MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.
Director

BULLETIN 78

MARSHALL COUNTY GEOLOGY

By
FRANKLIN EARL VESTAL, M.S.

UNIVERSITY, MISSISSIPPI
1954

MISSISSIPPI
STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.
Director

BULLETIN 78

MARSHALL COUNTY GEOLOGY

By

FRANKLIN EARL VESTAL, M.S.

UNIVERSITY, MISSISSIPPI

1954

MISSISSIPPI GEOLOGICAL SURVEY

COMMISSION

STAFF

LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey

University, Mississippi, March 15, 1954

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

Gentlemen:

Geology of Marshall County
Sand, sand, sand everywhere, and not one grain to know.
Sand, sand, sand everywhere, and not one bed to place.
Trite, yes; but so true, so applicable, so completely summarizing.

"Stratigraphic relationships in northern Mississippi have passed, and probably will continue to pass, complete understanding." So says the author, climaxing seventy years of geologic studies of the "sand problem" by various workers.

And yet the author "believes that he has identified the major stratigraphic units which crop out in Marshall County, and has found a sufficient number of points on their contacts to enable him to delimit the units geographically and stratigraphically, at least in a general way."

And so at last the foundations are laid for the conclusions he so cautiously presents in the report.

It has been a tough assignment — an assignment so challenging that the State Geologist craved it for his own, but other matters consumed his time.

Perhaps the discovered "points on their contacts" will enable the "surface oil geologist" to determine favorable oil structures deep beneath the sands. At least they point up the region where geophysical crews should begin their more expensive exploration.

Naturally the State Geologist hopes his forecasts of 20 years ago, that deeply sand-buried structures would probably yield oil, will prove correct. In fact they have been found to contain gas and distillate, but the "tight-sand reservoirs" have, for the most part, yielded up the hydrocarbons too slowly to be economically profitable. Yet Carter Oil Company technologists with the "know-how" have fractured the reservoirs in northeastern Mississippi to the extent of making them productive.

The report, Geology of Marshall County by Franklin Earl Vestal, to be printed as Bulletin 78.

Very sincerely yours,

William Clifford Morse
Director and State Geologist

CONTENTS

ILLUSTRATIONS

FIGURES

PLATE

MARSHALL COUNTY GEOLOGY

FRANKLIN EARL VESTAL, M. S.

INTRODUCTION

Marshall County, an area of 689 square miles,[1] is the westernmost, except for DeSoto, of the six Mississippi counties which border Tennessee (Figure 1). It is bounded on the east by Benton and Union Counties, on the south by Lafayette, and on the west by Tate and DeSoto. Roughly, the county lies within a quadri-

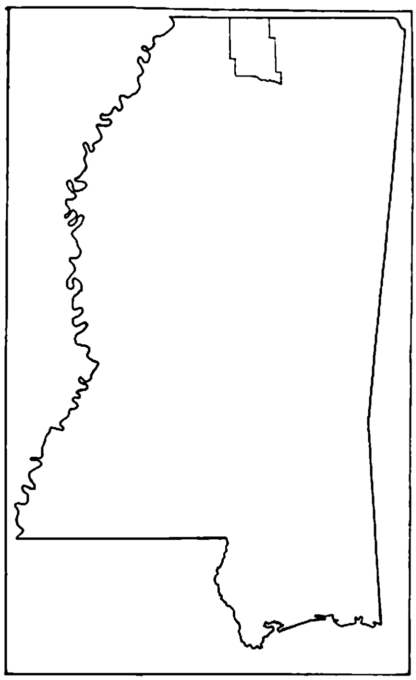


Figure 1.—Location of Marshall County.

lateral formed by the parallels of 34°30′ and 35° north latitude, and the meridians of 89°15′ and 89°45′ west longitude.[2] Its maximum east-west straight-line length is 27 miles, and its greatest north-south extent is 34 miles. All boundary lines are straight with the exception of the eastern half of the southern boundary-line, which is the Tallahatchie River. The boundary-line on the east is offset in two places, so that in the southeastern corner of the county it is 6 miles east of its position in the northeastern corner. The western boundary-line also is offset in such a way that its southernmost 9-mile segment is 3 miles farther east than the 21-mile segment of the remainder (Plate 1). The locations of the boundary-lines, giving the county such an irregular shape, resulted from changes during its history.

According to Rowland,[3] Marshall County, named for Chief Justice John Marshall, was established February 9, 1836, and formerly included territory which has since been apportioned among Benton, Tate, and other counties. Originally it comprised about 23 townships, 828 square miles. "In 1870 it gave up part of its territory on the east to Benton County, and in 1873 it gave up another portion of its area to assist in the formation of Tate County, and received in lieu of the portion surrendered to Tate, all that portion of DeSoto County lying within Townships 1 and 2, Range 5 West. Subsequent slight modifications of its boundaries have resulted in reducing its area to 689 square miles."

The population of Marshall County on April 1, 1950, was 25,106, fewer by 416 than the 1940 population of 25,522. In contrast to the 1.6 percent loss of population for the county as a whole, the population of Holly Springs, the county seat, increased from 2,750 in 1940 to 3,276 in 1950 — a gain of 526 people, or more than 19 percent, in the decade.[4] Except for the people of Holly Springs, the population of Marshall County is entirely rural, by the definitions of "urban" and "rural" adopted by the U. S. Department of Commerce Bureau of the Census for the 1950 census, according to which population is classed as urban only where it lives in groups of 2,500 or more.[5] The rural population is fairly evenly distributed over the county.

Holly Springs is the largest town, Byhalia is second in population, and Potts Camp third.[6] Other towns and villages of the county are: Mount Pleasant, Slayden, Hudsonville, Victoria, Red Banks, Waterford, Chulahoma, Cornersville, Warsaw, and Watson. Other small groupings of population, or community centers, commonly are located at crossroads; for examples, Bethlehem, Laws Hill, Marianna, Barton, Cayce, and Higdon.

Holly Springs, a little east of the center of the county, is on two railroads — Illinois Central and the St. Louis and San Francisco ("Frisco"), and three pavement highways — U. S. 78, Mississippi 4, and Mississippi 7. Also, it is the center from which several local roads radiate. Holly Springs, "City of Flowers," was named by the roadsters who, before the middle of the 19th century, traveled from the Chickasaw Bluffs to the land office at Pontotoc. They found at the present site of Holly Springs a large ravine covered with holly, near thirty or more clear springs, and they named their camp Holly Springs.[7] The present town is one of the chief commercial and industrial centers of North Mississippi. It is, with good reason, proud of the Holly Springs Brick and Tile Company plant, the largest of its kind in Mississippi, a plant which compares favorably with the strictly up-to-date brick and tile plants of other parts of the country. The Erie Resistor Corporation, of Erie, Pennsylvania, is now building a factory on Highway 78 near the east edge of Holly Springs. It will manufacture equipment for electronics, and also plastic products. It is scheduled to begin operations in the summer of 1954 and plans to employ 250 people at the start, probably more later.[8] The Simpson Lumber Company is another large industrial organization in Holly Springs; also the Coated Abrasive Company, which employs about 30 people. The town is well known in the South for its handsome antebellum houses, and for its interesting history. The pilgrimage to these old houses and other points of historical interest has become an annual event, and attracts visitors from many parts of the United States.

The many prosperous business establishments should be mentioned, also; the two banks; and the several attractive church buildings. The building which housed the late Mississippi Synodical College is now a hospital. Two colleges for negroes, Rust College and the Mississippi Industrial College, are located at Holly Springs. The most prominent building of all is the county courthouse, situated in the center of the square, the main business section of the town.

Byhalia (population 581 April 1, 1950[9]) is on Highway 78 and the Frisco Railroad about 14 miles northwest of Holly Springs. It is a farming and small business center. Recently a mop factory was built there.

Potts Camp (population 432 April 1, 1950[10]) is on the Frisco Railroad and Highway 78, 10 to 12 miles southeast from Holly Springs. It is a farm center, and the site of a logging and lumbering business. If the iron ore of the region is ever mined, Potts Camp may become a relatively important shipping point.

The other villages mentioned owe their location and existence chiefly to agricultural occupations and possibly partly to logging and sawmilling. Waterford, on Highway 7, and Mount Pleasant and Slayden, on Highway 72, are perhaps the most important.

Four main highways extend across Marshall County. U. S. Highway 78, also known as the Bankhead Highway, the main Memphis to Birmingham route, lies diagonally across the county, northwest-southeast through Byhalia, Holly Springs, and Potts Camp; Mississippi Highway 7 trends south-north from the southern boundary of Marshall to Holly Springs, thence north by east and northeast into Benton County; U. S. 72 trends southeast and east across the northern part of Marshall County; Mississippi Highway 4 extends in a general southwest-northeast direction from its crossing of the Marshall County-Tate County line 6 miles north of the southwestern corner of Marshall, to the Benton County line 11 miles east by north of Holly Springs.

Local public roads and farm roads reach almost every section. Most of the public roads are graveled more or less, and those which are traveled frequently are good all-weather graveled highways. Examples are: 1) Highway 349, which leads south from Potts Camp and is black-topped for some 3 miles and well covered with gravel the remainder of its length; 2) the Waterford-Potts Camp road; 3) the Holly Springs-Mount Pleasant road; 4) the road from Slayden to Highway 7; 5) roads between Highway 7 and Laws Hill. Some other local roads are not kept in good condition, and in bad weather become difficult or impossible for a motor vehicle to travel. At a few places erosion has forced abandonment or relocation of roads, and elsewhere it is threatening other roads.

Two railway lines extend across Marshall County — the St. Louis and San Francisco (Frisco), which roughly parallels Highway 78 less than a mile from it at any place, and the Illinois Central, which is east of Highway 7 and sub-parallel to it less than a mile distant except at places between Holly Springs and Hudsonville.

The Tennessee Gas and Transmission 24-inch and 26-inch pipe lines have been laid across the county from the southwest corner northeast to the Benton County line 7.5 miles east of Holly Springs. Electric power is supplied by the Mississippi

Power and Light Company and the Tennessee Valley Authority via several lines. At least one oil pipe line has been laid across the southeastern part of the county.

As has been indicated, agriculture is the chief occupation of the people. Farming is carried on to some extent in almost all parts of the county, but in the more rugged regions it is pretty well restricted to the valley flats. The best farm land is in the western half of the area. A few large tracts of level or slightly rolling upland are very favorable for cultivation. The main crops are cotton and corn. Chewalla Farms (SE.¼, NE.¼, Sec.1, T.4 S., R.2 W. and SW.¼, NW.¼, Sec.6, T.4 S., R.1 W.) is known throughout the northwest Mississippi region as a model farm. Diversified farming has been encouraged and promoted by the Experiment Station along Highway 7 north of Holly Springs.

Logging and sawmilling still employ a few people, but are not nearly so important as they once were. Almost all the large timber has been cut, and many logs that are fed to the mills today are cut in almost inaccessible places and hauled long distances. Moreover, trees of a size and kind which in the early days of the lumber industry would not have been considered usable, are now being freely used.

The Holly Springs National Forest occupies a very large area in the eastern and southeastern parts of the county, and the Sardis Dam Reservoir includes a strip of varying width north of the Tallahatchie River along the east half of the southern boundary.

CLIMATE

Marshall County is in the northern part of the region in which the humid subtropical type of climate prevails. The type is somewhat modified, however, by types farther north. The general characteristics of the humid subtropical type are: Summers long, temperature above 90 on fifty or more afternoons every year, but range moderate; relative humidity high, daytime breezes light, air sultry; torrential thunderstorms bring most of the rain, and now and then hail; winters short, bring light frost during three or four months, short periods of below freezing weather several times each winter, and infrequent hard freezes and sub-zero temperature; fair weather alternating with rainy spells, during which drizzles may persist for 12, 24, or 36 hours;

some snow almost every winter, and infrequent heavy snows, up to a foot or more; winds variable in direction and strength, include "Northers," raw, violent, gusty winds followed by a sudden drop in temperature to below freezing. Other characteristics are: Wide range of temperature from summer to winter; average ratio of rainy to fair days, 1 to 2½; autumn the least rainy season; prevailing winds the southwesterlies, but irregular winds mask them much of the time, especially in winter, when winds are stronger than in summer; occasional violent and destructive whirling storms — tornadoes and hurricanes.[11]

No complete records of the weather of Marshall County are available, but data assembled by the U. S. Weather Bureau station at Batesville, Panola County, 40 to 50 miles southwest of Holly Springs, are essentially accurate for Marshall County. The Batesville records[12] show that in general the climate is temperate, and changes of temperature gradual. Summers are long and hot, winters short and mild; January and February are, as a rule, the coldest months, the time of snowfalls and freezes, but cold spells last only a short time. The average date of the first killing frost is October 24, and of the last is March 24. The earliest and latest killing frost dates recorded are October 9 and April 7, respectively.

The normal monthly, seasonal, and annual temperature and precipitation data recorded at the Batesville Weather Bureau station are tabulated below:

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE AND PRECIPITATION AT BATESVILLE, PANOLA COUNTY, MISS.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F	°F	°F	Inches.	Inches.	Inches.	Inches.
December	44	75	1	4.4	3.9	3.1	0.5
January	44	76	—3	5.2	6.0	5.4	1.4
February	43	79	—5	4.4	0.5	5.0	0.7
Winter	44	......	......	14.0	10.4	13.5	2.6
March	53	83	17	5.9	4.2	2.0	0.6
April	62	93	29	4.0	3.3	7.4	0.0
May	70	96	36	3.9	1.7	13.5	0.0
Spring	62	......	......	13.8	9.2	22.9	0.6
June	78	103	40	4.4	3.6	7.7	0.0
July	80	107	53	4.6	6.6	2.3	0.0
August	79	105	49	3.3	0.5	3.0	0.0
Summer	79	......	......	12.3	10.7	13.0	0.0
September	72	97	34	2.6	1.0	8.3	0.0
October	61	92	18	1.7	1.7	0.3	0.0
November	51	81	16	3.6	3.6	5.3	0.0
Fall	61	......	......	7.9	6.3	13.9	0.0
Annual	61	107	—5	48.0	36.6	63.3	3.2

PHYSIOGRAPHY

PROVINCES, TOPOGRAPHY, RELIEF

Marshall County is in the North Central Hills physiographic province, except for a strip along the western border, which is part of the Loess or Bluff Hills province. As the names indicate, the surface is hilly. Viewed from the air, the county appears a complex of hills, ridges, and valleys, decidedly more rugged through the central and eastern and northeastern parts, and much more of the western half occupied by valley flats and other areas of slight relief. In a few places, notably at and a little below some valley heads, and where the lateral planation of streams has been especially effective, slopes are steep, even precipitous. The southeast wall of the lower reaches of Tippah River Valley is a good example of steepening by the second process named; the heads of small tributaries of Chewalla Creek southeast of Higdon afford excellent examples of the first. Also, the so-called "mountains," high hills capped with sandstone, commonly have relatively steep slopes toward their tops. As a whole, however, the topography expresses the mature stage of the cycle of erosion — thorough stream dissection of the terrane, which has left comparatively little upland flat surface; moderate to gentle slopes; flats developed along the streams from their mouths well up toward their heads, and terraces or second bottoms bordering the flood plains of the larger streams; region as a whole well drained by a complex of streams forming a dendritic pattern. The general slope of the surface is south to southwest in the southern part, north to northwest in the northern, and west in the western part. In fact, the over-all slope radiates from Holly Springs, which is situated at one of the highest parts of the county.

As stated, the surface is in general at the mature stage of the erosion cycle. However, several upland remnants remain, the upper surfaces of which have undergone little erosion, and have only slight relief. They are remnants of an old plateau which sloped gently southward and westward. Some of these level patches of the old surface are prominent in Marshall County, especially in the northern part.[13] The clear evidence that the stream-trenched north-south belt of upland of which Marshall County is a part is a dissected plateau, led to the designation

"North Central Plateau" for the physiographic province. "North Central Hills" later supplanted the original name. Shaw[14] found evidences of "several more or less distinct stages in erosion" in the surface features of Northern Mississippi. As the most striking of the evidences, he mentioned the "isolated monadnock-like hills which rise above the general upland where the underlying material is sand, for sand seems to be much more favorable to their preservation than limestone or clay." A few of the hills, locally called mountains, referred to by Shaw, have been alluded to in the present paper. He observed that their tops were more or less concordant in altitude, and concluded that such rough accordance of summits suggested a peneplain. He noted also that the crests of the divides "are so nearly even that more and better wagon roads are to be found on them than at any other topographic position," and furthermore, that the divides are not only even crested, but are not of widely different height. He expressed the opinion that the even-crested divides of roughly accordant altitudes are remnants of a lower peneplain developed by a distinct cycle of erosion — a plain which is at present "by far the most extensively represented" of all the plains which erosion has cut in this region in the past.

The maximum relief of the county is approximately 450 feet. The greatest surface altitude, between 680 and 700 feet above mean sea level, is at the site of Scales Forest Tower (NW.¼, Sec.33, T.3 S., R.1 W.) near the Benton County line, approximately 6.5 miles east of Holly Springs. The Sardis Reservoir spillway crest elevation is 282 feet, but the conservation pool elevation is only 235 feet. The most rugged part of the region is a belt extending diagonally southwest-northeast from southwest of Holly Springs to and beyond the county line near Hudsonville and including the territory east and slightly southeast of Holly Springs. In this territory are several areas which have an elevation of more than 600 feet above mean sea level, and some points which reach beyond 640 and 660. The greatest elevation (660+ feet) of the southern part, south and west of Holly Springs, is on the west side of the Laws Hill-Galena road, approximately 2 miles southwest from Galena (SW.¼, NE.¼, Sec.24, T.5 S., R.4 W.). A few small areas south of Holly Springs, near Highway 7, have an elevation between 640 and 660 feet, and a "mountain" some 4 miles southeast of Holly Springs has approximately the same altitude. At the other extreme the low-water surface of the Coldwater River on the Marshall County-DeSoto County line is less than 290 feet. The average relief is approximately of the order of 100 to 150 feet.[15]

DRAINAGE

Marshall County is drained by three main streams and their tributaries. Tallahatchie River, before the construction of Sardis Dam, was the southern boundary from the southeastern corner west by north almost to Highway 7 — that is, for more than half the width of the county. Since the completion of the dam the water of the reservoir has occupied a valley area which has varied much from time to time according to the fluctuation of the pool level. However, the part of the valley which borders Marshall County is only infrequently occupied by the reservoir pool. For practical purposes, then, the Tallahatchie may still be considered part of the southern boundary. Its chief tributaries in Marshall County east of Highway 7 are Tippah River, Big Spring Creek, and Little Spring Creek. Tributaries of the Tallahatchie west of Highway 7, chief among them Oak Chewalla and Blackwater Creeks, carry the run-off from roughly two townships of the southwestern corner. Thus the total drainage area of the Tallahatchie in Marshall County is between a third and a half of the entire county.

The Coldwater River basin includes at least half of the area. It is roughly triangular in shape, the western boundary-line of the county being the base of the triangle, the headwater area of the river the apex, and the southeast and north limits the other two sides. In fact, the south headwater branch of the Coldwater has its sources in eastern Marshall County, in Townships 2 and 3 South, Range 1 West. The chief tributaries of the Coldwater in the region are Pigeonroost, Red Banks, and Byhalia Creeks, all which flow westward. The Coldwater itself flows northwest in general entirely across the county, almost at the northern edge of its basin.

An irregular strip ranging in width from approximately 7 miles in the northeastern corner of the county to as narrow as half a mile at a place some 3 miles northwest of Mt. Pleasant, is drained by tributaries of the Wolf River in Tennessee.

STRATIGRAPHY

GENERAL

Stratigraphic relationships in northern Mississippi have passed, and probably will continue to pass, complete understanding.

The writer of this report does not pretend to have learned all about them and to declare herein exactly what they are; but he believes that he has identified the major stratigraphic units which crop out in Marshall County, and has found a sufficient number of points on their contacts to enable him to delimit the units geographically and stratigraphically, at least in a general way. The difficulties are due chiefly to the prevalence of sand. This was recognized three quarters of a century or more ago so well that the problem of gaining an understanding and offering an explanation of the geology of much of North Mississippi and West Tennessee came to be known as the "sand problem." The presence of sand almost everywhere in the region; notable thicknesses of sand at widely different elevations; sand of the same general character spread over almost the entire area; sands of different characters in juxtaposition; sands of all sorts of colors and grain sizes intermingled; sands bedded at almost every conceivable angle and lying in almost every imaginable position — these conditions are some of the elements of the "sand problem." To recognize and define stratigraphic units in this chaos seemed all but impossible, at least at first glance. Obviously, if it could be done it would have to be done through the application of the principle of working from the known to the unknown. Far to the south, in Webster, Montgomery, and Carroll Counties, and in other counties still farther south and southeast, the Wilcox and Claiborne formations had been named and their stratigraphic sequence established.[10] They are, to the top of the Kosciusko formation:

- Claiborne
  - Kosciusko
  - Zilpha
  - Winona
  - Tallahatta
  - Meridian
- Wilcox
  - Ackerman
  - Fearn Springs

It seems pertinent to note, however, that geologists are not agreed on the classification — specifically as to the rank of the various units, and whether the Meridian is Claiborne or Wilcox.

Of the Claiborne units, the Meridian is almost entirely sand; the Tallahatta contains fine sand in abundance, interbedded with clay shale and silt shale; the Winona is mainly gray-green and red and yellow sand; the Zilpha is sandy and silty clay shale and clay, and the Kosciusko is sand and re-worked clay. In the counties named, where all these formations are present, they are readily distinguishable, the one from the other. In Grenada County, north of Carroll, the Tallahatta beds are prominent, and the three formations above them can be identified, also, although somewhat masked by the loess.[17] The Meridian and Tallahatta are well represented in Yalobusha County, but the Winona and Zilpha are all but absent. The Kosciusko, however, is fairly extensive, reaching far to the east, overlapping the older formations.[18] In Lafayette County, which borders Marshall on the south, the picture is more confused. Outliers of Kosciusko sand cap hills and ridges almost to the eastern border of the county, lying on Meridian sand and on Tallahatta sands and shales.[19] The Neshoba and the Winona are only doubtfully represented, and the Zilpha is absent. According to Attaya, "The Winona and Zilpha formations are not recognizable on the surface at any place in the county."[20] Furthermore, in Lafayette and Marshall Counties, especially in Marshall, a much greater proportion of the Tallahatta formation is sand than in the counties farther south Another factor which increases the difficulty of discovering the secrets of the stratigraphy, is the unconformities. In some places Tallahatta sands have been channeled and the channels filled with Kosciusko sand, and elsewhere Tallahatta shales have been trenched and the depressions filled with younger sands. Such relationships, added to shifting of materials occasioned by later weathering, erosion, and deposition, have masked and confused the terrane to an extreme degree. In fact, the Ackerman-Meridian (Wilcox-Claiborne) and that between the older formations and the Loess, are the only formational contact traces which can be followed with certainty through the county.

Originally the outcropping strata of Marshall County were referred entirely to the Wilcox series, except for the Citronelle, the Loess, and the Recent, some forty years ago by Dr. E. N.

Lowe, the late State Geologist of Mississippi. Dr. Lowe recognized two formations in the Wilcox — the Ackerman and the Holly Springs. He applied the name "Holly Springs" to the great thicknesses of sand that overlie the Ackerman: "Being typically developed at and for several miles east of Holly Springs these beds might appropriately be called the Holly Springs sands."[20a] More recent studies have shown, however, that the "Holly Springs sands" of Northern Mississippi do not belong to a single geologic unit, but consist of parts of at least three formations which are readily distinguishable from each other farther south — the Meridian, the Tallahatta, and the Kosciusko.[20b]

The Wilcox in the northern territory is now restricted to two formations, the Fearn Springs and the Ackerman. These two formations crop out in the southeastern one-fifth of Marshall County. Both consist of sand, clay, silt, iron ore, and a little lignite. The Fearn Springs is 100 feet or less thick; the Ackerman 300 feet maximum, approximately. The Ackerman rests unconformably on the Fearn Springs or on the Naheola.

The Claiborne series of Marshall County consists of three formations: the Meridian sand, the Tallahatta shale and sand, and the Kosciusko sand. The Winona and Zilpha are absent, or very doubtfully represented in a few places.

The Meridian sand, 200 feet or more in thickness, constitutes the greater part of the old Holly Springs. It lies unconformably on the Ackerman formation of the Wilcox, and laps over onto the Fearn Springs and probably onto the Naheola. It is probable that the sandstone along Highway 30 in Union County is Meridian.

The Tallahatta formation, 200 feet or more thick, rests conformably on the Meridian and crops out far to the west and northwest; it is represented by lignitic and white shale, and much sand.

The Kosciusko formation, sand and sandstone, approximately 100 feet thick, lies unconformably on the Tallahatta and the Meridian, and extends eastward to or beyond the eastern border of the county.

The Citronelle sand and gravel, of Pliocene age, occupy a strip a few miles wide in the extreme western and northwestern parts of the county, and the Pleistocene Loess is spread over a wide territory, being thicker in the west, and thinning eastwards.

The Wilcox and Claiborne beds both have a regional dip of 15 to 20 feet a mile or less, varying in direction from north of west to northwest, but surface features seem to indicate local changes, even reversals. These structural irregularities in the outcropping strata possibly signify structural conditions in the underlying Paleozoic beds which could serve as traps for the accumulation of oil and gas.

The major stratigraphic units which crop out in Marshall County are named, classified (and briefly described) below, in older to younger order, reading from the bottom upward:

GENERALIZED SECTION OF ROCK UNITS EXPOSED IN MARSHALL COUNTY

Thickness feet

Cenozoic group

Quaternary system

Holocene series

Recent formation

Alluvium: Gravel, sand, silt, and clay underlying flood plains, est. 50 to 75.0

Unconformity

Pleistocene series

Loess formation

Silt, massive, gray and brown; est. maximum 20.0

Unconformity

Tertiary system

Pliocene series

Citronelle formation

Gravel, sand, silt, and clay, irregularly bedded; max. 25.0

Unconformity

Eocene series

Claiborne sub-series

Kosciusko formation

Sand, sandstone: sand white to brown, red-brown, and other iron oxide colors; massive to cross bedded;

coarse and gritty to fine, micaceous; sandstone ferruginous, coarse-grained to fine-grained, blocky. A little quartzite and some re-worked clay and shale toward the base; est. up to........100.0

Unconformity

Zilpha formation (doubtfully represented)

Clay shale and clay, light gray to dark gray; contains concretions of siderite........ 8.0

Winona formation (doubtfully represented)

Sand, deep red, and irregular sandstone, coarse to medium ....

Tallahatta formation

Clay shale, silt shale, siltstone, sand, sandstone, silty limonite; shale gray to brown or black lignitic or white, and well bedded; sand fine, micaceous, white to various iron colors; sandstone fine-grained ferruginous; crusts and thin layers and some masses of varicolored silty limonite or limonitic siltstone........200.0

Meridian formation

Sand, coarse and gritty to fine white, pale yellow, brown and red brown micaceous massive to cross bedded; some ferruginous sandstone; maximum........225.0

Unconformity

Wilcox sub-series

Ackerman formation

Sand, silt, clay, lignite, iron ore: Irregular lenses and other bodies and discontinuous beds of sand, silt, and clay; sand coarse and gritty to fine; white to brown and red; silt and clay gray to black and blue and green and white; beds and concretionary masses of iron carbonate and oxide; maximum........300.0

Fearn Springs formation

Shale, clay, sand, silt, iron ore: Shale gray to greenish gray or yellowish sandy and silty; clay gray to white; sand fine white, masses of iron ore abundant towards top of formation; maximum........100.0

Unconformity

Midway sub-series

Naheola formation

Clay shale, clay, sand, iron ore; Shale gray to black sandy and silty well bedded, interbedded with thin layers of fine gray sand; contains concretions and thin seams of iron carbonate and oxide; maximum........100.0

NAHEOLA FORMATION

The areal geology map of Union County[21] shows Naheola terrane in Union County (Secs.19, 30, 31, T.6 S., R.1 E., and Secs. 6 and 7, T.7 S., R.1 E.,) at the Marshall County line opposite Sections 24, 25, and 36, Township 6 South, Range 1 West, and Section 1, Township 7 South, Range 1 West, Marshall County. Unfortunately for the study of the geology of the Marshall County sections named, their surface is almost entirely flood plain, which

Figure 2.—Eastward dipping Naheola strata in the north wall of a road cut (SW. cor., Sec.30, T.6 S., R.1 E., Union County) a mile south of Cornersville. April 1, 1953.

affords no outcrops. However, a road cut (NW.cor., Sec.31, T.6 S., R.1 E., Union County) in the east wall of the valley of Mills Creek, almost on the Marshall County line, has exposed an excellent section of the upper part of the Naheola (Figure 2). The material is conspicuously bedded fine gray to black and rusty micaceous sand and sandy and silty gray to brown and black clay shale. Iron ore masses project from the face of the wall at two levels. One mass is 3 feet long and a foot thick; another, at a higher level, is 0.5 foot thick. A prominent feature of this outcrop is the strong east to southeast dip of the beds. The section includes a 40-foot vertical interval, from water-level under the bridge to the road junction at the top of the valley wall. The uppermost beds, exposed at the junction, are black lignitic clay and gray to white kaolinitic clay, probably representing the Midway-Wilcox contact zone (Betheden formation). The black and white beds show also in gullies 200 to 250 yards east of the north-south Union County road; also 0.3 mile northeast of the junction, on the west side of this road, at which place they are not exposed on the opposite side of the road at the same level, the interval being compact olive-drab to greenish silt, probably of Fearn Springs age. The elevation of the top of the Naheola here is about 339 feet, and of Mississippi State Geological Survey Prospect Hole 1, on the hill slope above the outcrop and a few yards east of it, 345 feet. The log of the hole is given below:

LOG OF PROSPECT HOLE 1

Location: Northwestern Union County, a few yards north of a road junction (SW.¼, Sec.30, T.6 S., R.1 E.) a little east of the Marshall County line, above a road cut and a few yards south of a U. S. Geological Survey bench mark, Elevation 329 feet.

Property: Campbell Elevation: 345 feet

Int.	Thick.	Depth	Description of strata
			Fearn Springs formation
1	2.0	2.0	Clay, brown, sandy
2	24.0	26.0	Clay shale, light gray to dark gray sandy and silty; darker downwards; some lumps of light-gray clay
			Naheola Formation
3	74.0	100.0	Shale, blue-black to dark greenish sandy and silty; some small brown clay lumps; $FeCO_3$ concretions at a place or two.

The southeast wall of Mills Creek Valley between the two road outcrops referred to is steep, and shows one other Naheola outcrop.

An outcrop of white clay 1.2 miles east of the Marshall County line, on the north side of the road which leads east into Union County a little north of Cornersville, may mark the top of the Midway.

The southeastern corner of Marshall County is of sufficiently low altitude to show Naheola outcrops, especially if the southeast dip of the beds exists far to the northwest. However, an examination of the slopes north, northwest, and west of Corners-

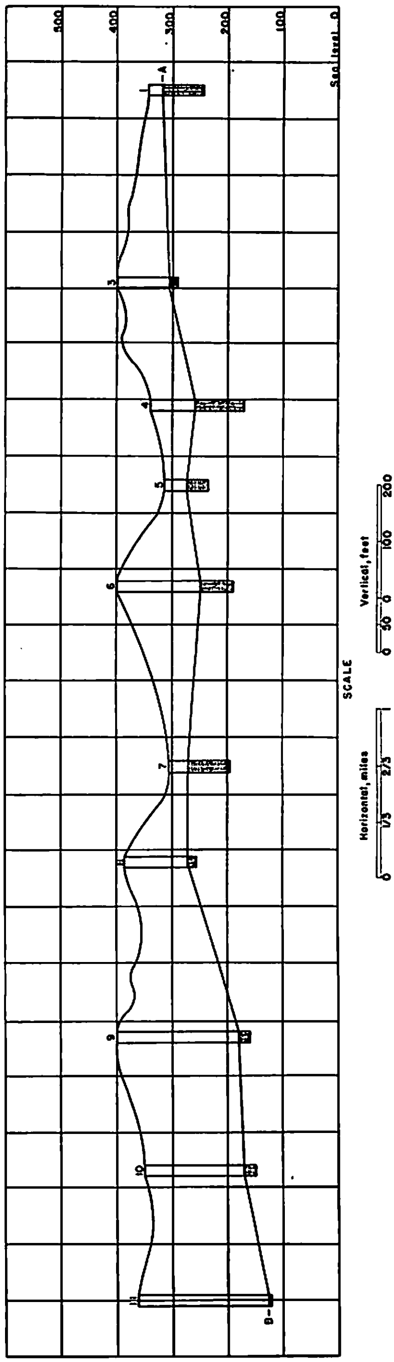


Figure 3.—Surface of the Naheola formation, A-B, from test hole depths along a line (A-B, Plate 1) in southeastern Marshall County.

ville failed to find any beds which could be positively identified as Naheola.

It was found by a linear series of prospect holes along and near the Cornersville-Bethlehem road and roads west of Bethlehem, from Cornersville almost to Tippah River, that the upper surface of the Naheola is very irregular, but that in general it slopes northwestward at a low angle (Figure 3). Prospect Hole 3, three quarters of a mile west by south of the road junction in Cornersville, encountered the Naheola at about 94 feet. Hole 9, a little more than 5 miles northwest of No. 2, reached the Naheola at 220 to 225 feet. The two locations have essentially the same elevation, 400 feet. It appears, then, that the over-all slope of the top of the Naheola in this region is at the rate of 126 to 131 feet in 5 plus miles, or 25 to 26 feet to the mile (Figure 3).

The thickness of the Naheola and Porters Creek formations underlying Marshall County is at least several hundred feet. Conant estimated the thickness of the same formations at 480 feet plus or minus in Union County.[22] The log of the public well at Potts Camp records some 625 feet of "Ackerman formation and underlying Midway group."[23] The driller's log of the H. C. Forte No. 1 oil prospect well, a well about half a mile northwest of Holly Springs, records shale from 805 to 1242 feet — 437 feet of shale, presumably Midway. According to the driller's log, Huffman No. 1, approximately three quarters of a mile east of Holly Springs, was in shale from 400 feet to 1106 feet — that is, 706 feet; but the "gray shale," "green brown shale," "brown shale tough," and "brown shale rotten," comprising the upper 275 feet of the shale section, probably are Wilcox. Huffman No. 2, a short distance from Huffman No. 1, encountered shale at 408 feet and continued in it to 1112 feet, if the driller's log is accurate; but in this well also probably at least 250 feet of the upper part of the shale interval should be assigned to the Wilcox. The log of one of the water wells in Holly Springs records the top of the Ackerman (questionably) at 357 feet,[24] which is reasonably consistent with the records of the Huffman wells, if the interpretations given above are permissible. The Forte and Huffman wells are at almost exactly the same altitude, and the Holly Springs well is only 30 feet higher.

The No. 1 Fee well, approximately 4 miles east of the Huffman wells, at an altitude of some 450 feet, logged the top of the

Midway at a depth of 500 feet.[25] However, a well at Camp Yacona (Chewalla Organization Camp? SW.¼, Sec.8, and NW.¼, Sec.17, T.4 S., R.1 W.), 2 to 2.5 miles south by east of No. 1 Fee, at an elevation of perhaps 440 feet, was reported to have reached the top of the Midway Porters Creek clay at a depth of 215 feet, and the bottom at 843 feet[26] — that is, the well passed through 628 feet of Midway strata, according to this interpretation.

The data briefly summarized herein suggest that the thickness of the Naheola and Porters Creek formations which underlie the surface of Marshall County varies notably from place to place, but is of the order of 400 to 500 feet.

FEARN SPRINGS FORMATION

Conant reported "an apparent thickness of at least 115 feet" of Fearn Springs strata in northwestern Union County and adjacent parts of Benton County, and his map shows part of the Fearn Springs area of outcrop at the Union County-Marshall County line in Sections 7, 18, and 19 of Township 6 South, Range 1 East. He found the formation to consist of "a basal sand some 10 to 20 feet thick, commonly brown and fine-grained, but locally coarse-grained . . . overlain by an irregular series of gray or lignitic silty plastic clays and laminated micaceous silty clays and sands which locally are strongly cross-bedded." He adds, "In some places siderite concretions are present, in others as many as three probable siderite layers a few inches thick and a few feet apart are found."[27]

Along the road which leads east into Union County a little north of Cornersville, the steep east wall of Mills Creek Valley is brown micaceous silt or fine silty sand below, and gray and lignitic clay above, including a 1-foot to 2-foot bed of iron ore well up above the flat. Conant assigns these beds to the Fearn Springs formation. He states that the irregular silty clays crop out above and east of the "fine-grained brown micaceous silt or sand" of the basal portion, and include "three ferruginous rock layers which, when fresh, were probably siderite."[28]

Along the road which leads northwest from Cornersville, Marshall County, half a mile or less west of the Union County line, a section of Fearn Springs and Ackerman beds is exposed by ravines and road cuts:

STRATIGRAPHIC SECTION (NEAR CENTER, AND NW.¼, SEC.24, T.6 S., R.1 W.) OF THE NORTHEAST WALL OF THE VALLEY OF A TRIBUTARY OF MILLS CREEK NORTHWEST OF CORNERSVILLE

	Feet	Feet
Ackerman formation		70.0
Clay shale, dark, sandy and silty, and clay, light gray to dark gray and lignitic; interbedded with fine dark-gray and olive-drab sand and gray silt; bedding irregular — lentils and stringers and lenses; some iron ore; to top of upland farther north	40.0	
Sand, white to brown and red brown; irregularly bedded in places; generally fine, but coarse, gritty and pebbly in lower part; contains scattered white clay and silt inclusions; to top of ridge	30.0	
Fearn Springs formation		55.0
Shale, silty and sandy, light gray where fresh, but stained yellow and brown and black by iron rust; weathers to white sandy clay; some thin beds of clayey and silty sand; conspicuously laminated, bedding and lamination planes defined by iron rust; some ragged limonite fragments. To base of section a little above the valley floor	55.0	

The Fearn Springs part of this section probably is correlative with the irregular silty clays of the east wall of Mills Creek Valley, Union County, described by Conant.

Prospect Hole 2, located only a few feet from this outcrop, 25 feet above its base, and a few feet from the road on the southwest side, passed through the strata described below:

LOG OF PROSPECT HOLE 2

Property: Swain or Rip Morgan Elevation: 380± feet

Int.	Thick.	Depth	Description of strata
			Fearn Springs formation
1	12.0	12.0	Soil, subsoil, and other mantle rock — brown and gray sandy loam and brown clay
2	19.0	31.0	Clay shale and clay, light gray sandy and silty, rusty
			Naheola Formation
3	2.0	33.0	Shale, brown and black, rusty (transition?)
4	27.0	60.0	Shale, bluish and greenish black.

A vertical-faced scarp (NE.¼, NW.¼, Sec.24, T.6 S., R.1 W.) which includes the lowermost 30 feet or more of the steep 100-foot west wall of the valley of Cornersville Creek east of the road, shows two outcrops of very irregular terrane. Angular blocks and rounded masses, large and small, of laminated bluish-gray to light-gray sandy silt have been worked into a gray sand matrix, forming a coarse conglomerate or breccia; and stringers of gray clay and lenses of light-brown sand are woven into the pattern. The two outcrops expose sections which probably are slightly above the base of the Fearn Springs formation.

A little east of a junction (NW.¼, Sec.25, T.6 S., R.1 W.) and 0.6 mile west from the road junction in Cornersville, the south wall of a cut shows a 30-foot interval of steeply (2.5 feet in 25.0 feet) westward dipping beds of brown and gray silt and sand overlying a thin interval of black lignitic clay and white clay at an elevation of approximately 370 feet. A piece of silicified wood was found at about the level of the black and white clay. The writer believes that the lignitic and white clay mark the Fearn Springs-Ackerman contact at this place. Prospect Hole 3, 200 to 300 yards northwest of the outcrop, started near the top of the Fearn Springs formation at an altitude of 400 feet, and reached the Naheola at a depth of 94 feet, thus proving a Fearn Springs thickness of at least 94 feet at this place.

LOG OF PROSPECT HOLE 3

Location: 0.6 mile west of the road junction in Cornersville and some 200 yards north of the Cornersville-Bethlehem road, on the west side of a short road which leads to a sand pit, and about 75 yards south of a red house (SW.cor., Sec.24, T.6 S., R.1 W.)

Property: G. A. Robinson — Elevation: 400 feet

Int.	Thick.	Depth	Description of strata
			Fearn Springs formation
1	8.0	8.0	Soil, subsoil, and other mantle rock; brown sandy clay and loam
2	39.0	47.0	Clay, light gray, rusty; small concretions (gravel)
3	47.0	94.0	Sand, fine gray; more clayey and silty with depth
			Naheola Formation
4	16.0	110.0	Lignite and lignitic clay through an interval of 6 to 7 feet, underlain by Naheola shale.

Road cuts through the upper parts of three or four ridges west of the Section 25 outcrop and Prospect Hole 3 expose Fearn Springs shale, silt, sand, clay and iron ore. The cut a few rods west of the junction (NW.¼, Sec.25, T.6 S., R.1 W.) near Hole 3, shows a section of gray clay shale, greenish and olive-drab sand and silt, and black clay, containing many masses of iron ore. The bodies of the different materials are variously oriented in relation to each other. Some iron ore masses are inclined westward at a high angle. The confused structural relationships extend farther west, as shown by other road cuts through gray and greenish-gray and lignitic clay. In general the dip is westward, but much diagonal bedding is present.

Prospect Hole 4 (SE.¼, SW.¼, Sec.23, or NE.¼, NW.¼, Sec. 26, T.6 S., R.1 W.) on the G. A. Robinson property a few yards north of the Cornersville road, passed through some 80 feet of Fearn Springs strata above the Naheola.

LOG OF PROSPECT HOLE 4

Location: Approximately 75 yards north of the Bethlehem-Cornersville road, at the north end of a pond (SE.¼, SW.¼, Sec.23, T.6 S., R.1 W.) at the foot of the slope south of Mr. Robinson's residence.

Property: G. A. Robinson Elevation: ±340 feet

Int.	Thick.	Depth	Description of strata
			Fearn Springs formation
1	5.0	5.0	Soil, subsoil, and other mantle rock; brown sandy rusty clay, iron oxide gravel and small pieces of limonite
2	16.0	21.0	Clay, light gray and yellowish and rusty; grades downwards into light gray and chocolate brown: rock between
3	7.0	28.0	Clay, shades of gray, containing thin lignite beds and thin layers of fine sand
4	4.0	32.0	Clay, gray
5	12.0	44.0	Clay, dark-brown streaks near top, light gray below
6	0.5	44.5	Iron carbonate ($FeCO_3$)
7	6.5	51.0	Clay, light gray, as Interval 5
8	29.0	80.0	Clay, dark gray, containing thin layers of lignite; alternates with light-gray clay, and sand streaks
			Naheola Formation
9	91.0	171.0	Clay, slate gray to dark bluish gray, sandy and silty.

Grading for farm roads in the vicinity, and excavations for a small lake spillway have made good outcrops of the light-gray, yellowish, and dull white rusty clay shale and some lignitic clay.

Half a mile farther west by north, Hole 5, a few yards north of the road, in a valley, passed through some 42 feet of Fearn Springs beds similar in character to those of Hole 4.

Log of Prospect Hole 5

Location: On the north side of the Bethlehem-Cornersville road, in the west edge of a creek valley in a grove of trees (SE.cor., Sec.22, T.6 S., R.1 W.) about 0.5 mile west of Hole 4, and 0.3 mile northwest of the creek bridge.

Property: Kirk? Elevation: 310-15 feet

Int.	Thick.	Depth	Description of strata
			Fearn Springs formation
1	4.0	4.0	Soil and subsoil, brown and dark
2	12.0	16.0	Clay shale, very light gray to white; rusty; contains iron oxide gravel and crusts; pure white at 9 feet or so
3	2.0	18.0	Clay and sand; dark-gray clay and about a foot of fine gray sand
4	4.0	22.0	Clay shale, as in second Interval
5	3.0	25.0	Clay, mostly lignitic black; some light and gray streaks
6	7.0	32.0	Clay, darker than Interval 2; mixed with black; grades downward into
7	5.0	37.0	Clay, light gray, as Interval 2
8	0.5	37.5	Clay, lignitic
9	2.5	40.0	Clay, light gray to white
10	2.0	42.0	Sand, fine gray water-bearing
			Naheola Formation
11	22.0	64.0	Clay, dark bluish gray to black; Core taken at 50 feet
12	16.0	80.0	Clay, dark gray to greenish black; thin rock at 74 feet.

A little south of the intersection of the main Cornersville road with a local road (SE.¼, NW.¼, Sec.22, T.6 S., R.1 W.) fragments of silicified wood are lying on an outcrop of silty gray clay. Their presence suggests a Fearn Springs-Ackerman contact, as in many other places in Marshall County. A short distance farther south, a road cut in the hill slope exposes 25 feet or so of greenish-gray rusty clay shale, at an elevation of 360 to 400 feet.

Prospect Hole 6, a few rods south of Salem Church (SW.¼, Sec.15, T.6 S., R.1 W.) on the west side of the same local road some 0.7 mile north from the main Cornersville road, begun at an elevation of 400 feet, reached the Naheola at a depth of about 150 feet:

LOG OF PROSPECT HOLE 6

Location: About 0.7 mile north from the Bethlehem-Cornersville road, on the road to Salem Church, 50-60 yards south of the church (SW.¼, Sec.15, T.6 S., R.1 W.) under trees.

Property: Salem Church Elevation: 400 feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	15.0	15.0	Soil and subsoil, brown sandy loam and clayey sand
2	7.0	22.0	Clay, light gray to white, darker downwards
3	2.0	24.0	Clay, lignitic, dark; thin interval of lignite at 24 feet
4	2.0	26.0	Clay, dark gray; thin lignite at top
5	26.0	52.0	Clay, lighter gray to bluish gray, rusty; continues various shades of gray downwards
6	7.0	59.0	Clay, sandy gray and yellowish mixture; some small sandy lumps
7	0.8	59.8	Iron carbonate, $FeCO_3$
			Fearn Springs formation
8	10.2	70.0	Clay, similar to that of Interval 6, but a greater proportion of light gray, varies from lighter to darker and vice versa; a streaked clay
9	5.0	75.0	Sand, light brown to yellowish, fine, argillaceous
10	7.0	82.0	Clay, gray, sandy
11	68.0	150.0	Sand, as 9th interval, streaked with clay; grades downwards into gray to brown silt, so fine that most of it went into suspension, making sampling difficult
			Naheola Formation
12	35.0	185.0	Sand, blue, medium to fine, and thin layers of dark shale
13	15.0	200.0	Sand, changing to darker color, and some shale; a few cemented crusts
14	10.0	210.0	Shale, dark sandy, and fine sand; some hard lumps.

Contacts could not be definitely determined, but the hole probably started in Ackerman beds and reached the Fearn Springs at approximately 60 feet. If the contact is at this depth, the

Fearn Springs formation is 100 feet thick, a little more or less, at Salem Church.

A short distance east by north of the junction of the Bethlehem-Cornersville road with a local road leading south, a cut (Extreme southern part, Sec.16, T.6 S., R.1 W.) through the upper part of a ridge exposes a few yards of an irregular contact trace between light-gray red mottled and dark-gray clay below and brown sand and sandstone above. A large piece of silicified wood is lying on or a little below the contact. The contact is believed to be the Fearn Springs-Ackerman. Another contact exposure between clay and sand (northern part, Sec.21, T.6 S., R.1 W.) is shown by a cut for the north-south road less than 0.2 mile south of the outcrop just described. Silicified wood is present at this place, also. The contact line is at a lower level than that on the main road. Probably the Fearn Springs-Ackerman unconformity and the lowering of the surface towards the valleys could account for elevation differences.

Prospect Hole 7, at the Cornersville road bridge over Jones Creek (SW.¼, Sec.16, T.6 S., R.1 W.) a quarter of a mile or less west of the cut which exposes the Fearn Springs-Ackerman contact, encountered Naheola beds under 35 feet of alluvium. Inasmuch as the altitude of the contact referred to is about 370 feet, and the altitude of the mouth of the hole is approximately 305, the thickness of the Fearn Springs interval at this place may be 90 to 100 feet.

Hole 8 (Northern part, Sec.17, T.6 S., R.1 W.) in the village of Bethlehem, started at an elevation of approximately 385 feet and reached a depth of 130, of which the last 15 feet was dark clay shale, probably Naheola.

Log of Prospect Hole 8

Location: At Bethlehem, on the east side of the Bethlehem-Cornersville road, and about 100 yards south of the Pipkin general store, in woods at an abandoned sawmill site (Northern part, Sec.17, T.6 S., R.1 W.)

Property: Lester Cook — Elevation: ±385 feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	1.0	1.0	Soil and subsoil, light sandy loam and clayey sand
2	17.0	18.0	Sandy clay and fine sand, brown; 4-inch rock struck at about 7 feet
3	4.0	22.0	Clay, gray and brown

4	6.0	28.0	Sand, brown and gray fine with many black inclusions
5	0.5	28.5	Sandstone
6	5.5	34.0	Sand, as Interval 4
7	4.0	38.0	Sand, yellowish and gray fine, and thin layers of gray clay
			Fearn Springs formation
8	72.0	110.0	Clay and silt chiefly; yellowish and gray sandy micaceous; very fine; continues downward
9	5.0	115.0	Sand, as above; silty
10	15.0	130.0	Clay, dark blue (top of *Naheola*?)

No definite Fearn Springs-Ackerman contact was detected in the hole, but possibly the yellowish clay and silt encountered at about 38 feet marked the top of the Fearn Springs.

In the head of the valley just northwest of Bethlehem (SW. ¼, Sec.8, T.6 S., R.1 W.) lignitic and white clay, exposed in the main creek channel and that of a tributary, is thought to be part of the uppermost Fearn Springs beds (elevation 360 feet or less). It is at the top of a section of gray, yellow, and brown to cream colored and white jointed shale, chiefly silt, interbedded with fine gray and olive-drab sand, the bedding being conspicuous on the outcrop and commonly defined by iron rust. Masses of iron carbonate inside oxide shells are scattered thinly through the shale, and are especially abundant in the uppermost few feet below the lignitic and white clay.

The small southward-flowing creek affords an almost continuous outcrop of the light colored sandy silt shale for a distance of perhaps three quarters of a mile, the stream channel being a trench cut in the shale. An interval at least 30 feet thick of shale is exposed. The bedding is not regular, but shows undulations, and local dips in two or three directions. Iron ore is not conspicuous in the shale exposed by this creek except, as stated, in the uppermost few feet. However, concretions are present here and there. About a third of a mile south of the road, a pipe-like "log" of impure iron ore extends entirely across the creek, causing a 1.5 foot waterfall.

Lignitic and white clay is exposed (Southern part, SW.¼, Sec.6, T.6 S., R.1 W.) along a northeast-southwest road, a little above Tippah River flat, and half a mile south of a bridge over Potts Creek. Fragments of silicified wood and iron ore are lying about. The place is believed to be on the Fearn Springs-Ackerman contact. The elevation is about 320 feet.

Along the road which leads south from its junction (Near center, Sec.17, T.6 S., R.1 W.) with the Bethlehem-Cornersville road, some iron ore shows in surface brown silty clay, probably Ackerman; but at the junction (extreme southern part, Sec.17, almost on the line between Secs.17 and 20) of this short north-south road with an east-west road, light-colored shale, believed to be Fearn Springs, is exposed. The same shale shows in the lower part of the west wall of the same valley, along the east-west road; also a quarter of a mile east of the junction.

The data relating to the Fearn Springs formation, presented in the foregoing text, show, according to the writer's interpretation, that 1) the formation in Marshall County crops out only in the region east of Tippah River and south of Potts Creek; 2) its base is not exposed in the outcrop area, but short segments of its contact trace with the overlying Ackerman beds are at the surface, and may be recognized by white or light-gray clay below the contact line, commonly associated with black lignitic clay or yellow clay or sand, and in places with silicified wood; 3) it is unconformable on the Midway Naheola and under the Wilcox Ackerman; 4) the thickness varies from place to place, because of the unconformable contacts, but the maximum thickness found by prospect holes is of the order of 90 to 100 feet; 5) the regional dip is northwest or north-northwest at a low angle, but in a few places the dips are relatively steep and in various directions; 6) the formation is composed of sand, clay, and silt, but contains a considerable quantity of iron ore.

ACKERMAN FORMATION

At a few places in southeastern Marshall County the lowermost unit of the Ackerman formation is a sand. The farthest southeast exposures of the sand are in the vicinity of Cornersville. The stratigraphic section (Near center, and NW.¼, Sec.24, T.6 S., R.1 W.) described under "Fearn Springs formation," includes 30 feet or so of Ackerman sand well exposed by an old sand pit. It is, in general, a coarse to medium quartz sand, brown and red brown, yellowish and dull white. The road cut exposes light-colored gritty and pebbly silty sand. Almost all the pebbles, none of which is larger than a quarter of an inch in diameter, are milky quartz. The sand body contains stringers and other inclusions of light-colored sand and sandy clay, probably reworked from Fearn Springs or Betheden beds. As indicated in the description of the section, the sand interval is succeeded upward by irregularly bedded gray and lignitic clay shale, fine gray and tan sand, silt, and iron ore.

About 0.6 mile west of the road junction at Cornersville, and 0.2 mile north of the road, is another pit (SW.¼, Sec.24, T.6 S., R.1 W.) in Ackerman sand, at the same elevation. A quartzite bowlder was found a little south of the pit.

Prospect Hole 6 (SW.¼, Sec.15, T.6 S., R.1 W.) some 2.3 miles northwest of the sand pit referred to in the preceding paragraph, and at the same elevation, encountered very little sand above a depth of 70 feet (see log under "Fearn Springs formation.") The position of the Fearn Springs-Ackerman contact could not be determined with accuracy in this hole; the sand which is the lowermost unit of the Ackerman in many places may be absent here. However, the road cut outcrop (Extreme southern part, Sec.16, T.6 S., R.1 W.) referred to in the description of the Fearn Springs formation, shows 8 to 10 feet of basal Ackerman brown sand and sandstone. The sandstone pieces are fluted, tubular, and various other shapes, including roughly spherical contorted masses. In places thin sandstone separates the clay below from the sand above. The sand contains clay inclusions. Less than 0.2 mile south of this outcrop the walls of a north-south road cut (Northern part, Sec.21, T.6 S., R.1 W.) are clay below, and red-brown sand, presumably basal Ackerman, above. Some 0.7 mile farther south along the same road, a cut (NE.¼, SW.¼, Sec.21, T.6 S., R.1 W.) in the southeast wall of a valley, exposes 20 feet or so of the same kind of red-brown sand, containing some reworked dull-white sandy clay. Although the exposed sand on the north-south road is at a lower level than that shown by the cut on the main road, all is believed to be basal Ackerman.

Prospect Hole 8 (Northern part, Sec.17, T.6 S., R.1 W.) passed through some Ackerman beds. The base of the Ackerman probably was reached at a depth of approximately 38 feet. Above that depth the material was chiefly sand and below it, clay and silt (see log, under "Fearn Springs formation"). Hole 8 is about 1.3 miles northwest of the Section 16 outcrop and 15 feet higher in elevation. It would appear, then, that between the two places referred to, the degree of northwestward slope of the Fearn Springs-Ackerman contact is about 17.5 feet to the mile. A comparison of the elevation of the contact at the Section 16 outcrop with the elevation of the presumed contact (SW.¼, Sec.8, T.6 S., R.1 W.) in the small valley west of Bethlehem, indicates a slope of about 20 feet to the mile.

West of the small valley mentioned above, gray and reddish clay, and brown iron ore, presumably Ackerman, crop out along the main road leading west from Bethlehem, also along roads south of the main road. A particularly good exposure (SE.¼, NW.¼, Sec.18, T.6 S., R.1 E.) has been made by cuts in a north-south road 0.2 to 0.3 mile south of its junction with the main northeast-southwest road. The terrane here, consisting of clay shale and clay, sand, and silt, is very irregularly bedded. The sand is green and silty; the clay is gray and lignitic and rusty, and some of it has well-developed conchoidal fracture.

Ackerman clays, silts, and sands crop out in many places on both sides of the valley of Tippah River. One of the best exposed stratigraphic sections in the entire Ackerman outcrop area is along the road which leads southeast from the river bridge (SW. ¼, Sec.12, T.6 S., R.2 W.):

SECTION OF THE EAST WALL OF THE VALLEY OF TIPPAH RIVER ALONG A ROAD LEADING SOUTHEAST FROM THE RIVER BRIDGE (SW.¼, SEC.12, AND NW.¼, SEC.13, T.6 S., R.2 W.)

	Feet	Feet
Ackerman formation		89.8
Weathered material: a brown structureless mixture of sand, silt, and clay; contains iron ore, particularly a 0.6-foot layer which caps the hill. To the top of the valley wall	25.0	
Silt, thin-bedded and laminated, jointed, blocky; gray to buff, mottled and streaked with rust; light colored below, almost white at top; some laminae paper thin	15.0	
Clay shale and clay, light gray to greenish, as Interval 10; not continuously exposed	5.2	
Silt, lignitic, blocky; greenish cast on surface	4.8	
Clay shale, light gray; surface has a greenish cast	4.5	
Clay, lignitic, dark gray to black; uppermost one foot or so is an impure black lignite	5.0	
Silt, greenish	1.0	
Clay shale, light gray to greenish, rusty; streaks of lignitic clay	12.0	

Clay shale, gray and black lignitic; contains stringers of impure lignite	3.0
Iron ore, oxide, slabs and boulders	0.5
Shale, clay, and shaly sandy silt and silty sand, as second interval, but grading upwards into green; weathers to sticky clay	3.0
Iron ore, oxide, concretions	1.0
Shale, clay, and shaly sandy silt and silty sand: Greenish-gray clay streaked and spotted with iron rust; sandy and silty; contains thin iron ore	4.8
Covered, to road level at the junction, approximately bridge level	5.0

Gray and lignitic clay containg iron ore, correlative with some strata of the section, crops out (SW.¼, SE.¼, Sec.12, T.6 S., R.2 W.) in the main Tippah River-Bethlehem road at a flowing well at the site of a burned house. Also, along the creek a little north of this place shale and iron ore are at the surface.

Prospect Hole 9 (Western part SE.¼, Sec.7, T.6 S., R.1 W.) at a road junction, passed through 75 feet of clay, and below it 145 feet of sand.

LOG OF PROSPECT HOLE 9

Location: Between roads at junction (SE.¼, Sec.7, T.6 S., R.1 W.) a mile west of the Bethlehem-Potts Camp road (Highway 349).

Property: Scott (Colored) Elevation: 400 feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	5.0	5.0	Soil, whitish sandy loam, and subsoil, brown sandy clay
2	23.0	28.0	Clay, light gray to dull white, and concretions and crusts of iron oxide; rock, probably iron carbonate, at 18 feet; all material yellowish and rusty
3	5.0	33.0	Clay shale, brownish black, lignitic, lumpy, tough
4	5.0	38.0	Clay shale, blue, tough
5	7.0	45.0	Clay, gray, dark to light, darker downward; probably a jointed or fractured clay shale; took up water. Streak of lignite at about 44 feet
6	20.0	65.0	Clay, light gray, containing thin seams of lignite and lignitic clay
7	10.0	75.0	Clay, light brown and yellow; more sandy below 72 feet

8	145.0	220.0	Sand, brownish gray, coarse, angular grains; gray, and dries almost white; contains scattered small gravel, also clay fragments, and some gray clay laminae; clay stringers at 205-210 feet
9	20.0	240.0	Sand and clay, clay content increasing with depth; slightly below 220 the material was chiefly dark bluish and gray clay, probably *Naheola.*

In sharp contrast, Hole 10 (SE.¼, NE.¼, Sec.12, T.6 S., R.2 W.) only 0.6 mile northwest of 9, and approximately 50 feet below it, found nothing but clay to a depth of 200 feet.

LOG OF PROSPECT HOLE 10

Location: North side of an east-west road 50 to 60 yards west of its junction with a southwest-northeast road; 80 to 100 yards east of Mr. Whaley, Sr.'s residence, and a little farther west of Mr. Whaley, Jr.'s home, in a grove of forest trees (SE.cor. NE.¼, Sec.12, T.6 S., R.2 W.).

Property: Whaley Elevation: 340-360 feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	6.0	6.0	Soil and subsoil: Sandy clay and silt, light brown to darker brown, grading downwards into brown clay
2	6.0	12.0	Clay, stiff, plastic, alternating lighter and darker gray — light-gray, iron-stained clay towards top
3	0.4	12.4	Sandstone, ferruginous
4	8.6	21.0	Clay, dull white to yellow and brown
5	6.0	27.0	Clay shale, dark blue to almost black; lumpy
6	4.0	31.0	Clay, bluish-green to green
7	2.0	33.0	Clay, chocolate brown to dark
8	0.5	33.5	Iron carbonate
9	6.5	40.0	Clay, dark gray to light gray, contains fragments of lignite
10	17.0	57.0	Clay, bluish green as Interval 6, 2 feet, grading downwards into dark gray; color change at short intervals, through varying shades of gray; thin bed (about 2 feet) of lignite at about 52 feet
11	14.0	71.0	Clay, green, grading downwards into shades of gray, including thin green and chocolate-brown beds, specifically at 60 and 65 feet
12	2.0	73.0	Lignite bed
13	127.0	200.0	Clay, chocolate brown, and light and dark gray; at greater depth, lumpy bluish-gray clay shale, probably *Naheola;* no change after reaching bluish-gray clay shale.

It was reported that an artesian well on the ridge a quarter of a mile east by south of Hole 9, and less than 20 feet higher, encountered a thick sand at about 96 feet.

It is not easy to explain the extreme thickness of the sand found by Hole 9, and especially its relationship to the entirely clay section passed through by Hole 10, hardly more than half a mile farther northwest. A hypothetical explanation, which seems plausible, is, that during the period of erosion which followed deposition of the Fearn Springs strata, a deep valley was cut along a course possibly subparallel or at a low angle to the present Tippah River Valley, and that this old valley was filled with sand early in Ackerman time, and later covered with beds of clay. Prospect Hole 9 was located above the old valley fill, and Hole 10 on one of the valley walls. This would mean that part of the section of Hole 10 may be of Fearn Springs age. The explanation suggested here of the contrasting sections of Holes 9 and 10 might be strengthened or weakened by data obtained by additional drilling, which might provide a basis for a different explanation.

A road cut (Near center, Sec.13, T.6 S., R.2 W.) in the south wall of a small valley, half a mile south-southeast of the Tippah River bridge section, exposes well bedded buff to greenish to white silt shale, dipping steeply north.

On the northwest side of a local road which leads to a plantation on the Tallahatchie flood plain, a ravine (Southern part, NE.¼, Sec.23, T.6 S., R.2 W.) exposes 30 to 40 feet of banded yellowish and gray and black sandy silt and silty sand, containing masses of iron ore. Half a mile west and northwest of this place, Tippah River is against a high steep bluff, the east wall of its valley (SE.¼, Sec.14, and NW.¼, Sec.23, T.6 S., R.2 W.). Reconaissance along this bluff for half a mile or so failed to find any outcrops, but fragmental iron ore is lying on the surface here and there.

Several cuts for the Bethlehem-Potts Camp road have made outcrops of Ackerman strata, but only in the walls of the valley of Potts Creek do they show any of the beds prominently. The cut in the south wall (SE.¼, NE.¼, Sec.6, T.6 S., R.1 W.) is through a terrane of complicated structure (Figure 4), a jumble of bodies of clay, sand, and silt of various shapes. Nevertheless, in the extremely irregular pattern shown by the faces of the

Figure 4.—Ackerman-Meridian contact zone, in a road cut (NE.¼, Sec.6, T.6 S., R.1 W.) in the south wall of the valley of Potts Creek about a mile north of Bethlehem. June 18, 1952.

Figure 5.—Ackerman beds, south wall of the valley of Potts Creek (NW.¼, Sec.4, T.6 S., R.1 W.) some 2 miles north by east of Bethlehem, and a little east of a road bridge. June 9, 1953.

cut walls, a general southward dip exists. Along the main road in the north wall of Potts Creek Valley, also, a section across the Ackerman-Meridian contact is exposed by cuts and gullies. Gray and lignitic clay is overlain by brown and red-brown sand (NE. ¼, NW.¼, Sec.32, T.5 S., R.1 W.).

Probably the best outcrop of Ackerman terrane in Marshall County is the face of the south wall of the valley of Potts Creek, some 75 yards east of a road bridge (NW.¼, Sec.4, T.6 S., R.1 W.) and less than a mile west of the Benton County line. The vertical face, reaching 40 to 50 feet above the creek floor at its base and 100 feet or so along the channel, is a cross-section of beds and irregular bodies of silt, sand, and clay, chiefly silt (Figure 5), in which, in places, are "boulders" of iron ore and a conglomerate of rounded or angular masses of hard sand or clay. The structure is fairly regular in the western part of the outcrop, but irregular towards the eastern end, where a diagonal contact trace trends downward towards the east across the face of the wall. Along this contact trace is a concentration of clay and sand breccia and iron ore boulders. The sharply defined contact line and the structural relationships of the materials suggest a filled erosional channel. The floor of the present creek channel and a few inches of the lowermost part of the wall are a dense sky-blue clay which is greenish on the surface, due to oxidation of the iron. Lignitic clay and a little lignite show farther west along the wall above the blue clay. Possibly these blue and lignitic clay beds mark the base of the Ackerman. Talus at the foot of the cliff is chiefly thin blocks and slabs of laminated silt, which separated from the wall along planes parallel or subparallel to the face. The face of the wall shows a rusty brown to yellow, but the fresh silt is gray to black, and contains abundant comminuted plant debris and larger fragments of leaves.

The road cut in the Potts Creek Valley bluff a short distance southwest of the cliff exposes a good section of the same interval. Ackerman beds crop out also (Sec.32, eastern part, and Sec.33, SW.¼, T.5 S., R.1 W.) along a north by west and south by east local road, in the north wall of the valley of Potts Creek. Another fairly well exposed section is along a southwest-northeast road (SE.¼ and NE.¼, Sec.33, T.5 S., R.1 W.) between its junction with the road last mentioned and the Benton County line. At the top of the section, overlying gray clay, is a layer of dense brown silty limonite or limonitic silt, slabs and irregular fragments of which, mixed with ferruginous sandstone, are scattered over the surface. This kind of rock is present at both the Fearn Springs-Ackerman and the Ackerman-Meridian contacts in some places, but at this particular place it could hardly represent the former, because the elevation (400 to 460 feet) seems too great, unless the dip is almost zero, or even reversed.

The uppermost few feet interval of surface Ackerman terrane can be traced by outcrops from a mile or less northeast of the mouth of Little Spring Creek (NE.¼, Sec.23, T.6 S., R.3 W.) which is on the Marshall County-Lafayette County line almost exactly at its middle point, north by east along the west wall of the valley of Big Spring Creek for approximately 7 miles, thence northeast for roughly an equal distance to near the Benton County line (Sec.28, T.4 S., R.1 W.).

At the southwestern end of this outcrop belt are several small exposures of gray red-mottled clayey silt, white to light-gray silt, and gray clay. More extensive outcrops (SW.¼, Sec.18, and NW.¼, Sec.19, T.6 S., R.2 W.) on the slopes at the end of a ridge, show gray and white silty sand; abundant fragments of thin sandstone and cemented silt; gray, red, white, and yellow clay; numerous ferruginous sandy concretions; and a little silicified wood. Large ravines in the east slope of the ridge show two, possibly three levels of silty iron ore concretions, the uppermost of which is about 15 feet below the Ackerman-Meridian contact. Also, two layers of iron ore concretions are exposed in the slope along a farm road (SE.¼, Sec.18, T.6 S., R.2 W.) where the Ackerman-Meridian contact is approximately 29 feet above the valley flat.

The northwest wall of the valley of Big Spring Creek (SW. ¼, Sec.17, T.6 S., R.2 W., and SE.¼, Sec.18) is seamed by ravines and gullies, which have exposed thicknesses up to 35 to 40 feet of very irregularly bedded silty sands, and silts; thin ferruginous sandstone; silicified wood; gravel, and cobbles. Prominent outcrops show little or no clay. Multitudes of sandy concretions of almost every conceivable shape litter the surface. The sands and silts are olive drab, gray, yellow, white, and combinations of colors; they are well bedded in places, but cut by thin indurated ferruginous crusts into irregular units. The road cut (NW.¼, Sec.17, T.6 S., R.2 W.) about 0.2 mile southeast of Mt. Vernon

Church, provides another cross-section of the Ackerman-Meridian contact zone. Ackerman silts, clays, sands, and silty iron ore of confused structure underlie coarse Meridian sand. Masses and seams of impure iron ore lie diagonally across the faces of the cut, at various angles. Farther down is greenish silt. Similar features are present in the uppermost 50 feet or so of the Ackerman, all along the strike.

Perhaps the best Wilcox-Claiborne contact zone outcrop in the county is on the main Waterford-Cornersville road, where

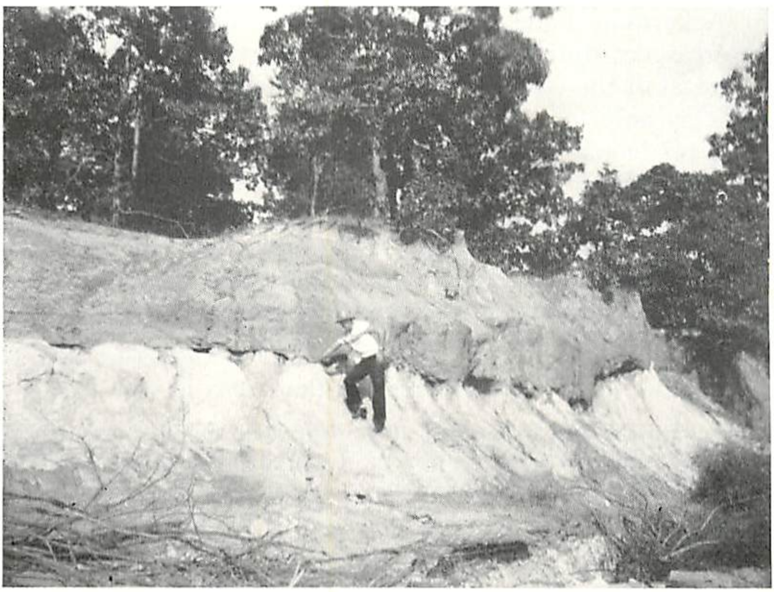


Figure 6.—Ackerman-Meridian contact, exposed by a road cut (SE.¼, SW.¼, Sec.28, T.5 S., R.2 W.) in the west wall of the valley of Big Spring Creek 4 miles southeast of Waterford. August 20, 1952.

a cut (SE.¼, SW.¼, Sec.28, T.5 S., R.2 W.) in the west wall of Big Spring Creek Valley a few yards northwest of a road junction has exposed gray and black clay shale and white and lignitic silts (Figure 6). The lowermost part, topographically, of the stratigraphic section is a white sandy silt shale mottled pink and brown. Above it, some 7 feet above the base of the section, is a dark silt, shaly near the surface at least; it is overlain by a thin black band of lignitic clay or silt, which is succeeded upwards by a dark silt containing numerous marcasite concretions. The top member of the section is a bluish-white silty clay or clayey silt, yellowish in places. The Ackerman part of the section seems to be chiefly silt, the white silt shale being a leached phase of the dark. The feature at this outcrop is the bed of gray lignitic clay shale and lignitic silt, which forms a ledge in the ravine on the northeast side of the road. It was found also in a ravine in Section 14, 3.5 miles northeast of the road outcrop. The structure of the strata exposed by the outcrop described above is not notably irregular.

Along the road leading north from the Waterford road outcrop, Ackerman material is at the surface for more than half a mile. Prospect Hole 12, located 0.2 mile north of the junction and 25 feet east of the road, at an elevation of approximately 360 feet, found clay only to a depth of 194 feet, except for a 5-foot bed of sand at 147 feet, and a 7-foot bed at 168 feet. At 194 feet a coarse angular grained sand was encountered, which the drill penetrated to 240 feet, the total depth of the hole, but did not get through it. The lowermost sand is thought to be basal Ackerman. It would appear, then, that the Ackerman formation at the prospect hole site and in the vicinity of the road junction is at least 280 to 300 feet thick.

Log of Prospect Hole 12

Location: On the east side of a south-north road about 25 feet from the road and 0.2 mile north of a junction, in the edge of a cotton field (hole near center, Sec.28, T.5 S., R.2 W.).

Property: M. B. Smith, Spring Lake   Elevation: 360 feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	8.5	8.5	Soil and subsoil, brown sandy clay, grading downwards into lighter brown and light-gray sandy clay
2	14.5	23.0	Clay, light gray rusty, yellowish and dull white
3	9.0	32.0	Clay, slate gray alternating with lighter colors towards the top; darker with increased depth, approaching black
4	14.0	46.0	Clay, bluish green or greenish blue, interlaced with black
5	21.0	67.0	Clay shale, light bluish gray to black; at 48 feet, top of 1.5-foot black bed; green clay at about 55 feet; thin rock at 61 feet

6	21.0	88.0	Clay, green, with gray intervals; contains chalky material; rocks at 81-83 feet
7	8.0	96.0	Clay, dark gray to light gray
8	10.0	106.0	Clay, green and dark gray
9	1.0	107.0	Rock (iron carbonate?)
10	40.0	147.0	Clay, gray to bluish gray
11	5.0	152.0	Sand, fine; clay stringers
12	16.0	168.0	Clay, gray, lumpy
13	7.0	175.0	Sand, fine, gray; thin rock a foot or two below the top of the interval
14	19.0	194.0	Clay, gray; hard clay shale toward the bottom; hard sand rock at about 193 feet
15	46.0	240.0	Sand, light gray, coarse, angular white to clear quartz grains; limonitic at top of interval.

Approximately 1.5 miles north by east of the Section 28 outcrop, cuts for the Waterford-Potts Camp road, and washes on both sides of it (SE.¼, NE.¼, Sec.21, T.5 S., R.2 W.) in the west wall of the valley of Big Spring Creek, have exposed a section of the Ackerman-Meridian contact zone. The 25- to 30-foot thickness of Ackerman terrane visible consists of silt, almost entirely: light-gray to dull white well bedded silt banded with iron rust, overlain by slightly carbonaceous silt, which in turn is succeeded above by compact moderately indurated yellowish silt grading upwards into quartzitic silt and a foot or more of quartzite. The quartzite and quartzitic silt contain numerous impressions of plant roots and stems. Brown gritty Meridian sand overlies the quartzite along an irregular contact. The outstanding feature of the outcrop is the quartzite. In other counties (Lafayette, Yalobusha, Montgomery, and Webster, for examples) quartzite is present in many places at the Wilcox-Claiborne contact, but the Section 21 outcrop is the only place in Marshall County where quartzite exists as a bed at the contact named, so far as observed by the present survey. Another feature which the Section 21 exposure shares with all other outcrops in the county at the same stratigraphic position, is the thousands of multi-shaped sandy and silty concretions covering the surface.

The Ackerman outcrop described above extends along the road for about 100 yards, and the contact is 29 feet above the culvert at the foot of the slope. Bedding is almost horizontal; not conspicuous.

Sections of the Ackerman-Meridian contact zone show in several places in the east wall of Big Spring Creek Valley and in the west wall of the valley of Tippah River. A little northeast of the road junction (SW.cor., Sec.16, T.6 S., R.2 W.) white silty clay and silt of the Ackerman are overlain by coarse pebbly and gritty Meridian sand. Less than half a mile farther south, a pit (NW.¼, Sec.21, T.6 S., R.2 W.) a few yards north of a road junction, shows white silty sand. The floor of the pit is yellow clay in places, and a silicified log is lying in sand which was excavated when the pit was dug. Both the outcrops are only a few feet above the uppermost terrace of the Tallahatchie River here.

Upper Ackerman beds, correlative with strata passed through by Hole 12, crop out in the east wall of the valley of Big Spring Creek along the Waterford-Cornersville road (Secs.33 and 34, T.5 S., R.2 W., and Sec.3, T.6 S., R.2 W.) for 0.8 mile. The outcrops show light-gray and lignitic clay, and iron ore, but little or no sand. A few yards of a sharp Ackerman-Meridian contact trace is exposed by a cut (NW.¼, NE.¼, Sec.3, T.6 S., R.2 W.) 1.6 miles southeast from the creek bridge, at an elevation of about 400 feet. Also, Ackerman clay may be seen in a place or two a short distance northeast of the road junction (NE.cor., Sec.33, T.5 S., R.2 W.).

Along the Waterford-Potts Camp road Ackerman silts and gray and lignitic clay crop out east and southeast of the bridge over Big Spring Creek for almost half a mile (Eastern part, Sec.22, T.5 S., R.2 W.). Upper Ackerman beds are rather poorly exposed about 1.5 miles farther northeast, in a ravine which heads (Southern part, NE.¼, Sec.14, T.5 S., R.2 W.) on the west side of a north-south road. The uppermost bed, 40 feet below the road, is sandy and silty lignite and lignitic silt, probably correlative with the stratum of the same material in the Section 28 outcrop 3.5 miles to the southwest at approximately the same elevation (380). The lignitic layer in the ravine is underlain by mottled yellow and gray sandy clay.

Prospect Hole 16, approximately half a mile northeast of the last outcrop mentioned, passed through the section described below:

Log of Prospect Hole 16

Location: On the inside of a west bend of a north-south road (SW.cor., Sec.12, T.5 S., R.2 W.) about 2 miles south of Highway 78 and 3 miles west by north of Potts Camp.

Property: Holly Springs National Forest — Elevation: 460 feet

Int.	Thick.	Depth	Description of strata
			Meridian formation
1	59.5	59.5	Soil and subsoil and sand; Clay, brown, sandy, grading downwards into sand, red-brown, clayey, and clear quartz; some lumps of white clayey sand
			Ackerman formation
2	18.5	78.0	Clay, white, and sand, alternating thick and thin stringers
3	13.0	91.0	Clay, brownish gray and mottled; tough
4	15.0	106.0	Clay, dark bluish gray sandy, as in Hole 15
5	39.0	145.0	Clay, light gray or mottled, to bluish gray; softer than that of Interval 4; grades downward into
6	30.0	175.0	Clay, yellow and light gray sandy, much streaked (oxidized zone?); less of yellow with depth
7	0.7	175.7	Silt, hard blue
8	105.3	281.0	Silt and fine sand, clayey, compact, tough, hard lumps (silt shale?). At 200 feet, lost circulation temporarily. Thin lignite seam at 205; thin rock at 208. Material continued blue sandy and silty shale and very fine sand, hard to drill, to bottom of hole.
			Naheola may have been reached.

A long road cut (NE.¼, Sec.20, T.5 S., R.1 W.) in the southwest wall of the valley of Oaklimeter (or Ocklimita) Creek, three quarters of a mile to a mile southwest of U. S. Highway 78 at Potts Camp, has exposed a good stratigraphic section of Ackerman and Meridian.

Section of the Southwest Wall of Oaklimeter Creek Valley (NE.¼, Sec.20, T.5 S., R.1 W.) Some 0.75 Mile Southwest of Potts Camp.

	Feet	Feet
Claiborne sub-series		
Meridian formation		60.0
Sand, coarse to fine; gritty near base, medium to fine at higher levels; sparingly to abundantly micaceous; white where fresh, but most of it yellow and brown and red brown; massive to cross bedded or horizontally bedded, to top of ridge	60.0	

Wilcox sub-series		
Ackerman formation		43.6
Clay shale, light gray to white and red and yellow, jointed, breaks out in blocks and thin slabs; pure to silty; ferruginous crusts at base	13.4	
Silt, bluish-gray to dark to almost black; dark color due to comminuted carbonaceous material, contains leaf impressions; irregularly bedded; crust of rust-cemented silt at base	11.5	
Silt, clayey, bedded, somewhat shaly structure; olive drab on surface, gray where fresh; leaf-bearing	2.4	
Covered with sand, silt and clay wash from above, to foot of slope on southwest side of road	16.3	

A quarter of a mile, more or less, north of the stratigraphic section described above, another (SE.¼, Sec.17, T.5 S., R.1 W.) along a road up the same valley wall, shows the same types of materials in the same sequence, but in addition a layer of iron ore concretions 1.0 foot to 1.5 feet thick, 10 feet above the base of the section (creek flat). The clay-sand contact is 38.5 feet above the creek flat.

In the north wall of the valley of Tippah River a mile southwest of Highway 78 bridge over the Frisco Railroad, and near the mouth of a small tributary from the northwest, a road cut and gullies (Northern part, Sec.7, T.5 S., R.1 W.) have uncovered gray and yellowish to dull-white clay containing two layers of large concretionary masses of iron ore, chiefly oxide. This is at the southeast end of an artificial lake.

From the junction (NE.cor., Sec.8, T.5 S., R.1 W.) a road extends east into Benton County, along the foot of the north wall of Tippah River Valley; another road leads up the ridge northwards; and a cutoff segment of old Highway 78 lies subparallel to new 78 and a short distance south of it. At and near this junction Ackerman beds crop out; also along Highway 78 northwestward to beyond the Frisco Railroad underpass; along the segment of old 78 for most of its length; along the west-east road to beyond the Benton County line, and along the northward trending road to the top of the ridge. The best outcrops are afforded by the Highway 78 cuts. The face of the northeast wall of the cut just northwest of the junction shows two layers of iron ore concretions, each a foot or more thick, 7 to 10 feet below the top of the face. The layers are 2 to 3 feet apart, and are embedded in a buff, dark-streaked mixture of sand, silt, and clay, which is underlain by some 10 feet of light-weight black shale. The southwest wall of the cut shows that the shale is underlain by a yellowish fine velvety silt. Between the shale and the silt is a bed of iron carbonate and oxide several inches thick. The same beds are exposed in the slope along the north road, and some of the section along old Highway 78. Along the road which leads east iron ore is prominent in several places, but in general the containing clay and silt beds are poorly exposed.

Figure 7.—Uppermost Ackerman irregularly bedded sand, silt, clay, and iron ore, Highway 78 cut (SE.¼, Sec.6, T.5 S., R.1 W.) some 3 miles northwest of Potts Camp. July 3, 1952.

The structure as shown by the Highway 78 cut at the junction is regular; but as shown by the highway cuts farther northwest it is very irregular.

Highway 78 right-of-way is cut in Ackerman and Meridian beds (SE.¼, Sec.6, T.5 S., R.1 W.) a quarter of a mile northwest of the highway bridge over the Frisco Railroad, exposing very irregularly bedded sand, silt, clay, and iron ore (Figure 7) overlain by white and red-brown sand. The clay appears to be a minor component of the Ackerman beds, but the iron ore is prominent on the outcrop, where two northward or northwestward dipping main layers and six shorter layers are conspicuous. The same zone can be followed northward along the west wall of the valley of Chewalla Creek, and is well exposed (NW.¼, Sec.5, and NE.¼, Sec.6, T.5 S., R.1 W.) along a local road down the valley wall a third of a mile north of the highway. Six iron ore levels are included in the clay, silt, and sand section. Gray and lignitic clay crop out at the top of the slope, just under the contact.

The west wall of Tippah River Valley is Ackerman material through much of its height. A section across the Ackerman-

Figure 8.—Ackerman-Meridian contact (Near center, Sec.11, T.6 S., R.2 W.) in the west wall of the valley of Tippah River 3 miles west of Bethlehem. June 18, 1952.

Meridian contact is exposed by a cut for the Waterford-Cornersville road (NW.¼, Sec.11, T.6 S., R.2 W.) (Figure 8). Along the road which leads north by east from the junction (NW.¼, Sec. 11) are several outcrops of Ackerman sands and silts and gray and lignitic clays, especially on both sides of small valleys. One of the best of these (SE.¼, SW.¼, Sec.36, T.5 S., R.2 W.) has been made by gullies in the west wall of the valley of Tippah River 0.2 mile north of a road junction. Here Ackerman gray and greenish-gray and lignitic clay is exposed. The contact with overlying coarse sand is approximately 51 feet above the road, which is a few feet above the valley flat. In the bare slope west of the road junction a gully has cut through a section which includes the same and higher beds.

At the junction (SW.cor., Sec.25, T.5 S., R.2 W.) of the north-south road and an old farm road which leads southeast, Ackerman materials just under the Meridian are well exposed. White silts and sands are conspicuous, and lignitic clay shows poorly. Other features of the outcrop are ferruginous sandstone, impure iron ore, and sandy concretions. A short distance along the old road to the southeast, cross-laminated gray and tan sand is prominent. A gully along the west side of the north-south road shows a yellowish mixture of sand, silt, and clay far down the slope. The surface section here, added to the section of Prospect Hole 11, located 40 feet, more or less, below the top of the ridge, completes a section of approximately 280 feet of Wilcox (and Midway?) strata.

LOG OF PROSPECT HOLE 11

Location: On the west side of a south-north road half a mile south of Lebanon Cemetery and 2.5 miles east of Hole 12; a few yards west of the road, 10 yards north of the section line, and 50-60 feet northeast of an abandoned cabin, under a large oak tree (SW.cor., Sec.25, T.5 S., R.2 W.).

Property: Hubert Evans or Butler Overton

Elevation: 360+ feet

Int.	Thick.	Depth	Description of strata
			Ackerman formation
1	14.0	14.0	Soil and subsoil: Thin light-brown sandy loam, and brown sand
2	51.0	65.0	Sand, yellow, lumpy, containing rust-cemented aggregates, and ferruginous gravel; specks of blue; more clayey downwards
3	11.0	76.0	Clay, dark gray to bluish gray; green at 76 feet and at one or two higher levels
4	15.0	91.0	Clay, greenish blue or bluish green
5	20.5	111.5	Clay shale, gray, jointed, rusty; grades in color through gray and blue; contains streaks of lignitic clay, especially at 106 feet
6	0.25	111.75	Rock
7	0.75	112.5	Rock, 0.2 foot; gray clay above and below
8	1.5	114.0	Clay, gray, as above

9	0.25	114.25	Rock
10	3.75	118.0	Clay, gray
11	7.0	125.0	Clay, lignitic, underlain by green clay
12	4.0	129.0	Clay, gray
13	19.0	148.0	Clay, lignitic, underlain by gray clay; thin lignite at about 144 feet
14	20.0	168.0	Clay, green and greenish blue, grading downwards into gray
15	2.0	170.0	Lignite
16	4.0	174.0	Clay, gray
17	16.0	190.0	Clay, light gray
18	50.0	240.0	Clay, shale, dark gray to black, and light gray; grades through various shades of gray, to the bottom of the hole.

Along an abandoned road (Sec.12, NW.¼, and Sec.1, SE.¼, T.5 S., R.2 W., and Sec.7, NW.¼, T.5 S., R.1 W.) a mile, more or less, south of Highway 78, cuts and washes expose Ackerman and Meridian beds. A little less than two-thirds of a mile along the old road from its junction (NW.¼, Sec.12) with a north-south road, the walls of a small valley are Ackerman white silt and sand and clay, furrowed by gullies. Many of the sandy concretions and small pieces of sandstone which are present here as at all other outcrops of the Wilcox-Claiborne contact zone, have been left on 2-inch to 3-inch high columns.

On the east side of the north-south road referred to above, the slope to a small valley tributary to the valley of Tippah River exposes the white contact zone from the lake in the valley to road level, or through a vertical interval of 60 to 80 feet. The many ravines have increased the area of outcrop. A little below the head of a ravine not far down slope, pure white clay is interbedded with very micaceous brown and white sand and silt and mixtures of sand and silt. Farther down slope, all is white sand and silt and clay, and numerous sand concretions are scattered over the surface. No doubt much of the material which crops out in this valley has been re-worked from the Ackerman into the Meridian.

North of U. S. Highway 78, besides the outcrops already mentioned are others of the white contact zone. In the south wall of the valley of a tributary of Chewalla Creek a short distance south of the Frisco Railroad and some 0.6 mile north of the highway, a road cut and a ravine (South of center, Sec.31, T.4 S., R.1 W.) show the usual white silt and sand, a little clay, and numerous ferruginous concretions. Also, in the east wall of Chewalla Creek Valley the Ackerman terrane can be followed far to the north, probably at least to the junction of the two main head branches (NW.¼, Sec.29, T.4 S., R.1 W.). The most northeasterly outcrop in Marshall County observed during the present survey is on the eroded slopes a quarter of a mile or more southwest of Bethany Church (NE.¼, Sec.28, T.4 S., R.1 W.) less than half a mile west of the Marshall County-Benton County line. Light-colored clayey sand is exposed. A quartz boulder was found among the many concretions.

From the distribution of outcrops it appears that the area where the Ackerman formation reaches the surface or is covered with mantle rock only, is hardly a fifth of the area of the county. It is in the southeastern corner, extending west to the west wall of the valley of Big Spring Creek and north to the Benton County line (Sec.28, T.4 S., R.1 W.). The strike is north by east almost to the latitude of Potts Camp, thence northeast, and the regional dip varies from northwest by west, to northwest. The degree of dip is difficult to determine, but, as already stated, appears to average somewhere between 15 and 20 feet to the mile — figures based on differences of elevation of points on the Fearn Springs-Ackerman unconformable contact. Conant[20] computed a dip of 10 to 15 feet a mile on the Midway-Wilcox contact in Union County. The maximum thickness of the Ackerman in Marshall County was found by outcrops and prospect holes to be 300 feet or more (see log of Prospect Hole 12), but thickness varies considerably even along the strike at the Ackerman-Meridian (Wilcox-Claiborne) contact trace, because of unconformities above and below.

MERIDIAN FORMATION

As has been brought out in the description of the Ackerman formation, the Ackerman-Meridian contact zone crops out in a belt which extends roughly southwest-northeast across the southeastern part of the county. The westernmost Ackerman outcrops are along a ragged contact trace following the west wall of the valley of Big Spring Creek, and the northernmost outcrop is near the county line five miles north of Potts Camp. However, the Meridian sand reaches eastward and southeastward to and beyond the Tippah River Valley. In many places, as has been indicated, sections across the Ackerman-Meridian contact are well exposed. The Meridian sand at the most prominent of these outcrops, may be briefly described:

Along the road up the west wall of the valley of Big Spring Creek (NW.¼, Sec.17, T.6 S., R.2 W.), some 2 miles above the mouth of the creek, a section of 30 to 40 feet of Meridian sand crops out above the Ackerman. The sand is coarse towards the base, containing grit and pebbles. At an outcrop in the valley wall a quarter of a mile farther east, the pebbles are even more abundant.

At the exposure (SW.¼, Sec.28, T.5 S., R.2 W.) in the west wall of Big Spring Creek Valley, the Meridian sand shows the same character as at the first place referred to — it is coarse, micaceous, gritty, red-brown on the exposed surface. At the very base it is cemented in places to a gritstone crust.

In the west wall of the same valley 2 miles farther north, on the Waterford-Potts Camp road, the outcrop (SE.¼, NE.¼, Sec. 21, T.5 S., R.2 W.) shows 55 feet of red-brown Meridian sand overlying Ackerman silts. Prospect Hole 13, at the road junction at the top of the section, passed through 70 feet of sand, red-brown towards the top, but grading downwards into sand of a lighter color and coarser texture.

Log of Prospect Hole 13

Location: Northeast side of the Waterford-Potts Camp road a few yards northwest of a road junction (NE.¼, Sec.21, T.5 S., R.2 W.) approximately 2.5 miles east by south of Waterford.

Property: Holly Springs National Forest, or county road

Elevation: 440 plus feet

Int.	Thick.	Depth	Description of strata
			Meridian formation
1	5.0	5.0	Soil and subsoil: Brown sandy loam and sand; subsoil somewhat clayey, grading downwards into light colored silty sand
2	68.0	73.0	Sand, red brown and lighter of color, somewhat clayey and silty in upper part; grades into lighter colored coarse sand with depth. A little under 60 feet clay pellets and black ferruginous particles appear in the coarse sand

			Ackerman formation
3	13.0	86.0	Clay, light yellow to light gray sandy, iron oxide streaked; stringers of blue clay
4	1.0	87.0	Sand, dark
5	33.0	120.0	Clay, bluish gray to darker gray to black lignitic; some thin sand streaks; a little lignite at about 107 feet. Core taken at 100 feet.

The color of the Meridian sand varied through shades of brown to almost white, no one color persisting through more than a few feet. The sand from somewhere above 50 feet appeared brownish gray in the mass, but examination with the microscope showed it to be composed of angular to sub-angular grains of rock crystal, among which were mixed some milky quartz, a little muscovite mica, a few nodules of clay and silt, and a very few grains of dark minerals. In the mass it appeared coarse. A sample of fresh light-brown to white sand from an outcrop in the small valley 100 yards north of the prospect hole and 30-40 feet below it, had the same mineral composition, but a higher mica content, and was of finer grain. A sample from the hole at a 50-60 foot depth was coarse, about the same as the first sample referred to above, but was rust brown from iron oxide stain on the quartz grains; also the range in grain size was considerable. The sand superjacent to the Ackerman quartzite on the outcrop is brown and coarse, containing grit.

Many large masses of sandstone, most of them roughly tabular, are scattered about on the Ackerman clay (Western part, Sec. 7, T.6 S., R.1 W., and eastern half, Sec.12, T.6 S., R.2 W.), and, according to Mr. Joe Whaley, a farmer of the vicinity, a solid floor of this rock underlies a pond in front of his residence (SW.cor., NW.¼, Sec.7, T.6 S., R.1 W.). Several large blocks are lying on the bank of the pool and in the ravine below it. South of the Whaley residence many other masses, large and small, of this sandstone, are lying on the hill slopes at approximately the same elevation as that of the rock under the pond (340-360 feet). Still farther south by west, on the main Waterford-Cornersville road at a flowing well, are blocks of the same sandstone (Southern part, SE.¼, Sec.12, T.6 S., R.2 W.). The rock had served as foundation for a house which was destroyed by fire. Other blocks were found in nearby fields.

The sandstone is composed of fine white sand, friable to firmly cemented, commonly more firmly cemented near the surface of the rock than towards the center; somewhat iron stained on the surface and to a slight depth. It appears to be identical with the large masses and ledges of white sandstone which are so conspicuous in Union County along Highway 30 from a short distance west of the Tallahatchie River bridge to 2 miles, more or less, east of it, and in the hills on both sides of the

Figure 9.—Sand pit (SW.¼, Sec.9, T.7 S., R.1 E.) on the north side of Highway 30, Union County, a mile or so northeast from the Tallahatchie River bridge. Massive sandstone at the top. June 9, 1953.

highway in the same vicinity. In Union County the sandstone blocks are scattered over the slopes and through the sand at almost all levels through perhaps a 40-foot to 50-foot interval; but the most significant exposures of the terrane — sand, sandstone, and underlying Porters Creek shale — are afforded by a large pit (SW.¼, Sec.9, T.7 S., R.1 E.), and nearby cuts for the old and new highways. The face of the north wall of the pit shows a sharply defined section of fine micaceous sand, white, cream colored, pale yellow, purple, brown, and red, woven into a pattern of thin highly cross-bedded tongues and lenses and lentils. Sandstone blocks are confined to the top of the wall, forming a rough layer above the face, except for a few which have worked down into the sand below the surface slope at the west end (Figure 9). The inference seems warranted, then, that little if any sandstone below this level is in place. Furthermore, the thick ledges of this same sandstone in the uppermost part of the ridge between old and new Highway 30 across the valley a mile or more farther east (SW.¼, Sec.10, T.7 S., R.1 E.) appear from their almost horizontal positions, to be in their original places. The rock above the pit is at approximately the same altitude (400 feet) as that farther east, and not more than 40 to 50 feet higher than the Marshall County sandstone, which is some 11 miles distant northwest, almost down dip, and may be several feet below its original position. It seems significant, too, that the Ackerman-Meridian contact trace in the west wall of Tippah River Valley on the Waterford-Cornersville road is at an altitude of slightly less than 400 feet.

The writer believes that the sandstone in Marshall County and that in Union County are parts of the same stratigraphic unit, and are of Meridian age. In Marshall County the rock lies on the Ackerman formation, and in Union it rests on the Porters Creek. During the field work on which this report is based, an effort was made to determine whether or not the sand and sandstone along Highway 30 could be traced northwestward and found to underlie any beds of clay or silt; but the attempt was unsuccessful. The writer ventures the opinion that the Highway 30 sand and sandstone belong to a Meridian outlier — a remnant of the formation which once reached far to the southeast, and still extends far to the east, overlapping older formations. Furthermore, he suspects that many sand accumulations which rest on Wilcox beds farther south along the strike are also outliers of the Meridian formation, not basal Ackerman, to which they have been generally assigned.

An old sand pit (SE.¼, SW.¼, Sec.36, T.5 S., R.2 W.) in the upper part of the west wall of the valley of Tippah River a short distance northwest of the junction of the north-south and east-west roads, has exposed several feet of yellow and brown Meridian sand lying on Ackerman beds. The sand is cross bedded and very coarse, containing abundant grit and small gravel.

The sand immediately above the Ackerman in the north wall of the valley of Potts Creek on the Bethlehem-Potts Camp road is like that described above — red brown, coarse and gritty, micaceous, and cross bedded.

The outcrops southwest of Potts Camp, along local roads (NE.¼, Sec.20, SE.¼, Sec.17, T.5 S., R.1 W.) referred to in the description of the Ackerman formation, show good sections of the Meridian sand (see description of section). The sand of the Section 17 outcrop is a deep red on the exposed surface, and slightly crusted; coarse and gritty in places, but fine and micaceous and white elsewhere.

Figure 10.—Meridian sand pit (SE.¼, Sec.29, T.5 S., R.1 W.) 2 miles south by west of Potts Camp. June 18, 1952.

The upper part of the section exposed by the Highway 78 cut (SE.¼, Sec.6, T.5 S., R.1 W.) is Meridian sand, showing the same characters as exhibited by the contact zone sand at the other places mentioned: Coarse gritty and pebbly sand; some ferruginous sandstone towards the base.

Above the Ackerman-Meridian (Wilcox-Claiborne) contact the Meridian sand crops out in numerous places, because of the maturely dissected terrane. Mention of some features of a few of the leading outcrops may help in understanding the character of the formation.

A large pit (SE.¼, Sec.29, T.5 S., R.1 W.) affords one of the best views of Meridian sand to be found in the county (Figure 10). It is at the junction of the Bethlehem-Potts Camp highway (349) with a local road approximately 2.4 miles south by west from the Frisco Railroad at Potts Camp. In the deepest part of the pit some of the sand is fine, micaceous, white to pale yellow, and strongly cross laminated; higher in the pit walls all the sand is brown and red brown. A little ferruginous sandstone is scattered through it. The bottom of the pit probably is not

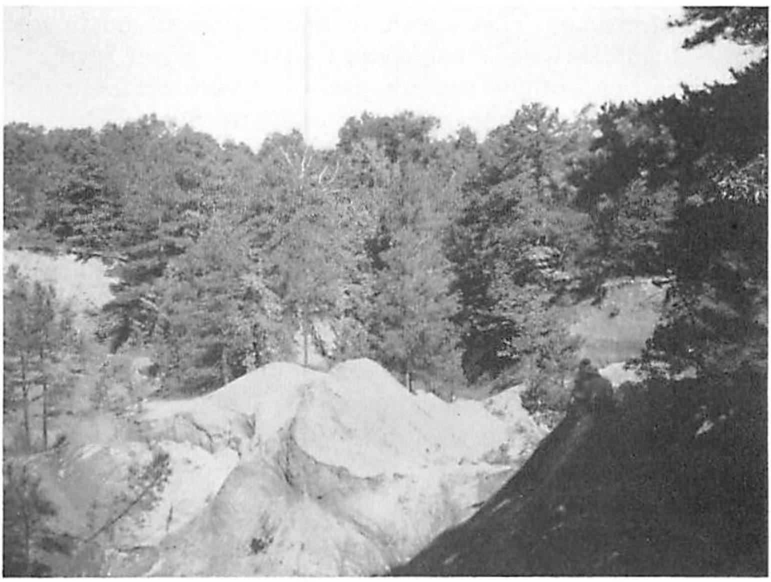


Figure 11.—Big ravine in the Meridian sand (NW.¼, Sec.7, T.6 S., R.2 W.) on the northwest side of a road 1.5 miles east of Highway 7 at Malone. June 24, 1952.

more than 20 to 25 feet above the base of the Meridian, and the pit may have a maximum depth of 40 feet.

Exposures of the Meridian sand are very numerous in the southwestern and central parts of the outcrop area. The east wall of the valley of Little Spring Creek along a road (Central part, Sec.12, T.6 S., R.3 W.) is entirely Meridian sand through a vertical interval of 100 feet. The road cut in the slope, and a pit above the 80-foot level afford very good outcrops. The section shows the usual red-brown, brown, dull-white and white micaceous sand, ranging from coarse to fine. In the lower part of the slope the sand contains grit and small gravel. That the base of the section probably is not far above the top of the Ackerman is suggested by Ackerman outcrops 1.5 miles or less farther south.

A mile or so northeast of the exposure just described, large ravines (NW.¼, Sec.7, T.6 S., R.2 W.) have been cut in Meridian sand (Figure 11) of the same character as that at the other outcrops. Perhaps 35 feet below the road is a lens of bluish-white to yellowish silty clay, probably Ackerman material re-worked into the Meridian. The stream channel leading northwest is cut in red sand, which is coarse and gritty at lower levels. The road at the head of the ravines has an elevation of 440 feet or more, and the flat of the tributary of Little Spring Creek into which the ravines lead, a quarter of a mile to the northwest, has an elevation of 300 to 320 feet; thus the sand has a thickness of at least 120 feet at this place.

Two other places along the roads in Section 7 show considerable areas of bare and eroded Meridian sand — one in the southwest corner of the section, the other in the southeast corner north of two junctions. Still other prominent Meridian outcrops along local roads may be mentioned: 1) The faces of the walls of a cut a few yards northwest of a junction (NE.¼, SW.¼, Sec.6, T.6 S., R.2 W.), where the white, gray, pink, brown, and red-brown colors of the sand are conspicuous; 2) an eroded area northwest of a junction (SE.¼, NW.¼, Sec.32, T.5 S., R.2 W.); 3) the north wall of a cut (NW.¼, NE.¼, Sec.29, T.5 S., R.2 W.) which shows uncommonly well the coarse and gritty to fine micaceous white to light-brown and red-brown sand, and small white clay and silt inclusions; 4) an eroded terrane at a junction (SE.cor., Sec.19, T.5 S., R.2 W.) about 1.5 miles southeast of Waterford; 5) the intricately eroded northeast wall of the valley of a small southwestward flowing tributary of Big Spring Creek (SE.¼, Sec.9, T.6 S., R.2 W.); 6) the walls of cuts (SE.¼, Sec.19, and SW.¼, Sec.20, T.5 S., R.1 W.) along the Potts Camp-Waterford road across Tippah River; 7) walls of ravines and cuts along the east-west road (Secs.16, 17, 18, T.4 S., R.1 W., and Sec.13, T.4 S., R.2 W.), especially in the walls of the valley of Chewalla Creek; 8) the east wall of Chewalla Creek Valley at Chewalla Farms, at the site of old sand pits (NW.¼, Sec.6, T.4 S., R.1 W.)

where the eroded sand shows the so-called Meridian-type bedding prominently (Figure 12).

The Meridian-Tallahatta contact trace can be followed by exposures here and there from the north wall of the valley of the Tallahatchie River (now the Sardis Dam Reservoir) a little west of Highway 7, almost north to the Lake Mimosa vicinity. Also, it crops out (doubtful) south and southeast of Holly

Figure 12.—Meridian sand pit (NW.¼, Sec.6, T.4 S., R.1 W.) in the east wall of Chewalla Creek Valley at Chewalla Farms. March 13, 1953.

Springs, and is sharp and clear in places towards the head of Chewalla Creek and tributaries.

The contact trace could not be located exactly in the north wall of the Tallahatchie Valley, but along a south-north road (Western part, Sec.14, and on the line between Secs.10 and 11, T.6 S., R.3 W.) and a west by north road (Northern part, Sec.11) the terrane is brown and red-brown sand, which is well shown where deep ravines have been cut in it (SE.¼, Sec.10, and SW.¼, Sec.11, T.6 S., R.3 W.). The sand is iron brown to white, coarse and gritty to fine; micaceous; and contains small light-colored silt or clay inclusions here and there, and a little ferruginous sandstone. Some of the upper part at least may be Tallahatta.

At the cross roads half a mile or more farther north is a good outcrop of Tallahatta shale (NE.¼, Sec.10) underlain by brown sand; and the lowermost member of the outcrop less than a quarter of a mile farther west is a yellow sand which may be upper Meridian (see Tallahatta formation). Still another outcrop, a short distance north of the road intersection, shows white micaceous sand in the lowermost part.

The Meridian-Tallahatta contact trace can be seen along the shores of Lake Mimosa and in the wall of the small valley north

Figure 13.—Meridian-Tallahatta contact (SW.¼, SE.¼, Sec.1, T.5 S., R.3 W.) in a ravine at the north end of Lake Mimosa, 0.1 mile west of Highway 7. February 3, 1954.

of the lake (Near center, Sec.1, T.5 S., R.3 W.). An erosion remnant in a big wash a few rods west of the north end of the lake shows a sharp contact line (Figure 13) between fine white micaceous Meridian sand below and Tallahatta shale above. The elevation of the contact here is approximately 400 feet.

A prospect hole at the south end of Lake Mimosa penetrated Meridian sand to a depth of close to 100 feet, and found clay inclusions in the sand in the lowermost few feet. A strong flow of water was obtained.

A short distance south of where Highway 7 crosses the Tennessee Gas Transmission Pipe Line, and northeast of the north end of Lake Mimosa, a small excavation on the east side of the highway exposes a face of Meridian sand — fine white and brown very micaceous sand showing conspicuously cross-bedded units alternating with thinner intervals of horizontally bedded sand (Figure 14). The top of the face is at an elevation of about 400 feet.

Figure 14.—Meridian sand pit (NW.¼, SE.¼, Sec.1, T.5 S., R.3 W.) on the east side of Highway 7, 0.3 mile north of the entrance to Mimosa Lake. July 11, 1952.

A segment a few feet in length of the Meridian-Tallahatta contact trace and sections of underlying and overlying beds are exposed (Northern part, SE.¼, Sec.12, T.4 S., R.2 W.) in an abandoned east-west road a mile south of Chewalla Farms. Cross-bedded Meridian sand is overlain by thin platy silty limonite interbedded with thin clay and fine sand, and, higher, some 15 to 20 feet of gray clay (Figure 15). The dip of the Tallahatta beds appears to be east.

A large outcrop (NW.¼, SE.¼, Sec.6, T.4 S., R.1 W.) on the southeast wall of a tributary of Chewalla Creek half a mile east of Chewalla Farms, shows a section across the Meridian-Talla-

Figure 15.—Meridian-Tallahatta contact (hammer) (NW.¼, SE.¼, Sec.12, T.4 S., R.2 W.) exposed by a wash in an abandoned road some 2 miles southeast of Higdon. March 5, 1953.

Figure 16.—Meridian and Tallahatta beds (NW.¼, SE.¼, Sec.6, T.4 S., R.1 W.) in the southeast wall of a tributary of Chewalla Creek 0.5 mile east of Chewalla Farms. March 13, 1953.

hatta contact (Figure 16). The lowermost unit is a fine white and yellowish cross-bedded sand, which is overlain along a smooth contact trace by 2 to 3 feet of light-colored silty clay; this in turn is overlain by a brown sand which contains white sandy clay and silt fragments towards the top. Superjacent to the brown sand is a very irregular contact surface, believed to be the Meridian-Tallahatta contact.

The upper limit of the Meridian was not found definitely by the present survey in the region between Highways 7 South and 78. The terrane in this part of the county is almost all sand, and deeply eroded; elevations above mean sea level run up to more than 600 feet in many places, and the maximum relief is close to 300 feet. Parts of three formations — Meridian, Tallahatta, and Kosciusko — are present, above the Ackerman.

The distribution of Meridian outcrops, as described in the foregoing pages, indicates that the area of outcrop of the main body of the formation in Marshall County is a narrow belt of varying width which strikes north by east from the southern boundary of the county to Lake Mimosa, thence northeast into Benton County, the easternmost Meridian outcrop being on the east wall of the valley of Chewalla Creek east of Chewalla Farms (NW.¼, SE.¼, Sec.6, T.4 S., R.1 W.). Southeast of the main outcrop belt several outliers cap the higher ridges and hills. The dip of the beds is low, perhaps not more than a maximum of 15 feet to the mile. In fact, calculations based on approximate elevation differences of points on the Ackerman-Meridian contact found a dip of only 13 feet to the mile towards the west, and less than 10 feet towards the north. The maximum thickness of the formation is somewhat more than 200 feet. As stated in the description of the Meridian sand of the south end of the outcrop belt, the exposed thickness there can not be less than 120 feet. A prospect hole at the south end of Lake Mimosa, located 40 feet below the Meridian-Tallahatta contact, passed through 100 feet of Meridian sand, but did not reach the Ackerman. Prospect Hole 14, located above a Tallahatta outcrop along Highway 4 about six miles northeast of Holly Springs, passed through the entire Meridian formation, 152 feet, possibly 173 feet.

LOG OF PROSPECT HOLE 14

Location: At the top of the ridge above an outcrop of Tallahatta white clay shale on the north side of Highway 4, approximately 6 miles northeast of Holly Springs. (Northern part, Sec.24, T.3 S., R.2 W.)

Property: D. A. Higdon Elevation: 500 feet app.

Int.	Thick.	Depth	Description of strata
			Tallahatta formation
1	48.0	48.0	Sand, brown clayey and silty towards top; considerable ferruginous sandstone at slight depth; sand fine to medium; grades downwards into white
2	34.0	82.0	Clay, white, sandy and silty, plastic; contains lentils of fine white sand
3	12.0	94.0	Sand, white, medium fineness, angular grains
4	9.0	103.0	Clay, as Interval 2
			Meridian formation
5	35.5	138.5	Sand, as Interval 3; contains clay streaks
6	116.5	255.0	Sand, light colored, silty
			Ackerman formation
7	5.0	260.0	Clay, light gray mottled with brown; silty; grades downward into
8	31.0	291.0	Clay, dark blue to almost black and gray; sandy and silty

Prospect Hole 15 also passed through the entire Meridian formation. It was located about 6 miles south of 14, and 1.8 miles, more or less, southwest of the Chewalla Organization Camp well, referred to in the part of this paper which relates to the Naheola formation, and also in the part which relates to Structure.

LOG OF PROSPECT HOLE 15

Location: On the northeast side of the Waites-Higdon road approximately 4.5 miles north from Highway 78, and about 100 feet north of a junction (NW.¼, SE.¼, Sec.13, T.4 S., R.2 W.) with a west-east road.

Property: Henry Dobbs (Holly Springs National Forest) Elevation: 530 feet

Int.	Thick.	Depth	Description of strata
			Meridian formation
1	5.0	5.0	Soil, brown sandy and clayey loam; subsoil, brown sandy clay, grading downwards into brown medium to coarse sand
2	16.0	21.0	Sand, medium to coarse, lighter of color than above; yellowish

3	29.0	50.0	Sand, yellowish, somewhat clayey; streaks of very micaceous silt
4	173.0	223.0	Sand, dull white, coarse, sparingly micaceous; very coarse and gritty at some levels, notably at 85-90 feet; streaks and lumps of white and pink clayey sand at 65 feet and a little below. Heavy water sand encountered at about 215 feet; almost lost circulation. Thin sandstone at base
			Ackerman? formation
5	13.0	236.0	Clay, blue, sandy, to bottom of hole

It will be noted that a thickness of 223 feet of Meridian sand was found by this drilling. However, according to one interpretation of data from the Chewalla Organization Camp well (see Naheola formation) less than two miles northeast of Hole 15, Porters Creek [Naheola] clay was reached by that well at 215 feet. To the writer of this paper it seems probable that the clay identified as Porters Creek was Wilcox, and that much of the overlying material was Meridian.

Brown[30] states that in the outcrop belt the Meridian sand averages about 200 feet in thickness; also, that it is characterized by much kyanite, staurolite, and muscovite, as well as quartz.

TALLAHATTA FORMATION

The Tallahatta formation lies on the Meridian. At the few places in Marshall County where part of the contact trace between the two can be seen, it shows little or no evidence of unconformity, with one exception, the outcrop east of Chewalla Farms, as already noted. At most places where it crops out the basal Tallahatta consists of thin beds of indurated silty limonite or limonitic silt alternating with thin beds of clay or clay shale and fine sand. On the outcrops the materials have a variety of colors, due to oxidation of iron and the presence of carbonaceous matter. Red, brown, yellow, pink, black, white, tan, gray, and various combinations are common. Descriptions of Tallahatta lithology as it appears at some prominent outcrops should convey some idea of the lithological character of the formation as a whole.

A few rods southeast of a road intersection, an outcrop (NE.cor., Sec.10, T.6 S., R.3 W.) of dense light-gray to white silty clay, mottled with pink and light brown, is conspicuous in the walls of a cut at an elevation of about 390 feet, and the same clay shows in the banks of a pond a short distance southwest of the road outcrop. It breaks in blocks along numerous joints. This clay or clay shale is believed to be near the base of the Tallahatta. Less than a quarter of a mile farther west, ravines (NE. ¼, Sec.10, T.6 S., R.3 W.) tributary to the valley of Oak Chewalla Creek, especially about 250 yards south of the road, expose a section consisting of a lowermost unit of 5 feet of yellow and brown sand grading downward into fine white micaceous sand; 5 to 8 feet of white to pink clay shale superjacent to the sand and several feet of red-brown sand overlying the shale. In places a friable ferruginous sandstone lies between the yellow sand and the shale. It seems possible that this section transects the Meridian-Tallahatta and the Tallahatta-Kosciusko contacts. The altitude is about the same as that of the road intersection outcrop.

Highway 7 is in or near the valley of Little Spring Creek from the southern boundary of the county almost to Waterford, and in this 7-mile to 8-mile length it does not reach an elevation of 400 feet, which is the elevation of the Meridian-Tallahatta contact at Lake Mimosa. However, the local road which is subparallel to the highway a mile, more or less, west of it, is 400 feet and more above mean sea level through most of its length, and reaches 500 at one place. As would be reasonably concluded, then, Tallahatta beds crop out in a few places along this local road, and the position of the formation contact trace is between it and the highway.

A quarter of a mile or less northwest of the white clay outcrop at the road junction, is a pit in Meridian sand (elevation, 360 feet) above which is some white clay shale (SE.cor., Sec.3, T.6 S., R.3 W.) overlain by red-brown sand. About 250 yards farther north, and slightly higher (elevation, 400 feet) white and pink clay is overlain by coarse, gritty ferruginous sand and thick ferruginous sandstone which are believed to be Kosciusko. Approximately 0.3 mile still farther north, ravines west of the road and 40 feet below it expose white iron oxide-stained clay shale and silt (SE.¼, NE.¼, Sec.3). At road level (400 feet) and below are red and yellow sand, abundant ferruginous sandstone float, and some silt quartzite, presumably Kosciusko.

A short distance southwest down the ravines from the highest point, 500 plus feet (West of center, Sec.26, T.5 S., R.3 W.) along this road, white and pink clay is exposed. All the overlying rock material is coarse gritty red sand, containing quartz pebbles. The sand is believed to be Kosciusko.

No Tallahatta material was recognized along Highway 7 south of Waterford, but a highway cut in the north edge of the village has brought to view bedded white and pink silty clay shale and sand at an elevation of 400 to 420 feet (SE.¼, NE.¼, Sec.13, T.5 S., R.3 W.).

The Meridian-Tallahatta contact at the north end of Lake Mimosa has been mentioned in the description of the Meridian formation.

Less than a quarter of a mile farther north, and a short distance west of Highway 7, cuts for the Tennessee Gas Transmission Pipeline have exposed considerable thicknesses of Tallahatta sand and other materials. Roughly, the outcrop shows, as the lowermost interval, some shale and a mixture of white clay balls and sand; next above it, coarse sand; superjacent to the coarse sand, highly cross-bedded and otherwise irregularly bedded purple, pink, and red-brown sand; and uppermost, red sand a little under the top of the high ridge. Less than 100 yards farther north, the walls of a short, deep ravine on the same level are Tallahatta shale, gray to black, containing thin seams of lignite.

The stratigraphic section along and near Highway 7 from Lake Mimosa to the crest of the ridge beyond McKenney School 1.8 miles farther north, appears to include the entire thickness of the Tallahatta formation. Sand from a little below the middle of the unit, exposed by highway cuts and ravines (NE.¼, Sec.1, T.5 S., R.3 W.) near the top of the first rise north of the lake, consists of several feet of coarse gritty gray sand as the lowermost interval, and above it perhaps 15 to 20 feet of light-brown or white or yellow fine micaceous sand. Some layers are cross bedded. The base of this outcrop is at an altitude between 460 and 480 feet, which is about the same as that of the top of the valley wall west of the highway along the gas pipeline. At the top of the ridge north of McKenney School, deep ravines (North of center, Sec.36, T.4 S., R.3 W.) on both sides of the highway are cut through an uppermost brown compact sand several feet thick into fine white micaceous sand containing stringers and other irregular bodies of white clay. The contact between the sands, at an altitude of close to 580 feet, is believed to be the

Tallahatta-Kosciusko contact. If it is, the entire thickness of the Tallahatta can be measured along the highway, from the top of the Meridian (elevation about 400 feet) in the lake walls, to the base of the Kosciusko (elevation about 580 feet) at the top of the ridge — a thickness of 180-200 feet.

Figure 17.—Tallahatta beds and Tallahatta-Kosciusko contact (SW.¼, NE.¼, Sec.25, T.4 S., R.3 W.) exposed by ravines some 100 yards west of Highway 7, and 4 miles south of Holly Springs. January 28, 1954.

Erosion of the walls of a small valley (North of center, Sec. 25, T.4 S., R.3 W.) a short distance west of Highway 7 and 4 miles south from Holly Springs, has laid bare patches of upper Tallahatta terrane and a few feet of Kosciusko sand. Tallahatta white shale and the red and purple and brown thin rock which is present almost everywhere on the outcrops of the formation, are conspicuous here (Figure 17). The contact with the overlying Kosciusko (altitude, 580 feet) is strongly unconformable, and marked by large blocks of ferruginous sandstone.

A quarter of a mile southeast of the road junction in Higdon, and perhaps 0.1 mile southeast of the church, a road cut (SW.¼, NW.¼, Sec.2, T.4 S., R.2 W.) has exposed a few yards of a sharp contact trace (Figure 18) between light-gray to white brown-mottled and pink-mottled clay and sandy and clayey silt below, and coarse bedded brown sand above. The clay beds dip rather strongly northwest. West of the road two ravines which head on each side of the church show good clay outcrops 35 to 40 feet below the road outcrop. The clay-sand contact is marked by seepage and springs. Road cuts 0.1 to 0.2 mile farther southeast are in the same body of clay shale, and a small outcrop a few yards west of the road is scattered over with ferruginous con-

Figure 18.—Tallahatta-Kosciusko contact in the southwest wall of road cut (SW. ¼, NW.¼, Sec.2, T.4 S., R.2 W.) 0.2 mile southeast of Higdon church. January 20, 1953.

cretions. A ravine west of the road a little farther southeast exposes both clay and sand.

The outcrops described above are believed to show the Tallahatta-Kosciusko contact.

In the vicinity of Holly Springs are several extensive outcrops of Tallahatta beds. One of the largest has been made by headward erosion of a small valley (NE.¼, Sec.5, and NW.¼, Sec.4, T.4 S., R.2 W.) less than half a mile east of Holly Springs and a quarter of a mile south of the Holly Springs-Higdon road. The valley walls show Tallahatta pink and white clay, clay shale, sand, and silt, and much red and pink float of ironstone crusts.

The light-colored Tallahatta terrane is overlain at an elevation of approximately 580 feet, by red-brown sand, believed to be Kosciusko. From this clay deposit the old Holly Springs Stoneware and Fire Brick Company obtained most of its raw clay.

A short distance north of the junction of Highways 7 and 78 northwest of Holly Springs, on the west side of Highway 7 a little south of the Frisco Railroad, is one of the main pits (NW. ¼, Sec.31, T.3 S., R.2 W.) of the new Holly Springs Brick and Tile Co., Inc. It shows a face of 15 to 20 feet of white and dark clay. The same body of clay is exposed on the east side of the highway, and other outcrops on both sides of Highway 78 farther west may be showings of the same body or separate bodies. All this clay is at an elevation ranging from 540 to 560 feet.

Along the Frisco Railroad 2 miles or more northwest of the railroad underpass of Highway 7 is a deep cut, on both sides of which are large outcrops of white Tallahatta shale, silt, sand, and clay (NE.¼, Sec.26, T.3 S., R.3 W.), extending on the south side of the track to a height of 75 feet or more above the rails. Northwest along the track from the crossing of an old road the contact trace between the clay and overlying brown and red-brown sand (Kosciusko?) descends until sand only is exposed above the track (elevation, 560-580 feet). The old road crosses the same contact trace on both sides of the track.

Along Highway 4 northeast from Holly Springs no white outcrops are visible southwest of the west wall of the valley of Chewalla Creek (NE.cor., Sec.23, T.3 S., R.2 W.). A mile or so farther east, a highway cut (Northern part, Sec.24, T.3 S., R.2 W.) is walled on the north by well bedded white clay shale and sand (Figure 19). A prominent feature of this outcrop is the sharp contacts of the clay with the brown sand above and at both ends of the clay body, the face of which appears like a white marble plaque set in a brown stone wall. This mass of white clay shale, clay, silt, and sand may be the upper part of a once buried eroded Tallahatta hill. It is a conspicuous landmark. Northeast of it at about the same elevation (450 feet) is an old pit which exposes brown and fine white micaceous sand containing thin stringers of white clay. The sand is strongly cross bedded in places. Probably it is Tallahatta. Prospect Hole 14, located on the ridge above the highway outcrop, passed through 103 feet of

Tallahatta beds, of which 60 feet were sand (see log under Meridian formation).

Except at the brick company's pits almost in the north edge of Holly Springs, referred to in a foregoing paragraph, no white material crops out along Highway 7 northeast of the town and south of the valley of Coldwater River. The north wall of the river valley is sand, but half a mile to a mile farther northeast, especially at and near the intersection (Southern part, Sec.34, T.2 S., R.2 W.) are three or four showings of bedded white silt

Figure 19.—Tallahatta beds (NW.¼, NE.¼, Sec.24, T.3 S., R.2 W.) in the north wall of a Highway 4 cut 6 miles northeast of Holly Springs. June 19, 1952.

shale and clay. Also, along the road half a mile or so northeast of Atway, bodies of white and pink sand, silt, and clay are enclosed in brown sand (NE.¼, Sec.33, T.2 S., R.2 W.), and half a mile, more or less, still farther northeast, the walls of an old sand pit (NW.Cor., Sec.34, T.2 S., R.2 W.) show cross-bedded fine white micaceous sand containing white silt-shale beds. The kind of sand and the Meridian-type cross bedding suggest Meridian sand, although the geographic location and the altitude do not favor such an identification. Probably it is Tallahatta sand. The outcrops at all three of these localities are at altitudes of 480 to 500 feet.

Along the south-north road midway between the east and west boundaries of Township 2 South, Range 2 West, are several outcrops of Tallahatta strata. One of the largest in the county has been made by a road cut and ravines (SE.¼, Sec.21, T.2 S., R.2 W.) approximately 2 miles north of Atway. Here a section of at least 30 to 35 feet of somewhat dark to white silty clay shale is exposed by the road cut (Figure 20), and west of the road 50 to

Figure 20.—Tallahatta beds exposed by road cut (SE.cor., Sec.21, T.2 S., R.2 W.) 1.5 miles north by east of Atway. July 24, 1952.

75 yards steep-walled ravines have been cut in the same body of shale. Above the shale is a thin (up to two feet) layer of coarse brown sand, overlain by loessial material. The lowest part of the terrane is a coarse, gritty, gray sand, more grit than sand in places. The elevation of the entire exposure ranges from about 520 to 560 feet.

A steep-walled branch on the east side of the road (Near common corner, Secs.15, 16, 21, and 22, T.2 S., R.2 W.) has exposed Tallahatta white clay shale for 100 yards or more (elevation, 480-500 feet). Upstream from the shale outcrop the gorge walls are coarse, gritty, red-brown sand. The diagonal contact between shale and sand on the same level is sharp, but next the contact the sand is cross bedded and the shale horizontally bedded. At the downstream end of the shale outcrop the beds dip south at a relatively high angle, suggesting a fault; loessial material only overlies the shale at this place.

Approximately 1.8 miles south of the northeast corner of the county and 1.5 miles north of Highway 72, the west wall of a small valley north of a local road has been deeply eroded, exposing a section of at least 25 to 30 feet of white clay shale, sand, and silt (Near center, Sec.25, T.1 S., R.2 W.). Above the white material are large slabs of ferruginous sandstone, and, in places, red-brown sand. The sand and sandstone are believed to be Kosciusko. The altitude ranges from 440 to 500 feet.

Half a mile north of the outcrop last mentioned, a considerable body of buff and pinkish clay shale is exposed (SE.¼, Sec. 24, T.1 S., R.2 W.) on the north side of an east-west road, about a quarter of a mile west of the Benton County line. Some three quarters of a mile northeast of Early Grove a road cut (NE.¼, Sec.23, T.1 S., R.2 W.) shows sand overlain by heavy ferruginous sandstone; probably Tallahatta and Kosciusko, or all Kosciusko. The elevation is perhaps 520 feet. Another possible Tallahatta-Kosciusko contact is brought to view by a big road cut (SE.cor., Sec.21, and SW.cor., Sec.22, T.1 S., R.2 W.) in the west wall of the valley of Clear Creek, where a rather definite contact trace between light-colored sand below and red-brown sand above, extends along the faces of the walls at an altitude of 460 to 480 feet. Other small outcrops of white clay and silt and sand, believed to be Tallahatta, are: 1) At the junction (on the line between Secs.24 and 25, T.1 S., R.3 W.) where a relatively large body of white and pink clay is overlain by brown sand along an irregular sharp contact; 2) the walls of a road cut (SE.¼, Sec.22, T.1 S., R.3 W.) which show white and pink clay; 3) a small body of white material at the road junction a mile or more north of Mt. Pleasant.

East and southeast of Slayden, Tallahatta beds are well exposed. Ravines at the head of the valley (NW.¼, Sec.5, T.2 S., R.2 W.) southeast of the intersection of Highways 72 and 311 in Slayden, have been cut in Tallahatta terrane for the most part. The lowermost material, which shows in an old sand pit, is a fine white sand; above it, a little farther up stream, are pink and purplish sand and some white silt and clay. At the foot of the slope south of Highway 72 and the Marshall County School, on the north shore of a small lake, is a very good outcrop of white shale (elevation, 540-560 feet).

Cuts for the Holly Springs-Hudsonville road expose Tallahatta beds just below the Tallahatta-Kosciusko contact (see Kosciusko formation). Perhaps the most prominent outcrop of Tallahatta material along this road is about 2 miles north by east of Holly Springs, where a cut (Common corner, Secs.20, 21, 28, 29, T.3 S., R.2 W.) has been made in a fine white micaceous sand containing mottled pink and white and light-brown clay and silt. The altitude is about 480 feet. Half a mile or less farther northeast are two road cuts a short distance apart which expose Tallahatta beds below and Kosciusko above. The farthest northeast of the two (elevation, 520 plus feet) shows white, light-brown, and pink sandy and silty clay, in the upper part of which is a wedge or lens of fine white micaceous sand such as is present at many places at the top of the Tallahatta. Another cut (SW. cor., Sec.10, T.3 S., R.2 W.) in the northeast wall of the valley of a tributary of Coldwater River only a few yards from the Illinois Central tracks, at an elevation of 460 feet, is walled, toward the foot of the slope, with yellowish-brown fine to medium silty sand, in which are thin lenses and stringers of white clay and gray to white clayey sand, and above, to the top of the ridge, with brown sand. The lower, lighter colored sand probably is Tallahatta; the red sand may be Kosciusko.

Outcrops of Tallahatta-type material, either in place or reworked, are scattered widely over the western half of the county. Some of the more prominent and significant of them may be described briefly, in south to north and east to west order.

About 2.5 miles west by south from the outcrops (NE.¼, Sec.10, T.6 S., R.3 W.) already described, big ravines in the west wall of the valley of Oak Chewalla Creek (Western edge, Sec.9, and eastern edge and SE.¼, Sec.8, T.6 S., R.3 W.) short distances south and northeast of a road junction, have exposed 40-foot to 50-foot sections of sand and included stringers and fragments and larger irregular masses of white sand and silt and clay shale, interwoven in a complicated pattern. The eastern of these large washes (Secs.8 and 9) is perhaps 200 yards long, 75 to 100 feet wide, and 40 to 50 feet deep (estimated maximum dimensions), and is cut entirely in white and brown banded sand. The western ravine system (SE.¼, Sec.8) displays the lithologic and structural features more clearly. At the base, and reaching 10 feet or more above the floor of the ravines, is a coarse, gritty, somewhat ferruginous sand, which is overlain, above a rather sharp contact, by a fine micaceous sand, banded white and brown on the surface, and cross bedded and otherwise irregularly bedded. Either below the gritty sand or included by it is a body of white

Figure 21.—Tallahatta-Kosciusko contact (SE.¼, NW.¼, Sec.12, T.6 S., R.4 W.) on the west side of the road, about 0.5 mile south by east of Laws Hill store. December 11, 1952.

to pinkish clay, and scattered through the fine white sand are pellets and larger bodies of white clay. Much of the sand may be Meridian, and the clay shale included in it may be part of Tallahatta material from a higher level filling an old valley at the site of the present ravines. The top of the valley wall here, at the road junction, at an altitude of more than 420 feet, is more than 120 feet above the creek flat, and less than half a mile from it.

Approximately 0.7 mile east of Laws Hill, erosion on the north side of the road has laid bare a 15-foot to 20-foot section of white sandy clay shale, pinkish in places (NE.¼, Sec.12, T.6 S., R.4 W.).

South by east of Laws Hill between 0.3 and 0.4 mile, deep erosion (SE.¼, NW.¼, Sec.12, T.6 S., R.4 W.) of the upper steep part of the slope between two roads a little south of their junction, has uncovered a section across the Tallahatta-Kosciusko contact trace, at an elevation of 520-540 feet. One ravine shows a large outcrop of white and pink clay shale overlain above a sharp irregular contact by brown sand which contains reworked clay (Figure 21). The hill is capped, below some loessial material, by ferruginous sandstone, of which large and small blocks and fragments are scattered over the slope.

Half a mile farther south by east, the lower part of the east wall of a road cut (NW.¼, NE.¼, Sec.13, T.6 S., R.4 W.) is bluish-white pink-mottled clay. The outcrop is almost covered with sand concretions. Still farther south less than half a mile, erosion cuts some distance east of the road show prominent white outcrops, and at the junction (SE.cor., Sec.13) with an old road which leads east, a deep erosion hollow at an elevation of 440 feet + exposes well bedded white, yellow, pink and red fine micaceous sand, crusts of red sandstone and siltstone, numerous sand concretions, and other Tallahatta features. At least half of the entire thickness of the Tallahatta formation is included by the interval along this north-south road.

A short distance west of the junction (NW.¼, Sec.12, T.6 S., R.4 W.) of the north-south road and an east-west road at Laws Hill, on the south side of the road, a deep ravine at an altitude of 460 to 520 feet exposes white sand, presumably Tallahatta, at least for the most part.

On the west side of the road, opposite Laws Hill School (SE.¼, SW.¼, Sec.1, T.6 S., R.4 W.) erosion has made a good outcrop of bedded white Tallahatta shale and sand. The altitude is 460 to 500 feet.

A little more than 4 miles west by north from Laws Hill, on the Chulahoma road, at a bend where the road direction changes from west by north to north by west are huge erosion gashes on both sides of the road (NW.¼, Sec.4, T.6 S., R.4 W. and SW.¼, Sec.33, T.5 S., R.4 W.). A few yards north of the road a remnant of Tallahatta white shale, silt, and sand has been left by erosion all around it (Figure 22). The Tallahatta beds have a steep south dip, and are overlain by loess. Their elevation is between 420 and 440 feet, but the elevation along the road here ranges from 400 feet less than a quarter of a mile southeast of the Tallahatta outcrop to 520 feet some three quarters of a mile north by west of it. The terrane at the higher levels is Kosciusko.

No Tallahatta outcrops were found by the present survey in Townships 5 South and 6 South west of the place described in

Figure 22.—Tallahatta-Kosciusko contact? (SW.¼, Sec.33, T.5 S., R.4 W.) on the east side of the Laws Hill-Chulahoma road, 0.5 mile south of Bell Grove church. June 25, 1952.

the foregoing paragraph. Some of the exposures farther north and east may be referred to.

A few rods south of the road junction (SE.¼, Sec.31, T.5 S., R.3 W.) are big hollows left from erosion of red-brown sand which contains a number of bodies of re-worked white clay and silt and sand. The elevation is about 460 feet.

Approximately 3 miles north from Laws Hill and 2.5 miles south by west from Galena, white silt shale and coarse sand and ferruginous sandstone crop out (Northern part, Sec.25, T.5 S., R.4 W.) on the east side of the Galena-Laws Hill road a short distance north of a road junction and a small lake, at an elevation of approximately 500 feet. Three quarters of a mile southwest of this outcrop, and 0.8 mile northwest from the junction mentioned, are big washes on the west side of a local road, showing white, yellow, and red sand (SE.¼, NE.¼, Sec.26, T.5 S., R.4 W.) which may be in the Tallahatta-Kosciusko contact zone. The elevation is 520 to 540 feet.

The west wall of the valley of Little Spring Creek south of the Waterford-Galena road has been intricately eroded, and red-brown, brown, and yellow sand exposed from top to bottom (SW.¼, Sec.13, and SE.¼, Sec.14, T.5 S., R.3 W.). The elevation here, 340 to 420 feet, would seem to indicate that the upper part of the ridge is Tallahatta sand, the lower part probably Meridian.

West from Highway 7 at Waterford about 2.4 miles, cuts for the Waterford-Galena road in the east wall of a small valley (Near common corner, Secs.10, 11, 14, and 15, T.5 S., R.3 W.) have exposed a stratigraphic section which is believed to include both Tallahatta and Kosciusko beds. The lower intervals are well-bedded white and light-colored fine micaceous sand containing stringers of white clay shale and silt, and lentils of purple sand. The light-colored material is overlain above a sharp irregular contact by coarse brown sand which contains clay balls and fragments a little above the contact, also purplish, pink, and other colors in the sand. The west wall of the same valley (NE.cor., Sec.15) shows the same succession — light-colored fine micaceous sand below, and coarser brown sand above, associated with some purple sand, ferruginous sandstone, whitish to pink and gray sandy clay, and white sand. The elevation is 420-440 feet. And 0.3 to 0.4 mile east of these outcrops a big erosion hollow (SW. cor., Sec.11) a few rods north of the road, has exposed white sand and bodies of pink and white clay in rust-brown sand, at about the same elevation as the larger showings farther west.

The outcrops last described (vicinity of common corner, Secs. 10, 11, 14, 15, T.5 S., R.3 W.) showed the farthest west Tallahatta terrane observed along the Waterford-Galena road. West of them the surface elevation increases by 100 to 200 feet, and Kosciusko sand is thick. However, a little more than a mile east of Chulahoma, white shale is visible on the south side of Highway 4 (Northern part, Sec.15, T.5 S., R.4 W.), at an altitude of 500 feet or more. It is the westernmost showing of Tallahatta material along Highway 4, and may have been worked into the overlapping Kosciusko.

Along Highway 4 northeast of Galena, Tallahatta beds crop out at a few places. About 2.8 miles northeast of Galena, and 0.4 mile northeast of the junction of the highway and a local road at the highway bridge over Jones Creek, erosion gashes (SW. ¼, Sec.33, T.4 S., R.3 W.) on both sides of the highway in the east wall of the creek valley, have exposed brown sand, white and pink clay, white sand, purple sand, and material of other colors, at an elevation of 500 feet more or less. The white clays

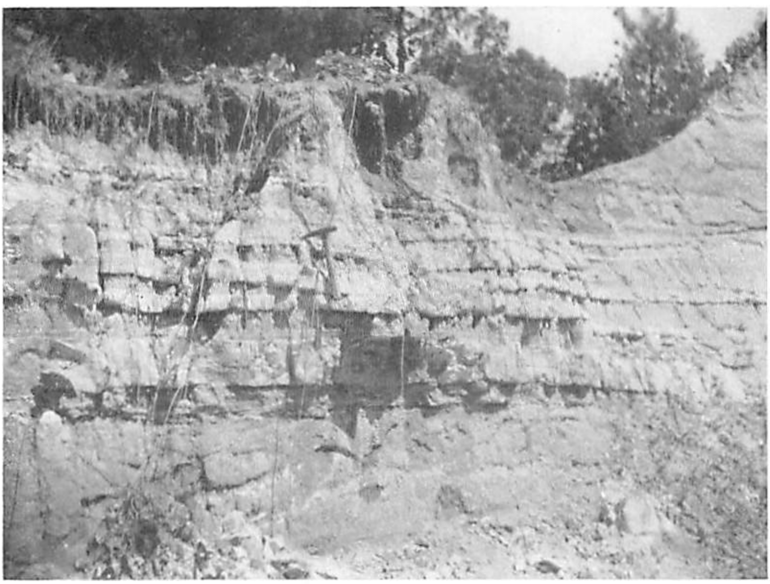


Figure 23.—Tallahatta thin beds of white silt and sand (SE.cor., Sec.36, T.3 S., R.4 W.) on a north-south section-line road at a junction 4 miles south of Red Banks. July 22, 1952.

and silts are shaly in places. On the northwest side of the highway, a few yards down slope, a body of light-gray iron oxide-stained and mottled clay has been cut through, forming a ledge in the ravine. Slabs of limonitic siltstone or silty limonite 3 inches thick, and some sandstone, overlie the clay. The clay body may represent the top of the Tallahatta, or it may be reworked into the Kosciusko sand.

A little north of a bridge over Pigeon Roost Creek, on the east side of the road, is a relatively large body of clay, in sand

(Western part, Sec.7, T.4 S., R.3 W.), at an elevation of 380 feet, and at the junction (elevation 420 feet) a short distance farther north, is a road cut in red-brown sand. The Tallahatta-Kosciusko contact trace may trend between the two outcrops. About 0.8 mile northeast of the junction, an exposure (SE.¼, Sec.6, T.4 S., R.3 W.) shows light-colored sand, banded brown and white, below, and approximately 10 feet of red-brown sand above, separated by a sharp contact line (elevation 500+ feet). The structure suggests faulting.

Along the road which leads north from the junction referred to above, and some 1.5 to 1.75 miles north of the junction, a cut (On line between Sec.31, T.3 S., R.3 W. and Sec.36, T.3 S., R.4 W.) only slightly above creek level, shows white bedded siltstone that is thought to be Tallahatta (Figure 23). The elevation is between 400 and 420 feet.

Half a mile or less west of the western corporate limits of Holly Springs, on the north side of the road at the base of the west wall of the valley of a small headwater tributary of Pigeon Roost Creek, is an outcrop (SW.¼, NE.¼, Sec.1, T.4 S., R.3 W.) of blocky gray to white pink mottled clay overlain by brown sand along a sharp contact. The basal part of the overlying sand contains many clay inclusions. The elevation of the contact line is about 500 feet.

Some 260 yards east of the outcrop last mentioned and 0.1 mile east of the bridge, the north wall of a road cut near the foot of the east wall of the valley shows the section described below:

SECTION OF THE NORTH WALL OF A ROAD CUT (SW.¼, NE.¼, SEC.1, T.4 S., R.3 W.) ABOUT 0.8 MILE WEST OF HIGHWAY 7 IN HOLLY SPRINGS VIA CHULAHOMA STREET, NEAR THE FOOT OF THE EAST WALL OF A VALLEY.

	Feet	Feet
Kosciusko? formation		6.0
Sand, brown, coarse to medium; contains stringers of grit and small pebbles and of lighter colored clayey sand. Including a thin sandy soil, 5.0 to	6.0	
Sharp unconformable contact		
Tallahatta formation		8.0
Weathered zone: Compact clayey sand and sandy clay, blocky where dry; slightly carbonaceous; mottled and streaked iron brown and gray like the sand below	3.0	
Sand, mealy, rather coarse, steel gray and slightly iron streaked. To bottom of roadside ditch	5.0	

Possibly the uppermost sand of the section is Tallahatta, but probably it is Kosciusko filling an old valley in the Tallahatta terrane.

Approximately 1.3 miles to 1.4 miles farther northwest, road cuts and ravines (NE.¼, SW.¼, Sec.35, T.3 S., R.3 W.) expose a considerable section of Tallahatta terrane, the layers of silt, sand, clay, and silty limonite showing almost without a break through a vertical interval of 40 to 50 feet, from the bottom of the small branch below a culvert to the top of the rise 0.2 mile southeast of it. The north wall of the road cut up slope southeast of the

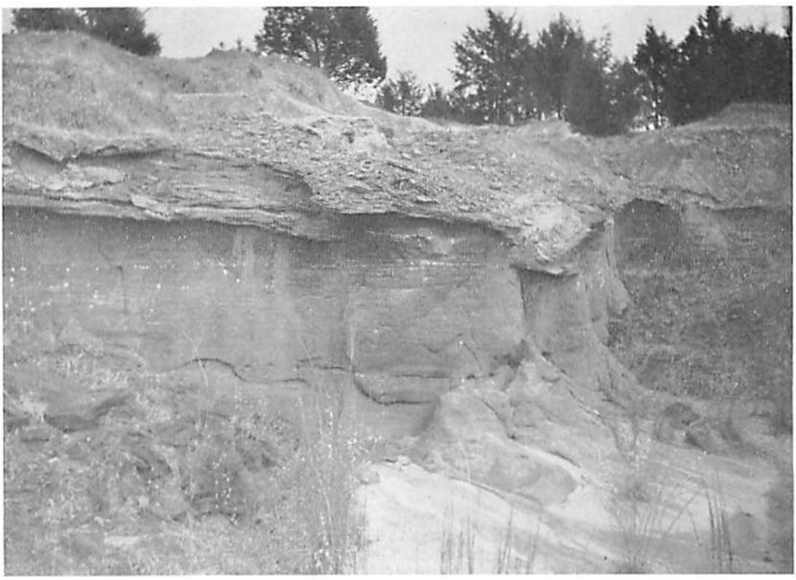


Figure 24.—Kosciusko sand and sandstone, superjacent to Tallahatta beds, exposed by a ravine (SE.cor., Sec.29, T.3 S., R.3 W.) 5 miles west by north from Highway 7 in Holly Springs, and 2 miles south of Highway 78. December 12, 1952.

culvert is a succession of thin layers of silty sand and clay separated by partings of silty limonite or limonitic silt, all brightly colored red, yellow, pink, white, brown, etc. The clay is white where fresh, and very plastic. Near the head of a ravine a few yards north of the road is a 6-foot cliff of the bright-colored layers, capped by 2-inch to 3-inch slabs of the silty limonite. The ravine below the cliff is cut in the same kind of layers. The dip of the beds, as shown by the road cut, is east to southeast. The other cut, at a somewhat greater elevation, a little below the top of the rise, exposes a lens of bluish-gray pink-mottled clay in the sand, overlain by slabs of ferruginous silty limonite. The altitude of the stratigraphic section ranges from 520 to 580 or 600 feet.

About 3.5 miles southeast of Red Banks, and 0.5 to 0.6 mile west of a road junction, outcrops (SE.Cor., Sec.29, T.3 S., R.3 W.) of Tallahatta shale are overlain by Kosciusko sandstone and sand. The shale, exposed in the walls of an old pit or part of an exca-

Figure 25.—Tallahatta-Kosciusko? contact (SE.cor., Sec.7, T.3 S., R.3 W.) in the north wall of a road cut 0.8 mile east of Red Banks. March 13, 1953.

vation for a pond, at an elevation of about 520 feet, is white on the surface, but darker where fresh. The overlying sand is coarse and gritty, and much ferruginous sandstone float is lying about. A ravine some 60 to 75 yards north of the road shows thick ferruginous sandstone overlying coarse brown sand, and underlying loess (Figure 24).

Three quarters of a mile or a little more east of the road intersection in Red Banks, on the north side of the Pleasant Grove Church road some 200 yards west of the church, a sand pit in the north wall of the road cut, and ravines a short distance north of the road have exposed white shale and white, brown and red-brown sand (SE.¼, Sec.7, T.3 S., R.3 W.). The sand exposed by the pit is coarse, micaceous, and cross bedded, and is overlain by a 1-foot bed or wedge of white shale, above which is a ledge of coarse friable ferruginous sand and sandstone (Figure 25). The diagonal bedding of the sand is much like that of the Meridian formation, and the sand itself resembles Meridian. It seems possible that the Meridian, Tallahatta, and Kosciusko are all represented here. However, the altitude of the outcrops, 460 to 480 feet, seems too high for any part of the Meridian, unless dips are abnormal. The erosion hollows north

Figure 26.—Sharp contact between red-brown sand and white silt shale, on the same level, in ravines a few yards north of the outcrop shown by Figure 25. August 22, 1952.

of the road show several feet of white, pink-mottled clay shale and silt shale underlain by white micaceous sand and overlain by brown and red-brown sand. In one place the outcrop shows an interval of brown sand adjacent to one of white shale on the same level, the two separated by a sharp diagonal contact (Figure 26). The sand is cross bedded and the shale horizontally bedded. At other places coarse brown sand alternates, is interbedded with, and grades laterally into white to pink-mottled and brown-mottled clay shale and silt shale.

About 0.3 mile south of the intersection of Highway 78 and the Red Banks road, Tallahatta white shale, clay, and sand are exposed for a considerable distance along the channel of Red Banks Creek (NE.¼, SE.¼, Sec.13, T.3 S., R.4 W.). A short distance northwest of the bridge leaf-bearing lignitic shale shows at the base of the right wall. The altitude is 420 feet or a little more.

Half a mile or so west of the road intersection in Red Banks, and a short distance north of Highway 78, is an outcrop (Southern part, Sec.12, T.3 S., R.4 W.) of indurated dense silty limonite or limonitic silt in the form of crusts or thin platy layers figured

Figure 27.—Tallahatta-Citronelle? contact exposed by a road cut (SW.¼, NE.¼, Sec.36, T.2 S., R.5 W.) in the east wall of Byhalia Creek Valley 0.5 mile east of Byhalia. July 10, 1952.

on the surface with sinuous or roughly circular designs such as might have been produced by drying and shrinking of iron oxide-saturated silt. This rock and the underlying white and yellow sandy clay are exposed in the local road and a ravine alongside it. The outcrop is believed to be approximately on the Tallahatta-Kosciusko contact. The elevation is around 460.

A road cut (SW.¼, NE.¼, Sec.36, T.2 S., R.5 W.) in the east wall of the valley of Byhalia Creek or the valley of a main head tributary a short distance east of Byhalia, has exposed a good section of Tallahatta (perhaps reworked), Citronelle gravel, and Loess at an elevation of 340 to 360 feet (Figure 27). The section is, roughly, as follows:

SECTION OF THE EAST WALL OF THE VALLEY OF BYHALIA CREEK ALONG A ROAD HALF A MILE EAST OF BYHALIA.

	Feet	Feet
Loess formation		2.0
Silt, gray to brown, about	2.0	
Unconformity, sharp contact		
Citronelle formation		11.0
Sand, brown, and gravel	11.0	
Unconformity; sharp		
Tallahatta formation		19.3
Sand and silt, white and brown	19.3	

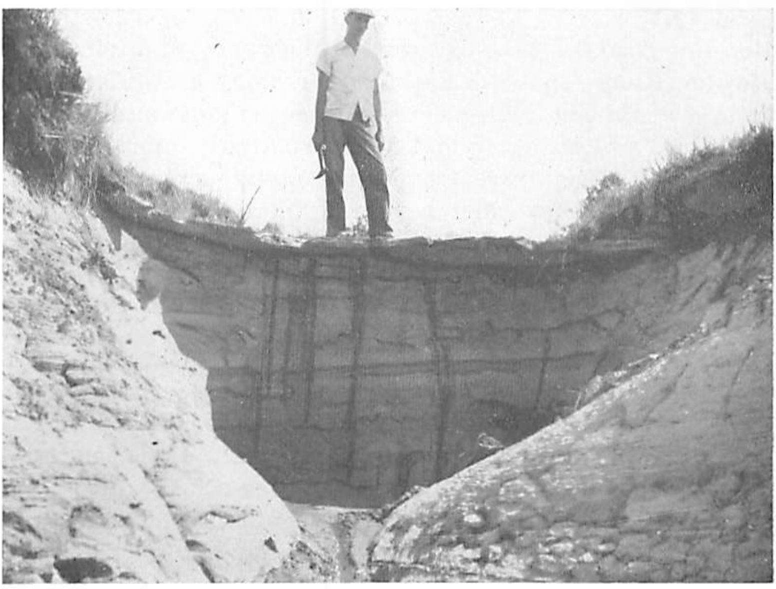


Figure 28.—Tallahatta-Kosciusko contact (SW.¼, NW.¼, Sec.27, T.2 S., R.4 W.) in a ravine east of the road, 2.5 miles north of Victoria. July 10, 1952.

North of Victoria 2.5 miles, Tallahatta and Kosciusko strata crop out along a ravine and small valley east of the north-south road. The contact is sharp at an 8-foot cliff (SW.¼, NW.¼, Sec. 27, T.2 S., R.4 W.) (Figure 28), a quarter of a mile or so down the valley from the road. The ledge is well bedded brown, yellow, red, and dark clay shale and silt capped with a 3-inch layer of silty limonite or ironstone. Except in the creek channel it is overlain by coarse brown sand which contains white inclusions here and there. The exposure is very similar to the outcrop (SW¼, Sec.35, T.3 S., R.3 W.) described in a foregoing paragraph.

Half a mile or so southeast of the intersection of Highway 72 and the Tennessee line, the walls, especially the north wall, of a highway cut (NW.¼, Sec.22, T.1 S., R.4 W.) at an altitude of around 400 feet, show a terrane of very irregular structure. White and light-brown silt and clay layers and thin ironstone layers or crusts are interbedded and interwedged. The light-colored material seems to be lenses in the sand. It is believed that this outcrop shows Tallahatta materials re-worked into the Kosciusko sand near the contact. Bedding dips steeply in places.

Some 3 miles south by west of Mt. Pleasant, the east wall of a cut (NW.¼, SW.¼, Sec.16, T.2 S., R.3 W.) for a north-south section-line road, in the north wall of the valley of a tributary of Coldwater River, shows a clear rather sharp irregular contact trace between a fine light-colored micaceous horizontally bedded sand below, and a coarse and gritty sparingly micaceous sand above. The contact trace trends diagonally across the face of the wall in one place, and here and there is marked by thin ferruginous sandstone. It looks like the trace of an erosional contact between two unlike sands, and may be an outcrop of the Tallahatta-Kosciusko contact. The altitude is 420 to 460 feet.

South along the same road 1.5 miles or a little more, at the top of the north wall of the valley of Coldwater River, near a house, big erosion hollows (NW.Cor., Sec.28, or NE.Cor., Sec.29, T.2 S., R.3 W.) expose varicolored sand, white shale, and white breccia. Probably the white material is reworked, and is somewhat above the Tallahatta-Kosciusko contact. The elevation is approximately 420 feet.

The term "Neshoba" was introduced by Thomas[31] to apply to a body of non-glauconitic to sparingly glauconitic sand which lies above the typical Basic City claystone member of the Tallahatta, and underlies the Winona sand. The type section is along the highway through the village of Neshoba, in Neshoba County. He considered the Neshoba sand a member of the Tallahatta formation. It is described as typically non-fossiliferous marine sand, well sorted, fine grained, micaceous, white where fresh, but on the outcrop almost everywhere stained red, brown, yellow, purple, or mottled. The sand is massive to cross bedded or otherwise irregularly bedded. The sand of the upper 5 to 15 feet is dark brick red, very argillaceous, medium grained, and poorly sorted. Greensands and glauconitic sands are present in a few places. Gray clay is abundant in the Neshoba member as pellets, partings, stringers, and lenses.

The Neshoba member of the Tallahatta formation is not differentiated from the formation as a whole in this report on Marshall County. At a few places the sand in the upper part of the Tallahatta is a very deep red, or a yellow, and perhaps has other characteristics of the Neshoba as described above; but it is not different in these respects from other sands at lower or higher levels. In fact, it is improbable that the Neshoba could be identified as a distinct unit in Marshall County, even by intensive study. Thomas[32] found that, no farther north than Grenada County, "Carbonaceous clays and shale become abundant as lenses and partings in the glauconitic to non-glauconitic micaceous sands and silts, and at a few localities discontinuous Basic-type siltstone ledges are found within the section." He included all these materials in his "undifferentiated Tallahatta" of Grenada County. The same conditions exist in Marshall County.

The area of outcrop of the Tallahatta formation in Marshall County, as roughly defined by the distribution of exposures described in the foregoing text, comprises almost all the region west, north, and northwest of an irregular contact line extending from the southern boundary of the county northwards along the valley of Little Spring Creek to Mimosa Lake, thence northeast to the Benton County line south of Scales Forest Tower. That is, it includes three-fourths of the county, more or less. However, a few outcrops which show characteristic Tallahatta white clay or silt shale as thin layers or stringers in fine light-colored sand, and for that reason have been interpreted as exposures of Tallahatta materials in place, may be showings of reworked Tallahatta, and thus of an overlying formation. Inasmuch as the Tallahatta beds are largely silt and fine sand, the shale being discontinuous, they are not everywhere readily distinguishable from underlying Meridian or overlying Kosciusko strata. The problem is made more puzzling by extensive overlap of Kosciusko and Citronelle on the Tallahatta. Thus the upper parts of the higher hills and ridges are composed of Kosciusko, Citronelle, and Loess materials.

The regional dip of the formation is low, perhaps not more than an average of 15 to 20 feet a mile for the upper contact, which is a surface of unconformity. The dip is irregular locally. The thickness of the formation is far from uniform, because of probable irregular original deposition and of extensive post-Tallahatta erosion. The maximum thickness of the Tallahatta in the area around Grenada, Grenada County, is about 200 feet, according to Thomas,[33] and the maximum thickness of the same formation in Marshall County appears to be approximately the same. Both the lower and upper contacts are exposed in the head of the valley of a tributary of Little Spring Creek, and the head ravines of the main creek, along Highway 7 (Sec.1, T.5 S., R.3 W., and Sec.36, T.4 S., R.3 W.). The Meridian-Tallahatta contact trace at the north end of Lake Mimosa is at an altitude of about 400 feet, and the Tallahatta-Kosciusko contract trace, 1.8 miles farther north almost along the strike, has an altitude of between 580 and 600 feet.

WINONA AND ZILPHA FORMATIONS

The Winona formation, as stated in a preceding section, is doubtfully represented in Lafayette County. In Marshall County also, its presence is doubtful. It was not positively identified anywhere. However, in several places superjacent to the uppermost recognizable Tallahatta materials, are beds of deep red sand and sandstone which are very similar in general appearance to the type Winona rock. They may, indeed, be Winona, but a search for glauconite in the red sand was unsuccessful, and no well defined lower or upper contact could be found, by which any presumed Winona section could be differentiated from underlying and overlying sands. Although it is possible, then, that painstaking study of the beds in Marshall County at the stratigraphic position occupied by the Winona terrane elsewhere, might discover some remnants of the formation, the Winona is not described as a separate unit in the present report. Brown[34] found that the Winona is absent "in the depths of the embayment north of Clarksdale," unless represented by shale; and that at Sardis Dam, Panola County, evidence exists that the Kosciusko rests on the Tallahatta.[35]

The Zilpha formation does not crop out anywhere in Marshall County, so far as was discovered by the present survey, except possibly at Mt. Olive Church at Walhill (SW.Cor., Sec.23, T.4 S., R.5 W.), where 7 to 8 feet of gray shaly silty clay is exposed by road cuts. It is overlain by a little Citronelle brown sand, and this by loess. The clay could possibly be part of the Tallahatta. The Zilpha shale at some outcrops in the counties farther south is much like the dark Tallahatta shale, and one could easily be mistaken for the other where the Winona is absent. One difference is, that in most places the Zilpha contains masses of iron carbonate or oxide.

KOSCIUSKO FORMATION

The Kosciusko formation, consisting of non-marine sand entirely except for a relatively little clay, shale, and silt, is the youngest Claiborne unit in the county. The main body of the formation is west of Highway 7, where its pattern of outcrop is interwoven with the pattern of the Tallahatta, Citronelle, and Loess formations, but fingers and outliers of Kosciusko reach far to the east, overlapping the Tallahatta and Meridian and forming the upper parts of the highest ridges and hills, including the isolated so-called "mountains." These highest land forms are, with few exceptions, capped by large roughly slab-like masses of hard ferruginous sandstone which probably has been the chief factor in determining their existence, location, and shape, by controlling erosion. The lowermost Kosciusko is sandstone or semi-indurated sand almost everywhere; in places the sand is quartzitic, or has been cemented to a true quartzite. However, Kosciusko quartzite is not nearly so abundant in Marshall County as it is in Lafayette.

Outcrops of Kosciusko sand and sandstone are so many that to describe or even to mention all would be pointless. The most prominent and significant will be described, however, in order to convey an understanding of the lithologic character, the structure, the stratigraphic relationships, and the distribution of the formation. Insofar as practicable, the south-north strike and dip order will be followed.

Possibly the southernmost outcrop of Kosciusko sand in the county is the uppermost unit of the section (NE.¼, Sec.10, T.6 S., R.3 W.) described in the Tallahatta part of this report. The elevation is about 420 feet. Little or no sandstone is present. Half a mile farther north, at approximately the same elevation, ferruginous sandstone a foot or more thick, and coarse, gritty, ferruginous sand, believed to be Kosciusko, overlie Tallahatta white and pink clay (SE.¼, Sec.3, T.6 S., R.3 W.). Another outcrop (SE.¼, NE.¼, Sec.3, T.6 S., R.3 W.) across the Tallahatta-Kosciusko contact trace is 0.3 to 0.4 mile still farther north, where red and yellow sand on which is a little quartzite float, shows at road level and below (elevation 400 feet, more or less). Kosciusko sand can be seen at several places along this south-north road. A quarter of a mile or less southeast of the highest point along the road (500 plus feet) the contact is crossed by ravines (Northern part, SW.¼, Sec.26, T.5 S., R.3 W.): Coarse, gritty sand containing small quartz pebbles overlies white and pink clay, at an elevation of 440 to 460 feet. From this point northward along the strike are outcrops here and there. Highway 7 crosses both the Meridian-Tallahatta and the Tallahatta-Kosciusko contact traces a little north of Mimosa Lake, along the 1.5 miles from lake level (elevation about 354 feet) to the ridge top north of McKenney School (580 plus feet). The position of the base of the Kosciusko could not be determined accurately here, but it may be at the base of the red-brown compact sand lying on the white sand 20 to 25 feet below the crest of the ridge. The "mountains" three quarters of a mile to a mile east and southeast of McKenney School (SW.¼, and SE.¼, Sec.31, T.4 S., R.2 W., and NE.¼, Sec.6, T.5 S., R.2 W.) are capped by Kosciusko ferruginous sandstone.

The eroded walls of a small valley (north of center, Sec.25, T.4 S., R.3 W.) 100 to 200 yards west of Highway 7, and 4 miles south from Holly Springs, expose part of the Tallahatta-Kosciusko contact trace. Ferruginous sandstone is abundant along the small branch. The contact trace is irregular (Figure 17). The elevation here is 560 to 580 feet.

Kosciusko sand is well exposed by ravines (Near center, Sec.30, T.4 S., R.2 W.) a mile east of the outcrop mentioned above, and a short distance south of a railroad crossing, at elevations of 540 to 600 feet and more.

The approximate position of the base of the Kosciusko can be located west of Holly Springs 0.6 mile to a mile, in the west wall of a small valley. At a road junction (NW.¼, Sec.1, T.4 S., R.3 W.) and east of the road south of the junction, the ridge is capped with huge blocks and irregular masses of ferruginous sandstone similar to that which tops several other so-called "mountains" of the county. The altitude reaches more than 640 feet. At this place and north of it along the strike to Highway 78 is the largest aggregate of ferruginous sandstone observed in the county. It is scattered over the surface northwest and north of the road junction for 0.3 to 0.4 mile.

A mile farther north by east, the same sandstone interval is exposed along old Highway 78 about a mile northwest of Holly Springs, and crops out uninterruptedly in the ridge northward

Figure 29.—Kosciusko sandstone (NE.cor., Sec.35, T.3 S., R.3 W.) about 1.3 miles northwest of Holly Springs, 0.5 mile south of Highway 78, and some 200 yards north of old Highway 78. January 13, 1953.

from this place to Highway 78 (NW.¼, Sec.36, SW.¼, Sec.25, T.3 S., R.3 W.). Blocks 2 to 3 feet thick show in the walls of a ravine on the north side of the old highway, and ledges can be followed along the slope northward; in places the rock is a solid floor. A quarter of a mile or so north of the old highway, sandstone blocks, large and small, are scattered widely over the surface of the slope, and near the top of the walls of a Highway 78 cut (SW.¼, Sec.25) masses of rock from the same interval are exposed. At the Old Highway 78 outcrop, cross-bedded ferruginous sandstone up to 2 feet or more thick overlies coarse to gritty deep red-brown cross-bedded compact sand, forming ledges across the gullies. Some 200 yards north of the old highway this sandstone wall is well exposed across an old road (Figure 29).

Down dip west and north of west from the Tallahatta-Kosciusko contact trace points mentioned above, and south of Highway 78, Kosciusko terrane has been bared in many places.

Figure 30.—Tallahatta and Kosciusko sand (NE.¼, Sec.11, T.6 S., R.4 W.) 0.7 mile west of Laws Hill, on the north side of a local road. June 25, 1952.

In the vicinity of Laws Hill, Kosciusko sand and sandstone are conspicuous. South by east of a road junction 0.3 to 0.4 mile, deep ravines west of the road (SE.¼, NW.¼, Sec.12, T.6 S., R.4 W.) have exposed Tallahatta white shale below and Kosciusko ferruginous sand and sandstone above (Figure 21) at an elevation of 520-540 feet. Fragments of ferruginous sandstone are scattered widely over the slope, and white clay balls and angular pieces have been worked into the sand just above the contact.

A segment of the contact is exposed by erosion a little west of Laws Hill (NW.¼, Sec.12, T.6 S., R.4 W.), on the south side of the east-west road, and another half a mile or so farther west, on the north side of the same road (Figure 30).

A long and deep road cut (NW.Cor., Sec.11, SW.Cor., Sec.2 and SE.Cor., Sec.3, T.6 S., R.4 W.) in the east wall of the valley of Blackwater Creek at elevations ranging from 380 to 460 feet, is in Kosciusko brown and red-brown sand entirely, except for a little white clayey and silty sand at the lower end of the cut, probably re-worked Tallahatta material.

Some 2.5 miles farther northwest along the same road (Laws Hill-Chulahoma road), at a place where the road bends to north by west, the Kosciusko sand is deeply eroded (NW.¼, Sec.4, T.6 S., R.4 W. and SW.¼, Sec.33, T.5 S., R.4 W.). A thickness of perhaps 50 feet of ferruginous sand, with abundant sandstone float, is exposed. The elevation reaches 520 feet a short distance north of the head of a big northwest-southeast ravine which trends subparallel to the road on the northeast side.

On both sides of the Waterford-Laws Hill road Kosciusko sand is exposed at the greater elevations (see Tallahatta formation). Prominent outcrops are: 1) Some 3 miles west by south of Waterford, ravines (NW.¼, Sec.22, T.5 S., R.3 W.) a short distance east of a road junction, have been cut in dull-white to red-brown coarse, gritty sand containing numerous fragments of sandstone, at an elevation of 480-500 feet. 2) Approximately 3.5 miles southwest from Waterford, erosion hollows (NW.¼, Sec.27, T.5 S., R.3 W.) at an elevation of 460 feet or thereabouts, show red-brown sand and a little re-worked white clay and silt and fine white micaceous sand. 3) An outcrop similar to 2) is provided by ravines (SE.¼, Sec.31, T.5 S., R.3 W.) a short distance southwest of a road junction — the same kind of red-brown sand and large and small fragments of re-worked white clay and silt and sand. The elevation is about the same as that of the Section 27 outcrop, and probably the stratigraphic position of the two is essentially the same, lower Kosciusko, not far above the Tallahatta.

Approximately a mile and a quarter north of the Section 31 outcrop, in a shallow valley at the north-south road (On the line between Secs.29 and 30, T.5 S., R.3 W.) blocks of ferruginous sandstone 1.0 foot to 1.5 feet thick, and also some coarse red-brown and pinkish sand, are believed to be basal Kosciusko material, probably let down. The altitude is 400 feet or a little more.

Half a mile to 0.6 mile farther north, almost on the gas line right-of-way, and a few yards south of a bridge, the east wall of a road cut (SW.Cor., Sec.20, T.5 S., R.3 W.) is banded brown Kosciusko sand. The elevation is 440 feet, more or less.

A mile south by west of Galena, and some 200 yards northeast of a road junction, a ravine 30-40 feet deep (SE.¼, SW.¼, Sec.18, T.5 S., R.3 W.) has been cut in Kosciusko sand. The elevation at the head of the ravine is 560 feet, but an elevation of more than 600 feet is reached a short distance south of the road junction, and very considerable altitudes to the east and northeast.

The Waterford-Galena road is on a rough terrane which ranges in altitude from less than 340 feet in the valley of Little Spring Creek (Sec.13, T.5 S., R.3 W.) to more than 640 feet northwest of Wilkins Cemetery (SW.¼, Sec.9, T.5 S., R.3 W.). Kosciusko sand and sandstone are prominent at several places along this road:

1) Approximately 2.4 miles west from Waterford (Highway 7) road cuts and nearby ravines (Near common corner, Secs. 10, 11, 14, and 15, T.5 S., R.3 W.) expose Kosciusko coarse brown gritty sand overlying light-colored to white sand and silt and clay shale believed to be Tallahatta (see description in section relating to Tallahatta).

2) East from Galena 1.6 miles more or less, a deep ravine (SE.Cor., Sec.8, T.5 S., R.3 W.) has been cut in Kosciusko sand (Figure 31). Blocks of sandstone show in the ravine walls and others are lying at the bottom. The ravine head is at an elevation of about 540 feet.

3) Approximately three quarters of a mile farther east, and 0.8 mile northwest of a road junction, a road cut at Wilkins Cemetery exposes Kosciusko sand and sandstone, and also some small clay inclusions (SW.¼, SE.¼, Sec.9, T.5 S., R.3 W.), at an elevation of 540 to 560 feet. Less than a quarter of a mile west by north of the road cut, the altitude reaches more than 640 feet, one of the highest points in the county. The maximum relief in Sections 9 and 16 is more than 240 feet in a distance of a mile

south of the Wilkins high point. The road cut outcrop shows a distinct contact between finer sand below, in which is the clay, and coarser sand above, which contains sandstone. Possibly the lower sand is Tallahatta, although the elevation seems too great for the Tallahatta-Kosciusko contact if the structure is normal. The slopes south and southeast of the road cut are deeply eroded, and sand is exposed from top to bottom, some of it being light of color and strongly cross bedded. The sandstone in the road cut probably can be correlated with that in the big ravine three quarters of a mile farther west.

Figure 31.—Ravine in Kosciusko sand (SE.cor., Sec.8, T.5 S., R.3 W.) 1.6 miles east from Galena, on the south side of the Waterford road. June 27, 1952.

Kosciusko sand crops out along Highway 4 between Highway 7 and Galena. Some 2.8 miles northeast from Galena and 0.5 mile northeast of a road junction and the Jones Creek bridge, the Tallahatta-Kosciusko contact is crossed by the highway and by ravines and gullies on both sides (see Tallahatta formation) (SW.¼, Sec.33, T.4 S., R.3 W.).

A little below the top of a rise, on the northwest side of Highway 4, 1.4 miles from the junction of Highways 4 and 7, erosion channels expose grayish-white and yellow and brown sand, only slightly micaceous. The altitude of the top of the hill is more than 600 feet. The outcropping sand probably is of Kosciusko age, then; most certainly the upper part of it is.

Kosciusko sand shows at several places along the road which leads southwest and west from Holly Springs to Marianna. One good outcrop of coarse sand (Northern part, Sec.10, T.4 S., R.3 W.) is about 3 miles from Holly Springs and half a mile east of a road junction.

Probably the best Kosciusko outcrops in the county are along or near the road which trends west by north from Holly Springs for 3 to 4 miles, thence due west to the DeSoto County line. The ferruginous sandstone near the base of the formation caps the high hill (640 plus feet) at the road junction a mile west of Holly Springs, as already described, and is scattered over the surface northwest of the junction, especially in the upper part of a hill (Common corner, Secs.35, 36, T.3 S., R.3 W., and 1, 2, T.4 S., R.3 W.), which has an elevation of 660 plus feet. Farther northwest, at a lower level, is red sand, and Tallahatta beds are exposed at a distance of 0.85 mile to a mile from the junction, at elevations ranging from 520 to 560 feet.

Approximately 3.5 miles west by north from Highway 7 (Chulahoma Street) in Holly Springs, in the walls of a ravine (SE.¼, NW.¼, Sec.34, T.3 S., R.3 W.) near the top of a ridge, a ledge of ferruginous sandstone crops out at an altitude of about 580 feet, probably part of the westward extension of the rock which caps the hills farther east. It is underlain by a vertical wall of red sand containing stringers and balls of white sandy clay. Some purple sand is bedded in on a level with the sandstone or above it. Farther down the ravine the sand is of lighter color, and half a mile farther west, at an elevation of 540 feet or less, a body of white and pinkish clay shale is exposed by a road cut (NE.¼, Sec.33, T.3 S., R.3 W.) near the valley bottom. It is overlain by brown and red sand and some loessial material. The contact of clay and sand is sharp but irregular.

At the junction (on the line between Secs.28 and 33, T.3 S., R.3 W.,) of the east-west road with a road which leads north to Highway 78, washes on the south side of the road expose cross-bedded fine white and pink micaceous sand, brown on the outcrop, beneath a ledge of heavy sandstone. Lower, the brown sand contains stringers and irregular bodies of white clay and sand. The deep red sand such as crops out here and some 0.3 mile east of the junction, suggests Winona material. The ferruginous sandstone at the junction is featured by its extreme surface irregularity, especially botryoidal and mammillary masses. Loessial material lies on the red sand above a very irregular contact.

Kosciusko sand and sandstone overlie Tallahatta white clay and silt shale (Figure 24) half a mile farther west (SE.Cor., Sec. 29, T.3 S., R.3 W.), as mentioned in the description of the Tallahatta formation.

Figure 32.—Kosciusko? sand (SW.¼, NE.¼, Sec.34, T.4 S., R.4 W.) north wall of the channel of Dry Fork, 1.5 miles south from Marianna, and 200 yards west of a bridge on the Chulahoma-Marianna road. June 25, 1952.

A mile and a half still farther west, big erosion gashes (NE.¼, Sec.31, T.3 S., R.3 W.) south of the road expose coarse, gritty sand. Other outcrops here and there along this road show the same kind of sand — red, brown, cross-bedded in places, and streaked with pink and purple sand. Altitude is less towards the west, until at the western border of the county it is only about 340 feet, on the divide between Red Banks Creek on the north and Pigeon Roost Creek on the south. From an undefined contact east of Watson, Kosciusko sand is overlain by Citronelle sand and gravel.

In the remainder of Townships 3 and 4 South, Ranges 3, 4, and 5 West, south of Highway 78, are a few prominent Kosciusko outcrops, and many smaller ones. Approximately 3 miles northeast from Chulahoma and a short distance northwest of a bridge over Dry Fork Creek, the right wall of the creek channel on the outside of a bend (Southern part, NE.¼, Sec.34, T.4 S., R.4 W.) is a sand cliff some 30 to 35 feet high. The sand is coarse to fine,

Figure 33.—Sand-filled canal of Cuffawa Creek (Northern part, Sec.28, T.4 S., R.4 W.) looking south from the bridge 1.5 miles west from Marianna. June 25, 1952.

varicolored brown, red, purplish-black, pink, and other colors, complexly cross bedded, and contains a large body of bedded white and pinkish clay. Bedding of the sand is well defined near the base of the wall (Figure 32). The sand of this outcrop may be Kosciusko. It is coarse towards the base, an interval which may not be far above the top of the Tallahatta. The altitude ranges from 400 to 420 feet. The whole terrane is flat-topped, a terrace of the creek, possibly a valley fill incised by the present stream.

The canal of Cuffawa Creek channel 1.5 miles west of Marianna, is choked with sand (Figure 33) south of the bridge (Northern part, Sec.28, T.4 S., R.4 W.).

Some 0.4 mile north of Marianna, a large erosion hollow (SE.Cor., NE.¼, Sec.22, T.4 S., R.4 W.) at the head of a creek exposes red-brown sand and some gray coarse friable sandstone, at an elevation of approximately 480 feet. The sand and sandstone are believed to belong to the Kosciusko formation.

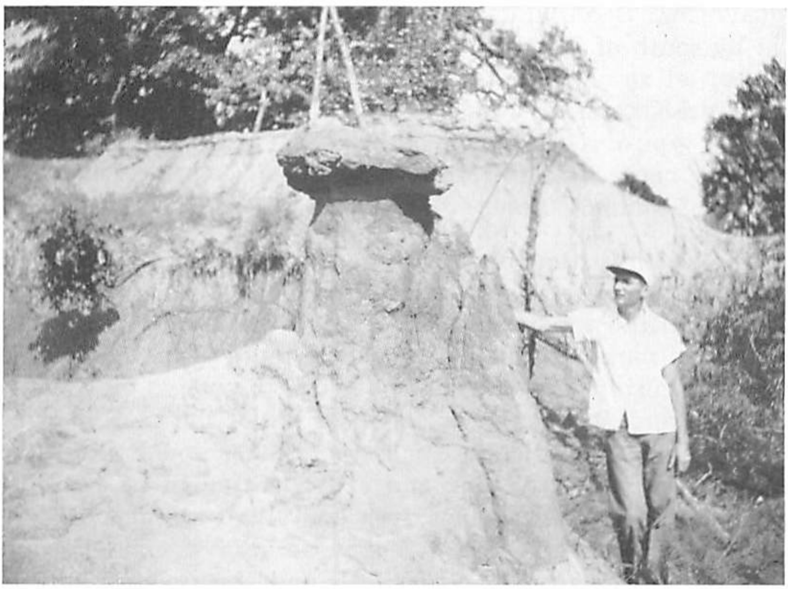


Figure 34.—Block of sandstone on top of a pillar of Kosciusko sand, at the head of a ravine (SE.cor., Sec.13, T.3 S., R.4 W.) a mile south by west of Red Banks. July 10, 1952.

Northwest of Marianna about 2 miles, road cuts (SE.Cor., Sec.9, and SW.¼, Sec.10, T.4 S., R.4 W.) in the east wall of the valley of Cuffawa Creek near Union Valley School, are in Kosciusko sand and a little Citronelle gravel. Also, several excellent Kosciusko sections are exposed by cuts along the road which leads southeast and south from the intersection (Common corner, Secs.7 and 18, T.4 S., R.4 W. and 12 and 13, T.4 S., R.5 W.) to Orion, thence south to Chulahoma.

A mile or less south by west of Red Banks, and half a mile, more or less, west of a road junction, an outcrop (SE.¼, Sec.13, T.3 S., R.4 W.) of red-brown and deep red and purplish sand is featured by abundant ferruginous sandstone. The terrane probably is basal Kosciusko, and the sandstone is part of the sandstone interval that crops out in several places in the county at the base of the formation. Some sandstone blocks cap columns or pillars of sand (Figure 34). The altitude of the outcrop is 460 to 480 feet.

In the walls of a creek channel at a bridge for old Highway 78 (SW.Cor., Sec.4, and NW.Cor., Sec.9, T.3 S., R.4 W.) a mile west by south of Victoria, large blocks of ferruginous sandstone crop out, at an elevation of under 400 feet. They may be on the Tallahatta-Kosciusko contact or near it stratigraphically, as is the same type of rock farther southeast and almost 200 feet higher. The same contact 2.5 to 3.0 miles north of Victoria is also at an altitude of under 400 feet.

The northwestern part of the county is in general a region of low relief and relatively low altitude — in fact, the maximum relief of all the territory north of Highway 78 and west of the Red Banks meridian, including a little more than the southern half of Township 1 South, Range 4 West; the whole of Township 2 South, Range 4 West except a very little of the southwest corner; six sections, a little more or less, of Township 3 South, Range 4 West; approximately nine and a half sections of Township 1 South, Range 5 West; and fourteen and a half sections of Township 2 South, Range 5 West — that is, an area of some 85 square miles — is little more than 200 feet, and the greatest altitude, reached in only one point, is between 500 and 520 feet. The Kosciusko sand outcrops in this region are less prominent than the exposures of the same formation south of the highway where the relief is greater.

A Highway 72 cut (NW.¼, Sec.22, T.1 S., R.4 W.) half a mile or more southeast of the highway crossing of the Tennessee line, has exposed irregularly bedded Kosciusko brown sand and white and light-brown clay and silt, containing thin ironstone layers. Some of the bedding is steep. The light-colored materials seem to be lenses in the sand. The uppermost interval of the outcrop is loess. Half a mile or so northeast of this highway cut, on the K. W. Taylor plantation, a well was drilled in search of water for irrigation. The rough log, as kept by the drillers, The Watson

Company, of Whitehaven, Tennessee, to a depth of 274 feet, is copied below:

Int.	Thick.	Depth	Description of strata
1	12.0	12.0	Clay
2	109.0	121.0	Sand
3	4.0	125.0	Sticky clay
4	20.0	145.0	Sand, with clay streaks
5	30.0	175.0	Sand, coarse, hard
6	45.0	220.0	Sand, medium coarse, medium hard; some rock at base
7	30.0	250.0	Sand
8	24.0	274.0	Sand, fine soft, clay streaks

The second interval probably is Kosciusko; the "sticky clay" may be Zilpha; the sand below it, down to 220 feet, could be assigned to the Tallahatta, and that below 220 feet to the Meridian.

A little southwest of Barton, where the direction of the road is changed from southwest to west, are old pits (NE.Cor., Sec.35, T.1 S., R.5 W.) in brown, pink, and white sand and a little purple clay. The material is believed to belong to the Kosciusko for the most part, but some of it probably is Citronelle.

South by east of Barton half a mile to three quarters of a mile, a road cut (NW.¼, SW.¼, Sec.36, T.1 S., R.5 W.) has exposed cross-bedded white and brown fine sand below Citronelle gravel, which is overlain by loess. The sand is very fine, and contains numerous black specks.

Approximately half a mile south of the road junction (Common corner, Secs.20 and 21 and 28 and 29, T.1 S., R.4 W.) erosion hollows (About center of western boundary, Sec.28, T.1 S., R.4 W.) on the east side of the road, expose several feet of Kosciusko brown sand.

The Tallahatta-Kosciusko contact zone near Pleasant Grove Church, half a mile or so east of Red Banks, has been referred to in the description of the Tallahatta formation, as has the same zone 2.5 miles north of Victoria.

The south wall of the channel of Little Coldwater Creek at a bridge (SW.¼, NW.¼, Sec.8, T.2 S., R.3 W.) is 25 feet or so of red-brown Kosciusko sand containing a pocket of white clay.

The north wall of the valley of Coldwater River (Secs.27 and 22, T.2 S., R.2 W.) along the Holly Springs-Mt. Pleasant road, is chiefly Kosciusko sand. Its altitude ranges from 400 feet at flood-plain level to 540 feet half a mile or more farther north by west, and sand is exposed through most of this 140-foot interval. The lower part of it at least is Tallahatta sand. Two miles farther north, perhaps 2.5 miles north from the Coldwater River, deep ravines (Near center, Sec.15, T.2 S., R.3 W.) which head at the road on the west side at altitudes ranging from 520 to 545 feet, have been cut in sand and silt, much of which is white. The section exposed extends through an interval of 40 to 50 feet, and much of it may be Tallahatta.

About 1.5 miles west by north of Atway, in the west wall of a valley, are deep ravines (NW.Cor., Sec.32, T.2 S., R.2 W.). The lowermost few feet of the sand is white, extremely fine, and very micaceous; the upper sand is coarse, contains numerous inclusions of white clay and silt, and lies on the lower sand along a sharp contact, marked in places by thin ferruginous sandstone. The elevation is 540 to 560 feet. The contact may be between the Tallahatta and Kosciusko formations.

The outcrop at the junction (on the line between Secs.24 and 25, T.1 S., R.3 W.) which is believed to show part of the Tallahatta-Kosciusko contact, has been referred to in the discussion of the Tallahatta. The elevation is 450 to 460 feet.

The north wall of a Highway 72 cut (SW.¼, Sec.32, T.1 S., R.2 W.) a short distance east of Slayden, and an erosional channel at its base, have exposed some 25 to 30 feet of sand — fine white sand overlain by coarse and gritty brown sand which contains inclusions of white clay and silt along and slightly above the contact.

Along the road northeast from Atway, outcrops of sand are conspicuous in a much eroded region where the greatest altitude is more than 640 feet. A ravine southeast of the road (Sec.27, T.2 S., R.2 W.) has been cut in red-brown sand to a level 40 to 50 feet below the road, where the sand is coarse and contains grit and small milky quartz pebbles. A little below the beds of coarse sand is a light-colored clay stringer. Probably 1.5 miles farther northeast (NE.¼, Sec.23, T.2 S., R.2 W.) erosion has cut almost through at or near the highest point along the road. On the east side is banded white and brown sand; on the west side, at a higher level, washes at the head of a ravine show a body of white, pink, yellow, and brown clay and sand and silt, like a lens, on the same level with coarse, gritty, yellow and brown sand and many weathered pebbles of milky quartz, along with ferruginous sandstone up to 2 feet or more thick. Above this is sand of a deep red-brown. The outcrop is believed to expose the Tallahatta-Kosciusko contact.

A prominent outcrop of Tallahatta or Kosciusko sand is shown by the walls of the channel of a creek (Eastern part, Sec. 1, T.2 S., R.2 W.) a short distance west of the Marshall County-Benton County line. A mile northwest of this place, and a little more than a mile west from the county line, on the south side of Highway 72, ravines (NE.Cor., Sec.2, T.2 S., R.2 W.) have been cut in red-brown sand, some of which is coarse and gritty, through a vertical interval of at least 40 to 50 feet. The sand contains inclusions of white clay and silt, and, especially at the lower levels, stringers of whitish clay. The terrane may include both Tallahatta and Kosciusko materials.

The Holly Springs-Hudsonville road between Highways 4 and 7, leads northeast from Holly Springs almost along the strike, through a hill belt. Cuts for this road transect a definite contact plane, probably the Tallahatta-Kosciusko. Three quarters of a mile northeast of the railroad crossing (NW.¼, Sec.32, T.3 S., R.2 W.), a deep ravine between the road and the railroad at a place where they are only 40 to 50 feet apart, has been cut through horizontally bedded red-brown compact sand and into cross-bedded light-brown to dull white fine micaceous sand. The contact between the two sands is marked by a thin layer of red indurated sand. Reworked white clay is embedded in the sand above the contact in a place or two. The walls of the railroad cut half a mile farther northeast show evidence of the same contact: Streaks of light-colored sand, thin friable ferruginous sandstone, ferruginous sand concretions, all along a thin zone. But the most prominent contact along this road is less than a quarter of a mile farther northeast, where the walls of a road cut (Common corner, Secs.20, 21, 28, 29, T.3 S., R.2 W.) in a northeast slope show a sharp contact trace between a very fine white micaceous sand below and a coarser red-brown more compact sand above (Figure 35). The contact is marked by thin rock. A feature of the outcrop is the white pink- and light-brown splotched clay and silt in place in the lower sand and stringers and angular and rounded masses of the same white materials worked into the upper sand.

Some 2 miles north by east of the crossing of the Holly Springs-Hudsonville road and the Illinois Central Railroad, which crossing is half a mile or less north of Holly Springs, are two considerable road cuts (SW.¼, Sec.21, T.3 S., R.2 W.) at an elevation of 520 to 540 feet. The walls of the cuts are light-gray, pink, brown, and yellow sand containing some light-brown to pink clay, semi-consolidated, and silt. The faces of the walls of

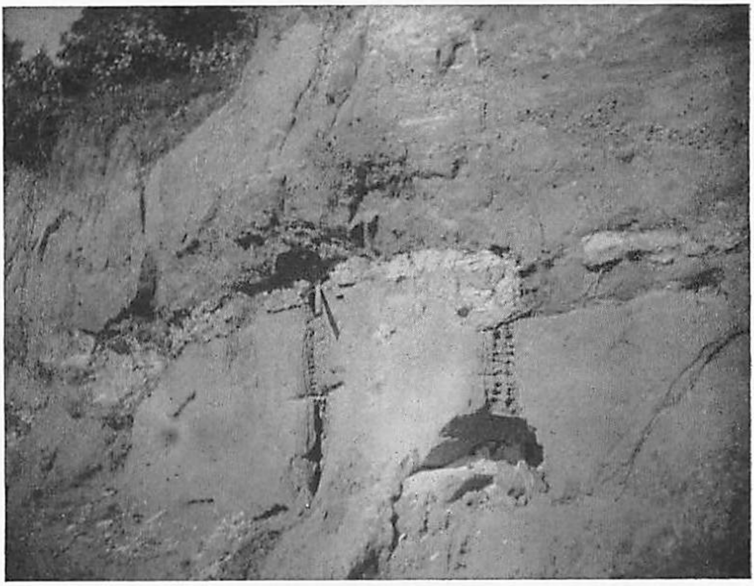


Figure 35.—Tallahatta-Kosciusko contact in the wall of a cut (SW.cor., Sec.21, T.3 S., R.2 W.) on the Holly Springs-Hudsonville road, 2 miles northeast from Holly Springs. September 23, 1953.

the cut farther southwest show an indistinct contact trace, below which the sand is finer and of a lighter color, cross bedded, micaceous, and contains thin platy limonitic siltstone or silty limonite. Above the line of contact the sand is brown and red brown, coarser, and more compact, and contains ferruginous sandstone and fragments of white clay, especially along the contact trace. This outcrop may be across the Tallahatta-Kosciusko contact. Many sand concretions are strewn over the surface.

Almost 1.5 miles farther northeast, and 1.8 miles southwest from Hudsonville, a big erosion chasm (NE.Cor., Sec.10, T.3 S., R.2 W.) north of the road, is cut in very red sand towards the top, and yellowish-brown sand at lower levels. The ravine gradient is steep through a vertical interval of at least 60 to 75 feet. Near the head of the ravine a yellowish band of more resistant material forms a sharp contact in the wall 4 to 5 feet below the ground surface. The altitude is 560 feet or more.

Along old Highway 4 a mile south-southeast of the two outcrops in Section 21 and at about the same elevation, is a cut (Northern part, SE.¼, Sec.28, T.3 S., R.2 W.) in the west wall of the valley of Coldwater River, which has exposed a good section of brown sand and a suggestion of a contact trace.

Along the road which leads northwest from its junction (Southern part, Sec.18, T.3 S., R.1 W.) with Highway 4, are several deep ravines in brown and red-brown sand. Some 0.3 to 0.4 mile from the highway, blocks of ferruginous sandstone crop out, and half a mile farther north, large erosion gashes (NW.¼, Sec.18) west of the road are walled with sand for the most part to a depth of 40 to 50 feet. A feature of the terrane here is an irregular interval, perhaps 25 to 30 feet below the road, of friable ferruginous sandstone, black on the surface, and bands and stringers of white sandy clay and white sand on the same level or slightly below the sandstone. The interval probably marks the Tallahatta-Kosciusko contact. The elevation is 560 to 580 feet. The interval referred to is overlain by brown sand. The upland surface along this road is in general of slight relief, like that of the upper surface of a plateau remnant.

In the north wall of the valley of Coldwater River on the southeast side of Highway 7 a mile southwest of the intersection of the highway and the Atway-Hudsonville road, slope wash has exposed the sand of a considerable area (Eastern half, Sec.4, T.3 S., R.2 W.). The sand is white and brown, noticeably current bedded in places, very fine to coarse. Some beds contain much grit and numbers of well rounded pebbles of milky quartz. The white sand is very fine, but not conspicuously micaceous. The outcrops may be on the contact belt of the Tallahatta formation with an overlying sand, which was deposited in valleys cut in the Tallahatta terrane. The elevation is approximately 460 to 480 feet.

Similar sand is exposed in the same valley wall a mile farther west, where deep ravines (Eastern part, Sec.5, T.3 S., R.2 W.)

threaten the Highway 7-Atway road. This is only 1.5 miles, more or less, south by east of the contact outcrop (Sec.32, T.2 S., R.2 W.) referred to on a preceding page.

Sections across the Tallahatta-Kosciusko contact in the vicinity of Higdon have been described in the part of this report which relates to the Tallahatta formation. Half a mile, more or less, north of Higdon, on the west side of a short local road, the eroded east wall of a deep valley is brown and red-brown sand (SW. Cor., Sec.35, T.3 S., R.2 W.). A short distance upstream from this outcrop, a body of dull-white pink- and light-brown mottled silt, forms the basal 5 to 6 feet of the channel wall for several yards; and downstream a short distance the west wall of the small valley is a 25-foot cliff of brown sand containing stringers and fragments of white clay and silt. It seems probable that the included white silt body may be some of the uppermost Tallahatta, and the sand, Kosciusko. The altitude is between 580 and 600 feet — about the same as, or only slightly less than, the altitude of the Tallahatta-Kosciusko contact trace near Chewalla Church, Higdon (see Tallahatta formation).

Approximately 1.5 miles southeast of Higdon, and a quarter of a mile northeast of the junction of the Higdon-Waites road and an abandoned road leading east, is a "mountain" (Eastern part, Sec.11, and western part, Sec.12, T.4 S., R.2 W.), one of several of the kind in the county. It is capped by enormous slabs and blocks of ferruginous sandstone, which are underlain by fine white sand; but the exact contact between sand and sandstone is concealed. However, in a similar elevation 200 to 300 yards to the southeast, pits expose fine gray to white and brown micaceous sand on and in which the masses of sandstone are lying. A quarter of a mile or so farther east and 30 to 40 feet lower, an old road cut in an eastward slope exposes irregular masses and smaller fragments and balls of white and mottled plastic clay embedded in brown sand, at an elevation of 560 to 580 feet. The top of the "mountain" is at an altitude of more than 640 feet. The clay conglomerate or breccia probably is in the Tallahatta-Kosciusko contact zone, and the sandstone cap of the "mountain," together with a considerable thickness of underlying sand, may belong to the Kosciusko formation.

Along the abandoned road already referred to, the elevation ranges from less than 400 feet at Chewalla Creek to more than

640 feet on the top of the "mountain," 1.5 miles west of the creek. Thus the relief is approximately 250 feet in this short distance. Ravines (SE.¼, Sec.11, and SW.¼, Sec.12, T.4 S., R. 2 W.) between the roads east of their junction, reach a depth of more than 120 feet below the road junction in 0.5 mile. They are walled with sand, red brown and coarser above, white and pink, fine, silty and micaceous below. A feature is the lentils and stringers and other large and small bodies and fragments of light-colored clay and silt worked into the sand (Figure 36).

Figure 36.—Eroded Tallahatta and Kosciusko terrane (SW.cor., Sec.12 or NW. cor., Sec.13, T.4 S., R.2 W.) at the head of the valley of a tributary of Chewalla Creek, 2 miles southeast of Higdon. March 6, 1953.

The large outcrops probably show both Tallahatta and Kosciusko material. Diagonal bedding is conspicuous in places.

The stratigraphic position of the Tallahatta-Kosciusko contact trace can be determined approximately in places along and near the Chewalla Farms road, where the elevation is 600 feet or a little less.

East of Chewalla Creek the relief is greater still, and the highest hills and ridges are capped with Kosciusko sand and sandstone. A conspicuous example is the ridge on which Scales

Forest Tower stands. The site of the tower (NW.¼, Sec.33, T.3 S., R.1 W.), the highest point of the ridge, has also the greatest altitude of the county — between 680 and 700 feet. The tower stands on large tabular blocks of dense hard ferruginous sandstone, and the same kind of rock is scattered widely over the surface and down the slopes. Sand is exposed underneath the rock along the main road a fifth of a mile southwest of the tower, and a short distance west of the junction (SW.¼, Sec.33), 0.7 mile south of the tower, ravines have been cut in brown and white fine sand containing reworked white clay.

The surface distribution of the Kosciusko sand has been indicated by the location of the outcrops. The thickness of the formation was not determined accurately, but probably is not more than 100 feet. The regional dip is north of west to northwest at a low angle; rough measurements and calculations showed a maximum of 10 feet or less a mile. Attaya[36] found that the Kosciusko beds of Lafayette County are near to horizontal over large areas. A like structure exists in Marshall County.

CITRONELLE FORMATION

The Citronelle of Marshall County, as of other regions, is composed of gravel, sand, and clay. In Marshall County the proportion of clay is small, and gravel is relatively abundant. The gravel is chiefly subangular chert, but quartz, sandstone, and quartzite pebbles are not uncommon. Sizes of individual pieces of gravel range widely — from cobbles 4 to 5 inches or more in diameter to very small pebbles. All are more or less rounded, the degree of rounding ranging from almost spherical to subangular. The gravel is unevenly distributed vertically and horizontally. A vertical face of a Citronelle section may show gravel only, but commonly shows gravel and sand interbedded or intermingled, or interfingered or intertongued. Stringers of gravel in sand and sand in gravel are numerous. Bedding is irregular; cross bedding is conspicuous in places. Here and there the sand is cemented to sandstone and the gravel to conglomerate.

The Citronelle materials lie unconformably on the Kosciusko terrane and underneath the loess. The thickness of the formation is far from uniform, no doubt because of 1) irregular original deposition; 2) irregularity of the eroded surface on which deposition took place; 3) post-Citronelle erosion. The maximum thickness observed in Marshall County is approximately 20 to 25 feet. The area of outcrop is in the western part of the county, extending eastward 6 miles or so from the western border. Several outliers occupy elevations east of the ragged edge of the main outcrop area.

The sand of the Citronelle formation is red on the outcrop in most places, differing little in this respect from the other sands of the county, from which a large part, probably the greater part of it, was derived. It ranges from coarse to fine. The clay is light gray to white, commonly sandy, and appears as small irregular bodies in the sand and gravel.

A few of the more prominent of the Citronelle outcrops are described in the following paragraphs.

A road cut (SW.¼, Sec.27, T.4 S., R.5 W.) on the Marshall County-Tate County line a mile or thereabouts southwest of Walhill and 0.8 mile south of a road intersection, shows Citronelle gritty red sand under the loess. The sand contains a body of white silty shale. Ferruginous crusts have formed at the shale-sand contact, and their fragments are scattered over the outcrop.

The region north and east of the place mentioned above is Citronelle-Loess outcrop area. Sections of both formations are exposed by road cuts and erosion channels. Two miles north of Walhill and 0.7 mile west of a junction, a road cut and a creek channel are walled with Citronelle gravel and brown sand containing stringers of white silt and clay (Southern part, Sec.10, T.4 S., R.5 W.). Another good Citronelle cut (NE.Cor., Sec.2, T.4 S., R.5 W., or SE.Cor., Sec.35, T.3 S., R.5W.) is about 1.3 miles south of Watson. Approximately 1.5 miles west of this outcrop, on the east side of a north-south road along the Marshall County-DeSoto County line, is an exposure (SW.¼, Sec.34, T.3 S., R.5 W.) of sand and gravel which appears to be across a sharp Kosciusko-Citronelle contact trace (Figure 37). An equal distance, more or less, farther north along the same county-line road, a pit (NW. ¼, Sec.27, T.3 S., R.5 W.) on the east side of the road, shows 15 to 20 feet of gravel and sand. The gravel is aggregated in the lower part of the pit wall, and scattered thinly through the sand above. A little farther north, on the west side of the road, in DeSoto County, a ravine exposes a large accumulation of gravel.

Surface rock materials in the vicinity of Watson belong to the Citronelle and Loess formations. Gravel deposits were observed as far east as 1.5 miles east of Watson, and crop out in a number of places north toward Warsaw. Road cuts (Sec.10, SW. ¼ and Sec.15, NW.¼, T.3 S., R.5 W.) in valley walls 1.6 miles west of Warsaw show cross-bedded Citronelle gravel and coarse brown sand containing fragments and thin lentils of whitish and iron-stained clay.

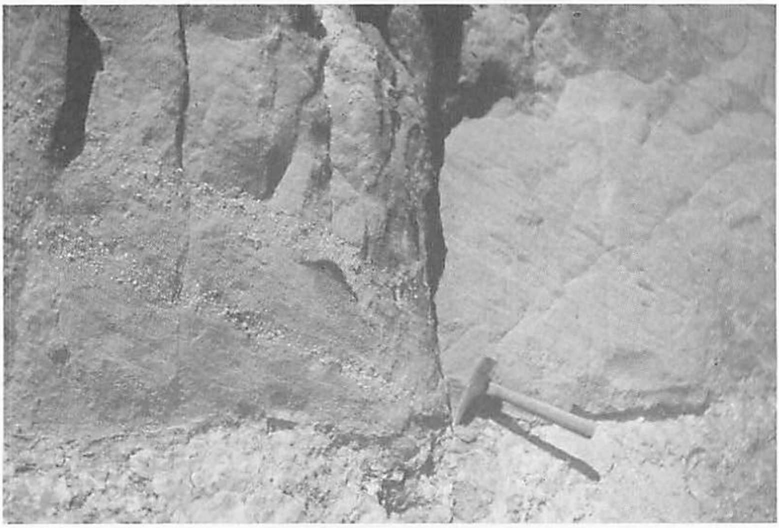


Figure 37.—Kosciusko-Citronelle contact, in the east wall of a road cut (SW. ¼, Sec.34, T.3 S., R.5 W.) on the Marshall County-DeSoto County line about 2 miles southwest of Watson. September 11, 1952.

Citronelle beds crop out in many places around Byhalia. Along roads west, south, and southwest from the town, cuts and ravines are walled with gravel and brown sand. The 11-foot gravel interval in the section half a mile east of Byhalia (SW.¼, NE.¼, Sec.36, T.2 S., R.5 W.) has been referred to in the description of the Tallahatta formation. East and east-northeast of Byhalia, and north of Highway 78 and the Frisco Railroad, are relatively thick deposits of gravel in which many pits have been dug. The walls of a pit (NW.¼, Sec. 31, T.2 S., R.4 W.) a mile east of Byhalia and a short distance north of the railroad, show some 10 feet of gravel, in two zones; also stringers of gravel in the brown sand. Another pit (SE.Cor., Sec.24, T.2 S., R.5 W.) approximately 1.5 miles north by east of Byhalia, shows the gravel beds very clearly (Figure 38). Two miles, more or less, farther north by east, and 0.1 mile north of a road junction, are old pits and washes (SE.¼, Sec.7, T.2 S., R.4 W.) on both sides of the road. Here the outcrop shows a lower interval of fine brown and red-brown sand into which has been worked much white silty clay shale from Tallahatta beds, and above it an interval of 3 to 4 feet or more of grit and very gritty sand and a little gravel. The contact between the finer sand below and the coarser sand above is sharp, and can be traced over the entire area, in the ravine walls. The lithology and relationships of the units suggest the Kosciusko (or Tallahatta)-Citronelle contact. Moreover, about

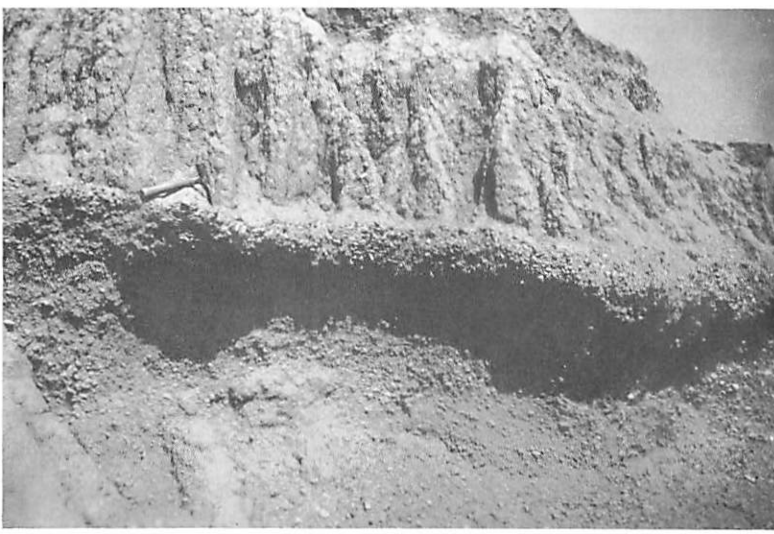


Figure 38.—Citronelle gravel: Wall of pit (SE.¼, Sec.24, T.2 S., R.5 W.) along a road, about 2 miles northeast from Byhalia. September 10, 1952.

the same distance east of the junction, on the south side of an east-west road, old pits and road cuts and ravines (NE.¼, Sec.18, T.2 S., R.4 W.) east and west of a bridge, show several feet of the finer sand below, and gritty sand above a well-defined contact.

The part of the county north of Byhalia shows Citronelle and Loess almost exclusively. The surface is of low relief — flat to rolling; valleys wide, low-walled, and flat-bottomed; inter-stream areas approaching flatness. Here and there, sand underlying the loess may belong to the Kosciusko. West and southwest of Barton are several good outcrops of Citronelle gravel and red sand. Citronelle gravel and sand are exposed by cuts along all the local roads, and in places extend eastward to a distance of 4 miles from the DeSoto County line.

The terrane herein referred to the Citronelle formation is terrace deposits of the Mississippi Valley, and can be traced southward into the type Citronelle formation of Southern Mississippi. Shaw[37] points out also: "Although the terrace deposits are such as are ordinarily called gravel, the bulk of the material is sand through which pebbles are irregularly distributed . . . Generally the pebbles occur in irregular and poorly defined lenses having a wide range in size . . . The terrace deposits are comparatively poorly sorted . . ." He notes further that in general "the lower part of each terrace deposit is more gravelly than the upper part," and that "Many pebbles of all rocks, even quartz, are ready to fall to pieces so long have they been exposed to the weather." The same writer cites evidence that the chert pebbles were derived from the Paleozoic cherts which border the Mississippi embayment, a leading evidence being that many of the pebbles contain identifiable Paleozoic fossils. He observed also that "The strata of the terrace deposits are commonly thick and persistent, they are commonly separated from one another by a gradation layer several inches thick, and few of them can be followed more than half a mile because, as a rule, they pinch out or become indistinct." He explains these characteristics of stratification by the hypothesis that the terrace deposits were made by a single large stream.

During the survey on which the present report is based, several boulders were found on the surface at widely separated localities. Similar boulders, of quartzite, quartz, ferruginous sandstone, and chert, some of them of large size, have been found in many parts of the state. They have been the subject of much speculation by geologists who have sought to explain their presence in Mississippi and determine their source. Shaw[38] published his opinion that they are residual from a widespread Pliocene formation which has been removed by erosion.

LOESS FORMATION

Unweathered loess is chiefly a fine velvety silt, although it contains some clayey material and some very fine sand.

A record of the results of mechanical analyses of unweathered loess by the Bureau of Soils, U. S. Department of Agriculture, is given by Shaw:[39]

"LOESS 20 FEET BELOW SURFACE AT SOUTH EDGE OF NATCHEZ, MISS. (CONTAINS FRAGMENTS OF SHELLS)

	[Percent]
Fine gravel (2 to 1 millimeters)	0.1
Coarse sand (1 to 0.5 millimeter)	0.1
Medium sand (0.5 to 0.25 millimeter)	0.0
Fine sand (0.25 to 0.1 millimeter)	0.2
Very fine sand (0.1 to 0.05 millimeter)	5.6
Silt (0.05 to 0.005 millimeter)	86.9
Clay (0.005 to 0.0 millimeter)	6.3
Total	99.2."

The record of a chemical analysis of loess from Yazoo County is quoted below. The material used was a composite of samples from a prospect hole on the J. A. Bunner property (NE.¼, SW. ¼, Sec.19, T.13 N., R.1 W.) from a depth of 0.5 foot to 63.7 feet.[40]

"CHEMICAL ANALYSIS, HOLE NO. C9
COMPOSITE OF SAMPLES C1, C2, C3, C4, C5, C6, C7, C8

	[Percent]
Ignition loss	8.10
Silica, SiO_2	66.27
Alumina, Al_2O_3	16.20
Iron oxide, Fe_2O_3	3.35
Titania, TiO_2	0.75
Magnesia, MgO	None
Lime, CaO	4.61
Potash, K_2O	0.05
Soda, Na_2O	0.25
Moisture at 100°C.	1.56
Sulfur, SO_3	1.23
Soluble salts, SO_4	0.75."

[Malcolm R. Livingston, Chemist]

The color of loess varies through shades of gray and yellow and brown, but the commonest color is brownish gray. The chief characteristics are: 1) Uniformity of texture; 2) irregularity of shape and extreme fineness of particles; 3) generally massive structure; 4) lack of coherence; 5) capacity to stand as vertical-faced walls; 6) capacity to absorb water.

The loess is now quite generally regarded as an eolian deposit, so far as its present position is concerned. Ice, water, and wind — all three agents — are thought to have had a part in its genesis. The silt is composed of extremely fine angular particles, which were at one time "rock flour," rock pulverized by glaciers. The rock flour was carried from under and around the glaciers by water from the melting ice, and southward by glacier-fed streams, notably by a Pleistocene Mississippi River. At times, especially during the intensely cold winters of the ice age, the volume of the river was much reduced, exposing a wide bare flood plain underlain to considerable depths by the glacial and glaciofluvial silt. Winds, chiefly from the west and southwest, swept great quantities of the silt from the river flat, transported it to the east wall of the valley, and deposited it thereon, building on the bluff a silt (Loess) formation. The accumulation of the loess along the east wall of the Mississippi River Valley proceeded at varying rates through many thousands of years. The old surface was covered; depressions were filled or partly filled, and loess was spread over the elevations. The formation reached its greatest thickness on the bluff adjacent to the flood plain, where the wind encountered the first obstacles, and wedged out eastward as the load carried by the wind became progressively less. In general, deposition of the loess tended to diminish topographic relief, but subsequent stream erosion has restored and even increased it.

Western Marshall County is in the eastern part of the Loess outcrop area — in fact, little or no unweathered loess is present farther east than the central meridian of Range 4 West, although loessial material has mingled with and enriched the sandy soils much farther east. Certainly the Loess formation was once more extensive than it is now. Weathering agencies have broken down and destroyed the thinner part of the wedge, or so changed it that it is not recognizable; and in many places erosion has removed the loess and so mixed it with sand and clay that it has lost its identity. The formation is thickest, then, along the western border of the county, particularly in the northwestern quarter, and thins eastward and southeastward until it disappears. It is the uppermost stratigraphic unit except for the alluvium and the residual mantle rock. Naturally it is very patchy, capping some interstream areas and other elevations, and lying in some depressions where it has escaped erosion. The areal geology map (Plate 1) shows its distribution only approximately.

In Marshall County the Loess has a maximum thickness of perhaps 15 to 20 feet.

RECENT FORMATION

The so-called "Recent" formation is composed, theoretically, of all sediments which have come to their present positions since the close of Pleistocene time. Obviously, just as no exact year or century or even millenium can be fixed upon as the final one of the Pleistocene epoch, so at few places, if at any place, can a sharply defined contact be found between sediments which can be proved to have accumulated during Pleistocene time and those which are demonstrably post-Pleistocene. It has been the custom to classify as "Recent" all mantle rock, including residuum, colluvium, alluvium, talus, and other forms of aggregates of weathering products which are uppermost in any region; but much of this material, especially alluvium, may be of Pleistocene age, specifically, in Marshall County, the oldest alluvium along the Tallahatchie River. No doubt the alluvial deposits of the smaller streams can be properly classified as Recent. Such deposits could include the material which underlies both the first bottom and the second bottom, if a second bottom is present. Probably, too, most of the other loose rock waste of the categories mentioned above was separated from its parent rock during the Recent age.

Recent alluvium is, of course, composed of all kinds of rock materials within the reach of the streams. In Marshall County it is sand, silt, clay, and gravel, to which are added relatively small quantities of fragments of sandstone, iron ore, siltstone, and other substances. In general the flood-plain materials are more or less sorted, because, inasmuch as the transporting power of moving water is a function of the velocity of the water, which in turn is controlled by other factors, chief of which are volume and gradient, the stream, as its velocity is lessened, drops the rock debris it may be carrying in suspension, in the order of specific gravity, the heaviest first and the lightest last. Deposition so controlled results in the building of discontinuous beds or lenses or other restricted bodies of alluvium, in each of which a certain kind of material is dominant. Thus, after many hundreds, perhaps many thousands, of risings and fallings of a river, its deposits come to be a complex of interwedged or interwoven bodies of sand, silt, gravel, and clay, showing essentially the same relationships longitudinally, laterally, and vertically. Nevertheless, in general, a flood-plain terrane is more sandy nearer its stream, the "front lands," and silty and clayey farther back, near the valley walls, the "back lands."

As has been noted, valley flats in Marshall County comprise a considerable area, and the volume of alluvium is great. The largest alluvial deposits are along the Tallahatchie and Coldwater Rivers, but the valleys of the larger tributaries also have been filled to considerable depths. The maximum thickness of the Tallahatchie River flood-plain deposits has not been accurately determined, but probably is at least 50 to 75 feet. The Coldwater River alluvium may be 50 feet or more thick. However, along the margins of the valleys some of the rock waste below the flood plain may be colluvium from the valley walls, never worked over by the main streams.

The residual soils and subsoils of the county, the greater part of which probably is Recent, are described in the section on Soils. In general, they are mixtures of sand, silt, and clay, in varying proportions.

Shaw[41] found evidence for the recognition of five more or less distinct parts in the upland surficial materials of Northern Mississippi. His classification was based on "the extent and nature of its modification by weathering and other erosive processes." The uppermost of the five units, a foot or so thick, was the soil; the second, in top to bottom order, 1 foot to 15 feet or more thick, consisted of "material from the outcropping edges of underlying formations which has been washed down slopes by sheet floods and small rills;" the third part, 1 foot to 4 or 5 feet thick, consisted of "surface portions of underlying formations which have crept a few or many feet down slopes." He designated Nos. 2 and 3, "colluvium," and stated that they were scarce or absent on the crests of divides. The fourth layer, 1 foot to 5 feet of very deeply weathered material, he referred to as "upper residuum," and the fifth unit, the lowest except for the regional strata in place, extending from the fourth layer "down to the lowest dry-season position of the ground-water surface," he named the "lower residuum." This fifth part, of varying thickness, he found deeply weathered, but much less so than the fourth.

Of course not all the weathered rock material which Shaw mentions can be considered to belong to the Recent formation. It has developed from ages of weathering, perhaps reaching back to Upper Eocene time.

STRUCTURE: OIL AND GAS PROSPECTING AND POSSIBILITIES

Data from field work of the present survey, from field investigations of other geologists as reported by them, and from well drilling, relating to the structure of the Marshall County strata, are presented herein. The writer is responsible for interpretations and correlations unless references are given. Structural relationships shown or suggested by outcrops and drainage patterns will be described first; information from drilling which applies to formations above the Paleozoic rock, will be presented next; the main features of the Paleozoic surface will be indicated, insofar as they can be on the basis of the data at hand; and finally an attempt will be made to determine whether or not logs of certain deep wells suggest the existence in the Paleozoic beds of structures which could serve as traps for oil and gas.

Lowe[42] refers to several calculations of the regional dip of the Midway and Wilcox strata, based on elevation differences of key beds and contacts, chiefly. The figures obtained indicated dips of 12, 15, 16, 17, 18, 21, 22, 24, 27.5, and 30 feet to the mile. Crider suggests that the dip flattens towards the west.

The wide range of results obtained by Lowe and others from their calculations point up the difficulties involved in any attempt to determine even the regional dip of the strata of Marshall County, from surface data. The one great obstacle, mentioned in the description of the stratigraphy, is obvious: Irregularity of bedding — discontinuity of individual beds, varying thicknesses, cross bedding, and so on. To want of uniformity of stratification within any one formation can be added the interformational unconformities. However, as stated in the sections on stratigraphy, calculations based on elevation differences of formational contacts indicated an over-all dip of all units towards the northwest and northwest by north — the Naheola at the rate of some 25 feet a mile; the Fearn Springs and Ackerman, 15 to 20 feet a mile; and the Meridian, not more than 15 feet a mile.

The Tallahatta and Kosciusko beds appeared to have a still lower dip.

The normal or regional dip is interrupted locally by steeper dips or dips in different directions, but in most of these places it is very difficult, or impossible, to distinguish true dip from diagonal bedding and lamination. However, these anomalies of dip suggest the existence of deep-seated structures which may constitute traps favorable for the accumulation of oil and gas. Perhaps the most prominent of them exposed are in the Wilcox outcrop area, in the southeastern part of the county.

In the extreme southeastern corner of Marshall County, extending into Union County, a stratigraphic section (NW.Cor., Sec.31, T.6 S., R.1 E., Union County) of Naheola beds shows a rather strong east to southeast dip (Figure 2). The exposure is only 0.1 mile long, but the dip is consistent through the distance and through a vertical interval of 35 to 40 feet. Some 0.3 mile north from the section the west wall of a road cut (SW.¼, Sec.30, T.6 S., R.1 E., Union County) exposes the white and lignitic clay that is the uppermost interval of the section; but this black and white clay does not show in the east wall of the cut, although the elevation is approximately the same. Instead, a tan to olive-drab sand and sandy clay shale form the east wall — beds which suggest the Fearn Springs formation. The altitude of the black and white clay is about 340. The wide flat of Mills Creek intervenes between the Union County outcrops and the low hills of the Cornersville vicinity, hills which show no outcrops of Naheola beds. The rusty sandy shale and included oxide ore which show in ravines (near Center, Sec.24, T.6 S., R.1 W.) are here considered Fearn Springs. The south wall of a road cut (NW.¼, Sec.25, T.6 S., R.1 W.) 0.6 mile west from Cornersville and a few rods east of a road junction, shows beds dipping steeply westward, and black and white clays, similar to those of the Naheola section, are exposed. The road cut being in a valley wall, the steep dip could be due to a landslip. However, in this connection attention should be called to the 50-foot greater elevation of the top of the Midway in Mississippi State Geological Survey Prospect Hole 2 than in Hole 3 only half a mile southwest of it, and also to Attaya's[43] description of faulted conditions in Lafayette County along Cypress Creek 5 to 6 miles south of the Marshall County locations referred to. It is possible that the east dip of the Naheola section beds south of Cornersville and the greater than normal west dip of the Fearn Springs beds west of Cornersville are related to the structural conditions described by Attaya. Furthermore, the asymmetrical valley of Cypress Creek appears to be continued along Mills Creek in Southeastern Marshall County and Northwest Union: The eastern wall of Mills Creek Valley is steep, the western wall gentle, whereas if normal west dip prevailed, the opposite condition would be expected.

Certain other stratigraphic relationships in Southeastern Marshall County appear to give at least a hint of structural conditions. The fine-grained white micaceous sandstone (NE.¼ and SE.¼, Sec.12, T.6 S., R.2 W.) described under Stratigraphy, appears identical with the sandstone which is abundant along Highway 30 northeast of the Tallahatchie River in the western part of Union County. Yet, as already pointed out, this rock in Marshall County is not more than 40 to 50 feet lower than that in Union County, although it is 11 miles northwest of it almost directly down dip. If the sandstone at the two places is indeed part of one and the same stratigraphic unit, and at least part of it at each place is in its original position, obviously its degree of dip is only 4 to 5 feet a mile. Inasmuch as the sandstone interval along Highway 30 has a thickness of only 3 feet to 10 feet,[14] any difference of altitude occasioned by the thickness factor would be negligible. In brief, the comparatively slight elevation difference between the sandstone in Union County and that in Marshall is here interpreted to indicate a very low dip towards the northwest, if not a horizontal position or a reverse dip of the sandstone bed.

Conant[15] states that at a place near Blythe School (SE.¼, Sec.8, T.6 S., R.1 E., Union County) laminated micaceous silty clays and interbedded sands, believed to be uppermost Fearn Springs, show southerly dips as great as 20 degrees. The place is only a little more than 1.5 miles east of Marshall County. Also, Conant[16] refers to and figures a U. S. Highway 78 cut a mile northwest from the Union County-Benton County line — a cut which exposes silty clays dipping west at angles of 7 to 10 degrees, and he states that the same kinds of materials crop out half a mile farther northwest, in the walls of the "blue cut" of the Frisco Railroad. Furthermore, he states that at a place (SE.

Cor., Sec.31, T.6 S., R.1 E.) 2 miles north of Rocky Ford, the laminated Porters Creek clay dips 5 degrees towards the north.[47] This place is only a little more than a mile southeast of the county line outcrops southeast of Cornersville.

All the places mentioned herein lie in a northeast-southwest belt through northeastern Lafayette County, northwestern Union, southeastern Marshall, and southern Benton. Taken together, they certainly suggest a zone of folding or faulting or both.

At the outcrop approximately 1 mile south of Chewalla Farms (SE.¼, Sec.12, T.4 S., R.2 W.) the thin Tallahatta beds superjacent to the Meridian sand (Figure 15) have a noticeable east dip, so far as could be determined from the small exposure. It should be noted also that the altitude of the sand-shale contact at this outcrop is 500 to 520 feet, whereas the same contact at the large outcrop (NW.¼, SE.¼, Sec.6, T.4 S., R.1 W.) east of Chewalla Farms, less than 1.5 miles northeast of the Section 12, Range 2 West exposure, has an altitude of only 400 to 420 feet. The 100-foot difference of elevation in such a short distance suggests folding or faulting, because in general the Meridian-Tallahatta contact is not one of unconformity.

The Tallahatta strata at the outcrop (NE.¼, SW.¼, Sec.35, T.3 S., R.3 W.) approximately 2 miles west from Holly Springs, have an east to southeast dip. Other outcrops which show unusual structural features are mentioned in the section on stratigraphy: Tallahatta shale at a place (near common cor., Secs.15, 16, 21, 22, T.2 S., R.2 W.) on a south-north road some 2.5 miles north of Atway; Tallahatta sand and shale along the channel of Red Banks Creek 0.3 mile south of Highway 78 at Red Banks, and northwest of a bridge (NE.¼, SE.¼, Sec.13, T.3 S., R.4 W.). The relationships of the strata at both the last places referred to suggest faulting.

Drainage patterns in certain parts of the county are rather peculiar, and could have been determined by structural irregularities. One example is afforded by the headwater branches of Chewalla Creek (SW.¼, T.3 S., R.1 W. and SE.¼, T.3 S., R.2 W.).[48] Two small tributaries from the west flow north for 2 miles or so, subparallel with the southward flowing main creek, at the end of which distance they bend toward the east and enter their main at a near right angle. The eastern of the two chief headwater forks of Chewalla flows west for 2 miles before making a right angle bend to the south. Farther south, a tributary from the east joins the main creek at a high angle. Furthermore, some 4 miles north of these streams, the north headwater fork of the Coldwater River describes a long bow, on the outside of which, near the middle, Hudsonville is situated. Chewalla Creek flows in a trench 180 to 200 feet below ridge crests a mile to 2 miles distant.

Clear Creek, in the northeastern corner of the county, flows due north for a distance of 5 miles, and another considerable creek follows a subparallel course a mile to 2.5 miles farther east. Both streams are relatively straight. A noteworthy feature of the eastern of the two is that it is crookedest and widest through a reach of approximately 2.5 miles, beginning at a point only a mile below its source, as if some resistant bed of rock had created a temporary base level. However, the part of Clear Creek only 2 miles west of this place, and 35 to 50 feet lower, is narrow and straight. It seems pertinent to note, also, that the drainage basin of Coldwater River is constricted here to some 3 miles between the northward flowing streams and southward flowing Chewalla Creek, and that Chewalla Creek rises on the same meridian as the eastern of the streams which flow in the opposite direction. Furthermore, the valley of Chewalla Creek is relatively straight, and lines up at its lower end with the valley of Tippah River, which trends due south through a distance of 5 miles.[49]

Of course these local departures from the general dendritic drainage pattern of the region possibly, perhaps probably, are due to stream adjustments during normal cycles of erosion, and as such do not require any hypothetical crustal disturbances for their explanation. However, considered in connection with the stratigraphic anomalies described in foregoing paragraphs, they are believed to strengthen the suggestion already made, that eastern Marshall County is part of a belt of faulting or folding, or both.

It may be noted also that Big Spring Creek and Little Spring Creek flow almost south in narrow straight valleys.[50] Probably this condition has no structural significance.

The course of Coldwater River seems somewhat different from the normal course of a stream in a region of horizontal or slightly inclined rock strata. Through almost its entire length in Marshall County it flows northwest. Six miles east of the western boundary of the county it changes direction to northwest by north; 4 to 5 miles farther on and a little less than 3 miles farther north, it swings west, and a mile farther west it changes its direction of flow to the southwest. Thus in the northwestern corner of the county the Coldwater describes an arc some 7 miles wide and 3 miles deep.[51] Such an erratic course could result from structural conditions, but does not necessarily have any relation to structure.

Obviously, information about the subsurface rocks in any region must be obtained from borings or excavations of one kind or another, or from geophysical exploration. Probable subsurface conditions can be deduced, of course, from interpretation of outcrops; but at best deductions from surface showings represent probabilities only. Although many wells have been dug or drilled for water in Marshall County, all are relatively shallow, the deepest being less than 800 feet in depth. Logs were kept for very few wells, and such logs as were made are very general and of doubtful accuracy. An attempt is made herein to summarize and evaluate available data provided by oil and gas prospect wells and the deeper water wells of the county, and to correlate them in order to obtain from them, where and if possible, a clue to subsurface structure. The information from these wells applies to post-Paleozoic strata almost exclusively, because only one of them penetrated Paleozoic rock to any considerable depth.

Four oil and gas prospect wells have been drilled in Marshall County. The earliest of which we have record was Thomas B. Slick's Huffman No. 1 (Sec.33, T.3 S., R.2 W.) which was begun April 14, 1925, and abandoned on September 24 of the same year, at a depth of 2,196 feet.[52] The driller's log is the only source of information, if it can be called a source of information rather than a source of confusion.

Slick's Huffman No. 2 (Sec.33, T.3 S., R.2 W.), an offset to Huffman No. 1, was begun on October 31, 1925, and abandoned March 18, 1926, on account of mechanical trouble, at a depth of 2,200 feet.[53] The driller's log is no more informative than that of Huffman No. 1. However, in No. 1 a 2-foot bed of lignite, recorded at a depth of 365 feet, and in No. 2 a 5-foot bed of lignite at 360 feet, may be at or near the top of the Ackerman formation.

The blue, dark, and black shale section (431 feet) recorded by the log of No. 1 probably is chiefly Midway—Naheola and Porters Creek; and the 275-foot section of gray, green, and brown shale above it probably is Wilcox—Ackerman and Fearn Springs, or Ackerman alone. The shale section from 408 feet to 1112 feet in Huffman No. 2 could include most of the Wilcox and all the Midway, the contact between the two being somewhere in the "mixed shale" interval between 591 and 1026 feet, perhaps at 660 to 670 feet. The lime rock subjacent to the Midway shale in both wells could be assigned, reasonably, to the basal Midway formation, the Clayton, and to the underlying Cretaceous formations, the Prairie Bluff, Ripley, and Selma. Possibly the "black lime" encountered at 2,168 feet in No. 1 and the "hard flinty gravel formation; rock and sand very hard," at 2,170 feet or the "sandy lime rock" at 2,197 feet in No. 2 mark the top of the Paleozoic. However, such tentative correlations are more or less guess work.

The Slick No. 1 H. C. Forte (Sec.36, T.3 S., R.3 W.), begun April 30, 1926, and completed September 8, 1926 at a depth of 3,248 feet,[54] was the deepest well in the county. The site is a short distance northwest of Holly Springs. Below an uppermost interval of 10 feet of sandy clay was a section of 420 feet of soft white sand, which probably includes a little of the Kosciusko and all the Tallahatta and Meridian. Below the white sand were intervals of shale, sand, and sand rock to a depth of 805 feet, presumably all Wilcox. A lignite bed was struck at 502 feet. The strata between depths of 805 and 1254 feet were shale, except for a basal unit of 12 feet of "water sand." All this section of 449 feet can reasonably be assigned to the Midway. It was found to be underlain by lime, sand, and shale, part of which is, no doubt, of lowermost Midway age, and the remainder Cretaceous, down to the Paleozoic, which was reached, questionably, according to one interpretation, at 2,372 feet.[55]

P. J. Lunati's No. 1 Fee (Sec.31, T.3 S., R.1 W., 660 feet N. and E. of SW.Cor., SE.¼), a mile or so northeast of the Chewalla Farms buildings, was begun March 24, 1941, and abandoned June 5, 1941, at 1,086 feet. No log of any kind is available, but report had it that the top of the Midway was reached at 500 feet.[56]

The altitude of the mouth of Huffman No. 1 well was 558 feet, 47 feet below U. S. Geological Survey Bench Mark JLB 20

(1928) (Elevation 605).[57] Positions of formation contacts are not specified in the driller's log. Furthermore, if any cuttings were taken, they are not available for study. However, as stated on a foregoing page, the writer believes, from a study of the log, that the top of the Midway was reached at 675 feet. He believes also, from a study of the log of Huffman No. 2, which was started at about the same elevation as No. 1,[58] that the Midway was reached in that well at about 660 to 670 feet.

The Lunati No. 1 Fee, about 4 miles east of the Huffman wells, was reported to have reached the Midway at 500 feet;[59] the elevation of the mouth of the well was approximately 450 feet. In the Forte No. 1, some 3 miles west of the Huffman wells, the top of the Midway was picked at 805 feet, although the elevation of the well was 561 feet (44 feet below B. M. JLB 20), only 3 feet greater than the altitude of Huffman No. 1.[60] It appears, then, from a comparison of the altitudes of the top of the Midway in the four wells, which are in almost a straight east-west line, that the Midway-Wilcox contact is 127 to 134 feet higher in the Huffman wells than in the Forte No. 1, and 60 to 77 feet lower than in the Lunati No. 1 Fee. The figures indicate a normal (14 to 18 feet a mile) west slope from the Fee well to the Huffman wells, and a much steeper (42 to 45 feet a mile) slope from the Huffman wells to the Forte well. The steep slope may be far from an index to structure, however. Other factors must be considered if a sound conclusion is to be reached on the matter of the relationship between the relative altitudes of the Midway-Wilcox contact and the dip of the strata: 1) An erosional unconformity exists at the top of the Midway, which could account for some elevation differences; 2) If Grim's[61] view is correct, that the upper Midway sediments (Porters Creek or Naheola formation) are part of a huge delta built out to the southwest by a large river which entered the Gulf embayment from the northeast in Early Tertiary time, the inconsistencies of altitude of the upper surface of the Midway could be due in part to irregular deposition; 3) the figures themselves may be inaccurate — that is, the depths picked for the top of the Midway may not be the correct depths, although the possible error involved is believed to be small. In short, a steep slope of this contact does not necessarily mean a steep dip of the beds. Nevertheless, it is suggestive of a structure, perhaps a fault or the limb of an asymmetrical fold, because it is improbable that of itself erosion during the Midway-Wilcox time interval brought about relief of the Midway surface sufficient to account for the difference in altitude specified. The relatively steep slope could, then, be a result partly of lack of uniformity of original deposition of the Midway beds, and partly of subsequent erosion; or it could be an expression in part of upwarping or faulting of the beds, or of both folding and faulting, which could have included Paleozoic strata and thus created a trap for oil and gas. The vexing problem is, to find out what actually did take place.

In this connection, logs of other wells may provide additional hints. The Holly Springs wells do not reach the Midway, but the deepest of them (elevation around 589 feet) reached the Ackerman formation at a depth of 357 feet, if the interpretation of the log is correct.[62] This is not inconsistent with the depth to the same contact in the Huffman wells (365 and 360 feet) but is 73 feet higher than in the Forte well (430 feet). It may be pertinent, also, to refer to the well at Camp Yacona (Chewalla Organization Camp?) (SW.¼, Sec.8 and NW.¼, Sec.17, T.4 S., R.1 W.), which was reported to have reached the Midway beds at approximately 215 feet.[63] It is on a ridge, at an elevation of perhaps 440 feet. The writer believes that the top of the Wilcox rather than the top of the Midway was encountered at 215 feet, inasmuch as the base of the Meridian was found at approximately 223 feet in Mississippi State Geological Survey Prospect Hole 15 less than 2 miles to the southwest of the camp well, and perhaps 90 feet higher; also as already mentioned, the top of the Midway was placed at 500 feet in Lunati No. 1 Fee, which is 2 miles north of the camp well and not more than 10 feet higher. The Potts Camp wells, starting from an elevation of about 345 feet, passed through part of the Wilcox and the entire Midway, but no detailed log was kept. A very generalized log of one of the wells reports, below a depth of 52 feet, "Gray clays (?) with occasional shells reported," through an interval of 593 feet — an interval which of course includes the Midway-Wilcox contact — but the depth to the contact is not stated.[64]

In 1940 a well, the Charlotte Stansback No. 1 (SE.¼, SE.¼, Sec.19, T.3 S., R.4 W.) was drilled some 6 miles south by east of Byhalia, and 11 miles west by north of Holly Springs. Although the contract depth was said to have been 3,500 feet, the well had reached a depth of only 703 feet at the time of last reports. From a depth of 561 feet, sand, shale, lignite, and blue gumbo were reported to have been found, and at 703 feet the hole was bottomed in shale.[65] It is probable that the well did not reach the Midway. It was begun at an elevation of 400 feet or a little more.

The seventeen stratigraphic prospect holes drilled by the Mississippi State Geological Survey ranged in depth from 60 feet to 291 feet (see Stratigraphy). All were in the southeastern and eastern parts of Marshall County, except one in Union County. As indicated by the logs, several of the holes reached the Naheola (upper Midway) and proved a very irregular upper surface (Figure 3). As stated in a foregoing paragraph, possibly the 100-foot southwest slope in the mile and a quarter between Holes 2 and 4 may be due in part to structural conditions, and may be connected with the other evidences of abnormal structure in the Cornersville region.

The topography of the part of the Paleozoic surface which underlies the post-Paleozoic strata of Marshall County is known to be irregular, and to have considerable relief, but no detailed data concerning it are available. However, an attempt will be made herein to examine and evaluate whatever records may be found which relate to the old Paleozoic surface, and also to the underlying Paleozoic terrane, because most certainly oil and gas, if obtained at all, will come from Paleozoic beds.

The top of the Paleozoic was reached by the Forte well (questionably) at 2,372 feet, according to Brown's (?) interpretation of the log. Possibly the Huffman wells also encountered Paleozoic rock at a depth of 2,000 feet or more, but, as already noted, the clues, if any, to the depth to hard rock afforded by the well logs are of very doubtful value. No other well in the county was deep enough to encounter Paleozoic rock, but possibly records of wells in adjoining counties can provide a basis for a reasonably accurate estimate of the depth to the Paleozoic surface in Marshall County. Such wells, unfortunately, are few, and are relatively distant from Marshall County lines.

Some 3.5 miles southwest of Walls, DeSoto County, Mississippi, approximately 27 miles west of the Marshall County line, Union Producing Company's No. 1 F. T. Withers Estate Well (NW.¼, Sec.18, T.2 S., R.9 W.) reached a depth of 4,884 feet.[66] It appears from the Schlumberger tops, which are not specific on the point, that the Paleozoic beds were encountered at 3,530 feet, assumed that the "1st chert" is the top of the Paleozoic. This depth is not inconsistent with the 2,372 feet to the Paleozoic in the Forte well, which is roughly 42 miles east by south of the Withers well, and at least 350 feet higher, the altitude of the Withers well being about 210 feet. A general westward slope of the old surface of about 36 feet to the mile is indicated.

The figure given for the depth to the top of the Midway in the Withers well, 2,034 feet, is reasonably consistent with that (805 feet) for the same horizon in the Forte well. The slope indicated is almost 38 feet to the mile.

The Lion Oil Refining Company's No. 1 Bateman, in Shelby County, Tennessee, on the 201.1-acre N. B. Persons Tract, approximately 12 miles north by east from Memphis and 2 miles southeast of Lucy, was completed May 23, 1941, at a depth of 2,865 feet. It was reported to have reached the Midway at 1,430 feet, the Cretaceous at 2,102 feet, and the Paleozoic at 2,715 feet, and to have been in the Lower Ordovician at 2,844 feet. Eutaw and Tuscaloosa formations were not present. The elevation of the mouth of the well was 250 feet, by estimate from the topographic map.[67]

It will be noticed that although the No. 1 Withers Estate well and the No. 1 Bateman are only some 30 miles from each other and at elevations that differ not more than 40 feet, the depth to the top of the Midway in the Withers well is more than 600 feet greater than in the Bateman well, and the depth to the Paleozoic rock possibly more than 800 feet greater. The figures could indicate a structural "high" in the vicinity of the Bateman well, or deep erosion of the Midway and older strata along a roughly northeast-southwest belt, or large-scale faulting, or errors in recognizing the tops and determining their depths below the surface. Which of the alternatives affords the correct explanation of the actual conditions could hardly be decided in the absence of a true key bed.

Wells in Lafayette County reached the Paleozoic terrane. The Dr. A. E. Russell No. 1 (SW.¼, Sec.9, T.10 S., R.1 W.), abandoned February 1, 1937, at a depth of 2,465 feet, was reported to have topped the Paleozoic at 1,865 feet.[68] The Z. E. Llewellyn No. 1 (NW.¼, Sec.9, T.10 S., R.1 W.), abandoned in 1939[69] at a depth of 4,005 feet, reportedly encountered Paleozoic rock at 1,855 feet.[70] The two wells are roughly 40 miles south by east of the Forte well. The elevation of the top of the Paleozoic in the Llewellyn well is 525 feet greater than in the Forte well, the altitude of the mouth of the Llewellyn well being given as 569 feet,[71] whereas the elevation of the Forte well is 561 feet. From these meager data it appears that the altitude of the old surface increases at the rate of about 13 feet a mile towards the south from the vicinity of Holly Springs.

The only well in western Union County which reached Paleozoic rock was the No. 1 Amos Robbins (Center SE.¼, SW.¼, Sec.3, T.8 S., R.1 E.) which was completed October 22, 1953, at a depth of 3,477 feet. The elevation of the mouth of the well was 409 feet D. F. The depth to the top of the Paleozoic was not given, unless the Devonian, which, according to the Schlumberger log, was reached at 1,546 feet, was the uppermost Paleozoic rock encountered.[72]

In southwestern Pontotoc County the No. 1 Rex Patterson well (NW.¼, SE.¼, Sec.21, T.11 S., R.1 E.) approximately 10 miles southeast of Llewellyn No. 1, reached the Paleozoic at 1,642 feet. The altitude of the well was 352 feet D. F.[73] Comparison of these figures with data from the Llewellyn well indicates that the Paleozoic surface is only 4 feet farther below sea level in the Patterson well than in the Llewellyn. Cullet No. 1 Nabors (Elevation, 425 feet G. L. estimated) in eastern Union County, encountered the Paleozoic at 1,565 feet.[74] The Nabors well is roughly 40 miles southeast of the Forte well. Along the line between the two wells, then, the Paleozoic surface slopes northwest about 17 feet a mile.

No deep well has been drilled in Benton County, but the No. 1 Martindale in northern Tippah County (SE.¼, Sec.27, T.1 S., R.3 E.) approximately 32 miles northeast of the Forte well, topped the Paleozoic rock at 1,435 feet. The elevation of the well was 615 feet D. F.[75] The figures indicate, then, that along the line between the Martindale well and the Forte well the surface of the old hard rock slopes southwest at the degree of 31 feet to the mile. However, the slope of the same surface along a straight line extending southwest by south from the Martindale well to the Llewellyn well, a distance of 65 miles, is only 7 feet to the mile; and along a line between the Martindale well and the Nabors well which is 36 miles south of the Martindale, the slope of the Paleozoic surface is 9 feet a mile.

Conclusions concerning the depth to Paleozoic rock at any place at a considerable distance from a point where the depth to it has been determined, are likely to be wide of the mark; and so are concepts of the topography and relief of the old surface. None the less, inferences may be drawn from data obtained from the widely spaced wells referred to — one in western Tennessee; one in the northwestern corner of Mississippi, in DeSoto County; one in the center of Marshall County; one in the southeastern corner of Lafayette County; one in eastern Union County; one in southwestern Pontotoc County, and a seventh in northern Tippah County. The depths to the Paleozoic in the seven wells, when referred to sea level, indicate a northwest slope of the old surface of 36 feet to the mile from the center of Marshall County to the northwestern corner of Mississippi, but only 17 feet a mile from eastern Union County to central Marshall County. The southwest slope from northern Tippah County to central Marshall is 31 feet to the mile, but along a southwest by south line from northern Tippah to southeastern Lafayette the slope is only 7 feet per mile, and along a north-south line to eastern Union County, 9 feet a mile. Moreover, the well data cited indicate that the Paleozoic surface slopes north from southeastern Lafayette County to central Marshall at the rate of 13 feet to the mile. All in all, it appears from the inadequate information available that in general the Paleozoic surface of Northwestern Mississippi slopes west-southwest at a low angle which steepens somewhere through eastern Marshall and Lafayette Counties; and that a low broad ridge underlies southeastern Lafayette County and extends northeastwards into Tennessee. No doubt the ridge is cut by valleys.

Some data which relate to the features of the old Paleozoic surface, and to its depth beneath the present land surface of Marshall County and adjoining territory, have been summarized, and some conclusions ventured, based on them. However, the hard rock surface may, or may not, reflect hard rock structure. The topography of a land surface does not, necessarily, bear any relationship to the structure of underlying rocks, although almost everywhere it does, in some degree. But even where such a relationship exists, correct interpretation of it is difficult, especially where the surface has been developed by weathering and erosion through many millions of years, and is hundreds of feet under younger formations. Where such conditions exist reasonably reliable information can be obtained only by a study of carefully recorded findings of wells: Intensive study of well samples and logs, especially electric logs, and careful correlation of the logs of many wells somewhat widely spaced over the territory. Unfortunately, in the region considered only a few wells reached the Paleozoic rocks, and the data obtained from them are insufficient for accurate correlation.

The "tops" from the Schlumberger log of the Withers well, DeSoto County, have been listed as follows:[76]

	Feet
Midway	2,034
Clayton	2,504
Selma	2,534
1st chert	3,530
Red shale (Silurian?)	4,180
2nd chert	4,273
Bentonite	4,395-4,430
Ordovician	4,430

It will be observed that the uppermost Paleozoic rock is chert. This "1st chert" is, possibly, the equivalent of the Iuka chert (Middle Mississippian) of the northeast Mississippi outcrop section. The bentonite almost certainly is Ordovician, probably the equivalent of the Pencil Cave formation of Kentucky, which lies on the Black River-Stones River beds.

In connection with the data on the wells in western Tennessee, certain other reports are interesting. Some 15 miles north of Holly Springs, in Fayette County, Tennessee, a little east of LaGrange, two wells were drilled on the Beasley property in 1935 or about that time, by Kerr and Anderson of Oklahoma City. Some time after abandonment of Beasley No. 2, reports were current that "live oil" was standing in it at a depth of approximately 1,400 feet; in fact, in 1950 and 1951 reputable geologists asserted that for years past oil had been standing in the hole. It was stated further that the well was pumped out and cleaned several times, and that after each cleaning, oil seeped back into the well. In 1950 a test well was drilled by C. L. Raines et al 2 miles southwest of the old Beasley No. 2. It was said to have lost circulation in a cavity, or fault, at 2,018 feet, and had to be abandoned because of a stuck drill stem. The same conditions were encountered in the old Beasley wells, according to reports.[77] Inasmuch as it is doubtful that any of the three wells reached the Paleozoic rocks, from which production, if any, must come, it appears obvious that the oil entered the Beasley well through fractures or faults or solution cavities or other openings in the underlying rocks.

The "tops" as encountered by Llewellyn No. 1 have been picked as listed below.[78]

	Feet
Selma group	635
Eutaw	Not given
Tuscaloosa	1,740
Paleozoic (Pennsylvanian?)	1,855
Mississippian	2,415

The Schlumberger log gives the lithology and depths and thicknesses as follows (below 295 feet):

	Feet
Shale	295-1,025
Chalk and shale	1,025-1,300
Hard shale	1,300-1,670
Hard sand	1,670-1,740
Shale	1,740-1,765
Hard sand	1,765-1,855
Shale and quartzite	1,855-2,490
Shale	2,490-2,610
Chert	2,610-3,610
Shale	3,610-3,645
Cherty lime and shale	3,645-4,005

(Bottom of well).

The electric log record of the kinds of rock encountered by the well and the depth at which each kind was reached does not agree with the log made by F. F. Mellen[79] from samples. Mellen found the uppermost recognizable Paleozoic rock (which he referred questionably to the Pennsylvanian Pottsville) at 1,890 feet. From that depth to 2,430 feet were beds of quartzite siltstone (some of which were petroliferous), quartzite, quartz, quartzitic sandstone, silty shale, and quartz grit. Some limestone was noted between 2,370 and 2,380, but below it, to a depth of 2,500, the rocks were chiefly quartzite; from 2,500 to 2,610 the section was hard shale, and from 2,610 feet to 3,700 feet all was gray limestone except for shale intervals from 3,570 to 3,600, and 3,610 to 3,640. The limestone from about 2,900 feet to 3,700 feet was cherty. The last sample examined, from 3,690 to 3,700 feet, contained some dark-red shaly limestone, which could have been from the St. Joe formation, the Fern Glen of the standard section. The St. Joe is near the base of the Mississippian system.

The log made from a study of the samples seems to indicate that the top of the Paleozoic was reached at approximately 1,890 feet, and the top of the Mississippian at 2,610 to 2,620 feet. The sample log ends at 3,700 feet, but, as already noted, the electric log records "cherty lime and shale" from 3,645 feet to the bottom of the well, 4,005 feet.

No attempt was made to determine the depths in the well at which the tops of the various geologic units of the Mississippian system were reached, even if they could have been differentiated at all, which is improbable. However, the hundreds of feet of cherty limestone suggest the Osage and Meramec series (Iuka formation on the outcrop in the northeastern corner of Mississippi), even though the tops given for the No. 1 Rex Patterson imply that the entire Mississippian section in the Llewellyn well is Chester. Certainly the writer does not know of any surface Chester that contains so much chert. The chert of the Llewellyn well may be correlative in part with the "1st chert" in the Withers well, although 1,279 feet higher.

The No. 1 Rex Patterson well (NW.¼, SE.¼, Sec.21, T.11 S., R.1 E., Pontotoc County) approximately 10 miles southeast of Llewellyn No. 1, found the tops as listed below, at the depths indicated, according to the Schlumberger and sample logs:[80]

	Feet
Clayton	300
Eutaw	1,170
Tuscaloosa	1,406
Pennsylvanian	1,642
Lewis sand (Mississippian-basal Chester)	4,117
Iowa	4,241
Devonian	4,340
Bottom of well, in Knox dolomite	5,904

The elevation of the well was 352 feet, D. F.

It will be noted by a comparison of the logs of the Patterson and Llewellyn wells that the Paleozoic rock (Pennsylvanian) was reached by the Patterson well at a sub-sea depth only 4 feet greater than the sub-sea depth to the Paleozoic (Pennslyvanian?)

in the Llewellyn well; and that the Lewis sand, of basal Chester (Upper Mississippian) age, was reached at a depth in the Patterson well greater than the entire depth of the Llewellyn well. It will be noted also that in the Patterson well only 99 feet are allowed for the entire Iowa series of the Mississippian, whereas the log of the Llewellyn well showed several hundred feet of chert and cherty limestone and shale, a large part of which, it seems to the writer, could on the basis of lithology, be assigned to the Iowa series.

The tops in the No. 1 Amos Robbins well, Union County, 5 to 6 miles south of the southeastern corner of Marshall County, were picked from the Schlumberger log at the depths here stated: Clayton, 360; Selma, 410; Eutaw, 895; Devonian, 1,546; Silurian, 2,044; Wayne, 2,256; Ordovician, 2,264; Knox, 2,696. It will be observed that the figure given for the depth to the Devonian, 1,546 feet, is only a little more than a third of that for the depth to the Devonian in the No. 1 Patterson, which is only 21 miles south of the Robbins well. If all figures are accurate, they indicate a southward slope of the top of the Devonian of approximately 135 feet a mile between the two wells. Comparison of the other "tops" figures for the two wells show wide differences also.

The well records are singularly elusive. They hint at structural conditions which are favorable for the accumulation of oil and gas, but do not prove the existence of any such conditions. On the other hand, they do prove that the altitudes of certain contacts between geologic units vary widely and irregularly — a fact which is of some significance in relation to regional structure, but is of very uncertain value as a guide to the location of oil and gas traps, especially when the contact surfaces involved are erosional. The available data from seven wells which reached Paleozoic rock have been given, and in general they seem to indicate: 1) The old Paleozoic surface slopes south and southwest at a relatively low angle which steepens somewhat towards the axis of the Mississippi Embayment; 2) the Paleozoic rock reached ranges in age from Cambro-Ordovician (Knox dolomite in the Patterson well) the oldest, to the top of the Lower Pennsylvanian (Pottsville series); 3) striking differences of elevation between the formational contacts in one well and the same contacts, respectively, in another perhaps only a few miles distant —

for examples, the Bateman well and the Withers well, and possibly the Llewellyn No. 1 and the Patterson No. 1; 4) not all geologic units passed through by a certain well may be found by another well in the same general locality.

Seven wells are too few to provide detailed information on such a large area. Many more are needed, and intensive study of their findings, if a clear picture of the subsurface geology of the region is to be obtained. Nor can the failure of any of the seven wells to get production condemn the territory.

To recommend any certain place in Marshall County for the location of a test well for oil or gas probably would be to go farther than is warranted by the data which have been summarized in the present report. Most of the data are of a general nature. As stated, it is believed that they suggest the existence of structures favorable for the accumulation of oil and gas; but it should be remembered that such structures do not necessarily contain oil or gas. The strata may not contain any oil or gas, or have any porosity necessary for its concentration. In fact, the Paleozoic section of the Forte well, as described by the driller's log, is not encouraging in the matter of porous beds — it is a succession of limestone, chert, and shale almost entirely, through a thickness of close to 900 feet, including only a few thin beds of hard sand. The Llewellyn well found 2,000 feet or more of hard limestone, quartzitic sandstone, shale, and almost impenetrable chert. The same dense rock made up much of the Patterson well section. It seems improbable, then, that oil or gas is present in the rocks of Marshall County above the Ordovician, which might be reached at a depth of 3,500 feet, more or less. This statement does not mean, of course, that in the writer's judgment there is no possibility that production can be obtained from post-Ordovician rocks, nor does it mean that oil and gas are sure to be found in Ordovician or older strata; but it does mean that in his judgment, based on rather meager information he admits, the prospects for commercial production from the Ordovician or older rocks are better than from younger beds.

Despite the reservations necessary and the risk of being all wrong which are involved in choosing a site for a prospect well in wildcat territory, the writer ventures to express the opinion that a well located in the eastern or southeastern part of the county would have a better chance of success than one located elsewhere. It may be that a site near the head of Chewalla Creek, north of Highway 4, would have advantages. But wherever a well may be drilled in the county, if it is to make a thorough test it should not be stopped above the Knox, unless satisfactory results are obtained at a lesser depth. That is, an adequate test might have to go 5,000 feet or more.

GEOLOGIC HISTORY; CONDITIONS OF SEDIMENTATION

In the larger sense, the geologic history of Marshall County includes all natural events which have affected that extremely small segment of the Earth since the beginning of its existence. All happenings which have had their time and place in or on the Marshall County terrane are parts of its history. However, it is customary to restrict an account of the geologic history of a region to the natural events which have occurred during the period from the earliest time represented by the rocks which show at the surface, to the present. In this sense, the geologic history of Marshall County extends from late Midway time to the present.

In Midway time the territory which is now Marshall County was part of the gently westward and southwestward sloping floor of the shallow Gulf Embayment sea. Sedimentation was proceeding slowly from waters laden with clay material, silt, and fine sand which had been transported to the sea by streams from the low lands to the north and northeast. The fineness of the sediment as seen today, indicates that the streams were of low gradient. A large river, the "Appalachian River," the ancestral Tennessee, was flowing into the embayment in what is now northeast-central Mississippi, and building a delta in the shallow marine waters. Smaller streams, farther north, were building deltas at the same time, and as all the deltas grew with the advance of Midway time, spreading north and south along the coast, they coalesced in the northern part of what is now Mississippi and the southern part of Tennessee.

In late Midway time erosion was more rapid, or more sand was available for the streams, as indicated by the greater proportion of sand in the Naheola formation. Probably such conditions were due to a gradual uplift of the source region (the Southern Appalachians) which began in early Midway time and continued through Wilcox time, increasing in intensity.[81]

As the Gulf waters slowly withdrew southward, the exposed sea bottom and deltas were subjected to weathering and erosion. A thick residuum accumulated in places, much of which was later removed by lengthened trunk streams and more numerous tributaries. After a period of relative quiescence, the source region underwent further uplift, which may have brought it back to the youthful stage of the physiographic development cycle. Westward and southwestward flowing streams and their delta-building processes were quickened. Erosion of the old source lands and of the newer lands continued, and deposition on the marine sediments which had been deposited in Midway time and had become a low coastal plain, went on at a more rapid rate. Deposits took the forms of flood-plain alluvium, alluvial fans and cones, and fillings of old lake basins, lagoons, and shallow stream channels. Transporting streams probably were braided, meandering, and a complex of shifting currents.[82] The Wilcox history of the Marshall County region was one of land and fresh water deposition. The Gulf shore line fluctuated south of the region, periodic subsidence dominating, but subsidence did not keep pace with sedimentation. As Grim puts it, "The characteristics of the Wilcox sediments in Mississippi point strongly to water as the chief agent of deposition, and to a somewhat variable non-marine environment adjacent to the sea. Such requirements are met by littoral, deltaic, lagoonal, or palludial conditions in a flat region. Under such conditions wind could have played the minor part suggested for it by the few examples of eolian cross bedding."[83]

Some time before the middle of the Wilcox epoch, deposition on the Midway floor went forward more slowly than erosion, and valleys and ravines were cut in the lower Wilcox terrane, in what is now known as the Fearn Springs formation. The depressions were filled subsequently when aggradation was speeded up in Ackerman time, under the same conditions as existed during the Fearn Springs age.

Towards the close of Wilcox time and the beginning of the Claiborne epoch, the Gulf seems to have begun a slow northward advance, not sufficiently rapid to keep ahead of deposition. The source regions provided sand and silt chiefly, which were deposited on the low land and in the edge of the sea. Some subsidence and tilting of the land took place. Probably the sand was carried to the area of deposition by several small streams.[84] As Claiborne time advanced, shallow Gulf water spread over the area, working over much of the lower Claiborne sand and the upper Wilcox deposits, and receiving clay material, silt, and fine sand from the adjacent low lands. The slow withdrawal of the Gulf waters marked the close of the Tallahatta age, and the northern part of the floor of the Tallahatta sea became a coastal plain, the site of the deposition of sand transported by streams from the rejuvenated Southern Appalachian region and territory farther west, but for a long post-Tallahatta period erosion was dominant in the Marshall County area. Later, during the Kosciusko age, the ever-active rivers and creeks carried abundant sand, most of it fine, and small quantities of silt and clay, which materials they deposited on the eroded surfaces of younger formations underlying the coastal plain,[85] from far to the east to and beyond the axis of the embayment.

Kosciusko time was succeeded by a very long period of land conditions, perhaps not notably unlike those which prevail in Marshall County today, although early in post-Kosciusko time the altitude of the region was considerably greater than it is now. Possibly Marshall County was not a site of deposition, except locally by streams as at present, from the close of Kosciusko time until the Pliocene epoch. Weathering and erosion were the dominant processes. The old plateau was lowered and thoroughly dissected. If any of the post-Kosciusko Tertiary formations which are present farther south were ever represented in the area which is now Marshall County, they were completely removed before the Citronelle was deposited.

Through probably the later half of the Tertiary period, then, the region which is now Marshall County was the scene of the operation of geological processes, primarily degradational, although some evidence exists that relatively minor crustal movements took place, as in the first half of the period. Uplands were no doubt worn down to peneplains, which in turn were uplifted only to be reduced again to near plains; cycle succeeded cycle.

According to Shaw,[86] in Pliocene time the main drainage course of the region was a large river which "followed the general course of the present Mississippi . . . as can be inferred from the remnants of its old deposits and valley floors which are preserved in the form of terraces." The same writer expresses the opinion that "the assumption is well warranted that the uplands of central and northern Mississippi have been worn down more than 100 feet in Pliocene and Quaternary time. The present rate of erosion is probably about a foot in 10,000 years."[87] Yet he believed the land was lower with reference to sea level than it is today, and that the surface of the entire state was smoother. "It must be assumed that all parts of the region that have been exposed since Miocene time have been subjected to a continuous and vigorous process of reduction, perhaps to an extent of 100 tons to the square mile each year. It seems reasonable to assume, therefore, that the surface at the beginning of Pliocene time was at least 100 feet above the highest hills remaining today, and that much of it was lowered more than 200 feet in the Pliocene epoch."[88]

During part of Pliocene time western Marshall County was a site of deposition. The large river, overloaded at times, meandered widely, spreading sand and gravel over its flood plain, and as it deepened its channel it left remnants of these blankets of sand and gravel as terraces.[89]

Pleistocene time saw a radical change of climate. Very probably erosion was intensified because of restriction of plant life by low temperatures, and because of increased volumes of water from melting ice, especially during the summer. At this time the wind was an important agent of deposition, spreading the loessial silt over the western part of Mississippi, including Marshall County. With the passing of the ice age, some warping of the terrane of Northern Mississippi took place, quickening erosion to some extent, and initiating Recent time, during which gradational agents, notably running water, have made geological history, bringing the Marshall County area to its present condition.

The climate of Tertiary time in the region which is now Marshall County apparently was much like it is today, moist and relatively mild. Biological history paralleled geological history: Plants were abundant, as, no doubt, were land animals except during the times of the Naheola and Tallahatta seas. Marine life may have been abundant during those ages, but if so it left few fossils. As already stated, life of all kinds was greatly restricted during the Pleistocene epoch.

ECONOMIC GEOLOGY

SOILS

Inasmuch as the mineral constituents of a soil are fragments or particles of pre-existing bed rock and possibly some mineral species created by chemical action on the rock particles, soils may properly be considered a mineral resource — indeed, the most valuable mineral resource of a dominantly agricultural region. The mineral matter of a certain soil may have been derived from bed rock which once underlay the area now occupied by the soil, or it may have originated from weathered material transported to the place where the soil now is. In the former case the soil is a residual soil; in the latter case, it is a transported soil. The character of the mineral content of any soil is a function of the character of the rock from which that mineral content was derived. However, in the development of a soil by weathering processes, the minerals of the source rock may be, and commonly are, greatly altered, and new mineral species or varieties created.

The soils of Marshall County, except relatively small percentages of the alluvial soils along streams which have their sources outside the county, were formed by weathering of bed rock which was present in the county. Furthermore, the lithologic character of the mantle rock, including the soil, indicates that the Marshall County soils came from the same kinds of rocks that crop out in the county today. As has been pointed out in the description of the stratigraphy, the outcropping formations are composed of sand, silt, and clay chiefly, in which are considerable quantities of iron ore in the southeastern part of the territory, and gravel in the northwestern part. Also, sandstone and quartzite and siltstone are present here and there, and particles of several species of heavy minerals, notably iron minerals, are scattered through the beds. The great body of underlying rock being what it is, then, the soils above it should be sandy and silty almost everywhere, and clayey where they are lying on clay or in such a position that they can be affected by a clay terrane. And the soils of the county are of such a character, at least in the eastern part. However, much of the western and northwestern region is mantled with loess, which extends far to the east and gives character to the soils, or at least strongly affects them, wherever it is present. The marked fertility of the soils of Marshall County probably is due in large part to mineral plant foods obtained from the loess, which has a considerable content of lime, soda, potash, and magnesia.

The U. S. Department of Agriculture Bureau of Soils has during the past half century or more made soil surveys of many counties of Mississippi, in co-operation with the State Geological Survey. The reports of the findings of these surveys include a classification and description of the soils, information concerning the distribution of each type, and some mechanical analyses of the leading types. Also, a map showing the distribution and area of each type accompanies the report. Unfortunately, no such survey has been made of Marshall County, but one has been made of Lafayette County, which, having the same rock formations, the same climate, and the same kinds of physiographic features, unquestionably has the same soil types as Marshall County, although the relative extent of each type may differ as between the two counties. The pertinent data for Lafayette County will be summarized in the present report, then, as applicable to Marshall County as well.

On the basis of mode of origin as well as topographic position, the soils of Lafayette County were classified as: 1) Old sedimentary upland soils; 2) wind-blown or loessial upland soils; 3) recent stream alluvium or frequently overflowed first-bottom soils; 4) old stream alluvium, or second-bottom soils lying above normal overflow. Series and types of soil were recognized, subordinate to the four classes. The types, distinguished on the basis of texture, numbered eleven, of which the Memphis silt loam, the Vicksburg silt loam, the Susquehanna silt loam, the Ruston fine sandy loam, and the Lintonia silt loam, are the five most extensive.[90]

According to the U. S. Bureau of Soils classification, based on the mechanical composition of soils, silt consists of particles .05 to .005 of a millimeter in diameter; clay, of particles less than .005 of a millimeter in diameter; fine gravel, 2 to 1 millimeters diameter; coarse sand, 1.0 to 0.5 millimeter; and medium sand, 0.5 to 0.25 millimeter. Silt loam is made up of more than 55 per cent silt and less than 25 percent clay; fine sandy loam, of less than 20 percent fine gravel and coarse and medium sand,

and more than 20 percent and less than 50 percent of silt and clay.[91]

The Memphis silt loam, occupying 242,944 acres (57.2 per cent of the total area of the county) is three times as widespread as the Vicksburg silt loam, the next most extensive. It is derived from the loess. The uppermost 8 inches or so is a yellowish-brown to buff friable silt loam. The subsoil is a light-brown to reddish-yellow somewhat friable silt loam which grades downwards into a compact silty clay loam. It averages 3 feet in thickness. The Memphis silt loam is in general well drained, but here and there are poorly drained patches where the soil is lighter of color and may be underlain some 20 inches down by impervious plastic silty clay, brownish-yellow to reddish-yellow, and mottled with gray, yellow, and brown.[92] This material has been used in the making of brick.

Hilgard[93] records the results of chemical analyses of Memphis silt loam soil, "a mellow soil, of a 'mulatto' tint," and subsoil from a plantation (Sec.30, T.2 S., R.1 W.) near Lamar, Benton County. The samples analyzed were taken from a level area a little below the summit of a ridge, the soil from a depth of 0-10 inches, and the subsoil from a depth of 10 to 20 inches. They were saturated at 62.4 degrees Fahrenheit, and the soil lost 6.842 percent of water at 400 degrees Fahrenheit, at which temperature it was dried, and then analyzed.

Chemical Analysis of Memphis Silt Loam, Marshall (Now Benton) County

	Percent
Insoluble matter	83.347
Potash	0.549
Soda	0.082
Lime	0.245
Magnesia	0.479
Brown oxide of manganese	0.760
Peroxide of iron	4.798
Alumina	6.282
Phosphoric acid	0.068
Sulphuric acid	0.062
Water and organic matter	4.195
Total	100.867

The subsoil, "a pretty solid yellowish-brown loam," was analyzed under the same conditions. It lost 7.423 percent of water at 400 degrees Fahrenheit, was dried at that temperature, and then analyzed.

CHEMICAL ANALYSIS OF MEMPHIS SILT LOAM SUBSOIL, MARSHALL (NOW BENTON) COUNTY

	Percent
Insoluble matter	83.993
Potash	0.700
Soda	0.049
Lime	0.139
Magnesia	0.579
Brown oxide of manganese	0.332
Peroxide of iron	3.862
Alumina	7.279
Phosphoric acid	0.236
Sulphuric acid	0.054
Organic matter and water	2.716
Total	99.939

The Memphis silt loam is fertile, but much of it can not be cultivated without risk of increasing erosion, because of the rough topography and steep slopes of the region it occupies. Most of the tilled soil is on ridge crests, along the foot of slopes, or on the more gently rolling areas. The control of erosion is a problem at all times, but the very considerable capacity of the silt loam and underlying loess to retain moisture helps to retard run-off and the concomitant washing away of the soil. The steeper slopes should be kept in forest.

A "smooth phase" of the Memphis silt loam, restricted to the almost level to undulating uplands, has a higher agricultural value than the type Memphis, because of its topography and ease of cultivation."[4]

The Vicksburg silt loam[95] is the largest and most important type of the flood-plain or first bottom soils. It borders almost all the streams. Typically, it consists of 8 to 10 inches of grayish-brown to brown silt loam. "The subsoil to 20 inches is a light-brown to brownish-yellow heavy silt loam, grading below into a yellowish-brown silty clay slightly mottled with gray and brown." The record of mechanical analyses follows:

Mechanical analyses of Vicksburg silt loam:

Soil, percent: Fine gravel, 0.1; coarse sand, 1.0; medium sand, 1.0; fine sand, 2.5; very fine sand, 6.5; silt, 67.8; clay, 21.2.

Subsoil, percent: Fine gravel, 0.0; coarse sand, 1.3; medium sand, 1.5; fine sand, 4.0; very fine sand, 7.6; silt, 61.3; clay, 24.4.

The Vicksburg silt loam is considered the most fertile soil of the county. Overflows repeatedly cover it with fresh coatings of silt and finely divided plant material. It is easily cultivated, but cultivation is likely to be delayed each spring because of floods from early spring rains.

The Susquehanna silt loam,[96] of the Susquehanna series, is grayish to grayish-yellow to an average depth of 8 inches. It is underlain by a heavy, plastic, red clay, mottled with drab and gray. Soil and subsoil combined have an average thickness of 3 feet. In places the lower part of the 3-foot section is a light-colored to white heavy plastic clay. Pieces of ferruginous rock are scattered through the section here and there.

The Susquehanna silt loam is derived from the older and more compact clays. It is a heavy soil, difficult to till, which accounts in part for much of the area being left in scrub timber.

The Ruston series[97] of Lafayette County originated from the weathering of the Wilcox and Claiborne sands and clays. The soils are gray to grayish-brown sand, sandy loam, and fine sandy loam, and the subsoils are yellowish-red or reddish-yellow friable sandy clay. The most extensive type of the series is the Ruston fine sandy loam. This soil type, 10 to 15 inches thick, is grayish, grading downwards into reddish yellow to reddish brown. The subsoil commonly is a reddish-yellow to yellowish-brown friable sandy clay, grading downwards into a brownish somewhat plastic sandy clay. The Ruston fine sandy loam is the most extensive of the upland soils. Topography is rough and broken, and natural surface drainage excellent.

The Lintonia silt loam[98] is the terrace or second bottom soil, derived chiefly from old alluvium by weathering. It is a light-brown or yellowish-brown silt loam, 8 to 10 inches thick. The subsoil is a brownish-yellow silt loam, grading downwards into a yellow silty clay mottled with brown and white. The Lintonia silt loam is moderately well drained, because it has a slight slope toward the streams and is sufficiently above the flood plains to be free from overflow. It is easily tilled, and naturally productive. Although it is composed chiefly of alluvial material, it is in part colluvial, having been modified to some extent along the outer margins by Memphis silt loam washed down the valley walls.

In addition to the five most important soil types described in the foregoing paragraphs, six others are described briefly in the Lafayette County Soil Survey report, but they are relatively unimportant, their total area being only 4.4 percent of the county."[59]

No doubt the soil types present in Lafayette County are distributed in Marshall County with the same relationship to topography and drainage as in Lafayette. The Memphis silt loam occupies the loess territory; the Vicksburg silt loam is the uppermost material of the first bottoms, or flood plains, of the streams, the greatest areas being along Tallahatchie and Coldwater Rivers; the Susquehanna silt loam and the Ruston fine sandy loam are upland soils, distributed over the region where the Wilcox and Claiborne beds crop out; and the Lintonia silt loam mantles terraces which border flood plains in places.

It is understood, of course, that no sharp contact exists between any two different soil types, because slope wash, stream erosion, soil creep, transportation of soil by winds, and other natural processes, have mingled the soils to an extreme degree, especially in the more rugged parts of the county.

WATER

Marshall County has been blessed, and sometimes troubled, by an abundance of water. As has been stated, the mean annual precipitation is 48 to 50 inches a year. Although the surface run-off is considerable, as attested by the multitudes of water courses, yet, because of the porosity of the underlying rock, which is chiefly sand and silt, the quantity of water which sinks into the ground and thus becomes ground-water, is great, also. Water has been stored in this manner through the ages. Furthermore, deep aquifers underlie the county. Farms and villages scattered over the county commonly obtain water for farm and domestic use from wells less than 100 feet deep in the Wilcox and Claiborne sands,[100] which are excellent aquifers. The Fearn Springs and Ackerman formations contain water-bearing beds of sand and silt, but the water from them may be so highly mineralized that it is unfit for general use. It is especially likely to contain an excess of iron and sulphur and perhaps lime. The Meridian sand, the lower part of the old "Holly Springs" sand, is one of the most prolific aquifers of the state. In Marshall County, and in Northwestern Mississippi in general, it transgresses the underlying Wilcox, and its outcrop area becomes wider northwards. The water is in most places low in dissolved solids, and suitable for general use.[101] Numbers of shallow wells in and near the Meridian outcrop area obtain water from the Meridian sand. The Tallahatta formation, as has been stated, is largely sand in Marshall County, and interbedded sand and shale. The sand beds yield large quantities of potable water. The Kosciusko is one of the leading water-bearing formations of the state, and in western Marshall County provides the water in many shallow wells.

The towns of the county obtain their water supply from wells. Some twenty-five years ago Holly Springs was supplied by four wells, one about 400 feet deep, the others approximately 350 feet. The deeper well reached the Ackerman, but all obtained water from the sand beds overlying the Ackerman. Back in 1898 a 750-foot well, drilled only 20 feet from the site of one of the 350-foot wells, yielded only a small quantity of water; and in 1899 a 1,500-foot well only 25 feet southwest of the 750-foot well, found no water below the 4-foot water-bearing stratum encountered by the older well.[102] The present water supply of Holly Springs is from two of the old 350-foot wells. Water is pumped from them at the rate of 550 to 600 gallons per minute for each well, the capacity of the pumps being 1,000 gallons per minute each. The producing sand is about 30 feet thick. The wells are provided, in the water-bearing sand, with 30-foot monel strainers around which gravel is packed, so that no silt or clay and very little sand is carried by the water. A new well is to be drilled in 1954.[103]

Potts Camp obtains water from the Ripley formation through a 718-foot flowing well.[104] A well 2 miles northwest of Hudsonville found water at 165 feet; a 100-foot well a mile south of

Mount Pleasant yielded ample water; two wells near Mahon struck good supplies of water, one at 90, the other at 98 feet; the town well at Byhalia was 85 feet deep; Waterford obtained its supply from wells 12 to 90 feet deep.[105]

Several flowing wells are located in the southeastern part of the county, in the valley of Tallahatchie River and the Tippah River Valley. One of these wells (SE.¼, Sec.12, T.6 S., R.2 W.) alongside a local road at the site of a burned dwelling 30 to 35 feet above the flood plain of Tippah River, flows a strong stream of somewhat mineralized water. The well is reported to be 673 to 678 feet deep, and to tap a water-bearing sand subjacent to several feet of hard rock. Very probably the water comes from the Ripley sand under one of the hard siliceous limestone beds. Other flowing wells are near plantation buildings (SW.¼, Sec.23, T.6 S., R.2 W. and SW.¼, Sec.21, T.6 S., R.2 W.) in the north edge of the Tallahatchie flood plain.

Springs are numerous in Marshall County, due to stream dissection of the interbedded or interlensed sands and clays or clay shales, which contain abundant water. Probably the largest and best known springs are those which give rise to Little Spring Creek and provide the water for Spring Lake, and which fed Lake Mimosa, north of Spring Lake in the same valley, before that lake was drained. These springs are so many that for considerable distances they form an almost unbroken line of flow. The water comes from the Meridian sand. Along much of the length of Little Spring Creek water flowing or seeping from the sand walls of its valley feeds the stream. Big Spring Creek, also, receives much spring water, especially from its headwater territory. In fact, every permanent stream in the county is fed to some extent by springs, and in many places people obtain their water supply from springs.

Several springs are mentioned in U. S. Geological Survey Water-Supply Paper 576, "The Ground-Water Resources of Mississippi," published in 1928: 1) On the J. M. Lambkin place, 1.5 miles southwest of Hudsonville; 2) the M. L. Patterson spring, a mile southeast of Mahon; 3) on the Judge H. K. Mahon property, 300 yards north of the waterworks at Holly Springs; 4) Eagle Springs, half a mile from Potts Camp.[106]

The springs for which the town of Holly Springs was named, have been referred to (Introduction).

The mineral content of five samples of underground water is indicated by the analyses records tabulated below. Sample No. 1 was from the town well of Byhalia; No. 2 was from one of the 350-foot Holly Springs wells; No. 3 was from the other 350-foot Holly Springs well; No. 4 was from the Potts Camp flowing well; and No. 5 was from the Judge Mahon spring in Holly Springs.[107]

MINERAL ANALYSES OF GROUND WATERS FROM MARSHALL COUNTY
(Parts per million)

	1	2	3	4	5
Silica (SiO_2)	25.0	19.0	20.0	8.0	14.0
Iron (Fe) and Aluminum (Al)	0.05	0.29	0.18	2.0	0.08
Calcium (Ca)	16.0	8.0	8.1	7.2	29.0
Magnesium (Mg)	9.6	3.1	3.7	2.8	11.0
Sodium and potassium (Na K) (calculated)	2.2	27.0	20.0	60.0	31.0
Carbonate radicle (CO_3)	0.0	0.0	0.0	0.0	0.0
Bicarbonate radicle (HCO_3)	51.0	71.0	52.0	176.0	62.0
Sulphate radicle (SO_4)	30.0	0.9	1.0	25.0	60.0
Chloride radicle (Cl)	2.2	17.0	15.0	1.3	31.0
Nitrate radicle (NO_3)	10.0	12.0	12.0	0.00	35.0
Total dissolved solids at 180°C	125.0	135.0	122.0	205.0	245.0
Total hardness as $CaCO_3$ (calculated)	79.0	33.0	35.0	30.0	118.0
Date of collection	Nov., 1911	Sept., 1919	Sept., 1919	1911	Sept., 1919

Analysts: 1, W. L. Perdue, University of Mississippi; 2, 3, C. S. Howard, U. S. Geological Survey; 4, E. S. Wallace, University of Mississippi; 5, Margaret D. Foster and Clara M. Forman, U. S. Geological Survey.

Sample Nos. 1 and 5 were from the Tallahatta formation; Nos. 2 and 3 probably from the Meridian, and No. 4 from the Ripley.

CERAMIC CLAY

As brought out in the description of the formations, almost all the clay is in the Fearn Springs, Ackerman, and Tallahatta. Bodies of re-worked clay are present here and there in the other formations, except Loess, but they are relatively small. All clay used in the county has been and is obtained from the Tallahatta.

Use of the white clay in the vicinity of Holly Springs for making pottery and fire brick began some three quarters of a century ago. In the first decade of the twentieth century two brick and pottery plants were operating in Holly Springs, getting their raw clay from deposits close by: The Holly Springs Stoneware Company and the Allison Stoneware Company. Besides pottery, these companies made their own fire brick.[108] Also, one brick plant, the Holly Springs Brick Manufacturing Company (Erby Bros.) was active.[109] The fire brick was made from a mixture of a very siliceous clay containing large sand grains, and the white plastic stoneware clay. An analysis of the siliceous clay is given below:[110]

Analysis of Fire Clay, Holly Springs

	Percent
Moisture (H_2O)	0.87
Volatile matter (CO_2, etc.)	1.93
Silicon dioxide (SiO_2)	88.52
Ferric oxide (Fe_2O_3)	1.64
Aluminum oxide (Al_2O_3)	5.26
Calcium oxide (CaO)	.73
Magnesium oxide (MgO)	.13
Sulphur trioxide (SO_3)	.43
Total	99.51

Rational Analysis

	Percent
Clay base	13.33
Free silica	80.45
Fluxing impurities	2.50

It was reported that brick made from this clay were in use in some of the kilns for 25 years. The fire brick were of a white or light cream color.[111]

The Holly Springs Brick Manufacturing Company used clay which varied from sandy loam at the top to a plastic jointed clay at the bottom of the pit, through a thickness of 5 to 6 feet. The record of the analysis of a sample from near the bottom is copied below:

ANALYSIS OF BRICK CLAY, HOLLY SPRINGS

	Percent
Moisture (H_2O)	1.08
Volatile matter (CO_2, etc.)	2.11
Silicon dioxide (SiO_2)	80.76
Iron oxide (Fe_2O_3)	4.50
Aluminum oxide (Al_2O_3)	8.50
Calcium oxide (CaO)	1.50
Magnesium oxide (MgO)	0.45
Sulphur trioxide (SO_3)	0.04
Total	98.94

RATIONAL ANALYSIS

	Percent
Clay substance	21.50
Free silica	70.67
Impurities	6.49

Physical properties were determined:

Water required for plasticity, 10 percent; drying shrinkage, 3 percent; tensile strength of raw brickettes, 42 pounds per square inch; tensile strength of soft-burned brickettes, 45 pounds per square inch; loss of weight in water smoking and burning, 16 percent.

The brick were moulded by hand, dried in the open air, and burned in a rectangular up-draft kiln.[112]

The old Holly Springs Stoneware Company manufactured a general line of stoneware, which included jugs, jars, crocks, churns, pitchers, bowls, flower pots, charcoal burners, chimney thimbles, and other things. The plant obtained most of its clay from pits a mile and a quarter east of Holly Springs (See section on Stratigraphy). The section of the pit showed 8 feet of white or cream-colored laminated leaf-bearing clay.[113] Records of analyses results are tabulated below, No. 2 being an average of the results of No. 1 and the analysis of a nearby sample.[114]

ANALYSIS OF HOLLY SPRINGS CLAY

	Percent (1)	Percent (2)
Moisture (H_2O)	0.94	1.23
Volatile matter (CO_2, etc.)	6.64	7.35
Silicon dioxide (SiO_2)	67.70	64.69
Aluminum oxide (Al_2O_3)	19.69	22.30
Ferric oxide (Fe_2O_3)	3.04	2.54
Calcium oxide (CaO)	1.06	0.70
Magnesium oxide (MgO)	0.58	0.70
Sulphur trioxide (SO_3)	0.19	0.20
Totals	99.84	99.71

RATIONAL ANALYSIS OF SAMPLE NO. 1

	Percent
Clay substance	49.90
Free silica	37.49
Fluxing impurities	4.68

A comparison is given below, of the rational analysis obtained from No. 2, with the average rational analysis of ten Pennsylvania clays:

RATIONAL ANALYSES OF HOLLY SPRINGS AND PENNSYLVANIA CLAYS

	Holly Springs clay Percent	Pennsylvania clay Percent
Clay substance	56.51	56.65
Free silica	30.48	37.45
Fluxing impurities	3.94	4.44
Moisture	1.23	1.57
Total silica	64.69	65.00

The physical properties of the clay used by the Holly Springs Stoneware Company[115] were found to be: Color of powdered clay, white to cream; specific gravity, 2.53 to 2.58; in water, slakes at a moderate to slow rate to fine grains or flakes; average tensile strength of air-dried brickettes, 58 to 62 pounds per square inch; air shrinkage, 7 percent; water required for plasticity, 30 to 33 percent. The changes which took place during firing are tabulated below:

Pyrometric cone	01	2	3	7	19
Color	white	pink	pink	light yellow	light blue
Hardness	soft	soft	medium hard	hard	vitrified
Fire shrinkage			2	4	5
Absorption	20	23	16	23	

The Holly Springs Stoneware Company plant was powered by steam, used coal, and had a capacity of 500,000 gallons of ware a year. The clay was mixed in a chaser or wet pan, and the ware dried by steam heat, and burned in two circular down-draft beehive kilns. The clay vitrified between Cones 5 and 6. Two kinds of glazes were used: A white glaze, obtained by a mixture containing feldspar and whiting; and a brown glaze, produced by the use of Albany slip clay. Both colors might be used on the same piece of ware, the white on the body, and the brown on the top or rim.[116]

The pit of the Allison Stoneware Company, a short distance from the Holly Springs Stoneware Company's pit, exposed 12 feet of laminated cream-colored clay underlain and overlain by sand. The record of a chemical analysis of a sample of the Allison clay is given below:[117]

Analysis of Allison Clay

	Percent
Moisture (H_2O)	1.51
Volatile matter (CO_2, etc.)	8.07
Silicon dioxide (SiO_2)	61.69
Aluminum oxide (Al_2O_3)	24.91
Ferric oxide (Fe_2O_3)	2.04
Calcium oxide (CaO)	0.34
Magnesium oxide (MgO)	0.83
Sulphur trioxide (SO_3)	0.20
Total	99.59

Rational Analysis

	Percent
Clay substance	63.13
Free silica	23.47
Fluxing impurities	3.21

The physical properties of the Allison clay were: Specific gravity, 2.28 to 2.58; average tensile strength of brickettes, 113 pounds per square inch; maximum tensile strength, 128 pounds per square inch; air shrinkage, 7 to 8 percent; water required for plasticity, 30 to 32 percent; color, white to light yellow; in water the clay slakes readily to medium grains.[118]

The Allison Stoneware Company manufactured a general line of stoneware. The clay was pugged in a vertical steel pug mill, and thrown on a potter's wheel; the ware was glazed with Albany slip glaze. The plant operated two potters' wheels, two circular kilns and a brick oven drier.[119]

Additional data on Marshall County clays, from Logan's report on the pottery clays of Mississippi, are presented in the following tables:[120]

MARSHALL COUNTY CLAYS
PHYSICAL PROPERTIES

No.	Color	Sp. gr.	Water of plasticity (percent)	Slaking	Tensile strength lbs. per sq. inch Average	Maximum	Air shrinkage (percent)	Other physical properties
1	Yellowish	2.54	25	Easy, to fine grain	109	121	8	
2	White, streaked, with yellow and pink	2.50	25	Easy, to medium flakes	68	75	5	
3	White	2.53	25		65		6	
4	White or yellowish white	2.20-2.36	1/5 of weight of clay	Slow to medium flakes	46	49	6	
5	Cream colored	2.47	25	Rapid to medium grain	51		4	
6	White	2.50	32		40		6	
7	White	2.40	25		45		8	
8	White	2.56-2.75	15		95		2	
9	White	2.63	14		102		None	Large grains of clear quartz

10	Light cream	2.30		Easy, to fine flakes		8	
11	Yellowish white	2.48				4	
12	White	2.37		Easy, to fine grain		8	
13	Pinkish to white	2.25	32			5	Many muscovite crystals
	Yellow sample	2.24			45	6	
	Cream colored sample	2.40				4	
14	Yellow to light cream	2.26	30			8	
15	White	2.41				4	
16	Cream colored	2.17		Slakes readily		6	
17	Salmon	2.51					Gritty; microscopic muscovite crystals
18	White	2.31				8	
19	White	2.67				6	Many visible quartz grains

CHEMICAL ANALYSES

No.	Moisture (H_2O, etc.)	Volatile matter (CO_2, etc.)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3
1	1.84	8.23	60.78	24.12	3.52	0.73	0.38	0.38
2	....	....	....	....	....	....	....	....
3	....	....	....	....	....	....	....	....
4	....	....	....	....	....	....	....	....
5	....	....	....	....	....	....	....	....
6	....	....	....	....	....	....	....	....
7	....	....	....	....	....	....	....	....
8	0.87	1.93	88.52	5.26	1.64	0.73	0.13	0.43
9	1.23	2.41	66.66	22.29	1.57	0.62	0.28	0.11
10	0.96	6.70	67.02	20.89	2.93	0.67	0.55	0.49
11	0.66	7.25	62.41	24.02	2.80	0.57	0.50	0.56
12	1.74	7.39	63.95	21.42	3.88	0.39	0.73	0.29
13	0.83	6.12	70.86	15.68	4.50	0.45	0.79	0.29
14	1.92	7.66	63.56	21.92	2.83	0.48	0.62	0.28
15	0.74	5.36	84.40	6.79	1.30	0.85	0.27	0.17
16	1.78	8.11	61.31	24.44	2.77	0.57	0.29	0.23
17	0.44	4.75	77.64	12.33	3.10	0.51	0.12	0.54
18	1.23	7.02	65.88	21.19	2.89	0.72	0.15	0.30
19	....	....	....	....	....	....	....	....

No.	RATIONAL ANALYSES: Clay substance (percent)	Free silica	Fluxing impurities	FIRING TESTS
1	61.12	23.28	4.62	At Cone 20 turned light gray and vitrified; no absorption
2	....	....	....	Shrinkage, 2 percent; becomes white, dense, and hard
3	....	....	....	Shrinkage, 4 percent; burns to dense, white body; at Cone 20 turns to gray or white, vitrifies, has no absorption
4	....	....	....	Vitrifies at Cone 20; dense strong gray body
5	....	....	....	Burns to strong white body
6	....	....	....	Vitrifies at Cone 20; dense white body; no absorption
7	....	....	....	
8	13.33	80.45	2.50	Cream or flesh tint; firm, compact body; unfused at Cone 20; hard, gray; no absorption. Fire clay

No.	Rational Analyses (Con't.) Clay substance (percent)	Free silica	Fluxing impurities	Firing Tests (Con't.)
9	56.49	32.46	4.83	Burns to pink tint, which disappears before vitrification, leaving burned clay white or cream colored. Highly refractory; unfused at Cone 20
10	52.95	34.96	4.15	Unfused at Cone 20, but vitrified; no absorption
11	60.87	25.56	3.87	
12	54.28	31.09	5.00	At Cone 20 vitrified but unfused; gray; no absorption. Dries and burns without checking
13	39.74	46.80	5.74	Unfused at Cone 20; gray; no absorption
14	55.55	29.93	0.93	
15	17.21	73.98	2.43	Unfused at Cone 20; vitrified; gray; no absorption
16	61.94	?	3,63	At Cone 20, vitrified but unfused; gray; no absorption
17	31.25	58.72	3.73	At Cone 20, hard and cream colored; absorption, 0.7 percent
18	53.70	33.47	3.76	At Cone 20, vitrified but unfused; dark gray; no absorption
19	....	....	....	Unfused at Cone 19; probably will withstand much higher temperature; fire clay

Sources of samples described in tables

1. Butler Hern farm, 2 miles west of Holly Springs
2. Old Hern farm, 1.5 miles west of Holly Springs
3. Ray farm, 0.5 mile west of Holly Springs
4. Cemetery, Holly Springs
5. Public road, 0.5 mile south of Holly Springs
6. Public road 1 mile south of Holly Springs
7. Grounds of negro school, Holly Springs
8. Frisco station, Holly Springs
9. Outcrop east of Illinois Central station, Holly Springs
10. Near brick yard, Holly Springs
11. Dunlap farm, 4 miles southeast of Holly Springs, near Frisco Railroad
12. Ballard farm, Holly Springs

13. E. T. Fant farm, north of Mahon
14. Home Terr farm, west of Hudsonville
15. Outcrop 2 miles south of Holly Springs
16. Marshall County Poor Farm
17. Railroad cut south of Mahon Station
18. Rand and Norfleet farm, northwest of Holly Springs
19. Jones farm just east of Holly Springs corporation limits

During the last few years the Holly Springs Brick and Tile Company, Incorporated has been the only manufacturer of clay products in Marshall County. The Company operates a large

Figure 39.—Holly Springs Brick and Tile Company plant. March 5, 1954.

plant (Figure 39) on the west side of Highway 7 and along the Frisco Railroad in the northern edge of Holly Springs (NW.¼, Sec.31, T.3 S., R.2 W.) — a plant which for all-around efficiency of plan and operation could well serve as a model for any other brick and tile plant in the country.

For this kind of industry, the location is perhaps as favorable as any that could have been found in the state. It is near immense quantities of excellent ceramic clay — large deposits within a few hundred feet of the plant, and a practically inexhaustible supply within 3 to 4 miles. Besides being alongside the Frisco Railroad and Mississippi Highway 7, the plant is less than half a mile north of U. S. Highway 78, and only a mile west of the Illinois Central Railroad. Its regional location is equally favorable: Within 40 to 45 miles of Memphis, which can be reached easily and quickly via the Frisco Railroad and U. S. Highway 78; on the direct route to Birmingham by the same highway and railroad; in short, not far from the center of a large and well populated region which is showing increasing interest in industrialization.

The organization of the business is excellent. The plan of the plant is such that the entire manufacturing process can be carried through with a minimum of loss of time and motion. The distance traveled by the clay from the pit to the exit of the tunnel kiln is no greater than is absolutely essential, and very little manual handling of raw material or finished product is necessary. Furthermore, not only is waste of time and motion reduced to a minimum, but waste of material as well.

The steps in the manufacturing process, from raw clay to finished product, may be described briefly:[121]

At the pit the clay is scooped up and loaded into dump trucks by a diesel-powered shovel. The trucks haul it to the plant and dump it into a disc-type Gleeson shredder, which can process 3½ to 4 yards of clay in two to three minutes, if the clay is dry. The shredded clay falls onto an inclined conveyor belt and is transported thereon into the cupola at the top of the large storage shed, where it drops onto a similar conveyor mounted on rails. By means of the conveyor in the top of the shed the clay can be distributed on the storage pile in any manner desired. The plan of the storage shed itself reflects the attention given to all details which could contribute to operating efficiency. The metal roof, reaching to within five feet of the ground on both sides, slopes at the angle of repose of the dry shredded clay which it covers.

Inside the shed a Hough Payloader picks up a measured quantity of sand and a scoopload of clay, and dumps the mixed sand and clay into the lower of two hoppers. Ground grog descends from an upper hopper through vibrating feeders onto a Jeffrey apron-feeder, where clay, sand, and grog are blended. The mixture is fed from the apron-feeder into a hammer mill, in which secondary sizing of the clay is effected. The fines and tailings are separated by two Link-Belt vibrating screens fitted with Tyler Ty-rod screening. The clay is carried from the hammer mill to the screens by rubber belt conveyors; the fines are carried to the dustbin, and the tailings are returned to the hammer mill by the same means.

Real brick production begins in the combination pug mill and de-airing brick machine, a Steele No. 50, powered by 100- and 150-horsepower General Electric motors. The finely ground clay is brought from the dustbin to the pug mill by a belt conveyor. Fines from the dustbin are fed to the conveyor, uniformity of feeding being insured by a Steele Even-feeder, which utilizes four counter-rotational cylinders or augers in controlling the gravity flow of the fines. The clay is mixed with water in the pug mill, and descends through the vacuum de-airing chamber.

Cutting the column of extruded clay is done by a Steele cutter. The green brick are carried by a belt conveyor over flat-topped kiln cars, on which they are loaded by hand. Faulty green bricks are returned to the pug mill by the return belt. Loaded cars go into the periodic dryer (new), thence into the tunnel dryer and kiln. They are pushed along through the tunnel dryer and kiln by hydraulic ram power, which can be regulated to any speed. Temperature increases from the entrance of the dryer, and the brick go direct from the dryer into the kiln, where the heat reaches an average of 2,200° Fahrenheit, and may rise to a maximum of 2,400° or more. The tunnel dryer and kiln can accommodate fifty-two kiln cars, each car carrying about 2,090 brick. After burning, the brick are pushed out of the exit of the tunnel as finished product. Finished brick or tile may remain on the cars until ready to load for shipment, or some may be temporarily stored for future delivery.

Instrument control of drying and firing zones in the Harrop Tunnel Kiln aids in maintaining uniformity of appearance and physical properties of the finished product. "Brown" instruments are used for this purpose. Frequent inspection of the finished product insures maintenance of high quality standards.

Batts are crushed by a single-roll crusher, and the grog made thus is ground and screened and carried to the storage hopper, from which it is fed onto a Jeffrey apron-feeder, as already noted.

Since the beginning of operations a new manufacturing unit for six periodic or "beehive" kilns has been added. Production began in March, 1953. The small cars carrying the brick or tile go through the dryer, thence into the beehive kilns, where the ware is unloaded from the cars and re-set in the kiln by hand. Each kiln holds approximately 90,000 brick.

When the plant is running at full capacity its output is about 80,000 brick in an 8-hour day. Figured on a tonnage basis, this is approximately 160 tons — that is, 1000 brick weigh two tons, more or less, and each brick about four pounds.

The notable success and growth of the Holly Springs Brick and Tile Company have been due to wise planning based on a thorough knowledge of all factors involved, and to astute and efficient management of operations. A consistently high-grade product has resulted from use of good raw material, and from direction and control of manufacturing processes in accordance with advanced technology of the industry. The staff members who deserve credit for making the business what it is today are: Mr. K. K. Kight, Vice-President and General Manager; Mr. R. W. Wilks, Plant Superintendent; Mr. B. J. Jones, Assistant Superintendent; Mr. J. C. Dunlap, Bookkeeper and Office Manager; Mr. A. E. Jenkins, Assistant Plant Superintendent; Miss Miriam Lesley, Secretary; and Mr. Hugh Nelson, Shipping Clerk. The total number of employees is 60.

Many prospect holes were bored for the purpose of determining the location of the clay deposits, their stratigraphic positions, their areal extent, their thickness, the thickness and stratigraphic positions of associated sand beds, if any, and other factors which might affect the quantity and quality of available raw material. Most of the prospecting to date has been done in three main areas: 1) In the immediate vicinity of the plant, west of Highway 7 and between Highway 78 and the Frisco Railroad (SW.¼, Sec.30, and NW.¼, Sec.31, T.3 S., R.2 W.); 2) on both sides of the Frisco Railroad some 2 miles northwest of the plant (W.½, NW.¼, Sec.25, and E.½, NE.¼, Sec.26, T.3 S., R.3 W.); 3) south of Highway 78 two miles or more northwest of Holly Springs (through center, Sec.26, T.3 S., R.3 W.). The prospect drilling extended over 113 acres or more in the first area mentioned, 100 acres in the second, and 125 acres in the third. The holes were somewhat irregularly spaced, but were located with the design of obtaining an accurate picture of the clay bodies down to the depth reached by the borings. In the area prospected in the vicinity of the plant a thickness of 21 to 29 feet of clay was found by Holes 1, 2, 3, 4, and 6a, all south of the plant and along an east-west and southeast-northwest line from Highway 7 to a point somewhat less than 200 yards west of the highway. Holes Nos. 7 to 17, southwest and west of the plant found sand only, except for 4 feet of clay in No. 7. Still farther southwest, on both sides of Highway 78 for some distance, white clay crops out. No information is available on seventeen additional holes scattered over the area, all except four of them northwest of the plant. Holes Nos. 1 to 17 ranged in depth from 5 to 32 feet.

In the second general area of prospecting, along the Frisco Railroad two miles northwest of the plant, forty-two holes were bored, ranging in depth from 8 feet to 35. The holes were arranged in north-south lines and roughly checker-boarded. In general the main clay body was found just south of the railroad, in the southeastern part of the area, where thicknesses of 35, 29, 27, 21, and 1.7 feet of clay were penetrated by the auger. Many of the holes were still in clay at their total depth.

The third area prospected was said to be underlain by the thickest and most nearly uniform deposit of clay discovered in the region. No detailed information is available, but it is reported that almost all holes found good clay, and many of them were in clay their entire depth, 30 to 35 feet or more.

It appears, then, from the results of prospect drilling, that in the three areas referred to above, the bodies of clay are very irregular, grading into sand laterally and vertically, or wedging into sand laterally; that no one stratum maintains a uniform thickness for any considerable distance, and that over-burden ranges from nothing to 20 to 25 feet.

IRON ORE

The Wilcox formations of Marshall County contain a considerable quantity of iron carbonate and iron oxide, most of which is sufficiently high in metallic iron to rate as ore. In the sections of this paper which relate to stratigraphy, the iron ore has been referred to in connection with descriptions of several outcrops. At all the places mentioned, it is in the form of concretions of various shapes and sizes, lying along the bedding planes of the enclosing strata, in such positions as to appear on the outcrop as broken beds. The commonest shapes of the concretions are ellipsoidal, discoidal, pillow-shaped, or roughly spherical, but all sorts of irregular shapes exist, and the ratios of length, breadth, and thickness vary widely. The length and breadth of individual concretions may range from less than an inch to several feet, the thickness from less than an inch to 2 to 3 feet, and the weight from less than a pound to several tons. Unless the concretion has been moved subsequent to its origin, it has its longest axis parallel to the bedding of the enclosing strata. The broken beds composed of these aggregates of concretions may be persistent for long distances, or they may be only a few rods or yards long—in fact, here and there a concretionary mass appears to be unassociated with others. Furthermore, the rough layers of iron ore "boulders" follow closely the structure of the terrane which holds them, and thus may show various degrees of dip; where the containing beds are literally churned up, the ferruginous concretions have little if any pattern of arrangement, as if they had been dislodged from their original places and rolled around by swift currents.

A few solid beds of ore, most of them short but some of considerable length, have been found. The greatest thickness observed was 2.5 feet. The present survey did not find any solid bed of ore in Marshall County.

As has been stated, all the ore is siderite ($FeCO_3$) and limonite ($2Fe_2O_3.3H_2O$) or hematite (Fe_2O_3). Both the carbonate and the oxide are present almost everywhere the ore crops out, and mining has shown that they are associated underground, also. This association is not accidental; conclusive evidence exists that most of the ore was originally carbonate, and that the greater part of the oxide ore originated from oxidation of the carbonate. Where oxidation is complete, as of iron minerals which have been long exposed to the atmosphere, no carbonate remains; but almost invariably iron ore freshly exposed is carbonate, or carbonate enclosed in a shell of oxide, and all gradations from carbonate to oxide can be found.

The principal outcrops of iron ore in Marshall County are herein located and briefly described:

Parts of at least two or three layers of ore are exposed by cuts along the Cornersville-Bethlehem road. The farthest southeast of the outcrops referred to (NW.¼, Sec.25, T.6 S., R.1 W.) shows very irregular bedding containing many concretionary masses of iron ore, some of which lie along steeply dipping planes. Maximum thickness of the concretions is about a foot. One mass measured 3 feet in length, 2 feet in width, and 1 foot in thickness. Two main layers were identified. In the west wall of the valley a 10-inch layer of ore crops out near the top, and two or three thinner layers, one 0.5-foot thick, toward the base of the eastern slope, in gray and greenish-gray clay. A cut through the upper part of the next ridge, a quarter of a mile or less farther west, exposes sections of two intervals of ore in gray and lignitic clay. Some ore masses are more than a foot thick, but the bedding is very irregular. Another road cut (NW.Cor., Sec.22, T.6 S., R.1 W.) shows large concretions of ore, one at least a yard long and a foot thick, in light-gray sandy clay shale. Other outcrops are a quarter of a mile and 0.45 mile farther northwest, in hill slopes. All the ore of the outcrops mentioned is believed to belong to the Fearn Springs formation.

Probably the largest visible aggregate of iron ore in Marshall County is in the region west of Bethlehem, between the Bethlehem-Potts Camp road (Highway 349) and the flood plain of Tippah River (Secs.7, 8, 17, 18, T.6 S., R.1 W., and 12, 13, T.6 S., R.2 W.). And the greatest visible concentration in this restricted area is in the upper end of the small southward trending valley (Western half, Sec.8, T.6 S., R.1 W.) a quarter of a mile west of the highway. Numerous huge concretionary masses of ore have been exposed by the two head forks of the small stream and by a ravine on the north side of the road. Individual concretions, most of which are of somewhat irregular shape although bounded by curved surfaces, may be several feet long and 2 feet or more in diameter (Figure 40). In the channel of the east fork the discrete ore bodies condition small waterfalls, and in places are so close together that they form a solid stone floor. All the ore appears to be embedded in sandy silt or silty sand, above the shaly beds and below white and bluish-white and lignitic clay. It is believed to be in the upper part of the Fearn Springs formation.

Concretions and fragments of ore make an almost unbroken train on the surface along the roads west of the valley, and are conspicuous at the junction (SE.¼, Sec.7, T.6 S., R.1 W.). Also, in the southeast quarter of Section 12, Township 6 South, Range

2 West, ore masses and debris are scattered along the road and in the channel of a small branch of Tippah River. Slopes, ravines, and road cuts north and south of the Bethlehem-Tippah River

Figure 40.—Concretion of iron ore (NW.¼, SW.¼, Sec.8, T.6 S., R.1 W.) in the west wall of a creek channel 100 yards or more north of a road and about 0.3 mile west of Bethlehem. April 2, 1953.

road have exposed ore in many places, too. Northwest along the road referred to, some ore 15 inches thick, in gray clay, may be seen just below the Ackerman-Meridian contact in the west wall of the river valley; and some 2 miles farther northwest, in the east wall of the valley of Big Spring Creek, ore concretions show in outcrops of gray clay.

The farthest southwest surface iron ore in the county, except for scattered "boulders" and fragments, is in the north wall of Tallahatchie River Valley, a mile north of the mouth of Big Spring Creek, where ravines (NW.Cor., Sec.19, and SW.Cor., Sec.18, T.6 S., R.2 W.) have exposed two, perhaps three, intervals of silty iron oxide concretions, the uppermost of which is about 15 feet below the Ackerman-Meridian contact. These layers can be traced, by ore in place and debris here and there, along the slope east and northeast for more than half a mile. Two beds of concretions which may be correlative with those mentioned above, are exposed in the same slope along a farm road (SE.¼, Sec.18, T.6 S., R.2 W.) where the formation contact is 29 feet above the flat.

Iron ore crops out here and there in the west wall of the valley of Tippah River. A little south of the road junction (on the line between Sec.36, T.5 S., R.2 W. and Sec.1, T.6 S., R.2 W.) a large mass of ore is lying in a field, suggesting the presence of much more in the vicinity.

On the outside (northwest wall) of the big bend in Tippah River Valley a mile southwest of Highway 78 bridge over the Frisco Railroad, at the southeast end of an artificial lake, large concretions of iron ore from two layers are exposed in the north wall of a road cut (Northern part, Sec.7, T.5 S., R.1 W.), and others are lying alongside the road. The concretions are a foot or more in diameter. Probably these layers are part of the series which crops out along Highway 78 a mile or so to the northeast.

No large aggregates of surface ore were found east and south of Tippah River except in the region west of Bethlehem, as already described, although small outcrops were noted in a few places: 1) Along the road which leads northeast from an intersection (NW.¼, Sec.8, T.6 S., R.1 W.) across Potts Creek Valley and into Benton County; 2) at the large outcrop (NW.¼, Sec.4, T.6 S., R.1 W.) a short distance east of the bridge over Potts Creek; 3) in the north wall of the valley of Potts Creek (NE.¼ and NW.¼, Sec.32, T.5 S., R.1 W.); 4) half a mile, more or less, southwest of the railroad at Potts Camp, and 10 feet above the flood plain of Oaklimeter Creek, in a road and the walls of a cut (SE.¼, Sec.17, T.5 S., R.1 W.); 5) in the small part of the county north of Potts Camp and south of Tippah River. The fourth outcrop mentioned shows a layer of concretions 1.0 foot to 1.5 feet thick.

The broken chains of iron ore masses are exposed almost uninterruptedly in the walls of Highway 78 cuts from Tippah River Valley to a quarter of a mile or more northwest of the bridge over the Frisco Railroad and Chewalla Creek. Two layers, some 3 feet apart, and each consisting of concretions a foot or more thick, crop out about 10 feet below the top of the northeast face of the cut at the junction (NE.Cor., Sec.8, T.5 S., R.1 W.). The same layers show a few yards farther northeast in the steep slope along a road which leads north from the junction, and the lower of the two is visible in the south wall of the highway cut, almost at the top. The southwest corner of the territory east of Chewalla Creek and north of Tippah River — the narrow strip of highland between Highway 78 and the river valley east of the railroad — contains a relatively large quantity of ore, if the float ore scattered over the slopes is a reliable index to the subsurface material. Farther northwest along the highway, also, many masses of oxide ore are involved in the irregular bedding. A quarter of a mile, more or less, northwest of the bridge over the railroad and Chewalla Creek, a highway cut exposes very irregularly bedded sand, silt, and clay, and prominent beds of iron ore. Two main layers and six shorter layers are in bold relief, all dipping strongly westward or northwestward, but no two at the same angle (Figure 7). The ore can be traced northeast along the west wall of Chewalla Creek Valley for a mile or more. Along a farm road up the valley wall less than half a mile north of the highway, six ore levels can be identified.

From the junction (NE.Cor., Sec.8, T.5 S., R.1 W.) on Highway 78, a road extends east along the foot of the north wall of the valley of Tippah River, into Benton County. Iron ore crops out on the north side of this road for a distance of 3.5 to 4.0 miles, but only 1.5 miles of this distance are in Marshall County. In Benton County, approximately 0.8 mile east from the county line, a prominent tabular bed of ore juts out from the wall of a cut, and can be traced along the wall 250 feet. The exposed part of one slab measured 7 to 8 feet long, 5 feet wide, and 15 to 16 inches thick. Probably two thick beds are present, but the question, whether or not two are present could not be answered, because of slumping of the ore over the underlying clay. Some 0.3-mile to 0.4 mile farther west, a higher bed, 0.5 foot thick, crops out. The low ridge along here is strewn with ore debris to a considerable height, a condition which possibly indicates additional beds of ore at a higher level. Less than a quarter of a mile farther west, a still higher layer, about 10 inches thick, is exposed, and is visible at another place 260 yards farther west. In Marshall County, half a mile west of the Benton County line, and some 200 yards east of a farm house, roughly spherical or ellipsoidal masses of ore up to 1.3 to 1.5 feet in diameter are embedded in clay at the roadside, and half a mile farther west are similar masses. In the road a few yards east of the highway a thin bed of pure iron carbonate is at the surface, and in the walls of the highway cut, slightly above the pavement, a bed of carbonate and oxide several inches thick is exposed at a place or two.

As indicated in the foregoing paragraph, at least six separate intervals of iron ore are present in the Ackerman strata along the east-west road referred to, and two others crop out at higher levels north of the road.

The earliest use of the iron ores of Mississippi for industrial purposes was in 1909-1911, and the first ore used was from the Marshall County region northwest of Potts Camp. During the winter of 1909-1910 some Birmingham men prospected in the vicinity of Potts Camp, and by the summer of 1911 a Birmingham company, later the Memphis Mining and Manufacturing Company, Mr. W. S. Allen, Vice-President, had taken options and mineral rights and erected a tipple at the point of the hill[122] which is now a little south of the Highway 78 junction (NE.Cor., Sec.8, T.5 S., R.1 W.). "A switch was run out from the railroad to the point of the hill . . . and twenty-five carloads of the loose ore was picked up from the surface and reported to have been shipped to Birmingham by the Allen Brothers during 1911. The ore came from the point of the hill nearest the railroad . . ."[123]

Dr. E. N. Lowe, State Geologist at that time, made an examination of the ore deposits north of Tippah River in the summer of 1911, and a more thorough examination in the spring of 1912 and at later dates.[124] His findings are summarized herein, insofar as they relate to Marshall County ores.

On the C. H. Reid property,[125] where the surface ore which was shipped in 1911 was picked up, loose ore is abundant, and prospect holes found, under 2 to 4 feet of loose earth, a bed of oxide ore 14 inches thick, lying on gray clay. That the ore is of good quality is indicated by the analysis record:

OXIDE ORE FROM REID PROPERTY, POTTS CAMP.

	Percent
Fe	53.64
Al	1.45
Mn	8.00
S	0.53
P	0.075
CO_2	0.87
SiO_2	5.34
O and H_2O	20.91
Insoluble	9.18.

On the Reid property a few hundred yards northwest of the prospect holes, well down on the north slope of the same ridge, an ore bed 12 to 14 inches thick crops out. It appears to be brown oxide, but probably is carbonate some distance back from the outcrop.

On the H. J. Gurley property,[126] which adjoins the Reid property on the north, brown oxide ore is strewn thickly over the greater part of the crest and upper slopes of the ridge from the Reid property to the Gurley residence, about a mile. The pieces of ore range in size from that of a walnut to masses of a thousand pounds weight or more. The loose ore apparently came from the same bed as the Reid property ore that was analyzed, which bed crops out in several places on top of the ridge on the Gurley farm. The greatest aggregate of large blocks of oxide ore is up the slope from some tenant houses (Sec.4, T.5 S., R.1 W.). A mile or so northwest of the Gurley home, three beds of excellent carbonate ore crop out on both sides of a small branch, all dipping south to southeast. The uppermost layer is 6 inches thick, the middle one 8 inches, and the lowermost 20 inches, but the 8-inch bed appears to be very limited in extent. The 20-inch bed, "solid light gray carbonate with a thin incrustation of brown oxide," appears to underlie the whole territory, but at a considerable depth at most places. The analysis report on a sample from this bed is:

CARBONATE ORE FROM GURLEY PLACE, POTTS CAMP

	Percent
Fe (About 67.0 calcined)	45.32
Al	1.22
Mn	3.90
S	0.01
P	0.045
CO_2	33.06
SiO_2	3.65
O and H_2O (in carbonate and hydrated oxides)	11.56
Insoluble	1.24.

Outcrops indicate that at least four beds of ore are present, above drainage, in the region north and northwest of Potts Camp, east of Chewalla Creek and north of Tippah River. It was reported that other beds were struck by wells and a prospect hole or two in the edge of Tippah River flood plain.[127]

Dr. Lowe believed that some of the Mississippi carbonate ores are of sedimentary (mechanical) origin, but that most of them are of chemical origin, "their accumulation and deposition being due to segregation and concretionary forces."[128] He expressed the opinion that in general the oxide ores originated by oxidation of the carbonate by surface exposure.[129] His explanation of the formation of bog limonite ($2Fe_2O_3.3H_2O$) and siderite (iron carbonate, $FeCO_3$) may be summarized:[130]

Atmospheric water, after it becomes surface water, absorbs oxygen and carbon dioxide from the atmosphere. As the water sinks through the rock material, its oxygen and carbon dioxide attack the iron which is almost everywhere present in the rocks in the form of ferric oxide. Although ferric oxide is insoluble in pure water, it gives up part of its oxygen to decaying plant debris, thus being reduced to the soluble ferrous oxide (FeO), which is carried in solution by the subsurface water to a point of emergence in a swampy area. In contact with the atmosphere it takes up more oxygen and is converted again to the ferric oxide, which solidifies to bog iron ore. The iron that remains in the ferrous state impregnates the silts and clays of the swamp floor, imparting a bluish color to them.

The change from ferric to ferrous oxide in the presence of CO_2 from decaying plant material results in many places in the formation of iron carbonate through the combination of CO_2 with FeO in the same solution. If the decaying vegetable matter is more than enough to de-oxidize the ferric oxide, carbonate of iron is deposited. Some beds, such as the Black Band ore of Ohio, were formed in the same geological age as the associated coal beds. The Mississippi concretionary deposits, however, although probably formed for the most part during the same geological time as the associated strata, could have been formed independently of the associated clays, silts, and lignites, and long after their deposition. The iron-bearing waters apparently traveled along open passageways or through pervious material, especially along stratification planes and joints, and dropped their iron as carbonate. Just why it took the form of concretions can not be answered correctly unless and until we understand better the laws of concretion and segregation.

Applying the general explanation of the origin of limonite and carbonate iron ores, summarized in the two last paragraphs, to the Mississippi ores, Dr. Lowe states:[131]

"It is probable that the deposition took place during Eocene times, but after the iron-bearing beds were laid down. The process was something like the following: During early Wilcox times much of the land of the present Wilcox area, together with much not now exposed, was low and constituted peat swamps in which at times pure peat was deposited, at other times the same area received less of the vegetable accumulations with the addition of considerable quantities of fine mechanical sediments, principally clay, silt, and fine sand. The result of these alternating conditions is alternating bodies of lignite and lignitic clays and sandy clays.

"The surrounding lands which furnished these sediments to the peat swamps contained more or less iron disseminated as a cement. The fineness of the sediments would suggest that the lands were low and that weathering of the surface resulted in the complete oxidation and solution of the materials. The iron was brought into the swamps in solution as the protoxide most probably. As a protoxide solution it impregnated the clay beds as they came to rest in the low swamp areas. The same beds received from the swamp solutions containing products of vegetable decay and the conversion of the protoxide to the carbonate of iron took place while the depositional process was still going on. It is probable that the segregation of the iron in concretionary masses and beds was synchronous with the conversion of the protoxide to the carbonate; or the carbonate in solution might have been slowly deposited from a concentrated solution by a gradual loss of water with the uplift of the region into higher and drier land, or with the building up of the low areas and simultaneous lowering of the general surface drainage, or by a combination of these conditions."

Inasmuch as relatively little prospecting of the iron ore of Marshall County has been done, and such prospecting as has been done has been restricted to the surface, any estimate of the quantity of ore which can be mined profitably can be little better than a guess. Dr. Lowe avoided making any definite tonnage estimate of the ore in Marshall and Benton Counties, because of insufficient prospecting; he would not go beyond the general statement ". . . We are safe in saying that it runs into the millions of tons."[132] Some such general statement is about as definite as can truthfully be made concerning the ore of Marshall County alone. The area within which the ore is at or relatively near the surface is only a fraction of the south-eastern one-sixth of the county. In this area most of the ore beds are not far above the valley bottoms, and several are near the crests of the ridges. If "mineable ore" is defined, physical factors only being considered, as ore which is of 2 to 3 feet aggregate thickness under not more than 25 feet of overburden, then the workable terrane is relatively extensive and the quantity recoverable probably not less than 10,000,000 long tons, possibly much greater. From the analyses referred to herein, and many others, the quality of the ore is proved to be uniformly good. Conditions for strip mining are favorable in general, also: The ore territory is hilly, but the topographic relief is not great; slopes are gentle almost everywhere, allowing underlying beds to be worked for considerable distances back from the surface before the line of prohibitive overburden is reached; in places the surface is level and the ore only a few feet beneath it; at the greater number of places where iron ore crops out, at least two beds are present, and at a few localities, three or four; the overburden is almost entirely unconsolidated sand, silt, and clay, easily removable; much of the ore country is not of agricultural value; the moderate to low gradients of the streams would prevent large scale washing of the loosened earth onto the cultivated bottom lands.

The most advantageous locations in the county for initiating mining ventures are: 1) The Potts Camp area, at the south end of the highlands between the valleys of Tippah River and Chewalla Creek, where ore was collected and shipped in 1911; 2) the small valley just west of Bethlehem; 3) somewhere along the Bethlehem-Cornersville road; 4) near the junction a mile or so west of Bethlehem, or along the road which leads southwest from the junction. The advantages of the first location suggested are obvious — nearness to a railroad and a main highway, and to a considerable deposit of high-grade ore. The second locality named is believed to be on a large body of ore, and is not more than a quarter of a mile from Highway 349, a good graveled road. The third and fourth localities are believed to be near large quantities of ore, and both are on good gravel roads.

GRAVEL, SAND, SANDSTONE AND OTHER ROCK

The gravel of Marshall County is restricted to the Citronelle formation, except for a little small gravel scattered through the coarse sand of other formations. The distribution of the Citronelle is described under "Stratigraphy," and the outcrop area is indicated on the map (Plate 1). It has been mentioned that pits have been dug in the gravel here and there, notably in the vicinity of Byhalia (Figure 38). Large quantities of gravel have been taken out for use as road metal, and probably for other purposes on a small scale. No screen analysis of Marshall County gravel is available, but analyses of two samples from Tate County gave the results tabulated below:[133]

SAMPLE OF SAND-CLAY GRAVEL FROM PIT NEAR SARAH; EXAMINED FOR USE ON GRAVEL ROAD.

Fraction (gravel)					Percent
Passing 3-inch,	retained	on	1½-inch	screen	5.3
" 1½-inch,	"	"	1-inch	"	16.2
" 1-inch,	"	"	¾-inch	"	4.3
" ¾-inch,	"	"	½-inch	"	14.1
" ½-inch,	"	"	¼-inch	"	16.1
" ¼-inch,					44.0
Total					100.0

The sample consisted "essentially of rounded and subangular fragments of chert and quartz with a considerable amount of quartz sand and ferruginous clay."

SAMPLE OF CHERT GRAVEL FROM PIT AT BUXTON; EXAMINED FOR USE ON GRAVEL ROAD.

Fraction (gravel)					Percent
Passing 2-inch,	retained	on	1½-inch	screen	10.3
" 1½-inch,	"	"	1-inch	"	11.7
" 1-inch,	"	"	¾-inch	"	9.7
" ¾-inch,	"	"	½-inch	"	11.4
" ½-inch,	"	"	¼-inch	"	11.2
" ¼-inch,					45.7
Total					100.0

The sample consisted "essentially of subangular fragments of partly weathered chert with a considerable amount of angular quartz sand and some little ferruginous clay."

The mechanical anlayses of which the results are tabulated in the foregoing paragraphs were made by the Department of

Engineering of Mississippi Agricultural and Mechanical College[134] (now Mississippi State College). The samples were taken from the Citronelle gravel, and were exactly like gravel from the Citronelle of Marshall County.

Possibly Marshall County has a more extensive surface area of sand than has any other county of the state. Sand is literally everywhere, and of course sand suitable for all its commoner uses, such as building and paving, is abundant. Lowe states, referring to the Holly Springs formation (now considered Meridian chiefly): "The sand of this formation furnishes excellent building material along most of the outcrop, the coarse sand especially being admirably adapted to the making of mortar and concrete. In some localities the sand is useful in road making. In many places where it contains a proper admixture of clay and iron it makes an excellent molding sand."[135] No sand which would be suitable for the manufacture of high-grade glass was found; too much iron oxide, carbonaceous matter, clay, and mica is present. Perhaps some of the sand could be used in making green or amber glass of low grade. However, no sand can properly be classed as a glass sand unless it contains at least 95 percent silica.[136]

It can be said, then, that of the three classes of sand recognized on the basis of industrial uses: 1) Structural sand, 2) Molding sand; and 3) Glass sand,[137] the first and second classes are present in Marshall County. In fact, where the quantity of sand is so great, much of the sand would almost certainly be included in the first two classes, because in several industries which use sand, specifications commonly are not very rigid, but are adjusted to fit supplies of sand available in the locality concerned.[138] This is particularly true of structural sand.

The only large-scale use made of the sand of Marshall County has been for road metal or as a component of a mix to be used for road pavement. Pits have been dug in taking out sand in almost all parts of the county. The largest of them have been mentioned in other sections of this report. Perhaps the most prominent is at the junction (SE.¼, Sec.29, T.5 S., R.1 W.) of Highway 349 with a local road some 2 miles south of Potts Camp (Figure 10). Records of analyses and tests of Marshall County sands follow:

GRANULARMETRIC ANALYSIS OF HOLLY SPRINGS SAND[139] (SAMPLE FROM EXPOSURE 0.5 MILE EAST OF HOLLY SPRINGS)

			Percent
1. Amount retained on 16-mesh sieve,	00.5;	passed	99.5
2. " " " 20-mesh sieve,	1.5	"	98.0
3. " " " 40-mesh sieve,	75.0	"	23.0
4. " " " 60-mesh sieve,	17.0	"	6.0
5. " " " 80-mesh sieve,	2.5	"	3.5
6. " " " 100-mesh sieve,	0.1	"	3.4

Percentage of voids, 39
Weight per cubic foot, 95 lbs.
Specific gravity, 1.52
Tensile strength of 1 to 3 mixture of standard cement, after 90 days, is 298 lbs.

TESTS ON SAMPLE SAND FROM NEAR HOLLY SPRINGS[140]
TENSILE STRENGTH-POUNDS PER SQUARE INCH, 7 DAYS

Ottawa sand	Holly Springs sand
260	280
265	300
280	270

The sample consisted essentially of angular fragments of quartz and feldspar, coated with iron oxide. The results of the 7-day strength test indicated that the sand was suitable for use in concrete road construction.

Sandstone is scattered thinly through the sands of the county, and is aggregated in a relatively few places which have been mentioned in the description of the stratigraphy. Almost all the sandstone is ferruginous, formed by the cementation of iron oxide-coated quartz grains by iron oxide precipitated from solution in percolating water. The greater part of it is colluvial, but as stated, considerable aggregates of large masses cap high hills and ridges. The largest accumulations seen are a little west and northwest of Holly Springs, especially in the uppermost part of the hill south of the road junction (NW.¼, Sec.1, T.4 S., R.3 W.), and in the ridge between old and new Highways 78 (NW.¼, Sec. 36, SW.¼, Sec.25, T.3 S., R.3 W.). Huge irregular and roughly tabular masses are lying on the surface or projecting from the slopes. Other prominent aggregates top the "mountains" here and there, notably the mountain (Eastern part, Sec.11, and western part, Sec.12, T.4 S., R.2 W.) near a road junction 1.5 miles southeast of Higdon, and the high point on which Scales Forest Tower stands (NW.¼, Sec.33, T.3 S., R.1 W.) in the extreme eastern part of the county.

The properties of a sample of ferruginous sandstone from Marshall County, as determined by the Department of Engineering of Mississippi A. & M. College many years ago, are indicated in the record quoted below:

REPORT ON SAMPLE FROM HOLLY SPRINGS, MARSHALL COUNTY, MISSISSIPPI[141]
MATERIAL: FERRUGINOUS SANDSTONE

Determinations:

Weight per cubic foot (lbs.)	181.00
Absorption per cubic foot	1.72
Percent of wear	28.10
French coefficient of wear	1.40
Hardness	15.40
Toughness	3.00
Cementing value	27.00.

The sandstone has been used locally for building of foundations, chimneys, retaining walls, walks, well curbs, fireplaces, and like structures, and even for the chief construction material of entire houses. At Chewalla Farms and at Spring Lake State Park it has been used extensively. Also it has been used on a small scale as road material. It is far from an ideal building stone, because of irregularity of surface and shape and lack of uniformity of cementation; but much of it is blocky, perhaps would not require much shaping; it is very durable, and its color fits in well with the landscape in a region of brown, red, and yellow sand. However, the quantity is relatively small, and much of the rock is not readily accessible. Besides, there would seem to be little point in using such natural rock for building, when brick of quality and appearance equal to any in the country is being manufactured on a large scale in Holly Springs.

Buildings at Spring Lake State Park (Secs.1, 11, 12, 13, T.5 S., R.3 W.) are excellent examples of what can be done with the natural rock of the county. The very handsome and substantial structures on the park grounds were built by the Civilian Conservation Corps in the 1930's. The C C C boys quarried the ferruginous sandstone from the "mountains" north and east of Spring Lake, hammered and chiseled the pieces into building blocks, transported them to the park, and constructed the buildings (Figure 41). Some of the rock of which the lodge was built was brought from Tishomingo County, but the other rock buildings on the grounds were built of Marshall County rock, or

Figure 41.—Superintendent's home and office, Highway 7 entrance to Spring Lake State Park. Built of local sandstone. February 5, 1954.

Figure 42.—Masses of silty iron oxide ore (NW.cor., SE.¼, Sec.6, T.4 S., R.1 W.) near the base of the Tallahatta formation a mile east by south of Chewalla Farms. June 19, 1952.

possibly partly of the same kind of rock from eastern Benton County. The interior stone of the lodge appears to be Tishomingo County sandstone.

Not only several buildings, but walks, walls, borders for flower beds, and other structures at the park are of this rock.[142]

Silty limonite or limonitic silt, mentioned in several places in the description of the stratigraphy, is of no economic value, although it has been used locally as road metal. It is most abundant in the Tallahatta formation. Unusually large masses of it are conspicuous near the base of the Tallahatta a little below the top of the outcrop east of Chewalla Farms (Figure 42).

Conglomerate formed by the cementation of Citronelle gravel has been used on farms here and there in the western part of the county for the same purposes served by the sandstone.

ACKNOWLEDGMENTS

The writer of the report on the geology of Marshall County hereby expresses his appreciation for assistance from many citizens of the county, who gave him information about geological features and other places of interest. Special mention should be made of Mr. Harris Gholson, President, Bank of Holly Springs, who emphasized the importance of a geological survey of the county; Mr. E. C. Rogers, Superintendent of the Holly Springs water plant, who provided data relating to the water supply of the town; and the staff of the Holly Springs Brick and Tile Company, who gave the writer full information concerning the results of the company's prospecting for clay, and also concerning the processes in the manufacture of brick and tile.

The State Geologist and others of the staff of the Mississippi State Geological Survey assisted greatly in the preparation of the manuscript for the printer and in editing the proofs. Also, several geologists, to whom credit is given in the list of references, contributed indirectly, through their writings, to the present report.

The writer wishes also to publish here an expression of his sincere appreciation for the very considerable help given him in the field by the late Mr. Fred Cullen Smith, Assistant Geologist of the Survey, and by Mr. Haskell R. Turner and Mr. Clyde O. Hurlburt, student assistants.

REFERENCES

1. Rowland, Dunbar, History of Mississippi, the Heart of the South: Vol. II, p. 788. The S. J. Clarke Publishing Company, Chicago-Jackson, 1925.
2. Topographic quadrangle maps, Byhalia, Holly Springs, Tyro, and Potts Camp: Corps of Engineers, U. S. Army; U. S. Coast and Geodetic Survey; Mississippi River Commission, 1948, 1953.
3. Rowland, Dunbar, Op. cit., Vol. II, pp. 787-88.
4. U. S. Department of Commerce, Bureau of the Census: 1950 Census of Population Advance Reports, Series PC-8, No. 23, September 27, 1951, pp. 3, 4.
5. U. S. Department of Commerce, Bureau of the Census: Op. cit. (1950 Census), p. 1.
6. U. S. Department of Commerce, Bureau of the Census: Op. cit. (1950 Census), pp. 3, 4, 5.
7. Rowland, Dunbar, Op. cit., Vol. II, p. 788.
8. The South Reporter, Holly Springs, March 19, 1953, p. 1.
9. U. S. Department of Commerce, Bureau of the Census: Op. cit. (1950 Census), p.3.
10. U. S. Department of Commerce, Bureau of the Census: Op. cit. (1950 Census), p. 5.
11. Jones and Whittlesey, An Introduction to Economic Geography: Vol. I, Natural Environment as Related to Economic Life, pp. 142-45. The University of Chicago Press, 1925.
12. Goodman, A. L., and Jones, E. M., Soil Survey of Lafayette County, Mississippi, pp. 7, 8. U. S. Department of Agriculture Bureau of Soils. Government Printing Office, 1914.
13. Lowe, E. N., Mississippi, Its Geology, Geography, Soil and Mineral Resources: Mississippi State Geol. Survey Bull. No. 14, pp. 32, 209. 1919.
14. Shaw, Eugene Wesley, The Pliocene History of Northern and Central Mississippi: U. S. Geol. Survey Prof. Paper 108, pp. 149, 150, 151.
15. Topographic quadrangle maps, Holly Springs, Potts Camp, Tyro, and Byhalia: Corps of Engineers, U. S. Army; U. S. Coast and Geodetic Survey; Mississippi River Commission, 1948, 1953.
16. Thomas, Emil Paul, The Claiborne: Mississippi State Geol. Survey Bull. 48, p. 13. 1942. See also other bulletins of the Mississippi State Geological Survey, particularly Bulls. 38, 41, 51, 52, 67, 71, 75, and 76.
17. Thomas, Emil Paul, Op. cit., pp. 86-87; also Priddy, Richard Randall, Tallahatchie County Mineral Resources: Mississippi State Geol. Survey Bull. 50, p. 17. 1942.

18. Turner, James, Yalobusha County Geology: Mississippi State Geol. Survey Bull. 76, pp. 17, 21-22, 26-28, 35-36. 1952.

19. Attaya, James Samuel, Lafayette County Geology: Mississippi State Geol. Survey Bull. 71, p. 35. 1951.

20. Attaya, James Samuel, Op. cit., p. 36.

20a. Lowe, E. N., Preliminary Report on Iron Ores of Mississippi: Mississippi State Geol. Survey Bull. No. 10, pp. 23, 24. 1913.

20b. Attaya, James Samuel, Lafayette County Geology: Mississippi State Geol. Survey Bull. 71, p. 47 and Letter of Transmittal. 1951.

21. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Union County Mineral Resources: Mississippi State Geol. Survey Bull. 45, Plate 1. 1942.

22. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., p. 18.

23. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., The Ground-Water Resources of Mississippi: U. S. Geol. Survey Water-Supply Paper 576, p. 331. U. S. Government Printing Office, Washington, 1928.

24. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., p. 330.

25. Dixie Geological Service, Vol. I, No. 2, p. 3, May 1, 1941, and Vol. I., No. 8, p. 3, June 12, 1941.

26. Brown, Glen Francis (?), Notes on Marshall County Geology.

27. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., pp. 46, 47, and Plate 1.

28. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., p. 54.

29. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., p. 54.

30. Brown, Glen Francis, Geology and Artesian Water of the Alluvial Plain in Northwestern Mississippi: Mississippi State Geol. Survey Bull. 65, p. 38. 1947.

31. Thomas, Emil Paul, The Claiborne: Mississippi State Geol. Survey Bull. 48, pp. 24, 25. 1942.

32. Thomas, Emil Paul, Op. cit., p. 26.

33. Thomas, Emil Paul, Op. cit., p. 23.

34. Brown, Glen Francis, Op. cit., p. 39.

35. Brown, Glen Francis, Op. cit., p. 40.

36. Attaya, James Samuel, Lafayette County Geology: Mississippi State Geol. Survey Bull. 71, p. 35.

37. Shaw, Eugene Wesley, The Pliocene History of Northern and Central Mississippi: U. S. Geol. Survey Prof. Paper 108, pp. 134, 138, 139.

38. Shaw, Eugene Wesley, Op. cit., pp. 142-145.

39. Shaw, Eugene Wesley, Op. cit., p. 135.

40. Mellen, Frederic Francis, and McCutcheon, Thomas Edwin, Yazoo County Mineral Resources: Mississippi State Geol. Survey Bull. 39, pp. 55, 109.

41. Shaw, Eugene Wesley, Op. cit., pp. 139, 140.

42. Lowe, E. N., Coastal Plain Stratigraphy of Mississippi, Midway and Wilcox Groups: Mississippi State Geol. Survey Bull. No. 25, pp. 9, 25, 37, 72.

43. Attaya, James Samuel, Op. cit., pp. 43, 44.

44. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Union County Mineral Resources: Mississippi State Geol. Survey Bull. 45, p. 50.

45. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., p. 47.

46. Idem, p. 47.

47. Conant, Louis Cowles, and McCutcheon, Thomas Edwin, Op. cit., p. 45.

48. Holly Springs Quadrangle map.

49. Potts Camp Quadrangle map.

50. Potts Camp Quadrangle map.

51. Byhalia Quadrangle map.

52. Steffey, Robert L., Special Scout Service: Log of Thomas B. Slick's Huffman No. 1 well.

53. Steffey, Robert L., Special Scout Service: Log of Thomas B. Slick's Huffman No. 2 well.

54. Steffey, Robert L., Special Scout Service: Log of Thomas B. Slick's Forte No. 1 well.

55. Brown, Glen Francis (?) Notes

56. Dixie Geological Service, Vol. I, No. 8, June 12, 1941, p. 3.

57. Brown, Glen Francis (?) Notes

58. Brown, Glen Francis (?) Notes

59. Dixie Geological Service, Vol. I, No. 8, June 12, 1941, p. 3.

60. Brown, Glen Francis (?) Notes

61. Grim, Ralph Early, The Eocene Sediments of Mississippi: Mississippi State Geol. Survey Bull. 30, pp. 48, 119-20. 1936.

62. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., The Ground-Water Resources of Mississippi: U. S. Geol. Survey Water-Supply Paper 576, p. 330.

63. Brown, Glen Francis (?) Notes

64. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., p. 331.

65. Steffey, Robert L., Special Scout Service, November 30, 1940.

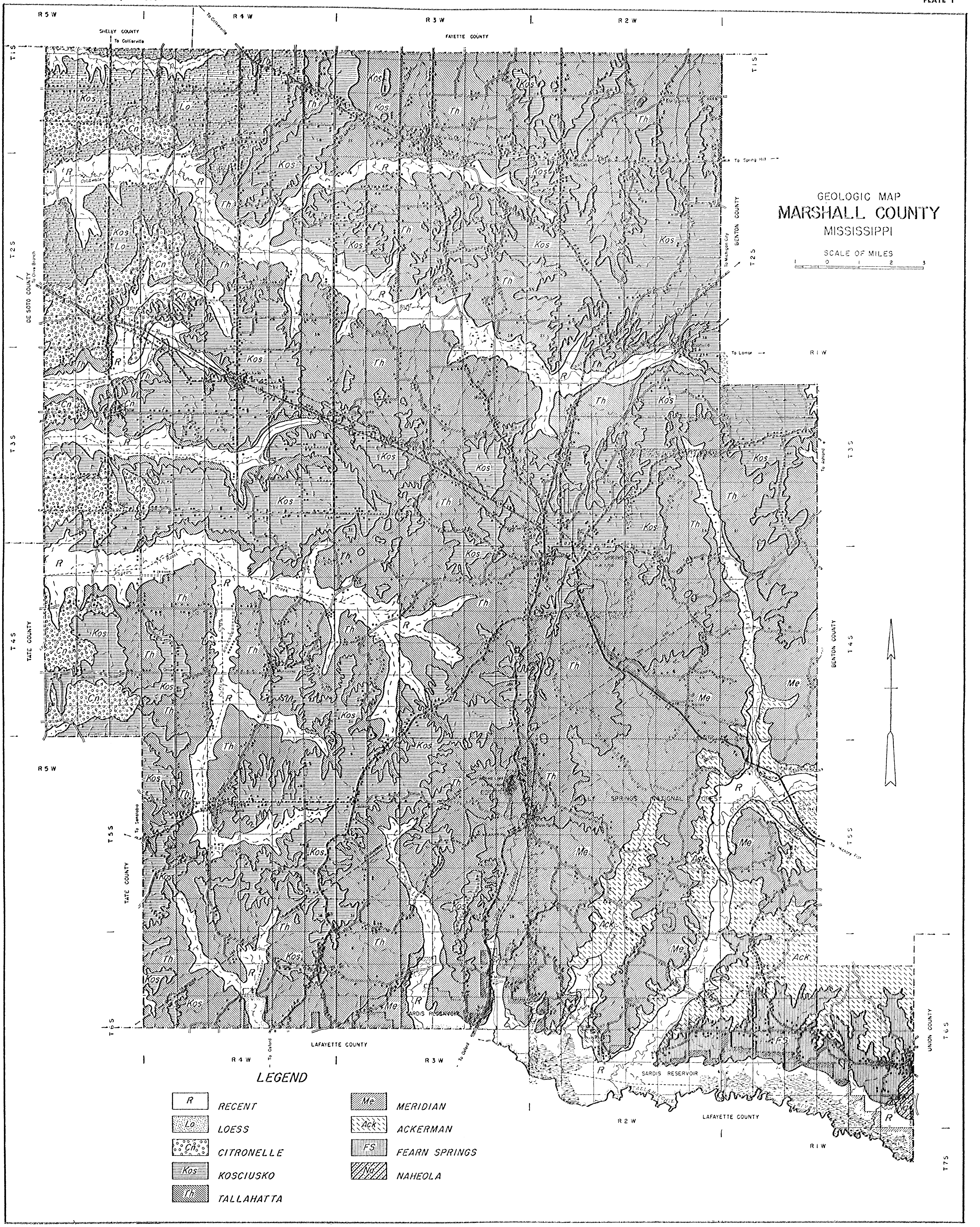
66. Dixie Geological Service, Vol. V, No. 14, April 5, 1945, p. 4.

67. Dixie Geological Service, Vol. I, No. 5, p. 8, May 22, 1941, and Vol. I, No. 6, p. 7, May 29, 1941.
68. Steffey, Robert L., Special Scout Service, February 5, 1937; June 17, 1937.
69. Steffey, Robert L., Special Scout Service, May 27, June 17, and October 7, 1939; April 27, 1940.
70. Electric log (Schlumberger) of Llewellyn No. 1 well, Brown's (?) interpretation
71. Electric log (Schlumberger) of Llewellyn No. 1 well, Brown's (?) interpretation
72. Dixie Geological Service, Vol. XIII, No. 43, p. 7, October 29, 1953, and Vol. XIV, No. 1, January 7, 1954, p. 11.
73. Dixie Geological Service, Vol. XIII, No. 45, November 12, 1953, p. 6.
74. Dixie Geological Service, Vol. XII, No. 50, December 11, 1952, p. 8.
75. Dixie Geological Service, Vol. II, No. 19, May 14, 1942, p. 4.
76. Dixie Geological Service, Vol. V, No. 14, April 5, 1945, p. 4.
77. Letters from Mr. C. L. Raines, September 13, 1950, and Mr. W. C. Scott, November 30, 1951.
78. Brown, Glen Francis (?) on Schlumberger log of Llewellyn No. 1 well; Mellen, Frederic Francis, sample log of Llewellyn No. 1 well.
79. Mellen, Frederic Francis, sample log of Llewellyn well.
80. Dixie Geological Service, Vol. XIII, No. 45, November 12, 1953, p. 6.
81. Grim, Ralph Early, The Eocene Sediments of Mississippi: Mississippi State Geol. Survey Bull. 30, pp. 42, 43, 44, 48.
82. Grim, Ralph Early, Op. cit., pp. 116, 117.
83. Grim, Ralph Early, Op. cit., p. 61.
84. Grim, Ralph Early, Op. cit., p. 209.
85. Thomas, Emil Paul, The Claiborne: Mississippi State Geol. Survey Bull. 48, pp. 46, 47.
86. Shaw, Eugene Wesley, The Pliocene History of Northern and Central Mississippi: U. S. Geol. Survey Prof. Paper 108, p. 156.
87. Shaw, Eugene Wesley, Op. cit., p. 161.
88. Shaw, Eugene Wesley, Op. cit., pp. 161-162.
89. Shaw, Eugene Wesley, Op. cit., p. 163.
90. Goodman, A. L., and Jones, E. M., Soil Survey of Lafayette County, Mississippi, p. 15. U. S. Department of Agriculture Bureau of Soils. Government Printing Office, 1914.
91. Lowe, E. N., Mississippi, Its Geology, Geography, Soil and Mineral Resources: Mississippi State Geol. Survey Bull. No. 14, p. 174. (Quoted from U. S. Soil Survey Field Book.)
92. Goodman, A. L., and Jones, E. M., Op. cit., p. 15.
93. Hilgard, Eugene W., Report on the Geology and Agriculture of the State of Mississippi, pp. 291, 292. E. Barksdale, State Printer, Jackson, Mississippi. 1860.

94. Goodman, A. L., and Jones, E. M., Op. cit., p. 18.
95. Goodman, A. L., and Jones, E. M., Op. cit., pp. 15, 20, 21.
96. Goodman, A. L., and Jones, E. M., Op. cit., p. 25.
97. Goodman, A. L., and Jones, E. M., Op. cit., pp. 14, 21, 22.
98. Goodman, A. L., and Jones, E. M., Op. cit., pp. 14, 19, 20.
99. Goodman, A. L., and Jones, E. M., Op. cit., p. 15.
100. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., The Ground-Water Resources of Mississippi: U. S. Geol. Survey Water-Supply Paper 576, p. 328.
101. Brown, Glen Francis, Geology and Artesian Water of the Alluvial Plain in Northwestern Mississippi: Mississippi State Geol. Survey Bull. 65, pp. 37, 39.
102. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., pp. 329, 330, 332, 333.
103. Oral communication from Mr. E. C. Rogers, Superintendent of Holly Springs Water Plant.
104. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., pp. 330, 331.
105. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., p. 329.
106. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., pp. 329, 330, 331, 333.
107. Stephenson, Lloyd W., Logan, William N., and Waring, Gerald A., Op. cit., p. 333.
108. Logan, William N., Clays of Mississippi, Part I, Brick Clays and Clay Industry of Northern Mississippi: Mississippi State Geol. Survey Bull. No. 2, p. 208.
109. Logan, William N., Op. cit., p. 209.
110. Logan, William N., Op. cit., p. 208.
111. Logan, William N., Op. cit., p. 209.
112. Logan, William N., Op. cit., pp. 209, 210.
113. Logan, William N., The Pottery Clays of Mississippi: Mississippi State Geol. Survey Bull. No. 6, p. 138. (Revised Edition, 1914.)
114. Logan, William N., Op. cit. (Bull. 6), pp. 139, 141.
115. Logan, William N., Op. cit., (Bull. 6), p. 141.
116. Logan, William N., Op. cit., (Bull. 6), pp. 138-139.
117. Logan, William N., Op. cit., (Bull. 6), pp. 141, 143.
118. Logan, William N., Op. cit., (Bull. 6), p. 143.
119. Logan, William N., Op. cit., (Bull. 6), pp. 143-144.
120. Logan, William N., Op. cit., (Bull. 6), pp. 144-152.
121. Maps, drilling records, and oral information from the Holly Springs Brick and Tile Company.

122. Lowe, E. N., Preliminary Report on Iron Ores of Mississippi: Mississippi State Geol. Survey Bull. No. 10, pp. 21, 27. 1913.
123. Lowe, E. N., Op. cit., (Bull. 10), p. 27.
124. Lowe, E. N., Op. cit. (Bull. 10), pp. 21, 22.
125. Lowe, E. N., Op. cit., (Bull. 10), pp. 27, 28.
126. Lowe, E. N., Op. cit., (Bull. 10), pp. 28, 29.
127. Lowe, E. N., Op. cit., (Bull. 10), pp. 29, 30.
128. Lowe, E. N., Op. cit., (Bull. 10), p. 25.
129. Lowe, E. N., Op. cit., (Bull. 10), pp. 27, 42.
130. Lowe, E. N., Op. cit., (Bull. 10), pp. 10-11.
131. Lowe, E. N., Op. cit., (Bull. 10), pp. 25-26.
132. Lowe, E. N., Op. cit., (Bull. 10), p. 42.
133. Lowe, E. N., Road-making Materials of Mississippi: Mississippi State Geol. Survey Bull. No. 16, p. 128.
134. Lowe, E. N., Op. cit., (Bull. 16), p. 81.
135. Lowe, E. N., Coastal Plain Stratigraphy of Mississippi, Midway and Wilcox Groups: Mississippi State Geol. Survey Bull. No. 25, p. 74.
136. Weigel, W. M., Techology and Uses of Silica and Sand:. U. S. Department of Commerce Bureau of Mines Bull. 266, pp. 9, 132. 1927.
137. Weigel, W. M., Op. cit., pp. 9, 72, 95, 108.
138. Weigel, W. M., Op. cit., p. 72.
139. Logan, William N., The Structural Materials of Mississippi: Mississippi State Geol. Survey Bull. No. 9, p. 53. 1911.
140. Lowe, E. N., Road-making Materials of Mississippi: Mississippi State Geol. Survey Bull. No. 16, p. 121.
141. Lowe, E. N., Op. cit., (Bull. 16), p. 83.
142. Mr. M. B. Smith, Superintendent of Spring Lake State Park, oral communication.

INDEX


GEOLOGIC MAP
MARSHALL COUNTY
MISSISSIPPI
SCALE OF MILES
1 0 1 2 3
R 5 W
R 4 W
R 3 W
R 2 W
R 1 W
T 1 S
T 2 S
T 3 S
T 4 S
T 5 S
T 6 S
T 7 S
SHELBY COUNTY
FAYETTE COUNTY
DE SOTO COUNTY
TATE COUNTY
BENTON COUNTY
UNION COUNTY
LAFAYETTE COUNTY
To Collierville
To Spring Hill
To Lamar
To Ashland
To Senatobia
To Oxford
HOLLY SPRINGS NATIONAL FOREST
SARDIS RESERVOIR
LEGEND
R RECENT
Lo LOESS
Cn CITRONELLE
Kos KOSCIUSKO
Th TALLAHATTA
Me MERIDIAN
Ack ACKERMAN
FS FEARN SPRINGS
Na NAHEOLA