2487	Red*	
	4	12.77	6.09	2.10	2.41	15.47	5.46	2863	Red*	
	6	7.54	3.79	1.99	2.15	11.39	3.95	3019	Red*	
	8	3.36	1.53	2.20	2.27	19.55	7.01	3312	Dk. red*	Bl.

* Stained with calcium salts.

Abbreviations: Bl., bloated; St. H., steel hard.

TEST HOLES L191, L193, L235, L243

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks
L191 5-6	03	18.00	9.11	1.98	2.41	11.43	3.99	2370	Salmon* St. H.
	01	18.44	8.03	2.05	2.40	11.40	3.99	2727	Lt. red*
	2	17.48	8.80	1.99	2.41	11.67	4.06	3123	Lt. red*
	4	16.33	7.26	1.98	2.42	11.12	3.88	2846	Lt. red*
	6	7.30	3.47	2.10	2.27	16.69	5.91	2889	Red*
	8	3.76	1.72	2.18	2.27	19.70	7.09	4118	Dk. red*
	10	1.49	.73	2.08	2.11	15.71	5.57	N.D.	Gray* Cr., Bl.
L193 5	03	11.36	5.83	2.14	2.39	10.23	3.25	3045	Lt. red* St. H.
	01	11.02	5.03	2.12	2.38	11.82	4.14	3237	Lt. red*
	2	11.30	5.39	2.11	2.38	11.73	4.10	3726	Lt. red*
	4	11.94	5.66	2.11	2.39	11.78	4.10	3800	Lt. red*
	6	5.17	2.34	2.21	2.34	15.66	5.53	4978	Red*
	8	.37	.16	2.27	2.28	18.23	6.52	4537	Dk. red*
	10	2.26	1.08	2.15	2.20	13.88	4.87	N.D.	Gray* Cr., Bl.
L235 2	03	18.77	9.63	1.98	2.38	6.13	2.11	2568	Salmon* St. H.
	01	17.10	8.67	1.95	2.40	7.86	2.71	3003	Salmon*
	2	15.93	8.00	1.99	2.37	8.21	2.85	3081	Lt. red*
	4	14.85	7.41	2.01	2.36	8.84	3.06	2814	Lt. red*
	6	10.82	5.18	2.09	2.35	12.35	4.32	2886	Red*
	8	8.30	3.96	2.10	2.29	13.13	4.61	3173	Red*
	10	8.18	4.01	2.05	2.23	10.92	3.81	3942	Grayish brown* Bl.
L235 3	03	25.58	13.61	1.88	2.53	11.92	4.17	2021	Salmon buff* St. H.
	01	23.28	12.44	1.91	2.36	11.38	4.08	2216	Salmon buff*
	2	22.70	12.09	1.88	2.43	11.91	4.17	2225	Salmon buff*
	4	18.88	9.84	1.87	2.44	11.51	4.03	2178	Salmon buff*
	6	15.34	7.56	2.03	2.40	18.46	6.59	2182	Salmon buff*
	8	8.66	4.11	2.09	2.34	21.71	7.87	2616	Grayish buff*
	10	2.17	1.00	2.17	2.21	23.74	8.66	4169	Grayish buff*
L243 2	03	17.63	8.98	1.97	2.38	9.33	3.24	2512	Buff* St. H.
	01	16.57	8.00	2.03	2.30	11.45	3.99	2996	Buff*
	2	14.49	7.19	2.02	2.36	11.30	3.92	3000	Buff*
	4	14.07	7.05	2.00	2.32	12.83	4.12	3214	Buff*
	6	9.86	4.71	2.10	2.33	14.69	5.16	3305	Buff*
	8	7.13	3.38	2.11	2.28	15.99	5.65	3576	Grayish buff*
	10	3.09	1.42	2.17	2.24	17.77	6.32	4566	Grayish buff*
L243 3	03	11.43	5.54	2.09	2.31	12.01	4.21	2756	Buff* St. H.
	01	10.85	5.18	2.06	2.35	13.00	4.54	3213	Buff*
	2	8.67	4.08	2.12	2.33	13.46	4.72	3542	Buff*
	4	8.29	3.92	2.12	2.40	12.81	4.50	3671	Buff*
	6	3.92	1.78	2.20	2.28	15.92	5.65	3523	Grayish buff*
	8	3.44	1.56	2.21	2.29	16.76	5.95	5240	Grayish buff*
	10	3.77	1.77	2.13	2.22	13.65	4.79	4451	Grayish buff*

* Stained with calcium salts.

Abbreviations: Cr., cracked; Bl., bloated; St. H., steel hard.

POSSIBILITIES FOR UTILIZATION

The Brick and Tile Clays—Dull are so identified because of the stain of calcium sulfate developed on drying. The true colors of the burned samples are masked by the white calcium sulfate stain.

The clays have excellent plastic properties and dry without warping or cracking. The drying shrinkage of samples L185 3, L185 5-6-7-8, L193 5, L235 2, and L243 3 is too high for most heavy clay products but could be controlled by coarse grinding and limiting the tempering water to the minimum. The modulus of rupture or strength of the dry raw clays is more than adequate.

On burning the clays do not completely vitrify before overburning; however, they have a long firing range in which there is little alteration of the clay. Within this firing range the clays vitrify sufficiently to develop a strong weather proof body. The linear burning shrinkage is uniformly low and varies within the approximate limits of 3-6 percent over the firing range of 6 to 8 cones. The fired modulus of rupture values at cone 03 are in the 2,000-pound range and increase to 3,000-4,000 pounds per square inch at cones 6-8.

The clays are not especially suited for face brick due to their dull appearance when burned; however, common brick, partition tile, load bearing tile, and drain tile are products which can be made from these clays with little difficulty.

BLOCKY CLAYS—LIGHT-WEIGHT

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
L67	2	59.92	24.94	9.14	233	Gray
L67	4	66.24	29.72	11.13	238	Gray
L67	6	64.78	28.46	10.58	257	Gray
L67	8	64.79	27.33	10.12	203	Gray
L108	4–5	50.49	33.59	12.76	228	Dk. gray
L209	1–2–3	31.83	23.74	8.66	223	Gray

SCREEN ANALYSES

Sample L67 2

Retained on screen	Percent	Character of residue
60	45.25	Abundance of gray micaceous clay nodules.
100	9.28	Abundance of gray micaceous clay nodules; trace of quartz.
250	10.18	Abundance of gray micaceous clay nodules; trace of muscovite.
Cloth	35.29	Clay substance including residue from above.

Sample L67 4

Retained on screen	Percent	Character of residue
60	35.77	Abundance of gray clay nodules.
100	12.78	Abundance of gray clay nodules.
250	10.77	Abundance of gray clay nodules.
Cloth	40.68	Clay substance including residue from above.

Sample L67 6

Retained on screen	Percent	Character of residue
60	43.32	Abundance of gray clay nodules.
100	10.38	Abundance of gray clay nodules.
250	10.65	Abundance of gray clay nodules; trace of quartz.
Cloth	35.65	Clay substance including residue from above.

Sample L67 8

Retained on screen	Percent	Character of residue
60	40.83	Abundance of micaceous gray clay nodules.
100	10.26	Abundance of micaceous gray clay nodules; trace of muscovite.
250	10.97	Abundance of micaceous gray clay nodules; trace of quartz.
Cloth	37.94	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES*

Sample L67 2

Ignition loss 8.20	Iron oxide, Fe_2O_3 ... 3.93	Magnesia, MgO 0.73
Silica, SiO_2 .... 67.94	Titania, TiO_2 .... 0.80	Manganese, MnO_2 None
Alumina, Al_2O_3 ...... 16.99	Lime, CaO 0.69	Alkalies, (K_2O, Na_2O) 0.51

Sample L67 4

Ignition loss 6.39	Iron oxide, Fe_2O_3 ... 3.86	Magnesia, MgO 1.08
Silica, SiO_2 .... 70.40	Titania, TiO_2 .... 0.80	Manganese, MnO_2 None
Alumina, Al_2O_3 ...... 16.47	Lime, CaO 0.49	Alkalies, (K_2O, Na_2O) 0.63

Sample L67 6

Ignition loss 6.65	Iron oxide, Fe_2O_3 ... 3.99	Magnesia, MgO 1.37
Silica, SiO_2 .... 69.76	Titania, TiO_2 .... 0.81	Manganese, MnO_2 None
Alumina, Al_2O_3 ...... 16.57	Lime, CaO 0.40	Alkalies, (K_2O, Na_2O) 0.49

Sample L67 8

Ignition loss 6.78	Iron oxide, Fe_2O_3 ... 3.77	Magnesia, MgO 0.95
Silica, SiO_2 .... 68.75	Titania, TiO_2 .... 0.80	Manganese, MnO_2 None
Alumina, Al_2O_3 ...... 16.66	Lime, CaO 0.58	Alkalies, (K_2O, Na_2O) 0.46

* Samples ground to pass 100-mesh screen.

B. F. Mandlebaum, analyst.

PYRO-PHYSICAL PROPERTIES

Test Holes L67, L108, L209

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
L67 2	03	47.91	37.29	1.29	2.49	15.26	5.38	1010	Salmon buff	
	01	44.19	31.85	1.39	2.47	16.64	5.91	993	Salmon buff	
	2	45.50	33.73	1.35	2.47	18.72	6.71	1222	Salmon buff	
	4	44.11	33.65	1.31	2.35	21.45	7.75	1142	Salmon buff	
	6	41.94	29.23	1.44	2.47	24.17	8.82	1072	Salmon buff	
	8	37.60	25.03	1.50	2.41	27.74	10.21	1588	Salmon buff	St. H.
	10	29.20	17.23	1.70	2.39	35.94	13.82	1681	Buff	
L67 4	03	46.20	36.15	1.28	2.50	15.24	5.38	1257	Salmon buff	
	01	44.71	32.35	1.38	2.38	20.46	7.36	1313	Salmon buff	
	2	45.01	32.98	1.36	2.47	20.27	7.28	1573	Salmon buff	
	4	45.46	33.78	1.35	2.47	19.61	7.05	1666	Salmon buff	
	6	40.55	27.76	1.47	2.47	26.12	9.63	1414	Salmon buff	
	8	37.17	24.24	1.56	2.47	30.48	11.42	1909	Salmon buff	
	10	26.07	14.66	1.78	2.41	38.12	14.82	2048	Buff	St. H.
L67 6	03	47.61	36.88	1.30	2.47	15.69	5.43	883	Salmon buff	
	01	46.12	36.97	1.29	2.48	15.14	5.35	1106	Salmon buff	
	2	47.07	35.03	1.34	2.54	19.13	6.86	1518	Salmon buff	
	4	44.29	33.12	1.34	2.41	18.74	6.71	1278	Salmon buff	
	6	39.87	26.82	1.49	2.47	26.49	9.75	1281	Salmon buff	
	8	37.93	24.87	1.55	2.49	28.80	10.71	1629	Salmon buff	
	10	28.24	16.47	1.73	2.41	37.09	14.32	1899	Buff	St. H.
L67 8	03	49.17	38.71	1.27	2.50	16.47	5.83	896	Salmon buff	
	01	48.84	38.03	1.29	2.51	17.44	6.21	1036	Salmon buff	
	2	47.20	36.91	1.28	2.43	17.46	6.21	1342	Salmon buff	
	4	46.32	35.08	1.32	2.46	19.58	7.01	1308	Salmon buff	
	6	43.84	31.45	1.39	2.48	23.87	8.70	1388	Salmon buff	
	8	36.20	23.00	1.57	2.46	33.04	12.54	1476	Salmon buff	
	10	27.37	15.48	1.77	2.44	40.34	15.84	1703	Buff	St. H.
L108 4-5	03	39.22	24.91	1.56	2.61	14.79	5.20	1084	Buff*	
	01	38.07	24.10	1.58	2.54	18.07	6.44	1152	Buff*	
	2	36.19	21.70	1.67	2.52	19.17	6.86	1683	Buff*	
	4	30.78	17.48	1.78	2.55	22.98	8.34	1746	Buff*	
	6	23.92	15.89	1.81	2.50	27.09	10.00	2288	Buff*	St. H.
	8	25.35	13.66	1.86	2.48	31.24	11.76	2117	Grayish buff*	
	10	14.13	7.34	1.93	2.24	33.70	12.70	N.D.	Grayish buff*	Cr.
L209 1-2-3	03	35.41	21.30	1.68	2.60	5.81	2.01	719	Buff	St. H.
	01	33.33	19.65	1.70	2.55	6.80	2.30	1154	Buff	
	2	33.21	19.56	1.70	2.55	7.58	2.50	1145	Buff	
	4	32.40	18.72	1.70	2.54	6.92	2.39	1181	Buff	
	6	30.26	16.70	1.73	2.56	8.78	3.02	1242	Buff	
	8	38.39	16.54	1.71	2.39	7.92	2.74	1244	Buff	
	10	26.18	14.18	1.85	2.50	15.15	5.35	1866	Buff	

* Stained with calcium salts.

Abbreviations: Cr., cracked; St. H., steel hard.

POSSIBILITIES FOR UTILIZATION

The Blocky Clays—Light-Weight are characterized by their high porosity and low shrinkage in the raw and fired states. Although the water of plasticity of typical samples is in the range of 59-66 percent, the linear drying shrinkage is only 9-11 percent. This condition is unusual and indicates that even the smallest clay particles are porous. The high porosity of the clay is maintained up to cone 8. Burning shrinkage is low but increases abruptly at cone 8. Alterations on burning from cone 03 through cone 6 are slight. The bulk specific gravity of typical clays at cone 03 is 1.27-1.29 and at cone 6, 1.39-1.49. The fired color of salmon buff is fairly uniform between cones 03 and 6. Modulus of rupture values for the raw and the burned clays are medium to low but adequate for most heavy clay products.

Because of the high porosity of typical clays they should be of value as an insulator. Face brick and building block are possibilities. The weather resistant quality of the material has not been determined, but it is likely that the burned clay would resist freezing and thawing conditions as do other materials having minute pores. The burned clay crushed to aggregate size would likely be suitable for making a light-weight concrete.

Samples L108 4-5 and L209 1-2-3 are not typical samples since they are contaminated with sand and silt. These clays are suitable for making drain tile.

CLAYS OF DOUBTFUL ECONOMIC VALUE

PHYSICAL PROPERTIES IN THE UNBURNED STATE

Hole No.	Sample No.	Water of plasticity in percent	Drying shrinkage		Modulus of rupture in pounds per square inch	Color
			Volume in percent	Linear in percent		
L20	8	50.58	49.00	20.10	204	Gray
L30	1	48.69	77.44	39.18	528	Brownish gray
L30	2-3-4	51.50	75.54	37.51	366	Gray
L32	5-6-7-8	44.75	48.00	19.59	404	Gray
L85	4-5-6	40.80	32.82	12.45	236	Lt. gray
L182	3-4	52.67	86.88	49.21	440	Brownish gray
L211	2-3	49.25	63.84	28.80	408	Brownish gray
L217	3	53.43	84.46	46.28	571	Lt. gray
L221	6-7-8	48.09	66.14	30.34	516	Brownish gray

PYRO-PHYSICAL PROPERTIES

TEST HOLES L20, L30, L32, L85, L182, L211, L217, L221

Hole No. Sample No.	At cone	Porosity in percent	Absorption in percent	Bulk specific gravity	Apparent specific gravity	Volume shrinkage in percent	Linear shrinkage in percent	Modulus of rupture in lbs./sq. in.	Color and remarks	
L20 8	03	21.27	11.05	1.93	2.45	26.17	9.63	1102	Lt. red	Cr., St. H.
L30 1	03	14.30	7.26	2.00	2.34	8.42	2.92	1243	Lt. red	Cr., St. H.
L30 2-3-4	03	13.26	6.23	2.12	2.45	21.22	7.67	709	Lt. red	Cr., St. H.
L32 5-6-7-8	03	27.53	15.00	1.84	2.54	18.04	6.44	1215	Lt. red	Cr., St. H.
L85 4-5-6	03 01	17.86 .97	8.62 .48	2.03 2.06	2.48 2.45	27.03 27.55	10.00 10.21	1978 558	Lt. red Brown	St. H. Cr., Bl.
L182 3-4	03	7.26	3.32	2.19	2.36	20.00	7.17	N.D.	Lt. red	Cr., St. H.
L211 2-3	03	17.38	7.34	2.37	2.86	31.16	11.72	909	Lt. red	Cr., St. H.
L217 3	03	11.99	5.85	2.05	2.27	14.61	5.16	959	Lt. red	Cr., St. H.
L221 6-7-8	03	15.02	7.26	2.07	2.44	19.81	7.13	361	Lt. red	Cr., St. H.

Abbreviations: Cr., cracked; Bl., bloated; St. H., steel hard.

POSSIBILITIES FOR UTILIZATION

The Clays of Doubtful Economic Value are from the Zilpha formation except sample L85 4-5-6 which is from the Holly Springs. These clays have an abnormal drying shrinkage, and on burning to cone 03 they crack to such an extent that they are unsuited for making ceramic products. Some of the clays have very high dry strengths and could possibly be used as a bond in foundry sand and abraisives.

GLAUCONITIC SANDS

SCREEN ANALYSES

Sample L210 P1

Retained on screen	Percent	Character of residue
60	76.66	Abundance of quartz; considerable quantity of glauconite.
100	12.21	Abundance of quartz; considerable quantity of glauconite; small amount of waxy clay.
250	4.46	Abundance of waxy clay nodules, some stained with limonite; considerable quantity of quartz; small amount of glauconite.
Cloth	6.67	Clay substance including residue from above.

Sample L234 P1

Retained on screen	Percent	Character of residue
60	76.46	Abundance of quartz; considerable quantity of glauconite.
100	12.62	Abundance of quartz; considerable quantity of glauconite.
250	4.42	Abundance of waxy clay nodules; small amounts of quartz and glauconite.
Cloth	6.50	Clay substance including residue from above.

Sample L238 P1

Retained on screen	Percent	Character of residue
60	52.58	Abundance of quartz; considerable quantity of glauconite, some stained with limonite.
100	28.00	Abundance of quartz; considerable quantity of glauconite; small amount of clay, some stained with limonite.
250	9.31	Abundance of limonitic waxy clay nodules; trace of quartz.
Cloth	10.11	Clay substance including residue from above.

Alta Ray Gault, laboratory geologist.

CHEMICAL ANALYSES*

Sample L210 P1

Ignition loss 2.48	Titania, TiO_2 .... Trace	Manganese, MnO_2 Trace
Silica, SiO_2 .... 82.23	Lime, CaO 0.33	Potash, K_2O 1.30
Alumina, Al_2O_3 ...... 6.36	Magnesia, MgO 0.29	Soda, Na_2O 0.25
Iron oxide, Fe_2O_3 ... 7.00		

Sample L234 P1

Ignition loss 2.25	Titania, TiO_2 .... Trace	Manganese, MnO_2 None
Silica, SiO_2 .... 83.45	Lime, CaO 0.20	Potash, K_2O 1.99
Alumina, Al_2O_3 ...... 5.69	Magnesia, MgO .... Trace	Soda, Na_2O 0.36
Iron oxide, Fe_2O_3 ... 5.96		

Sample L238 P1

Ignition loss 2.35	Titania, TiO_2 .... Trace	Manganese, MnO_3 Trace
Silica, SiO_2 .... 80.06	Lime, CaO 0.41	Potash, K_2O 2.18
Alumina, Al_2O_3 ...... 7.84	Magnesia, MgO 0.64	Soda, Na_2O 0.50
Iron oxide, Fe_2O_3 ... 5.70		

* Samples ground to pass 100-mesh screen.

B. F. Mandlebaum, analyst.

POSSIBILITIES FOR UTILIZATION

The glauconitic sands from the Winona formation have been used locally as a fertilizer. Glauconitic grains separated from the sands were found to contain 4.16 percent potash and 0.78 percent soda.[1] The ratio of silica sand to glauconite varies from place to place. Samples from Tallahatchie County[1] contained 0.41 and 0.55 percent combined alkalies. Samples from Montgomery County contain 1.55, 2.35, and 2.68 percent combined alkalies, a percentage which indicates a much higher proportion of glauconite in the sand from Montgomery County than from Tallahatchie County. At best, the alkali content is too low to permit extensive use of the sand as a fertilizer. It seems plausible that the glauconite could be separated from the silica sand and be used as a commercial fertilizer or as the weighting element in mixed fertilizer. This possibility should be investigated by commercial interests.

[1] Tallahatchie County Mineral Resources Bull. 50, Mississippi Geological Survey, 1942, p. 146.

LABORATORY PROCEDURE

PREPARATION

Preliminary drying of the clays was unnecessary, for they had been collected in the field and stored in a steam-heated laboratory several months prior to testing. Primary samples of about 200 pounds were crushed in a No. 2 jaw crusher. The crushed material was screened through a No. 20-mesh Tyler standard screen; residue coarser than 20-mesh was ground in a burr mill until it passed the 20-mesh screen. The clay which had passed 20-mesh screen was thoroughly mixed and reduced to a 10-pound sample by coning and quartering. This operation was accomplished in a metal lined tray approximately 4 feet square and 8 inches deep. The 10-pound sample was reserved for screen analysis, chemical analysis, and for making pyrometric cones. Approximately 75 pounds of clay from the remainder was mixed with water and kneaded by hand to a plastic consistency. The plastic mass was divided into small portions and thoroughly wedged to remove entrapped air and to develop a homogenous plastic body. The small portions were recombined in the same manner and stored in a metal lined damp box until used for making test pieces.

FORMING OF TEST PIECES

Test pieces were of two sizes: short bars, 1 inch square by 2 inches long, and long bars, 1 inch square by 7 inches long. The test pieces were made by wire-cutting bars of approximate size from the plastic mass and pressing in molds to the final size. The long bars were pressed by hand in a hardwood mold of the plunger type. The short bars were formed in a Patterson screw press fitted with a steel die. Each test piece was identified as to test hole number, sample number, and individual piece number. The identification was made by stamping the necessary letters and numerals on the test pieces. A shrinkage mark of 10 centimeters was stamped on the long bars. Sixty long bars and thirty short bars were made from each primary clay sample. Certain samples were not large enough to make the full number of test pieces.

PLASTIC, DRY, AND WORKING PROPERTIES

Immediately on forming the short bars their plastic volume was determined in a mercury volumeter. The plastic weight was measured to .01 gram using a triple beam balance. All of the test pieces were allowed to air-dry several days on slatted wooden pallets and then oven-dried by gradually increasing the temperature of the oven from room temperature to 100°C. in 4 hours and maintaining the oven temperature between 100°C, and 110°C. for an additional hour. After drying, the short bars were placed in desiccators, and on cooling to room temperature they were reweighed, and their vloume was determined as above described. Five long bars were broken on a Fairbanks cross-breaking machine to determine modulus of rupture.

The workability of the clay was observed during grinding, wedging, and the forming of the test pieces. The water of plasticity, modulus of rupture, and volume shrinkage were calculated by methods outlined by the American Ceramic Society. The linear shrinkage was calculated from the volume shrinkage and is based on the dry volume.

FIRED PROPERTIES

The long and short bars were burned in a down-draft surface combustion kiln especially designed for the purpose. Butane gas was used for fuel. Oxidizing conditions were maintained in the kiln during the entire period of firing. The test pieces were stacked criss-cross in the kiln to permit complete circulation of gases. The kiln was fired at the rate of 200°F. per hour to within 200°F. of the maximum temperature. The last 200°F. rise was accomplished in two to three hours. The rate of firing was measured by means of a Chromel-Alumel thermocouple up to 2,100°F., at which point the couple was withdrawn from the kiln; and, by means of pyrometric cones above 2,100°F.

On completing the firing of the long and short test pieces the kiln was cooled gradually in twenty-four to thirty-six hours, after which the short bars were immediately placed in desiccators and weighed to an accuracy of .01 gram on a triple beam balance. After weighing, the bars were placed in water which was then heated to the boiling point and was kept boiling for four hours. They were allowed to cool in the water to room temperature and were reweighed as before mentioned. Immediately thereafter the volumes of the test pieces were determined on a mercury volumeter. Volume shrinkage, porosity, absorption, bulk specific gravity, and apparent specific gravity were calculated in accordance with methods outlined by the American Ceramic Society. The long bars were broken on a Fair-

CONVERSION TABLE

Cones to Temperatures

Cone No.	When fired slowly, 20°C per hour		When fired rapidly, 150°C. per hour	
	°C	°F	°C	°F
010	890	1,634	895	1,643
09	930	1,706	930	1,706
08	945	1,733	950	1,742
07	975	1,787	990	1,814
06	1,005	1,841	1,015	1,859
05	1,030	1,886	1,040	1,904
04	1,050	1,922	1,060	1,940
03	1,080	1,976	1,115	2,039
02	1,095	2,003	1,125	2,057
01	1,110	2,030	1,145	2,039
1	1,125	2,057	1,160	2,120
2	1,135	2,075	1,165	2,129
3	1,145	2,093	1,170	2,138
4	1,165	2,129	1,190	2,174
5	1,180	2,156	1,205	2,201
6	1,190	2,174	1,230	2,246
7	1,210	2,210	1,250	2,282
8	1,225	2,237	1,260	2,300
9	1,250	2,282	1,285	2,345
10	1,260	2,300	1,305	2,381
11	1,285	2,345	1,325	2,417
12	1,310	2,390	1,335	2,435
13	1,350	2,462	1,350	2,462
14	1,390	2,534	1,400	2,552
15	1,410	2,570	1,435	2,615
16	1,450	2,642	1,465	2,669
17	1,465	2,669	1,475	2,687
18	1,485	2,705	1,490	2,714
19	1,515	2,759	1,520	2,768
20	1,520	2,768	1,530	2,768

Cone No.	When heated at 100°C per hour		Cone No.	When heated at 100°C per hour	
	°C	°F		°C	°F
23	1,580	2,876	32	1,700	3,092
26	1,595	2,903	33	1,745	3,173
27	1,605	2,921	34	1,760	3,200
28	1,615	2,939	35	1,785	3,245
29	1,640	2,984	36	1,810	3,290
30	1,650	3,002	37	1,820	3,308
31	1,680	3,056	38	1,835	3,335

The properties and uses of pyrometric cones: The Standard Pyrometric Cone Company, Columbus, Ohio.

banks testing machine to determine modulus of rupture. Five long bars were burned and tested for each clay at each cone temperature indicated in the table of pyrophysical properties. Three short bars were fired as test pieces for each clay at each cone temperature.

SCREEN ANALYSES

A quantity of clay from each quartered sample was dried at 110°C.—constant weight, after which exactly 100 grams were blunged in approximately two liters of water by pouring the slip back and forth until all the substance apparently disintegrated.

The disintegrated clay in slip form was poured through a nest of Tyler standard screens, the sizes being 60, 100, and 250. The material passing through the 250-mesh screen was caught on a cloth in a plaster vat. After a fair sample was caught on the cloth, the screens, still in nest, were then washed with a stream of water until no further material passed through the screens. The screens were dried at 110°C., after which residue from each screen was weighed and collected in glass vials for further study.

It is evident that the above treatment would not completely disintegrate all of the clay nodules; and though this could have been accomplished by blunging with rubber balls, it was not the purpose of this screen analysis to break the clay down to a finer state of division than would ordinarily occur in usual commercial blunging procedure; consequently, the screen analysis will show residue as "clay nodules" which indicates that a very thorough blunging will be necessary to disintegrate completely the clay in commercial use.

The residue from each screen was examined carefully under a binocular microscope. The finer material was examined under a petrographic microscope. Determinations were made from the psysical appearances of mineral grain and crystal form corroborated by use of physical properties test, magnetized needle, reactions to wet reagents; and, where grain size permitted, blow pipe analyses were made.

Undoubtedly there were minerals present in the clays that could not be distinguished under the microscope, because of their fine state of division. However, those that have been recorded have been definitely identified.

Terms used in the tables of screen analyses for describing quantity of residue are: "abundance," meaning one-half or more of residue on screen; "considerable quantity," between one-fourth and one-half; "small amount," less than one-fourth; and "trace," a few grains scattered throughout residue.

CHEMICAL ANALYSES

Grinding: Samples were ground to pass a 100-mesh screen.

Ignition Loss: One gram of each sample was heated in a platinum crucible at full heat of a blast burner for one hour.

Silica: Ignited samples were fused with 6 to 8 times their weight of anhydrous sodium carbonate, and the fusion dissolved in dilute of hydrochloric acid. The samples were double dehydrated with hydrochloric acid. The silica was filtered off, washed, ignited, weighed, volatilized by hydrofluoric acid, and the crucible reweighed. SiO_2 was found by loss in weight. Any residue after evaporation was fused with sodium carbonate and dissolved in the original filtrate for alumina determination.

Alumina: Alumina, iron, and titania were precipitated together by ammonium hydroxide in the presence of ammonium chloride. Double precipitations were necessary to remove all the chlorides. The mixed hydroxides were filtered off, washed free of chlorides, ignited and weighed. The weight represents the total alumina, iron, and titania. The mixed oxides were fused with potassium bisulphate and dissolved in dilute sulphuric acid. In some cases small amounts of silica were recovered by filtration, ignition, and volatilization with hydrofluoric acid. This was added to silica and deducted from alumina.

Iron: An aliquot of the solution of bisulfate solution was reduced with aluminum dust in sulphuric acid solution and titrated with standard potassium permanganate solution. The iron was calculated as Fe_2O_3.

Titania: Another aliquot of the bisulfate solution was placed in a Schreiner type colorimeter tube and a few drops of hydrogen peroxide added. This was compared in color with a standard titania solution. The total of iron and titania was subtracted from the mixed precipitate of alumina, iron, and titania, leaving alumina.

Manganese: Manganese was removed from the sample used for the ultimate analysis, but discarded, and the determination was made on a separate larger sample. The sample was treated with hydrofluoric acid and sulfuric acid, twice evaporated, and the insoluble residue removed by filtering. Manganese was determined colorimetrically using potassium periodate as the color reagent, and matching against a standard color sample.

Lime: Lime was determined from the filtrate of the manganese determination by precipitation as the oxalate in the presence of ammonium acetate in alkaline solution. It was weighed as CaO.

Magnesia: Magnesia was determined from the lime filtrate by precipitation as mixed ammonium phosphate in alkaline solution. It was ignited and weighed as $Mg_2P_2O_7$, and calculated to MgO.

Alkalies: Alkalies were determined by the J. Lawrence Smith method as outlined in Scott "Standard Methods of Chemical Analysis." Sodium and potassium were not separated but reported as combined oxides when the amount was less than one percent.

Sulphur: Sulphur was determined in a separate sample by a carbonate fusion, solution in hydrochloric acid, oxidation to SO_4 with bromine and precipitation with 10 percent barium chloride solution. Precipitate was weighed as barium sulfate.

Duplicates were made on all samples and the average reported.

PAGE REFERENCES TO TEST HOLES

Test hole No.	Sample No.	PROPERTY	Stratigraphic log	Ceramic tests	Chemical analysis	Citronelle	Kosciusko	Continental Zilpha	Marine Zilpha	Winona	Tallahatta	Meridian	Holly Springs	Porters Creek
L1		W. M. Hull	50				37, 50							
L2		W. H. Mortimer	51					34, 47, 51		51				
L3		Walter Witty Estate	52							52	27, 52			
L5		Will Holmes	53							30, 53				
L10		H. H. Kent	54								27, 54			
L20	8	C. E. Thompson	55	100, 101			55	34, 47, 55	32, 55	31, 37, 55				
L22	3	Lowe Whitehead	56	88, 90				35, 56	32, 33, 35, 56	31, 32, 56				
L25	3, 5	T. F. McCormick	57	88, 90	89			35, 57	35					
L30	1-2-3-4	J. W. Dunlap	57	100, 101				32, 34, 57		31, 32, 57				
L32	5-6-7-8	P. J. Hightower	58	100, 101			58	34, 58						
L67	2, 4, 6, 8	Charles Grant	59	96, 97, 99	98						25, 47, 59			
L68		Mrs. Matthew Britt	59								59	23, 59		
L72		Mrs. Tom Townsend	60				60	31, 32, 60		31, 32, 60				
L75		Allen Perry	61										22, 61	
L85	4-5-6	S. M. Parker	61	100, 101									19, 61	
L100		Pleassie Seale	62											15, 62
L101		Caleb Townsend	62										19, 62	
L102		C. A. Townsend	63								63	23, 63	63	
L106		Eubi Russell	64										19, 64	
L107		Dr. J. P. Synnott	65	96, 99 100									20, 65	
L108	4-5	Miss Lillie Dale	65	96, 99 100							25, 47, 65	23, 65		
L110		Caleb Townsend	66										22, 66	
L124	4	J. A. Dunn	66	92, 94									20, 46, 66	
	8			88, 90										
L133	2	Andrew Oliver	67	92, 94									67	

PAGE REFERENCES TO TEST HOLES

Test hole No.	Sample No.	PROPERTY	Stratigraphic log	Ceramic tests	Chemical analysis	Citronelle	Kosciusko	Continental Zilpha	Marine Zilpha	Winona	Tallahatta	Meridian	Holly Springs	Porters Creek
L178	2–3–4–5–6	L. C. Ray	67	82, 85									20, 67	
L180	4–5 7–8–9 14–15–16	Mrs. C. D. White	68	82, 85, 87									20, 40, 47, 68	
L182	3–4	J. S. Sullivan	69	100, 101				31, 69		31, 69				
L184	2 7	H. C. Aust	69	92, 94 82, 85, 87									20, 46, 47, 69	
L185	3 5–6–7–8 10	J. E. Lane	70	92-94, 96	93							70	20, 70	
L186	2–3–4 5, 6	J. E. Lane	70	82, 83, 86 87									20, 70	
L191	5–6	Harry Summers	71	92, 95									20, 71	
L193	2–3–4 5	Preston Brooks	71	82, 86 92, 95, 96									20, 71	
L209	1–2–3	Hooper Caffey	72	96, 99 100							25, 47, 72		20, 46, 72	
L210	P 1	Mrs. Katie Green	72	102	103					31, 72				
L211	2–3	Mrs. L. L. Latham	73	100, 101			73	31, 32, 73		31, 32, 73				
L217	3	Mrs. Sallie Greenlee	73	100, 101				31, 32, 73		31, 32, 73				
L221	6–7–8	City of Winona	74	100, 101			74	74	31, 32, 33, 74	31, 32, 74				
L225		Andrew Thompson	74			38, 74								
L233		C. A. Townsend	75					34, 75		30, 75				
L234	P 1	J. S. Sullivan	75	102	103					31, 75				
L235	1 2, 3	W. E. Armstrong	76	88, 90, 91 92, 95, 96									17, 76	
L236	3–4–5	Miss Lizzie Hamar	76	88-91	89								22, 76	
L238	P 1	J. W. Bamberg	77	102	103					31, 77				
L239		Willie Johnson	77										17, 47, 77	
L242		Highway	78										16, 47, 78	
L243	2, 3 5	W. W. Rivers	78	92, 95, 96 88, 91									18, 78	

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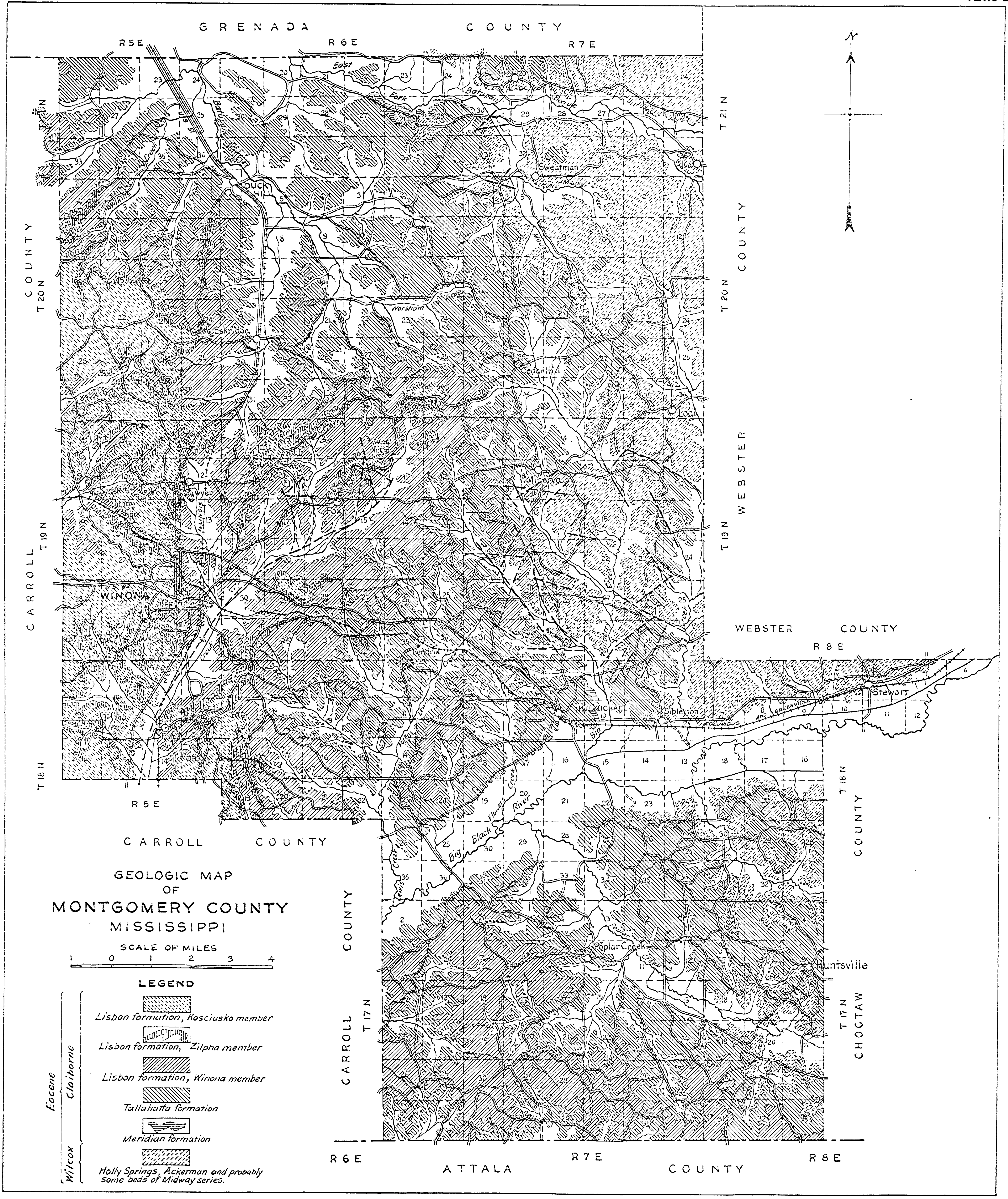
GRENADA COUNTY
R5E
R6E
R7E
T21N
T20N
T19N
T18N
T17N
WEBSTER COUNTY
R8E
CARROLL COUNTY
CHOCTAW COUNTY
ATTALA COUNTY
Duck Hill
Sweatman
Eskridge
Cedar Hill
Lodi
Minerva
Winona
Kilmichael
Sibleyton
Stewart
Poplar Creek
Huntsville
Big Black River
GEOLOGIC MAP OF MONTGOMERY COUNTY MISSISSIPPI
SCALE OF MILES
1 0 1 2 3 4
LEGEND
Eocene
Claiborne
Wilcox
Lisbon formation, Kosciusko member
Lisbon formation, Zilpha member
Lisbon formation, Winona member
Tallahatta formation
Meridian formation
Holly Springs, Ackerman and probably some beds of Midway series.