# MISSISSIPPI
# STATE GEOLOGICAL SURVEY

WILLIAM CLIFFORD MORSE, Ph.D.
Director

BULLETIN 81

## PANOLA COUNTY GEOLOGY

by

FRANKLIN EARL VESTAL, M. S.

UNIVERSITY, MISSISSIPPI
1956

FRED CULLEN SMITH

1921 - 1954

## FRED CULLEN SMITH

### 1921 - 1954

The study of Panola County Geology was begun in 1952 by the late Fred Cullen Smith, a trained geologist and a skilled and brave pilot. His geologic training was mostly under the direction of William Clifford Morse, Professor of Geology at the University of Mississippi and Director of the State Geological Survey.

Due to the fact the United States had not entered the conflict of World War II, Fred Smith enlisted first in the Canadian Air Force, transferred to the Royal Air Force, and finally to the U. S. Air Force when the United States became involved.

In his acknowledgements, Franklin Earl Vestal, author of the bulletin on Panola County, states that Mr. Smith had completed a reconnaissance survey of the county, and was therefore able to give him much useful information concerning locations and leading features of the more important outcrops.

Fred Smith's record is distinguished; he was one of the three survivors of the famous Second Eagle Squadron and, after his return to the University of Mississippi, he served his state in the air as the State Geological Survey helicopter pilot and, on the ground, contributed to the study of its geology by working with other members of the staff in several counties—especially, however, in Panola County.

Fred not only answered the call of duty but went far beyond that point—even to the breaking point—for the Good Lord has not created these bodies of ours to withstand such savage attacks.

William Clifford Morse

Fred Cullen Smith was a geologist and helicopter pilot for the Mississippi State Geological Survey from June 1, 1952 to March 21, 1954. He was associated with F. E. Vestal for a while in the survey of Marshall County, and with other geologists of the State Survey in work in other parts of Mississippi; but his chief assignment was the investigation of the geology of Panola County. At the time of his death he had completed a reconnaissance survey of the county, had acquired a very good general knowledge of the leading features of the geology, and had begun the writing of the report. It is fitting, then, that a memorial to Mr. Smith should accompany the report on the geology of Panola County.

Fred Cullen Smith was a veteran of World War II, with a distinguished record. He volunteered for service as a fighter pilot in the British Royal Air Force before America entered the war, and as a member of the famous Second Eagle Squadron took part in several battles. Shortly after the United States became a combatant, he was transferred to the American Air Force, where he saw much additional action, and was decorated for bravery and resourcefulness. Soon after the end of the war he entered the University of Mississippi, where he majored in Geology under Dr. William Clifford Morse, Head of the Department of Geology and Director of the State Geological Survey. He received the Bachelor of Arts degree in June, 1952, and some time later joined the staff of the Mississippi State Geological Survey. During the brief period he was with the Survey he was interested especially in field exploration and became a very competent geologist for one of his limited experience.

Mr. Smith was a likable man—quiet of voice and manner, at times even taciturn, and of an easy going disposition. However, although he did not receive any serious physical wounds in combat, his military experiences left an indelible impression on his personality, and almost certainly contributed to the circumstances surrounding his tragic and untimely death. In short, Fred Cullen Smith was a war victim, just as surely as if he had been killed in action. The members of the Survey express their appreciation of his service to his country and his contribution to the study of the geology of his native state, their sincere sorrow for his passing, and their deep sympathy for his parents and other loved ones.

Franklin Earl Vestal

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## MISSISSIPPI GEOLOGICAL SURVEY

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## LETTER OF TRANSMITTAL

Office of the Mississippi Geological Survey

University, Mississippi,

August, 1956

To His Excellency,
Governor James Plemon Coleman, Chairman, and
Members of the Geological Commission

The Mississippi State Geological Survey transmits herewith Bulletin 81, Panola County Geology, by Franklin Earl Vestal, Geologist. The field work was begun by the late Fred Cullen Smith and after his death was carried to completion by the author of the bulletin.

The report describes the climate, topography, drainage, stratigraphy and structure of Panola County, and summarizes its geologic history. The sections on these subjects are followed by a discussion of economic geology—mineral resources and their relationship to the geology of the region. The six geologic formations contain an immense tonnage of excellent ceramic clay, almost inexhaustible quantities of gravel and sand, and abundant water. The loess, which blankets the entire county except where it has been removed by erosion, contains essential elements of mineral plant food that have contributed materially to the maintenance of soil fertility through perhaps two centuries of cultivation. The wide alluvial plains which comprise a large part of the territory are underlain by some of the best soil in the world. And deep beneath the surface are aquifers capable of supplying the water needs of a large population for a very long time, provided proper conservation is practiced.

It is worthy of special note that the gravel and sand are today being used on a large scale, and that the mining, processing and marketing of the well-known "Enid clay" along the Mississippi River Valley bluff have grown into a large industry.

Sincerely yours,

William Clifford Morse
Director and State Geologist

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# PANOLA COUNTY GEOLOGY

FRANKLIN EARL VESTAL, M.S.

## INTRODUCTION

Panola County is an area of 704 square miles[1] in the northwestern part of the state (Figure 1). It is, roughly, between parallels 34° 9′ 35″ and 34° 33′ 15″ north latitude and meridians 89° 41′ 43″ and 90° 11′ 54″ west longitude. On the north it is bounded by Tate County, on the east by Lafayette and Yalobusha Counties, on the south by Yalobusha and Tallahatchie, and on the west by Quitman and Tunica. Except for irregularities

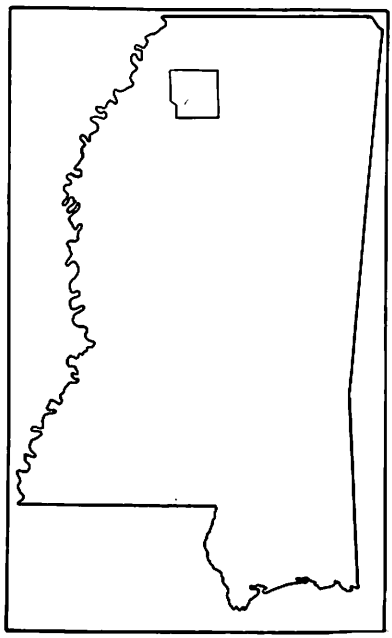

**Figure 1.—Location of Panola County.**

of the southern and western boundary lines in the southwest corner, the county would be a square. Each of the northern and eastern boundaries is approximately 27 miles long.

Panola County was established February 9, 1836, from the Chickasaw cession of 1832. The old line between the Chickasaw and Choctaw cessions lies across the southwestern corner area (Plate 1). On February 1, 1877, the county was reduced in size by the transfer of 60 square miles of its southwestern part to newly constituted Quitman County.[2]

The county's population on April 1, 1950, was 31,271, fewer by 3,150 than the 1940 population of 34,421.[3] In contrast to this 9.2 percent decline of population for the county as a whole, the population of Batesville increased almost 36 percent in the decade,[4] and Beat 5, which includes Batesville, contained, in 1950, 11,252 people, more than a third of the population of the county.[5] By the definition of "urban" and "rural" adopted by the U. S. Census Bureau for the 1950 census the population of Panola County was entirely rural at the time the last federal census was taken, although the number of people in Batesville was just under the 2,500 required for "urban" classification.[6] Probably the people of Batesville would now be classed "urban." The population of the county is unevenly distributed, by far the greater number living in the central and western parts, along and west of U. S. Highway 51. This distribution of population is partly due to the fact that most of the more easily cultivated land is in the central and western areas; also partly due to those areas being on the direct route from the cities farther south, to Memphis.

The centers of population commonly known as towns and villages are: Batesville (population, 2,463); Sardis (population, 1,913); Crenshaw (population, 740); Como (population, 703); Courtland (population, 275); Pope (population, 246); and Crowder (population, 476,[7] but only a part of the town, having a population of probably fewer than 200, in Panola County). All are farm and trading centers primarily, but Batesville, Sardis, Como and Crenshaw are the sites of small industries.

Scattered over the county commonly at crossroads are small groupings of population, or community centers: Tocowa; Longtown; Askew; Buxton; Pleasant Grove; Black Jack, for examples. Others may have no specific name, or may be known locally by the name of a store, or a church, or a plantation.

Batesville, the county seat, is at the intersection of U. S. Highway 51 and Mississippi Highway 6, and on the Illinois Central Railroad. It is strategically located, a little east of the eastern edge of the great agricultural "Delta," the "Cotton Empire," in the wide notch cut by the Tallahatchie River in the bluff which bounds the "Delta" on the east. The northwest edge of the town is almost on the river. Batesville is a prosperous, growing town, which has a large trade in agricultural products, especially cotton, and in farm equipment and supplies. Some of the more prominent industries are:

The Batesville Company, hosiery manufacturers

The Batesville Concrete Block and Tile Company

The Tennessee Gas Transmission Company

The Tallahatchie Valley Electric Power Association

Dunlap and Kyle Industries, which started with Southside Chevrolet Company in 1951

The Tucker-Brame Athletic Manufacturing Company

The Federal Compress, west of Batesville, one of the largest of its kind in the South.

The District Office of the Soil Conservation Service, State and Federal, and the District Office of the State Highway Department are located in eastern Batesville, on the east side of Highway 51 a short distance north of the intersection of Highways 6 and 51. Their fine new buildings and well-cared-for grounds are very attractive.

Sardis, on Highway 51 and the Illinois Central Railroad 7 to 8 miles north of Batesville, is the center of a large cotton growing area. It is connected with Sardis Dam by blacktop Highway 315.

Crenshaw is a small town in the northwestern corner of the county, at the junction of Panola, Quitman, and Tunica Counties, at the eastern edge of the Delta. It is a shipping point for cotton, gravel, clay, and lumber. The Crenshaw Oil Company, cottonseed oil and linters, is the leading industry of the town, but the Kentucky-Tennessee Clay Company's processing plant is on the Illinois Central Railroad (Y. & M. V. Branch) and a short distance west of Highway 3 some 3 miles south of Crenshaw.

The leading occupation of the people outside the towns is agriculture; indeed, most of the population are interested in agriculture directly or indirectly. Cotton is the chief crop; the word "Panola" is an Indian name, meaning "cotton." The county is well up towards the top among the counties of Mississippi in the production of cotton. Corn is second in importance among cultivated crops, and considerable areas are devoted to other kinds of crops. Live stock is receiving increased attention. Probably the best farm land is the alluvium of the valley bottoms, although most of the arable land is fertile, chiefly because of the influence of the loess. Other occupations are lumbering, on a scale much reduced from what it once was, and mining of gravel and clay. Sardis Lake has become a widely known fishing and boating resort.

A network of roads is superimposed on the county (Plate 1). The main pavement highways are U. S. 51, north-south a little east of the central meridian, via Como, Sardis, Batesville, Courtland and Pope; and Mississippi Highway 6, which lies south of west, south of the middle parallel of the county. The two intersect at Batesville. Other pavement highways are Mississippi 310, east-west through Como to Crenshaw; 315, Sardis to Sardis Dam; 35, Sardis Dam to Batesville; an unnumbered blacktop highway on the right-of-way of an abandoned railroad from Highway 6 to Crowder, southeast of the Tallahatchie River; and a few miles of No. 3 south from Crenshaw. The paving of two or three of these highways has not been completed, but the rights-of-way have been or are being prepared for paving; No. 315 south and southeast of No. 6, towards Water Valley; the unnumbered highway west from Sardis, a westward extension of No. 315. Almost all country roads are graveled. The road pattern is irregular over most of the county, the roads having been located on the crests of the ridges as far as proved practicable. However, in the northwestern part of the county, notably in Townships 6, 7, and 8 South, Ranges 7 and 8 West, the roads have been located on or parallel to the section lines, following a checkerboard pattern. The numerous roads, almost all which can be traveled at any season of the year, provide access to every part of the county. Furthermore, they are being steadily improved.

The railroads of Panola County are The Illinois Central main line, which roughly parallels Highway 51; and the Yazoo and Mississippi Valley Railroad, which parallels the western boundary of the county in the northwestern corner for some 6 miles. The Y. and M. V. is a part of the I. C. system.

Electric power is provided through several lines, reaching all parts of the county, by the Mississippi Power and Light Company, and by the Tallahatchie Valley Electric Power Association.

The Tennessee Gas Transmission Company pipe lines extend across the county southwest-northeast. The booster station and pipe-line district headquarters are on the south side of Highway 6 about 6 miles west of Batesville. A news story quoted the superintendent of the pumping station that 1,400,000,000 cubic feet of gas pass through the four big pipe lines each day, headed toward the Eastern states.[10]

A high-pressure oil pipe line has been laid across the southeast corner of the county. The American Telephone and Telegraph Company underground cable extends north-south, roughly parallel to Highway 51 and the Illinois Central Railroad.

## CLIMATE

Panola County is in the northern part of the region in which the humid subtropical type of climate prevails, somewhat modified by more northern types. In general, summers are long and hot, afternoon temperatures above 90 being common, and daily range moderate. Commonly, also, relative humidity is high, daytime breezes light southwesterlies, and the air sultry. Summer precipitation often comes as torrential rains, which may be accompanied by hail, high winds, and much thunder and lightning. Tornadoes may feature violent thunderstorms. The range of temperature from summer to winter is wide, but the transitional period, autumn, is oftener than not the pleasantest season of the year — the season of warm to cool days, cool nights, light rainfall, generally clear skies and bright sunshine. The average date of the first killing frost is late October. Winters are short and as a rule mild. During three or four months light frosts are frequent, and several short periods of below-freezing temperatures are part of each winter. Now and then hard freezes and sub-zero temperatures play a part in the humid subtropical winter, but such extremes are rare. Fair weather alternates with rainy spells which may last for days of cloudy skies and light to heavy showers or persistent drizzle. Some snow falls almost every winter, and very infrequently, perhaps once or twice in several years, snow may accumulate to a depth of a foot or more. Winter winds are variable in direction and strength, but stronger than summer winds, the prevailing southwesterlies being masked by irregular winds. Now and then raw, violent, gusty winds known as "Northers" develop and are followed by a sudden drop of temperature to below freezing. The average date of the last killing frost is late March. As a rule, January and February are the coldest months, July and August the hottest. Normally the precipitation is adequate, but long droughts are by no means unknown. The mean annual precipitation is approximately 50 inches. Distribution over the year is fairly uniform, although on the average Fall is the driest season and Spring the wettest."

Some precipitation and temperature data recorded by the Batesville Weather Bureau station are tabulated below:[12]

TABLE 1

CLIMATIC DATA, BATESVILLE

PRECIPITATION, MAXIMA AND MINIMA PER ANNUM, IN INCHES AND HUNDREDTHS; MONTHS OF MAXIMA AND MINIMA, AND TOTAL PER ANNUM, 1882 - 1930 INCLUSIVE

| Year | Maxima | Minima | Total for year or part of year |
|---|---|---|---|
| 1882 | 8.48 (July) | 1.51 (June) | 29.18 |
| (Apr.-Oct.) | 6.28 (May) | 1.66 (Oct.) | |
| 1883 | 5.72 (April) | 1.28 (July) | 16.21 |
| (Apr.-Aug.) | 4.39 (June) | 2.24 (May) | |
| 1884 | 11.90 (April) | 1.85 (Oct.) | 35.20 |
| (Apr. through October) | 7.23 (July) | 1.91 (Sept.) | |
| 1885 | 6.86 (Sept.) | .36 (Oct.) | 16.16 |
| (May through October) | 3.06 (June) | 1.43 (Aug.) | |
| 1886 | 6.35 (June) | .87 (Oct.) | 19.03 |
| (May-Oct.) | 5.23 (Sept.) | 1.79 (May) | |
| 1887 | 5.36 (March) | 1.20 (June) | 26.06 |
| (Feb.-Nov.) | 4.16 (Feb.) | 1.50 (July) | |
| 1888 | 9.68 (March) | .87 (July) | 52.61 |
| | 9.66 (Aug.) | 2.13 (April) | |
| 1889 | 9.55 (June) | .00 (Oct.) | 41.57 |
| | 8.27 (July) | .30 (Dec.) | |
| 1890 | 7.26 (May) | 1.65 (July) | 51.23 |
| | 7.15 (March) | 2.49 (Nov.) | |

| Year | Maxima | Minima | Total for year or part of year |
|---|---|---|---|
| 1891 | 10.22 (July)<br>7.43 (March) | .78 (Oct.)<br>1.44 (Sept.) | 57.52 |
| 1892 | 8.85 (Dec.) | .00 (Oct.)<br>.13 (Sept.) | 43.17 |
| 1893 | 13.49 (May)<br>8.27 (Sept.) | .28 (Oct.)<br>2.00 (Mar.) | 60.07 (No figures for Dec.) |
| 1894 | 7.79 (March)<br>7.16 (Feb.)<br>7.11 (Jan.) | .33 (Oct.)<br>.61 (June) | 46.05 |
| 1895 | 6.64 (July)<br>6.00 (Jan.) | .50 (Feb.)<br>.53 (Aug.) | 36.74 |
| 1896 | 8.01 (March)<br>6.85 (Nov.) | .60 (July)<br>.65 (Dec.) | 43.78 |
| 1897 | 12.02 (March)<br>6.98 (Dec.) | .00 (Sept.)<br>.14 (June) | 39.63 |
| 1898 | 6.32 (Jan.)<br>5.73 (Oct.) | 1.77 (Feb.) | 47.68 |
| 1899 | 10.49 (July)<br>7.04 (Dec.) | .94 (Sept.)<br>1.28 (Nov.) | 46.02 |
| 1900 | 10.85 (June)<br>7.72 (April) | 1.67 (Jan.)<br>1.71 (Aug.) | 58.71 |
| 1901 | 7.71 (Aug.)<br>6.82 (Jan.) | .79 (Oct.)<br>1.18 (July) | 44.52 |
| 1902 | 12.79 (March)<br>6.60 (Dec.) | 1.56 (May)<br>1.67 (Oct.) | 53.56 |
| 1903 | 8.80 (Feb.)<br>6.77 (May) | .40 (Sept.)<br>1.00 (Oct.) | 46.33 |
| 1904 | 8.80 (Dec.)<br>8.76 (March) | .46 (Sept.)<br>.75 (Oct.) | 41.12 |
| 1905 | 8.64 (May)<br>6.19 (April) | 1.95 (July)<br>1.95 (Oct.) | 52.58 |

| Year | Maxima | Minima | Total for year or part of year |
|---|---|---|---|
| 1906 | 10.37 (Sept.) | 1.10 (April) | 64.28 |
| | 9.93 (Nov.) | | |
| 1907 | 7.84 (May) | .81 (Sept.) | 43.06 |
| | 5.54 (March) | | |
| 1908 | 5.09 (Feb.) | .11 (Oct.) | 36.53 |
| | 4.79 (May) | | |
| 1909 | 9.97 (May) | .24 (Oct.) | 51.32 |
| | 7.54 (Dec.) | .83 (July) | |
| 1910 | 7.11 (May) | .30 (Sept.) | |
| | 6.12 (July) | .60 (March) | 46.69 |
| | 6.08 (June) | | |
| 1911 | 16.01 (Dec.) | .77 (Sept.) | 58.06 |
| | 10.65 (April) | .92 (May) | |
| 1912 | 11.71 (March) | 1.36 (Nov.) | 58.78 |
| | 9.61 (April) | 1.37 (July) | |
| 1913 | 12.16 (Jan.) | 1.01 (Nov.) | 53.63 |
| | 6.71 (Sept.) | 1.02 (Aug.) | |
| 1914 | 8.90 (Aug.) | .09 (June) | 48.90 |
| | 8.47 (Dec.) | .88 (Jan.) | |
| 1915 | 9.58 (Aug.) | .79 (April) | 55.11 |
| | 8.51 (Feb.) | | |
| 1916 | 6.74 (Jan.) | .49 (Sept.) | 46.11 |
| | 6.35 (June) | | |
| 1917 | 8.80 (March) | 1.11 (Dec.) | 51.99 |
| | 7.64 (June) | | |
| 1918 | 8.15 (April) | .30 (March) | 32.38 |
| | 4.85 (Jan.) | .82 (May) | |
| 1919 | 10.54 (Nov.) | .90 (Sept.) | 60.68 |
| | 9.78 (March) | | |
| 1920 | 11.58 (April) | 1.88 (Aug.) | 63.10 |
| | 8.14 (May) | 2.15 (Feb.) | |

| Year | Maxima | Minima | Total for year or part of year |
|---|---|---|---|
| 1921 | 8.85 (March) | .81 (May) | 48.88 |
| | 6.68 (April) | 1.53 (July) | |
| 1922 | 10.18 (March) | 1.43 (Oct.) | |
| | 7.56 (Dec.) | 1.52 (Aug.) | 55.55 |
| | | 1.59 (Sept.) | |
| 1923 | 10.45 (April) | 1.44 (Oct.) | 61.95 |
| | 6.97 (May) | 2.19 (Aug.) | |
| 1924 | 7.39 (April) | .02 (Oct.) | 45.19 |
| | 6.90 (May) | 1.22 (Aug.) | |
| 1925 | 7.92 (Oct.) | .97 (April) | 43.84 |
| | 7.09 (Nov.) | 1.07 (June) | |
| 1926 | 10.46 (Dec.) | .82 (Sept.) | 44.27 |
| | 6.46 (March) | 1.19 (May) | |
| 1927 | 9.74 (April) | 2.22 (July) | 59.89 |
| | 9.11 (March) | 2.90 (Oct.) | |
| 1928 | 8.14 (April) | 1.38 (Feb.) | 48.49 |
| | 6.26 (March) | 1.61 (Sept.) | |
| 1929 | 11.76 (Nov.) | 1.17 (Aug.) | 58.05 |
| | 6.95 (March) | 1.77 (June) | |
| 1930 | 11.52 (May) | .57 (June) | 46.72 |
| | 7.54 (Jan.) | 1.47 (April) | |

Averages for entire 49-year period:

| | | |
|---|---|---|
| January, 4.78 | May, 4.39 | September, 3.03 |
| February, 4.16 | June, 4.09 | October, 2.25 |
| March, 5.87 | July, 3.68 | November, 3.96 |
| April, 4.97 | August, 3.50 | December, 5.07 |

Average per year, including months of incomplete data, for entire 49-year period, 49.75 inches.

Average per year, excluding months of incomplete data, for 42-year period, 49.67 inches.

It will be seen from Table 1 that each and every month of the year has been a month of maximum precipitation for at least one year of the 49-year period and a month of minimum precipitation for at least one year. The summary follows:

| Month | Number of Maximum years | Number of Minimum years |
|---|---|---|
| January | 3 | 1 |
| February | 2 | 3 |
| March | 10 | 1 |
| April | 8 | 3 |
| May | 7 | 2 |
| June | 3 | 4 |
| July | 4 | 6 |
| August | 3 | 2 |
| September | 2 | 10 |
| October | 1 | 14 |
| November | 2 | 2 |
| December | 4 | 1 |

Maximum for any one month—16.01 inches, December, 1911
Minimum for any one month— .00 October, 1889
.00 October, 1892
.00 September, 1897
Maximum for any one year—64.28 (1906)
Minimum for any one year—32.28 (1918)
Range of annual precipitation totals for 42-year period—31.90
Average annual snowfall for 40-year period, 2.7 inches.

Brown[13] gives precipitation figures for the Batesville station, based on a 57-year record:

Maximum for any one year, 71.30 inches (1932)
Minimum for any one year 32.38 inches (1918)
Mean for the 57-year period 51.51 inches

TARLE 2

TEMPERATURE AVERAGES, DEGREES FAHRENHEIT
(DURATION OF RECORD, 40 YEARS)[14]

| Month | Maxima | Minima | Average |
|---|---|---|---|
| January | 53.1 | 32.9 | 43.0 |
| February | 55.1 | 34.5 | 44.8 |
| March | 64.9 | 42.3 | 53.6 |
| April | 73.8 | 50.4 | 62.1 |
| May | 81.8 | 58.4 | 70.1 |
| June | 89.5 | 66.2 | 77.8 |

| | | | |
|---|---|---|---|
| July | 91.8 | 63.7 | 80.2 |
| August | 91.5 | 67.8 | 79.6 |
| September | 87.4 | 61.4 | 74.4 |
| October | 76.6 | 48.7 | 62.6 |
| November | 64.7 | 39.4 | 52.0 |
| December | 54.1 | 34.0 | 44.0 |

| | |
|---|---|
| Annual maxima average | 73.7 |
| Annual minima average | 50.4 |
| Mean annual temperature (average of maxima and minima averages) | 62.0 |

TABLE 3

HIGHEST AND LOWEST TEMPERATURES, DEGREES FAHRENHEIT
(DURATION OF RECORD, 40 YEARS)[15]

| Month | Highest | Lowest |
|---|---|---|
| January | 80 | -6 |
| February | 84 | -8 |
| March | 92 | 17 |
| April | 95 | 27 |
| May | 98 | 35 |
| June | 104 | 46 |
| July | 108 | 48 |
| August | 107 | 49 |
| September | 108 | 34 |
| October | 97 | 24 |
| November | 88 | 13 |
| December | 80 | 1 |

Highest for 40-year period, 108—July and September
Lowest for 40-year period, -8 — February

Frost data (40-year period)[16]
1891-1930 inclusive

First killing frost in autumn
Earliest—October 9 (1895); latest, November 13 (1919)
Average—October 25

Last killing frost in spring
Latest—April 25 (1910); earliest, March 6 (1917)
Average—March 30

Length of growing season (last killing frost to first killing frost)
Extreme—244 days (1897)
Average—209

# PHYSIOGRAPHY

## PROVINCES, TOPOGRAPHY, RELIEF

Panola County consists of segments of three physiographic regions or provinces—North Central Hills, Loess or Bluff Hills, and Mississippi Alluvial Plain or "Delta."[17] Extending from the eastern boundary westward to an indefinite line which could be drawn roughly north-south through the middle of Township 6 West, is North Central Hills territory; a wide central belt bounded on the east by the same line and on the west by the foot of the Mississippi River Valley bluff, is in the Loess or Bluff Hills division; and the remainder of the county, a strip between the bluff and the county's western boundary, is part of the Mississippi Alluvial Plain. The names indicate the general characteristics of the provinces.

The North Central Hills region was originally named "North Central Plateau," because of its accordant summit levels and scattered areas of essentially flat-topped upland which appeared to be remnants of a low plateau.[18] Later the designation "North Central Hills" was substituted, as being more accurately descriptive, inasmuch as the region as a whole is in the mature stage of the erosion cycle, featured by thorough stream dissection, which has produced rounded hills, moderate to gentle slopes, and wide major valleys having flats developed well up toward their heads, and has left relatively little upland uneroded. Near valley heads and in places along the walls slopes may be steep, especially where the rock is shale or semi-consolidated sand, or where hard rock is interbedded with unconsolidated material. In fact, at such places many valleys have vertical-faced walls. The valleys and intervening ridges are variously oriented, of course, as determined by the direction of drainage; but the over-all trend of the larger features is northeast-southwest. In general, relief is greatest and hills most conspicuous in the North Central Hills area, where the loess is thin and the valleys have been cut in sand chiefly.

The Loess or Bluff Hills region is in general less rugged than the North Central Hills, although its western border belt, including the escarpment which bounds it on the west, is intricately eroded and has considerable relief. Farther east more of the surface is of relatively slight relief, and valleys are fewer. The topography of the western part of the region is characterized by steep slopes and narrow ridges and valleys, features due chiefly to the tendency of the loess to yield to erosional agents more readily vertically than laterally, and also to resistance in many places of underlying gravel and gravel conglomerate beds.

The westernmost physiographic region of Panola County is a strip of the Mississippi Alluvial Plain or Yazoo Delta which extends north-south the length of the county and west from the bluff escarpment to the county's western boundary. It is widest (8 miles) about 6 miles south of Sledge, along the Curtis Station-Macedonia School road, from where it narrows irregularly northward to almost nothing at Buxton, in the northwestern corner of the county, and southward to 3.0 to 3.5 miles at the county's southern boundary. The area of this strip of flood plain is about a tenth of that of the whole county. Its essentially flat surface slopes very slightly southward from an elevation of 180 feet at its northern end to 155 feet at its southern—25 feet in 27 miles, or a little less than a foot a mile. At its widest place it is some 10 feet higher near its eastern edge than at its western. In fact, a narrow piedmont alluvial plain has been built along the foot of the bluff escarpment, of sediment carried from the upland by the many streams, most of which are small and intermittent. This apron of detritus is most prominent between Crenshaw and Ballentine, where Indian, Floyd, and Peach Creeks debouch onto the plain; here it has an elevation at the bluff 30 feet greater than at flood-plain level, a mile to 1.5 miles farther southwest. The over-all flatness of the plain is broken by swamp, bayou and lake depressions, canals and by minor elevations—natural levees and other irregular deposits of sediment, and accumulations of debris left by floods or excavations. The Tallahatchie and Yocona Rivers have cut sinuous trenches across the southern part of the region.[19]

The upland of the county may be said to consist of two broad inter-stream areas; A southern, bounded by the Yocona River Valley on the south and by the Tallahatchie River Valley on the north; and a northern, comprising all the county territory north of the valley of the Tallahatchie. Subordinate ridges extend at many different angles away from the summit areas of the larger ridges. The regional slope is southwest.

The maximum relief of the county is approximately 440 feet. The greatest elevation above mean sea-level is somewhere between 580 and 600 feet, on the summit of Terrapin Mountain (Center, Sec.16, T.9 S., R.5 W.) half a mile west of the Lafayette County-Panola County line, and at the top of Lowe Mountain (SE. Cor., Sec.9, T.9 S., R.5 W.) a little west of the line and half a mile northeast of Terrapin Mountain. Some other points in the same vicinity are more than 500 feet above mean sea-level. Also, in the extreme northeastern corner of the county one point reaches an elevation of more than 520 feet. The lowest point in the county (150 feet or slightly less) is at the crossing of Tallahatchie River and the county line, at Crowder (SE. Cor., Sec.30, T.27 N., R.2 E.).[20]

Shaw noted that "west of a point some 9 miles east of Batesville, . . . The surface features differ more or less markedly from those to the east, although the general altitude is not much lower . . . . The principal difference in surface features is that to the east there are no extensive flat upland areas, whereas to the west the slightly lower interstream areas are commonly flat-topped, and from many points it is evident that several have almost exactly the same height, though different groups have different heights, suggesting several terraces." In fact, Shaw reached the conclusion that the topographic features mentioned are the surface expressions of "terrace deposits of the Mississippi Valley," although "Some of them have been so profoundly eroded that they are now scarcely recognizable as terraces . . ."[21] The same writer identified four main terraces in northern Mississippi, which he correlated with Matson's Brookhaven, Sardis, Canton, and Loxley terraces.[22] Remnants of the Brookhaven terrace, oldest and highest of the four, remain at elevations of 460 to 430 feet, elevations becoming less toward the north. The Sardis terrace, next highest and oldest, is a little better preserved than the Brookhaven, especially in the vicinity of Sardis, for which it was named. It ranges in width from 2 to 10 miles, and its top is practically horizontal. Its elevation is almost 400 feet at Sardis.[23] The Canton terrace is represented by flat-topped or southward-sloping remnants at approximately 300 feet. The patches of Loxley terrace are 275 to 300 feet above mean sea level in the northern part of the state. A terrace of equivalent age is fairly well preserved along the Tallahatchie River.[24]

## DRAINAGE

Panola County is part of the drainage basins of Yocona, Tallahatchie, and Coldwater Rivers, or, in a larger sense, of the Tallahatchie alone. Yocona River crosses the extreme southeastern corner of the county, and flows almost west from there to its junction with the Tallahatchie some 3 miles west of Crowder. It is slightly south of the eastern half of the southern boundary of the county, and a little north of the western half of that boundary—that is, the river is in Panola County from its crossing of the county line almost due south of Pope, westward to Crowder. The Tallahatchie River flows almost southwest, a diagonal across the county. The Coldwater River touches the northwestern corner of Panola County, from where it flows west by south and in several other directions in the Mississippi Alluvial Plain, at the end of its wanderings joining the Tallahatchie about 1.5 miles west of the mouth of the Yocona. Each of the rivers named has many tributaries, and these in turn have their branches, the whole system forming a dendritic pattern. The chief tributary of the Yocona in Panola County is Peters Creek, which is formed by the junction of Long Creek and Johnson Creek (Sec.10, T.10 S., R.7 W.) and flows southwest, joining the river some 3.5 miles southwest of Pope. It is canalized through its entire length. The Yocona carries the run-off from about the southeastern quarter of the county. The Tallahatchie drains a northeast-southwest belt comprising a little less than the central half of the county. Its chief tributaries are Thompson, Jones, Hotopha, and Buck Horn Creeks from the southeast, and Nelson, Wilborn, Clarendon, Oil, and McIvor Creeks from the northwest and north. All these waterways are relatively small, McIvor, the westernmost, and the largest, has five or six sizable branches, and is canalized (McIvor Drainage Canal) through its entire length except for the headwater forks. The canal is continued southward along the eastern edge of the Mississippi River plain to a junction with the Tallahatchie River about 7 miles west of Charleston, Tallahatchie County. Streams from approximately the northern quarter of Panola County flow northwest or north into Coldwater River. The largest of these is Senatobia Creek, which has two sizable tributaries, Wilborn and Nelson Creeks. The headwater forks of Arkabutla Creek and its chief tributary, Butterbowl Creek, are in the northwestern corner of the county, as are also the source branches of Egypt Creek. Other streams, the largest of which are Kirksey, Indian, Floyd, and Peach Creeks, flow southwest over the escarpment and lose themselves in the Mississippi Alluvial Plain.[25]

Prominent features of the stream system of Panola County are Sardis Dam and Reservoir. The dam, about 2.9 miles (15,300 feet) long, extends northwest-southeast across the valley of Tallahatchie River. The northwestern end is a little more than 5 miles and the southeastern end 3.5 miles west of the Panola County-Lafayette County line. Other items of information, listed on a board on top of the dam and published on folders issued by the Corps of Engineers, U. S. Army, and the Mississippi River Commission, Vicksburg District, are:[26]

| | |
|---|---|
| Type of dam | Earth fill |
| Purpose | Flood control |
| Maximum height | 117 feet |
| Volume of earthwork | 15,500,000 cubic yards (approximately) |
| Width of spillway | 400 feet |
| Drainage area above dam | 1,545 square miles |
| Area of permanent pool | 9,800 acres |
| Area of maximum flood pool | 58,500 acres |
| Capacity of maximum flood pool | 1,570,000 acre feet, or 512 billion gallons |
| Average base width of dam | 1,217 feet |
| Average height of dam | 95 feet |

The over-all cost of the dam was $14,000,000. Since the dam was put in operation, in October, 1940, it has controlled the flow of the Tallahatchie River.

# STRATIGRAPHY

## GENERAL

The stratigraphic units which crop out in Panola County are named, classified, and briefly described below, in older to younger order, reading from the bottom of the section upward:

GENERALIZED SECTION OF STRATIGRAPHIC UNITS EXPOSED IN PANOLA COUNTY

| | Thickness, feet |
|---|---|
| Cenozoic group | |
| Quaternary system | |
| Holocene series | |
| Recent formation | |
| Alluvium, colluvium, talus, residuum: Gravel, sand, silt, clay, sandstone, soil. Thickness extremely variable; maximum alluvium of Delta probably 75 to | 100 |
| Unconformity | |
| Pleistocene series | |
| Loess formation | |
| Loess: Gray to tan and brown massive silt, 25 to | 30 |
| Unconformity | |
| Tertiary system | |
| Pliocene series | |
| Citronelle formation | |
| Gravel and sand chiefly, some silt and clay; irregularly bedded, maximum thickness possibly up to | 125 |
| Unconformity | |
| Eocene series | |
| Claiborne sub-series | |
| Kosciusko formation | |
| Sand, sandstone, and re-worked clay up to | 150 |
| Unconformity | |
| Zilpha formation | |
| Clay, sand silt, lignite, sandstone, siltstone, 35 to | 40 |
| Winona formation | |
| Sand, sandstone, 20 to | 25? |
| Tallahatta formation | |
| Shale, clay, sand, silt, sandstone, siltstone | 200+ |

## TALLAHATTA FORMATION

The Tallahatta, the oldest geologic formation represented at the surface in Panola County, was named by Smith of Alabama. The name "Tallahatta" has been in general use in Mississippi since it was introduced by Johnson in 1905. Originally it was applied to the so-called "buhrstone" (claystone) only, which constitutes the greater part of the formation in eastern Mississippi. The claystone unit is now generally known as the Basic (or Basic City) member of the Tallahatta formation, from the town of Basic, Clarke County, near which it is well exposed along the railroad.[27] Thomas describes it in detail, but states, "It is composed chiefly of siliceous Claystone with interbeds of siliceous siltstone and sandstone." He describes the claystone as of light color, brittle, having a subconchoidal fracture, and of low specific gravity. On the outcrop and to a slight depth it breaks into angular blocks, the surfaces of which are stained yellow and brown. As a rule, too, each block is concentrically banded to its center. Other common features are small lenses, angular inclusions, and fucoidal structures of glauconitic silt.

The siltstone beds are light of color and for the most part stained by iron oxide; commonly, also, they are irregularly indurated and are knobby on the outcrop. Inclusions of clay and sand are numerous in the siltstone, as in the claystone.

The sandstone beds of the Basic City member are fewer than the claystone or siltstone beds. They range from fine grained to coarse grained, from highly glauconitic to nonglauconitic, and from semi-indurated to quartzitic. In general appearance they resemble the siltstones.

Shale or blocky clay makes up a considerable part of the Basic City, and a few stringers of greensand are present at bottom and top of the section.

The member is evenly bedded, and thin bedded to thick bedded. The beds are much jointed (Figures 2 and 15), and in some places large vertical bodies of claystone cut across the beds.

Northwestward along the strike the Basic City member of the Tallahatta formation changes character somewhat. The indurated material becomes thinner and more lenticular until all that remains of it is soft white glauconitic siltstone here and there between black carbonaceous silty micaceous fissile shale which dries to a light-gray to white slightly indurated flaky shale. Partings, stringers, and interbeds of micaceous non-glauconitic to sparingly glauconitic silt and sand are associated with the shale, and in Grenada County the flaky shale is overlain by 3 to 30 feet of light greenish-gray glauconitic sand or greensand containing many fucoidal structures and small clay inclusions.[28]

Thomas applied the name "Neshoba" to a sand section "above the Basic claystone and below the Winona greensand" which is typically represented in and near Neshoba, Neshoba County. He states that this sand unit, which largely replaces the Basic City member in Central Mississippi and farther north, has heretofore been included in the lower part of the Winona. However, he believes that it can be more properly considered a member of the Tallahatta formation because: 1) "It is the stratigraphic equivalent of part of the type Basic claystone section in Mississippi and of part of the type Tallahatta section of Choctaw County, Alabama . . .; 2) The Neshoba sand is overlain and underlain by typical Basic material in Newton and Lauderdale Counties; 3) The Neshoba and Basic facies are intimately interlensed over a wide area, and the thickness of the Neshoba fluctuates inversely with the thickness of the Basic."

The Neshoba of the type locality is described as "non-glauconitic to sparingly glauconitic non-fossiliferous marine sands which are typically well sorted, fine-grained, and micaceous, and which vary in structure from massive to irregularly bedded and to cross-bedded." The fresh sands are white, but the outcrop sands are in most places stained yellow, red, brown, purple, or mottled. A special feature, noteworthy in the present report because of the characteristics of some sands at the same stratigraphic position in Panola County, is, the sands of the upper 5 to 15 feet of the Neshoba are dark brick red, highly argillaceous, medium of grain and poorly sorted. "Their high clay content and dark color are derived from the overlying weathered Winona greensand through the action of percolating ground-water."[29]

The Tallahatta formation in Panola County crops out here and there within an area which has roughly the shape of an elongated right-angled triangle bounded on the east by the eastern boundary of the county (Plate 1). From a maximum width of 6 to 7 miles near its southern end, the outcrop area tapers northward to perhaps a mile or two at its northern end. Of the considerable number of outcrops, the more prominent are described herein, as illustrative of the general character of the upper part of the formation, which is the only part exposed in Panola County.

In the southeast corner of the county Tallahatta strata have been exposed by road cuts and ravines in several places. At the southeasternmost (SE.¼, Sec.29, T.10 S., R.5 W.) a short distance southeast and northwest of a road junction in the north wall of the Yocona River Valley (Enid Reservoir) the 0.6 mile long section is, roughly:

SECTION ALONG THE ROAD UP THE NORTH WALL OF YOCONA RIVER VALLEY

| | Feet | Feet |
|---|---|---|
| Recent | | 1.5 |
| Soil, loessial, and subsoil, to top of steeper slope | 1.5 | |
| Kosciusko formation | | 26.5 |
| Sand, brown, and slabs of ferruginous sandstone | 25.0 | |
| Sandstone, ferruginous, large slabs, up to | 1.5 | |
| Tallahatta formation (including covered intervals) | | 112.0 |
| Neshoba member | | |
| Sand, brown and red-brown; some deep red with light-colored streaks | 37.0 | |
| Sand and clay, bedded: Sand fine, varicolored; clay as laminae or very thin beds or stringers; silty; some silt laminae | 17.0 | |
| Basic City member | | |
| Shale, silt and clay, gray where wet, dries white; splits into very thin leaves | 10.0 | |
| Covered—red sand probably crept and washed down from upper intervals; to road junction | 15.0 | |
| Covered. Ravine on north shows mixture of red, brown, and yellow sand and thin beds of clay; layered in places; gravel float. To water level of Enid Lake | 33.0 | |

Some 0.2 mile southwest from the top of the section just described is a road junction, and cuts along the road which leads southwest from it down the Yocona River Valley wall expose Tallahatta beds in three or four places. The most prominent of these outcrops is on the steeper part of the slope.

SECTION (NORTHERN PART, SEC.32, T.10 S., R.5W.) OF UPPER PART OF NORTH WALL OF YOCONA RIVER VALLEY 0.6 MILE SOUTHWEST OF A ROAD JUNCTION

| | Feet | Feet |
|---|---|---|
| Recent, soil and subsoil and other mantle, to top of steep slope | 1.5 | 1.5 |
| Tallahatta formation | | 99.0 |
| Neshoba member | | |
| Sand, shaly, yellow; argillaceous and silty towards the top, brown lower in the interval; a few inches of ferruginous sandstone about the middle | 60.0 | |
| Basic City member (including covered interval) | | |
| Shale and clay, white and iron stained, and paper thin silt | 30.0 | |
| Covered, to bottom of valley at bridge | 9.0 | |

Some 0.2 mile farther southwest, on the eastern slope to the valley of Rowsey Creek, now an arm of Enid Lake, a thickness of 27 feet of white shale is exposed. It is overlain by red-brown sand along a sharp contact. Another outcrop, a tenth of a mile farther on, is only a few feet above lake level. Still another excellent outcrop (E.part, Sec.36, T.10 S., R.6 W.) shows 25 feet of white silt shale, the top of which is 50 feet above the river flat.

The approximate position of the top of the Tallahatta was determined along three north-south roads also (Secs.34,35,36, T.10 S., R.6 W.) in the north wall of the river valley. The elevation of the visible part of the contact of Tallahatta beds with overlying sand or sandstone ranges east-west from 370 to about 340 in 3.5 miles. At all three places the shale is overlain by ferruginous sandstone up to a foot in thickness. The Section 34 outcrop shows the westernmost Tallahatta observed along the north wall of the Enid Reservoir.

Cuts along the road (Secs.17, 20, 21, 28, 29, T.10 S., R.5 W.) which leads north from the stratigraphic section first described, have exposed other short sections of Tallahatta beds, the best of which (NW.¼, Sec.28) (Figure 2) are in front of a house 0.6 to 0.7 mile north of the junction in Section 29. Paper-thin laminae of white micaceous silt shale are prominent here. Approximately 0.8 mile farther north are other small but well defined outcrops.

Big ravines in the east wall of the valley of a small tributary of the Yocona River a few yards west of Pleasant Green church, Lafayette County, a little east of the Panola County line, have

Figure 2.—Tallahatta shale (NW.¼, Sec.28, T.10 S., R.5 W.) 2 miles north and a mile west of the southeastern corner of Panola County. July 24, 1953.

Figure 3.—Tallahatta-Kosciusko contact (NW.¼,SW.¼, Sec.15, T.10 S., R.5 W., Lafayette County) at Pleasant Green Church. March 18, 1954.

been cut through sand and sandstone into the underlying Tallahatta shale and sand (SW.¼, Sec.15, T.10 S., R.5 W.). At least 40 feet of Tallahatta strata are exposed here, and 30 feet of overlying ferruginous sandstone, limonitic siltstone or silty limonite, and yellow and red sand. The lower part of the sand body contains much re-worked white clay shale breccia or conglomerate. The contact is sharp and is defined by thin layers of hard silty limonite and ferruginous sandstone (Figure 3). The same contact, marked by thick sandstone blocks, can be seen in the local road a little northwest of the outcrop at the church.

An excellent stratigraphic section (SE.¼, Sec.17, T.10 S., R.5 W., Panola County) crops out along a northeast-southwest road up a hill about a mile and a half west of the Pleasant Green Church section:

SECTION ALONG A NORTHEAST-SOUTHWEST ROAD NORTHEAST OF A JUNCTION (SE.¼, SEC.17, T.10 S., R.5 W.) (FIGURE 4.)

| | Feet | Feet |
|---|---|---|
| Loess formation | | 8.0 |
| Silt, brown, clayey, somewhat weathered; includes brown loam soil, to top of hill at junction | 8.0 | |
| Kosciusko formation | | 30.0 |
| Sand, coarse to medium, and fine, white, yellowish brown, red | 20.0 | |
| Sand, coarse red-brown and purplish and Indian red; red friable sandstone at base, and a body of re-worked white clay | 10.0 | |
| Tallahatta formation (including covered interval) | | 55.0 |
| Shale, clay, and silt, white to yellowish on outcrop | 20.0 | |
| Sand, yellow and red-brown, micaceous, fine | 17.5 | |
| Clay shale, dun colored, leaches white, micaceous | 7.0 | |
| Sand, brown, clayey | 5.0 | |
| Covered, weathered material, to culvert at bottom of hill | 5.5 | |

The section is almost duplicated on the southwestern side of the ridge along the same road, but the top of the Tallahatta is 15 to 16 feet lower than in the northeast slope. The two contacts are 0.3 mile apart. About 0.2 mile southwest of the second of the sections a road cut (N. part, Sec.20) slightly above the valley floor exposes 10 feet of light chocolate-colored iron-stained micaceous shale some 30 feet below the top of the shale in the section. Near the base of the west wall of a valley 0.85 mile farther southwest a 10-foot section of light-colored shale crops out, and another short section shows near the top of the slope (SE.¼, Sec.19, T.10 S., R.5 W.). However, shale is not exposed at any other place along this new northeast-southwest road in a distance of 2 miles or more, but red and brown sand only, although two or three deep valleys and road cuts intervene.

On a southeast-northwest road half a mile northwest of an intersection, cuts in the walls of a shallow valley expose bedded white and mottled sandy clay and silt (SE.¼, NW.¼, Sec.19, T.10 S., R.5 W.). Thin ferruginous sandstone separates the dull white iron-stained blocky sandy and silty clay below from brown sand above. The contact is sharp; its elevation is about 360.

**Figure 4.—Section of Tallahatta shale and overlying sand (SE.¼, Sec.17, T.10 S., R.5 W.) at intersection east of Bynum School, 1.5 miles west of Pleasant Green Church. July 24, 1953.**

North of the stratigraphic sections at Pleasant Green Church and the road cuts a mile or more west of the church, three or four good outcrops have been made by cuts on two east-west roads (Secs.4, 5, 8, 9, T.10 S., R.5 W.) a little west of the Lafayette County-Panola County line. Along the southern of the two roads, which trends almost northwest, Tallahatta shale crops out in two or three places, especially a mile or so east of Highway 315. The most prominent outcrop (NW.¼, Sec.9, T.10 S., R.5 W.) shows several feet of well bedded white silt shale, including some of paper thinness. In the east wall of the valley of Bynum Creek, cuts on the northern of the two roads expose white silt shale (Western part, Sec.4, T.10 S., R.5 W.). Of the two outcrops, the eastern shows a ledge 5 to 6 feet high and approximately 128 feet long.

In Lafayette County, a little east of the Panola County line and 0.5 mile or so south of Sandy Springs Church (Orwood), Tallahatta white shale underlies red-brown sand (SW. Cor., Sec. 34, T.9 S., R.5 W.) at an elevation of approximately 360 feet. Here, as at most other places, a thin layer of solid rock separates sand from shale. Some slabs of this rock are composed of both ferruginous sandstone and dense silty limonite.

Three quarters of a mile, a little more or less, west of the church, and 0.5 mile west of a road junction, the section described below is exposed by an abandoned road cut in the east wall of a small valley:

SECTION (NEAR CENTER, SEC.33, T.9 S., R.5 W., PANOLA COUNTY) OF VALLEY WALL ABOUT 0.75 MILE WEST OF SANDY SPRINGS CHURCH

| | Feet | Feet |
|---|---|---|
| Recent | | 1.5 |
| Soil and subsoil, sandy and silty | 1.5 | |
| Kosciusko formation | | 20.8 |
| Sand, brown and red-brown | 20.0 | |
| Rock, ferruginous sandstone and limonitic siltstone, 0.5 to | 0.8 | |
| Tallahatta formation | | 50.0 |
| Clay, shaly, yellow to whitish, sandy, containing crusts of iron rust-cemented silt and fine sand, in relief. Up to | 1.5 | |
| Sand, yellow and gray and speckled, greenish-gray where wet; argillaceous, probably sparingly glauconitic; grades upwards into the clay and downwards into laminated sand containing laminae and stringers of gray clay | 24.5 | |
| Shale, silty, gray to white, iron-stained | 4.0 | |
| Covered, presumably Tallahatta beds, upper part a compact yellowish weathered mixture of sand and clay, to water level at culvert | 20.0 | |

The sand of the 24.5-foot interval resembles Winona sand, but probably belongs to the Neshoba member of the Tallahatta.

The elevation of the Tallahatta-Kosciusko contact is about 375 feet.

A more recent cut a few yards south of the section exposes the contact clearly. Here a 7-inch layer of dense brown limonitic siltstone lies between the yellow material and the overlying red sand (Figure 5).

Roads north of Sandy Springs Church and a short distance west of the Lafayette County-Panola County line are in general above the Tallahatta shale, and show only sand which in places contains re-worked white clay and sand. However, Tallahatta

Figure 5.—Tallahatta-Kosciusko contact (E.part, Sec.33, T.9 S., R.5 W.) three quarters of a mile west of Sandy Springs Church, and a mile west of Orwood. June 9, 1955.

beds crop out in a few places. Approximately 0.6 to 0.7 mile north by west of the church, and only slightly west of the county line, a section of Tallahatta strata is exposed by a road cut in the southeast wall of a small valley. The section shows 26 feet of yellow clayey and silty sand and sandy silt and laminae of gray clay. Harder thin beds are in relief. The Tallahatta part of the section extends to the top of the steeper slope and is overlain by thin rock below Kosciusko red sand. This outcrop (NE. Cor., Sec.33, T.9 S.,R.5 W.) is only about 0.5 mile northeast of the other Section 33 outcrop just described, and is on the same valley wall.

On both sides of Highway 315 in the vicinity of the junction of the highway with an east-west road half a mile or less south by east of Dees's store, Tallahatta material has been exposed by ravines (NW.¼, Sec.31, T.9 S., R.5 W.). White and mottled sand and silt and clay, and ferruginous sandstone and siltstone are prominent. The yellowish zone subjacent to the thin rock layer which marks the irregular contact with overlying loessial material is only 2 to 3 feet below highway level at the junction, and large slabs of red and yellow siltstone, such as is present at many places at the top of the Tallahatta, are approximately 30 feet below the junction. Although the elevation of the contact referred to, 400 feet or more, seems too great for the top of the Tallahatta when compared with the elevation of the same contact farther east, yet the very considerable area of outcrop, the absence of sand lenses, and the presence of lithologic features which characterize the upper part of the Tallahatta at many other places, suggest strongly that the white beds here are Tallahatta in place. The relief of the unconformity between the Tallahatta and overlying formations may be sufficient to account for seeming discrepancies of elevation, or the structure may depart somewhat from the normal monoclinal. Indeed, there is some slight evidence of structural irregularities in the southeastern part of the county.

A quarter of a mile or so west of the highway, the left wall of a small valley shows an outcrop (SW.¼, NW.¼, Sec.31, T.9 S., R.5 W.) of about 15 feet of thinly bedded varicolored sand interbedded with white silt and clay, the whole interval white on the surface, overlain by an equal thickness of compact brown sand (Figure 6). The elevation of the contact between the two is approximately 400 feet. The contact is sharp, and no hard rock is present. The white-surfaced beds may be Neshoba.

Tallahatta shale in place is exposed by ravines (NW.¼, Sec.19, T.9 S., R.5 W.) a few yards south of an east-west road, half a mile east of a bridge over Deer Creek, and a mile east of Highway 315. Bedded white, gray, bluish-gray, and yellow shale and thin reddish and yellow rock are overlain by red sand which may be Winona (Figure 7). The contact is at an elevation of about 385 feet, 35 feet below the top of a slight rise in the road.

Near the center of Section 34, Township 9 South, Range 6 West, some 260 yards northeast of a road junction, rock material which is like that observed in other places at the top of the

Figure 6.—Tallahatta-Kosciusko contact? (SE.¼, NE.¼, Sec.35, T.9 S., R.6 W.) 0.5 mile south by west of the junction at Dees store on Highway 315. June 24, 1954.

Figure 7.—Tallahatta-Winona? contact (NW.¼, Sec.19, T.9 S., R.5 W.) a mile east of the junction of Highway 315 and a local road. April 13, 1956.

Tallahatta formation is exposed by a road cut and roadside gullies. Here 5 to 6 feet of well-bedded pink and white silty clay shale lies on a floor of yellow and wine-red to maroon and purplish silty limonite or limonitic siltstone having a somewhat rounded surface. The top of the clay interval is rusty from iron oxide deposition. Although the elevation of this outcrop, around 400 feet, seems too great for Tallahatta beds in place so far west unless the normal regional structure has been disturbed, the lithology suggests strongly that the top of the Tallahatta formation is exposed here. Furthermore, other outcrops nearby show

**Figure 8.—Tallahatta-Kosciusko contact? (SW.¼, NW.¼, Sec.35, T.9 S., R.6 W.) a mile east by south of Henderson School. June 24, 1954.**

the same kinds of rock at approximately the same elevation. Half a mile or less northwest of the place just described, in the north wall of a small valley, along a local road, clay and sand and sandstone underlie Citronelle gravelly sand (NW.¼, Sec.34, T.9 S., R.6 W.). From near the base of the slope to a level 5 to 6 feet higher, a roadside gully exposes light-gray sandy and silty clay which dries a dull white. It is yellow toward the top and is capped by a 0.5 foot layer of dense silty limonite or limonitic silt. Above the hard rock is a body of gravelly sand at least 25 feet thick. The valley wall is between elevations 340 and 400 feet. A third outcrop (SW.¼, NW.¼, Sec.35, T.9 S., R.6 W.) half a mile or so northeast of the exposure near the center of Section 34 and at approximately the same elevation, has been made by ravines on both sides of the same road. The contact between the white material below and the brown and red-brown sand above is sharply defined (Figure 8). However, the absence here of the contact features so prominent at the Section 34 outcrops suggests that at least part of the white material may have been re-worked into the Kosciusko formation.

**Figure 9.—Tallahatta and Kosciusko beds (NW.¼, NE.¼, Sec.11, T.10 S., R.6 W.) approximately a mile northeast of Shuford. August 11, 1954.**

Several exposures of white clay and silt overlain by brown sand were observed in the northeast quarter of Township 10 South, Range 6 West, in the vicinity of Shuford. A good example is afforded by a large ravine (NW.¼, NE.¼, Sec.11, T.10 S., R.6 W.) (Figure 9). All these outcrops are at an elevation of 400 feet more or less. It seems significant that so much Tallahatta material, in place or re-worked, is exposed at relatively great altitudes in Township 10 South, Range 6 West and slightly farther north, and that the few Tallahatta outcrops in Township 9 South, Range 6 West, are at a considerably lower altitude.

Approximately two and a quarter miles farther north, along an east-west road which is almost a continuation of the road near which the contact of Tallahatta shale and Winona-type sand was noted (NW¼, Sec.19, T.9 S., R.5 W.), the top of the Tallahatta terrane is not exposed clearly, although in the lower part of the valley walls of a small tributary of Hotopha Creek yellowish sandy clay suggests that Tallahatta beds are near the surface (Northern part, Sec.22, T.9 S., R.6 W.). The elevation is 340-360 feet.

No Tallahatta shale in place shows south of Highway 6 along and near the north-south road a mile to 1.5 miles west of the Lafayette County line (Secs.4, 5, 8, 9, 16, T.9 S., R.5 W.), although in a few places fragments and stringers and other irregular bodies of white clay and silt have been worked into the sand. Perhaps the most prominent of these showings of re-worked Tallahatta material (SE.¼, Sec.5, T.9 S., R.5 W.) is a little north of a junction a mile south of Highway 6. Ravines at this place show a considerable outcrop of clay breccia in sand, overlain along a well-defined contact by red-brown sand. Quartz pebbles are numerous along and slightly above the contact. The elevation of the base of the sand is about 375 feet.

Half a mile or less southwest of the ravine outcrop described above, a cut in a west-facing slope on an east-west road exposes 15 to 20 feet of Tallahatta shale in place overlain by 20 feet of red-brown sand (NE.¼, NW.¼, Sec.8, T.9 S., R.5 W.). The contact (elevation about 360) is marked by a thin broken layer of silty limonite. Approximately 1.7 miles farther west, and a mile southwest of the bridge over Marcum Creek, the same contact shows in the east wall of the valley of a tributary of Hotopha Creek at an elevation of about 350. The uppermost Tallahatta beds here are laminated sand and clay, almost yellow ocher in places. At the top is thin sand rock, above which is the red-brown Kosciusko sand. A mile still farther west on the same road the contact appears in the west wall of Deer Creek Valley at an elevation of 340 feet more or less, 30 feet above the Deer Creek bridge. Much yellowish sand and sandy clay and large rock are present here.

On this same road a mile west from Highway 315 a cut in the east wall of a small branch of Hotopha Creek exposes interbedded fine sand and purple clay, above which is ferruginous

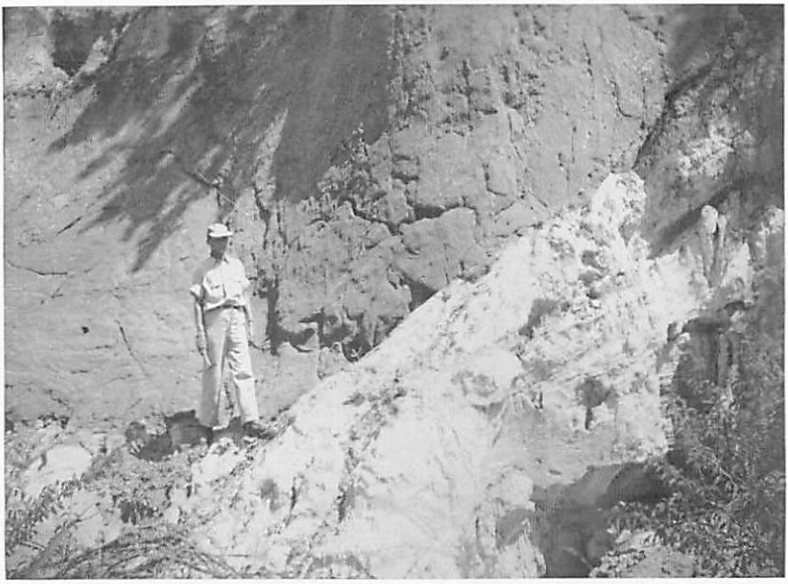

Figure 10.—Tallahatta and Kosciusko beds, possibly faulted, exposed by a road cut (SW.¼, NW.¼, Sec.15, T.9 S., R.6 W.) a quarter of a mile southwest of Central Academy. June 11, 1954.

Figure 11.—Tallahatta-Kosciusko contact (NW.¼, Sec.15, T.9 S., R.6 W.) 0.2 mile southwest of Central Academy. June 21, 1955.

hard rock underlying gray plastic clay, at an elevation of about 320 (NW.¼, Sec.14, T.9 S., R.6 W.). Dip appears to be slightly east. Some 0.35 mile farther west yellow sandy clay and sand rock show on a low ridge, and 0.6 mile still farther west, a little above the bottom of a small valley, is the westernmost showing (SE.¼, SW.¼, Sec.10, T.9 S., R.6 W.) of possible Tallahatta shale—iron rust-cemented shaly material containing a little white. The shaly beds are overlain by a layer of ferruginous sandstone 4 to 5 inches thick. The elevation is about 320. Citronelle gravel crops out a short distance farther west.

Half a mile south of the westernmost Tallahatta outcrop noted above, on or near a northeast-southwest road, are very interesting outcrops (SW.¼, NW.¼, Sec.15, T.9 S., R.6 W.) only 200 to 300 yards northeast of large gravel pits. Well down the slope along the road white and yellow sand abuts against brown sand along a diagonal contact (Figure 10); white and pink sand is overlain by brown sand along a horizontal contact; blocks of purple sand are enclosed by white, brown, and yellow sand. A short distance up slope, northeast of the sand exposure, the northwest wall of a cut shows a sharp diagonal contact between yellowish and brown and pink-mottled clay on one side and brown sand on the other. The contact is marked by rock slabs (Figure 11). Some 150 to 200 yards northwest of the road, ravines expose 15 to 20 feet of mottled clay and loessial mantle rock. Quartz pebbles and a few small fragments of silicified wood are scattered over the clay part of the outcrop. The elevation of the outcrops ranges from 320 to 340 feet. It seems possible that the mottled clay may belong to the Zilpha formation.

Westernmost surface segments of the contact trace of the Tallahatta formation and overlying beds show here and there north of the outcrops described. Along a south-north road, in the north wall of the valley of a tributary of Hotopha Creek, the shale and yellow sand are overlain by thick ferruginous sandstone (NE.¼, SE.¼, Sec.10, T.9 S., R.6 W.) at the base of a monadnock-like sand and sandstone hill, a little above the creek flat, at an elevation of 300 feet, more or less. Half a mile or less farther north, in the south wall of Hotopha Creek Valley, a road cut and an eroded slope west of it have exposed several feet of Tallahatta white silty and sandy shale and interbedded fine yellow and white micaceous sand under a layer of sand rock.

The outcrop is covered with ferruginous sandstone fragments and concretions. The elevation is 280-300.

A cut 350 feet long through a small oval hill on Highway 315 0.6 mile south of Highway 6 has exposed strata which are believed to include the Tallahatta-Kosciusko contact.

SECTION OF WEST FACE OF HILL (NW.COR., SEC.12, T.9 S., R.6 W.) ON EAST SIDE OF HIGHWAY 315, 0.6 MILE SOUTH OF HIGHWAY 6

| | Feet | Feet |
|---|---|---|
| Recent | | 0.7 |
| Soil, light-brown sandy, containing a little humus and fragments of sand rock, 0.5 to | 0.7 | |
| Kosciusko formation | | 8.0 |
| Sand, deep red brown, clayey, structureless; thin ferruginous sandstone at base, 5.0 to | 6.0 | |
| Sand, brown to red-brown, lowermost 0.5 to 0.7 foot yellow | 2.0 | |
| Irregular contact; small quartz pebbles | | |
| Tallahatta formation | | 17.0 |
| Sand, bedded; thin beds of different degrees of cementation; colors chiefly yellow and brown; sand contains stringers, threads, and fragments of white clay and sand; interval is more compact in the upper part, where there is no white material. To base of exposure, which is about 2 feet above the level of the flood plain and 4 feet below the highway, 15.0 to | 17.0 | |

North of Mississippi Highway 6 outcrops of Tallahatta beds are many. The easternmost outcrop along the highway itself is at the junction of Highways 6 and 315 (approximately the middle of the line between Secs.1 and 2, T.9 S., R.6 W.), where white sand and clay are interwedged with brown and red-brown sand at an elevation of about 300 feet. A quarter of a mile or so northeast of the junction and 35 to 40 feet higher, 5 to 7 feet of white shale crops out under loessial soil and other mantle (SW.¼, NW.¼, Sec.1, T.9 S., R.6 W.). Two or three cuts half a mile or less farther northeast have uncovered other short sections of shale, and west of them less than a quarter of a mile, on a north-south road a short distance north of a junction, is a larger outcrop on a steep slope (NW.¼, Sec.1, T.9 S., R.6 W.). It shows well bedded white and mottled clay shale interbedded with thin iron rock and capped by a 3-inch to 4-inch layer of brownish-red and yellow siltstone. The elevation of the top of the rock is about 370 feet; its position indicates a low west dip. Tallahatta shale is exposed in several places along a road which leads due west, north of Highway 6 and sub-parallel to it, from the junction of Highways 6 and 315 through Sections 2, 3, and 4, Township 9 South, Range 6 West. Only 0.1 mile northwest of the junction white and gray shale crops out on the west slope of the ridge through an interval of 30 to 40 feet (Eastern part, Sec.2, T.9 S., R.6 W.). The shale is white on the surface, darker where fresh. Much rock debris is lying about, especially slabs of dense fine-grained ferruginous sandstone and silty limonite, the sort of rock that is present almost everywhere the top of the Tallahatta is exposed. The greatest elevation is approximately 350 feet.

Along Highway 6 perhaps 150 yards south of the outcrops described above, white shale is at the surface, but 350 yards, more or less, farther west by south along the highway, coarse red-brown sand capped by ferruginous sandstone and dense silty limonite underlies sandy loess.

Farther west along the east-west road referred to above, gray to white sandy and silty somewhat rusty clay, mottled with pink in places, crops out here and there. It is associated with abundant rock float, including some large masses, and is underlain in one place by yellow ferruginous sand and soft clayey silt such as constitutes upper Tallahatta material elsewhere. This clay has an exposed thickness up to 15 feet. Notably, in the west slope of a ridge a quarter of a mile east of a junction and half a mile east of the Linn Sand and Gravel Company pits, at least 15 feet of whitish and light-gray and iron oxide-stained clay is exposed by a road cut (Western part, Sec.4, T.9 S., R.6 W.). The clay body here is in relief, and is reddish and brown towards the top, much like Zilpha clay as observed in several outcrops, but it is believed to be clay produced by the weathering of Tallahatta clay shale. No sharp contact was found anywhere between this type of clay and underlying shale. The elevation of the clay outcrops along the east-west road ranges from approximately 360 at the eastern end of the road to 320 at the western end.

Along and near roads farther north, Tallahatta beds crop out in many places. Half a mile or a little more south of the village of Black Jack a road cut exposes 20 feet of white to gray and pale yellow clay, overlain by 25 feet of red-brown sand at an elevation of 400 to 420 feet (SW.¼, SE.¼, Sec.30, T.8 S., R.5 W.). The section is believed to include a segment of the Tallahatta-Kosciusko contact trace. It is only about a quarter of a mile west of the junction where Mississippi State Geological Survey Prospect Hole Panola No. 1, begun at an altitude of approximately 424 feet, reached the Tallahatta at 14 feet.

A little less than a mile farther west and 0.2 mile east of a junction, ravines (NE.Cor., Sec.36, T.8 S., R.6 W.) across the road from a dwelling-house, have been cut in alternating thin beds of brown and yellow sand and white clay or silt shale, the outcrop edges of which appear as conspicuous bands (Figure 12). The elevation is around 320 feet. Half a mile or more southwest of

**Figure 12.—Banded Tallahatta beds (NE.Cor., Sec.36, T.8 S., R.6 W.) exposed by a ravine about a mile southwest of Black Jack School. June 14, 1954.**

this outcrop, on the west side of a north-south road, white clay shale and brown sand are exposed (NW.¼, Sec.36) at about the same elevation. More extensive exposures of white clay and shale, already described, are 0.6 to 0.8 mile farther south on the same north-south road, where a thickness of 30 feet or more was measured (SW.¼, Sec.36, T.8 S., R.6 W. and NW¼, Sec.1, T.9 S., R.6 W.). Rock debris is abundant; slabs of ferruginous sandstone are in the shale and above it. The top of the hill is at an elevation a little above 380 feet.

On and near the east-west road through the southern part of Township 8 South, Range 6 West, a mile and a quarter to two miles north of Highway 6, white clay and shale are at the surface in two or three places. Half a mile west of the intersection at Bluff Springs Church, near the top of a hill, in the walls of a road cut, white clay crops out under 15 to 20 feet of brown sand, and 50 to 75 yards northwest of the cut in the same slope, ravines have exposed gray and white sandy clay through a vertical interval of 20 to 25 feet. The clay is overlain by rock slabs. Some 0.3 mile farther west, a little above the floor of a small valley, bedded

**Figure 13.—Tallahatta shale and overlying Kosciusko? sandstone (S.part, NW.¼, Sec.7, T.8 S., R.5 W.) on the south shore of Sardis Lake at Black Jack Point. June 10, 1954.**

sandy clay and clayey sand are well exposed (NW.¼, Sec.34, T.8 S., R.6 W.). The clay is overlain by sand of a vivid brown containing some re-worked clay, and the contact between the two is sharp. Presumably the clay beds belong to the weathered upper part of the Tallahatta formation. They consist of gray clay shale which weathers white, at the base, and shaly clay or sand of various iron colors, brown, pink, red, yellow, above. The beds dip strongly westward. The overlying sand may be Citronelle; gravel containing some re-worked clay shows at a place half a mile farther west.

The easternmost outcrop of Tallahatta shale observed in Panola County north of Highway 6 and south of Sardis Lake is on the south shore of the lake at Thompson Creek Landing (NE.¼, Sec.7, T.8 S., R.5 W.) where a little white sandy shale shows under ferruginous sandstone a few feet above water level. Half a mile southwest of Thompson Creek Landing, at Black Jack Point, below and a short distance north by east of the 4-H Club camp, Tallahatta white shale and overlying sandstone are well exposed (NW.¼, Sec.7, T.8 S., R.5 W.) (Figure 13). And half a mile still farther southwest along the lake shore, at the southeast end of Sardis Dam, is an extensive outcrop of shale and overlying sandstone and silty limonite (Near center, Sec.12, T.8 S., R.6 W.). The sharp and uneven contact is at an elevation of about 280.

Approximately 1.5 miles south of Black Jack Point, Tallahatta shale and overlying Kosciusko sand have been exposed by cuts and gullies along a short east-west road across a small valley. In the east wall of the valley white and mottled shale and clay are visible in the roadside gullies through a vertical interval of 35 to 40 feet, and brown and red-brown sand through an additional 30 feet. The contact is at about 320 feet (SE.¼, SW.¼, Sec.18, T.8 S., R.5 W.). The same contact in the west wall of the valley is 30 feet above the bridge or about the same as the eastern contact. In both walls of the valley the contact is marked by slabs of yellowish and brown limonitic siltstone or silty limonite, and ferruginous sandstone. Deep red sand and sandstone superjacent to the contact suggest Neshoba or Winona lithology.

West from this valley, along and near an east-west road which extends through the middle of Township 8 South, Range 6 West, are two or three outcrops of Tallahatta strata. Half a mile or so southwest of Cold Springs, and half that distance southwest of a road junction, white and brown sand show prominently a little below the crest of a ridge (SW.¼, NW.¼, Sec.23, T.8 S., R.6 W.). The most conspicuous part of the terrane is bedded white and pinkish argillaceous and silty very fine sand, somewhat indurated. Bedding planes dip southward so steeply in places that they suggest faulting (Figure 14). The upper part of the outcrop shows brown sand containing a little gravel, probably Citronelle. Other Citronelle outcrops were observed less than

Figure 14.—Dipping Tallahatta sand beds, possibly faulted (SW.¼, NW.¼, Sec.23, or SE.¼, NE.¼, Sec.22, T.8 S., R.6 W.) half a mile southwest of Cold Springs. August 17, 1954.

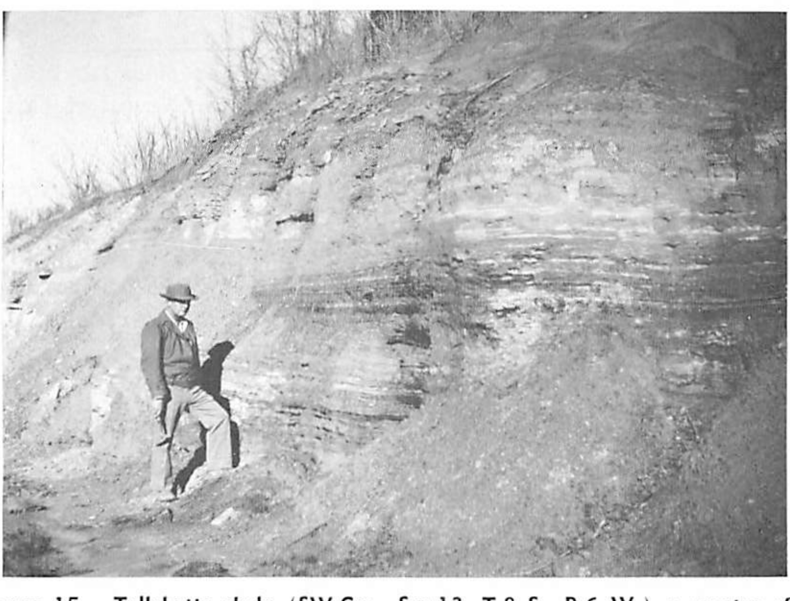

Figure 15.—Tallahatta shale (SW.Cor., Sec.12, T.8 S., R.6 W.) a quarter of a mile south of Sardis Dam spillway. December 10, 1952.

a mile farther northwest. The elevation of the top of the white bedded sand is about 320 feet.

The largest and best exposed outcrops of Tallahatta strata in the county are near the southeast end of Sardis Dam. A quarter of a mile or less south of the spillway at the southeast end of the dam, ravines have been cut deep into the shale and sand. An excellent section (SW.¼, Sec.12, T.8 S., R.6 W.) is afforded by the vertical-faced walls of the main ravine (Figure 15). The sharply and distinctly bedded silty shale is dark gray or chocolate colored to black where freshly exposed, but the outcrop is leached to a dull white or is stained yellow and brown by iron oxide. Much fine sand is associated with the shale as laminae or is disseminated along joints or fractures or other openings, and iron oxide-cemented crusts define laminae or fill joints or fractures. Superjacent to the well-bedded shale and sand is a sand and clay conglomerate or breccia, consiting of fragments or rounded lumps of white or mottled clay embedded in brown sand. The upper surface of the Tallahatta terrane is very irregular, and slopes towards the river; the formation, at least in the vicinity of the dam, appears to have been deeply eroded before deposition of the overlying beds.

No outcrop of Tallahatta material was observed along the road which leads southwest at the foot of the north wall of Tallahatchie River Valley west of the dam.

In Sardis Lake State Park, on the lake shore a few feet above the water, Tallahatta yellowish-white shale and yellow micaceous fine sand and silt are overlain by masses and slabs of ferruginous sandstone and silty limonite (East of center, Sec.35, T.7 S., R.6 W.) (Figure 16), as at the southeast end of the dam and in many other places.

In the west wall of the valley of Wilborn Creek, half a mile or less north of Moccasin Point, a short segment of the contact trace of the Tallahatta shale and overlying sandstone and sand is exposed (NE.¼, Sec.25, T.7 S., R.6 W.) (Figure 17). The well bedded white shale and clay contain partings of thin varicolored ironstone, silty limonite or limonitic silt. A thickness of some 10.5 feet of Tallahatta crops out here, and 8 feet of sand and soil. The elevation is between 300 and 320 feet.

Figure 16.—Ferruginous sandstone and silty limonite overlying Tallahatta shale (E.part, Sec.35, T.7 S., R.6 W.) on the north shore of Sardis Lake near the mouth of Patton Creek. September 3, 1954?

Figure 17.—Tallahatta-Kosciusko contact (NE.¼, Sec.25, T.7 S., R.6 W.) half a mile north of Moccasin Point on Sardis Lake. September 2, 1954.

Approximately a mile farther north by east, road cuts in the east wall of the valley of Wilborn Creek have brought to view about 15 feet of bedded white shale and clay and 30 feet of overlying red and brown sand (SE.¼, NW.¼, Sec.19, T.7 S., R.5 W.). A layer of sandstone marks the contact, at an altitude of 320 feet or less. Along and near the roads farther north are several other good outcrops. In the west wall of Nelson Creek Valley in an east-west road at an altitude of around 320 feet, yellowish clayey sand shows below thin limonitic rock which is overlain by sand, suggesting the Tallahatta contact (SW.¼, Sec.20, T.7 S., R.5 W.). Almost a mile farther north by west, and 0.2 mile north of a road junction, white and dark mottled clay and shale are exposed by a cut (SE.¼, SW.¼, Sec.18, T.7 S., R.5 W.), and white shale crops out west of the road 0.3 mile farther north. And a quarter of a mile or so still farther north, across the road east of Simon Chapel No. 2, are somewhat extensive outcrops of white shale (SW.¼, NE.¼, Sec.18, T.7 S., R.5 W.). Smaller exposures were observed in the same direction, one of them near a junction (SW.¼, Sec.7, T.7 S., R.5 W.); and a short distance northeast of the same junction, on both sides of a southwest-northeast road, Tallahatta strata crop out over considerable areas (SW.¼, Sec.7) of eroded slopes. The most prominent of these short sections (NW.¼, SW.¼, Sec.7) shows a thickness of 25 to 30 feet of well bedded white silt shale and very fine sand for a distance of 100 feet or so, overlain by brown sand along a sharp but irregular contact. The outstanding feature of the Tallahatta beds here is their strong west dip (Figure 18), a dip which prevails at all the outcrops of the area. White strata which crop out not more than 25 yards from the road show an equally strong dip in the same direction (Figure 19).

In the extreme northeastern corner of the county, a quarter of a mile or less north of a road junction and a short distance east of the road, extensive erosion has exposed white shale and silt and sand overlain by brown sand (South of center, Sec.21, T.6 S., R.5 W.). The contact is sharp, and much brown to black friable sandstone is lying on the white material. A quarter of a mile or so farther north, white shale and sand, brown sand, and loess crop out alongside the road on the east side. The elevation of the outcrops along this north-south road ranges from 440 or below to 460 feet.

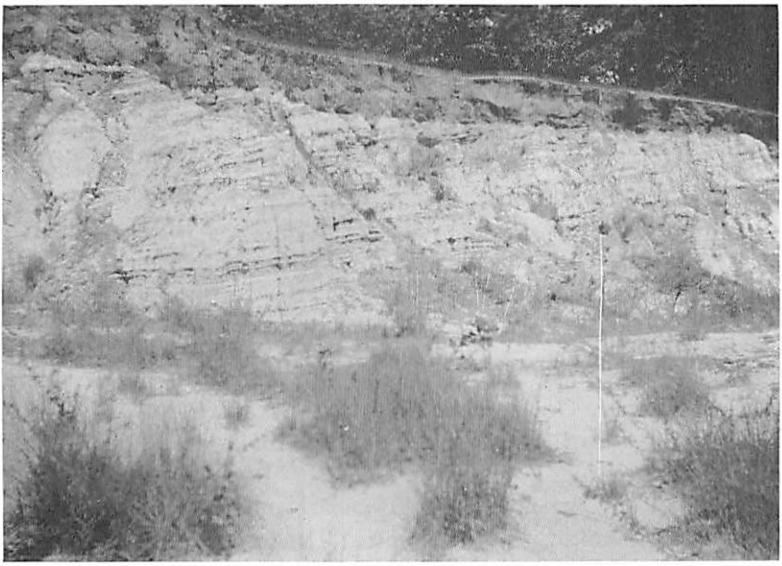

Figure 18.—Tallahatta shale (NW.¼, SW.¼, Sec.7, T.7 S., R.5 W.) showing strong west dip. One mile north of Simon Chapel No. 2. September 3, 1954.

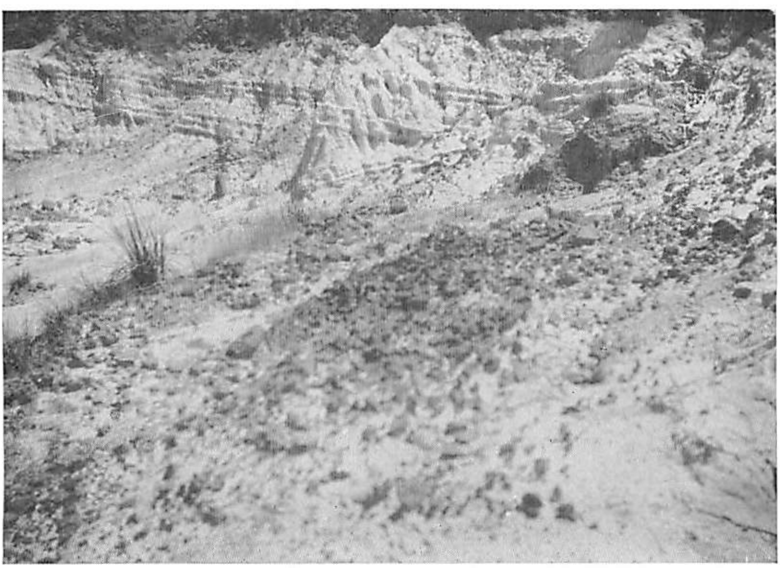

Figure 19.—Tallahatta shale outcrop (SW.¼, Sec.7, T.7 S., R.5 W.) showing strong west dip. A mile northeast of Simon Chapel No. 2. September 3, 1954.

No outcrops of Tallahatta beds in place were observed in the northeastern part of the county west of Range 5 West, although re-worked white material shows in a few places.

From the descriptions of outcrops it will be noticed that little or no typical Basic City claystone exists in Panola County, but that in general the Tallahatta formation consists of shale, clay, silt, siltstone, sand, and sandstone. The flaky shales described by Thomas are represented. In fact, the unit is similar to his "undifferentiated Tallahatta" of Grenada County.[30]

The unusual lithologic characteristics of the Basic City strata have led to much speculation as to the source of the materials, and their history. Grim[31] concludes, from the presence of glauconite, the character of the organic remains, including lignitic material as well as marine fossils, and also from the absence of any indication of surf action, that the environmental conditions were chiefly marine, and probably neritic. The layers of lignitic material indicate that non-marine conditions prevailed at times, and that the water was shallow. On the basis of adverse geologic evidence, he rejects two suggested explanations of the pronounced dominance of siliceous material, especially clay and silt and claystone and siltstone, and favors the hypothesis that during Basic time enormous quantities of volcanic dust (ash) fell, and that this dust formed the matrix of the claystone. However, he admits that he failed to identify any volcanic structures.

Thomas[32] cites as evidences of marine deposition: Glauconite; marine fossils; the persistence of the facies for more than 200 miles along the strike; thin beds and even bedding; and the abundance of fucoidal structures. He states also that the conditions cited indicate that the sediments were deposited in quiet water near the shore. Furthermore, he expresses the view: "The siliceous cement which binds the rocks of the Basic is apparently primary, since it is very uniformly distributed through 100 feet of sediments in eastern Mississippi. It was probably precipitated from the sea water under relatively quiet conditions." The claystone was formed, he states, "by surface induration from a dark greenish-gray somewhat micaceous silty clay that usually contains scattered plant fragments."

The author of this report on Panola County believes that most of the Tallahatta materials were derived directly from the

Meridian and the Wilcox and Midway beds. Surely the parts of the Porters Creek, Naheola, Betheden, Fearn Springs, and Ackerman terranes which have been removed by erosion contained sufficient clay and silt and fine sand to account for the lithologic character of the Tallahatta. The white color is chiefly on the outcrop, and almost certainly is due to bleaching, just as in the case of other shales, the Porters Creek for example, which in some localities is of as low specific gravity as the Basic claystones and siltstones. The lightness of weight is due to porosity. Furthermore, the consistent fineness of all sediments, and the presence of carbonaceous shales and silts and clays, and of lignite in all the formations from the base of the Porters Creek to the top of the Tallahatta, implies erosion from a region of low relief, and deposition in quiet water. It is doubtful that a satisfactory explanation of the lithology of the Tallahatta requires any appeal to vulcanism.

The thickness of the Tallahatta formation in Panola County varies from place to place, because of non-uniform original deposition and because of erosion following its deposition. Much of the up-dip part of it has been carried away during the beveling of the strata of the entire region, which has been in progress for ages and is still going on. However, inasmuch as the upper part only of the formation is exposed in Panola County, the complete thickness can not be determined from outcrops direct, but must be computed from angle of dip and width of outcrop belt, or measured in wells.

A log of a well in Sardis (Well No. 6 of Table 4) gives the thickness of the Basic City (Tallahatta) as 96 feet, and the log of a Memphis Stone and Gravel Company well (NE.¼, NE.¼, Sec.33, T.10 S., R.7 W.) (Well No. 33 of Table 4) indicates a thickness of 209 feet. The second well referred to is 18 miles south of the Sardis well. It would seem, then, that the formation thickens southward. Yet, if the log of the Linn Sand and Gravel Company well (Well No. 13, Table 4) is accurate, only 22 feet of Tallahatta strata were found by the well, although it is 7 miles south and 5 miles east of Sardis. Furthermore, if the log is to be believed, a well (Well No. 3a, Table 4), at the old Prisoner of War Camp 2.5 miles north of Sardis, although almost as deep as the Sardis well, found no Tallahatta at all. Even after due allowance is made for unquestioned irregularity of thickness, the disparity of thicknesses assigned to the formation by the logs of these four wells seems so great as to suggest inaccuracy of the logs or faulty interpretation. In this connection reference to the logs of four stratigraphic exploration holes drilled by the Mississippi State Geological Survey in the eastern part of the county may be enlightening.

Panola No. 1 (Center, SE.¼, Sec.30, T.8 S., R.5 W.) is at a road junction a quarter of a mile or less east of an outcrop which exposes a section across the Tallahatta-Kosciusko contact. It is about a mile north of Highway 6 and half a mile south by east of Black Jack. According to interpretation of the Widco electric log (Figure 20) the hole, started at an altitude of 423.81 feet, reached Tallahatta beds at 14 feet, and the Meridian sand at 228 feet, thus passing through 214 feet of Tallahatta strata, consisting of sandy shale and fine sand. The thickest shale interval was 62 feet — from a depth of 38 feet to a depth of 100 feet. Other thin shale intervals were encountered, but from a depth of approximately 100 feet to 228 feet the strata consisted chiefly of sand containing thin beds of shale and silt. Meridian sand was penetrated under the Tallahatta beds to the total depth of the hole — 345 feet.

Approximately three quarters of a mile northwest of No. 1, and a short distance west of Black Jack, Panola No. 4 (E.½, NW.¼, Sec.30, T.8 S., R.5 W.) reached a depth of 431 feet from a surface altitude of 360.3 feet, almost 63.5 feet lower than No. 1. The electric log of No. 4 indicates a succession of sandy shales and shaly sands. The Meridian-Tallahatta contact could not be picked with any degree of certainty.

Panola No. 2 (SE.¼, SE.¼, Sec.13, T.8 S., R.6 W.) at Saint Peter Church, about 1.5 miles south by east of Sardis Dam, reached a depth of 395 feet. The surface altitude of the site is 379.7 feet. The driller's log of the hole from the surface to a depth of 146 feet is given below:

Log of Prospect Hole Panola No. 2

| | Thickness | Depth |
|---|---|---|
| Kosciusko formation | | |
| Soil, sandy loam, grading into sand, red | 10 | 10 |
| Sand, red, streaks of clay and ferruginous sandstone | 77 | 87 |
| Sand, coarse; ferruginous sandstone at bottom | 9 | 96 |
| Tallahatta formation | | |
| Clay, yellow, silty, slightly sandy | 4 | 100 |
| Clay, dark gray; streaks of sand from 120-130 feet | 46 | 146 |

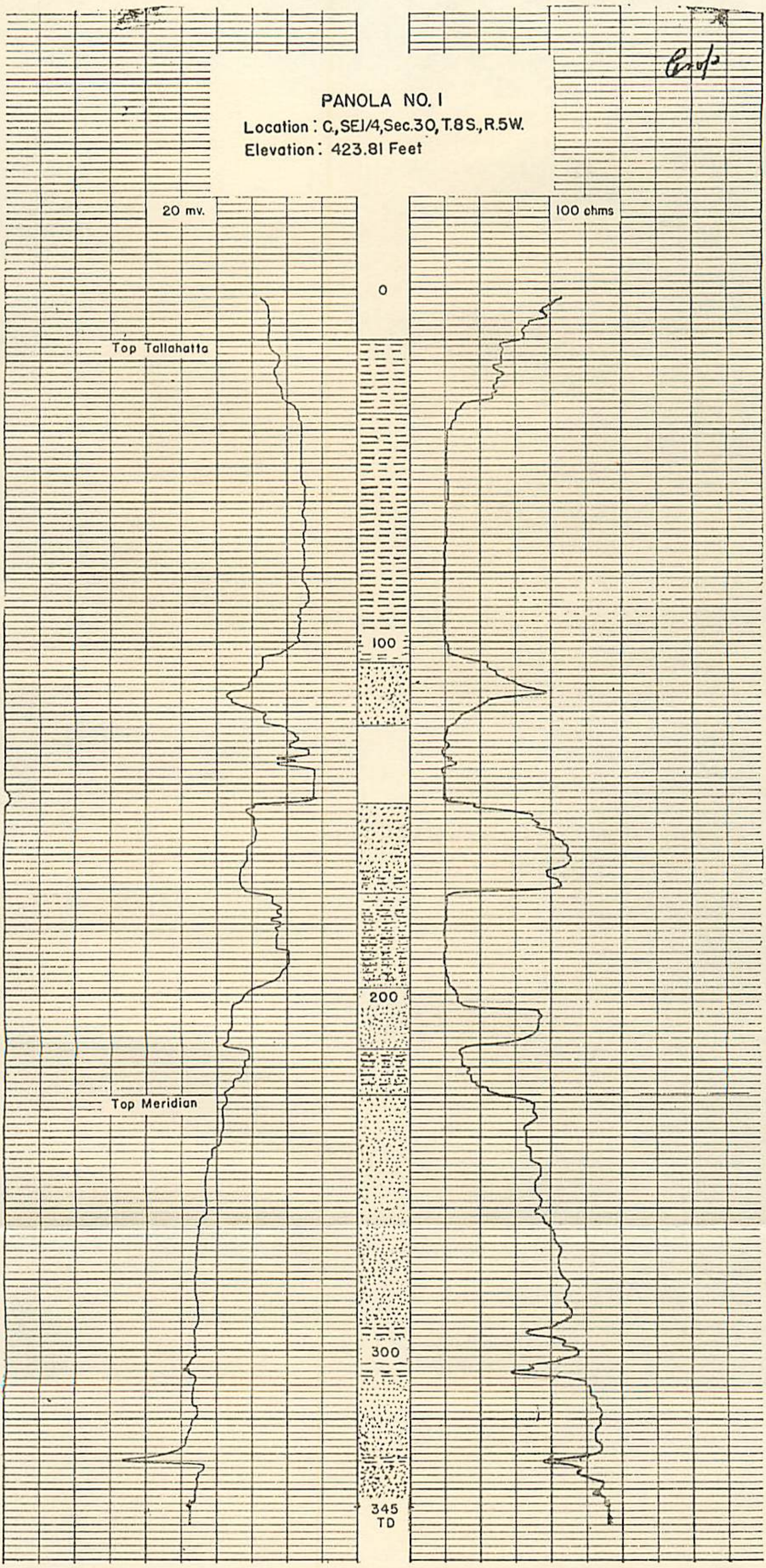


**Figure 20.—Widco electric log record of Mississippi State Geological Survey Prospect Hole Panola No. 1 (SE.¼, Sec.30, T.8 S., R.5 W.) half a mile south by east of Black Jack. February, 1954.**

The electric log indicates sand only to a depth of about 80 feet. The logs of this hole, however, describe a section which is somewhat at variance with the section revealed by the outcrops in the walls of the small valley a short distance east of the hole. In the valley walls the shale-sand contact is at an elevation of about 320 feet, a little less than 60 feet below the mouth of the hole. If the driller's log is accurate, then, the contact plane slopes westward approximately 36 feet in a distance of a quarter of a mile or less. The irregularity probably is due to the unconformity at the top of the shale. The thickness of the Tallahatta shown by the electric log is about 220 feet.

Panola No. 3 (NE.¼, NW.¼, Sec.35, T.7 S., R.6 W.) in the north edge of Sardis Lake State Park, was begun at an altitude of 343.8 feet, and completed at a depth of 395 feet. The Widco electric log indicates a shale and sand section. The Tallahatta was reached at 60 to 70 feet, and the Meridian at about 280.

## WINONA FORMATION

The Winona formation has not been positively identified in Panola County, but at several places, as has been stated, sand and sandstone lying on Tallahatta shale strongly resemble type Winona beds. This sand and sandstone at a few outcrops has been described on preceding pages as part of the Neshoba member of the Tallahatta formation. Probably most, if not all of it, is Neshoba. No glauconite was found in outcrop samples. Thomas[33] states that in some places where the Winona greensand overlies the Neshoba sand "the two facies are intimately mixed through two or three feet of section, and small lenses of glauconitic material are found several feet below the main body of the greensand. The glauconite is abundant and irregularly distributed at and just below the contact and becomes increasingly rare downward . . . . At other outcrops the transition from Winona to Neshoba facies is uniformly gradational through several feet of transition beds."

No such contact zone has been observed in Panola County. However, Brown[34] refers to Winona sand extending as far north as Sardis and interfingering with shale down dip in the western part of the county. Also, Priddy[35] reported that the Winona crops out as far north as Sardis, and states further, "The most northern outcrop of the Winona sand is at the Sardis Reservoir, Panola

County, where the Tallahatta and Winona contact is exposed." Later he favored the view that the material which he had classified as lower Winona belonged to the Neshoba member of the Tallahatta.[30]

The most prominent of the outcrops of these red and yellow sands and sandstones at the stratigraphic position of the Winona may be described briefly.

The bed or lens of Indian red to yellowish compact sand at the top of the section (SE.Cor., Sec.29, T. 10 S., R.5 W.) is a good example of the type of material referred to. The same kind of sand in the same stratigraphic position overlies Tallahatta beds at Pleasant Green Church, Lafayette County (Western part, Sec.15, T.10 S., R.5 W.), and is conspicuous in the section (SE.¼, Sec.17, T.10 S., R.5 W.) 1.5 miles farther west (see descriptions under Tallahatta formation) (Figures 3 and 4). Microscope examination of the sand from the Section 17 outcrop failed to find any glauconite or any fossils. The same sand interval crops out on the opposite slope of the ridge up which the section was measured.

Some others of the outcrops which show this same kind of red sand may be referred to again.

A few yards west of a road junction (NE.¼, Sec.32, T.9 S., R.5 W.) approximately a mile and a half west from the Panola County-Lafayette County line, red sand and sandstone are exposed in a hollow near the end of a culvert, at an elevation between 360 and 380 feet.

Somewhat less than a mile north of Liberty Hill Church, and 0.1 mile north of a road junction, 10 to 15 feet of dark red sand is exposed by a creek near a bridge at the crossing of the crude oil pipe line (SW.¼, NW.¼, Sec.15, T.10 S., R.6 W.). The elevation is about 320 feet.

Another outcrop of 10 to 15 feet of dark red sand (NE.¼, Sec.32, and NW.¼, Sec.33, T.10 S., R.6 W.) is on the road a quarter of a mile north of Oliver Ray Church, at an elevation of approximately 360 feet.

Along east-west roads 1.5 to 2.0 miles north of the Pleasant Green Church section, Neshoba or Winona type sand crops out in a place or two.

In the southwest quarter of Section 2, Township 10 South, Range 6 West, 0.2 mile west of a road junction, purplish red slightly consolidated coarse sand is exposed by a gully on the north side of the road a little above the bottom of a small valley. It is overlain by brown and yellowish sand, which is overlain by loess. The elevation is between 360 and 380 feet.

The most prominent exposure of this kind in the county has been made by ravines (NW.¼, Sec.19, T.9 S., R.5 W.) somewhat

**Figure 21.—Winona? red sand on Tallahatta shale (SW.¼, NW.¼, Sec.19, T.9 S., R.5 W.) a mile east of Highway 315 and half a mile east from a bridge over Deer Creek. June 24, 1954.**

less than 3 miles south of Highway 6 and a mile more or less east of Highway 315. At this place coarse sand of a hematite red to purplish red overlies Tallahatta shale along a sharp but irregular contact (Figures 7 and 21). Pale yellow fine micaceous sand and white silt are worked into the basal part of the sand. The elevation of the contact is approximately 385 feet.

At the outcrops along the road in the east wall of the valley of Wilborn Creek (SE.¼, NW.¼, Sec.19, T.7 S., R.5 W.) the sand which overlies the white shale strongly resembles Winona sand. It is a deep Indian red, rather coarse, loosely consolidated, and includes discontinuous beds of pitted and perforated and otherwise ragged sandstone, in which some of the small depressions are much like fossil imprints.

It may be significant that Mr. Tracy Lusk and the writer found in the abandoned clay pit of the Old Hickory Clay Company a few marcasite concretions pseudomorph after gastropod shells, also several cylindrical pieces of Winona-type iron ore, the surfaces of which showed a crust of red-brown oolites. Both the concretions and the iron ore suggested that the excavation had reached the top of the Winona formation, or that Winona material has been worked into the Zilpha. A few similar pieces of iron ore were found in the Kentucky-Tennessee Clay Company's pit, but no fossils. Fragments of lignitized wood were observed in both pits.

## ZILPHA FORMATION

The Zilpha formation, named from the Zilpha Creek region, Attala County, is clay, shale, sand and silt, chiefly clay or shale, lying conformably on the Winona.[37] In Panola County it is represented at the surface in a few places, especially in the lower part of the bluff which bounds the Mississippi River alluvial plain on the east. East of the bluff Zilpha material is exposed at one or two places certainly, and doubtfully at other places.

Stratigraphic sections at both ends of Sardis Dam probably include some Zilpha beds. In fact, in the exposed section (NE. Cor., Sec.14, T.8 S., R.6 W.) a short distance south of the spillway, the part above the Tallahatta shale of the main ravine and below the layer of hard, dense silty limonite is believed by the present writer to be part of the Zilpha formation. The lower part of this interval is a black to brown carbonaceous, in places lignitic fine sand and silt containing some clay shale, and the upper part is chiefly gray and iron-stained clay shale containing some lignite. The upper contact, at the base of the limonite layer, is sharply defined (Figure 22). The Emergency Spillway cut sections at the northwest end of the dam (NE.¼, Sec.3, T.8 S., R.6 W.) include the same succession, probably all Zilpha below the Kosciusko sand:

**Figure 22.—Top of Zilpha formation (SW.Cor., Sec.12, T.8 S., R.5 W.) a quarter of a mile south of Sardis Dam spillway. December 10, 1952.**

SECTION OF THE NORTHWEST WALL OF THE EMERGENCY SPILLWAY CUT OF SARDIS DAM, AT THE FOOT OF THE ROAD FILL APPROXIMATELY 40 FEET WEST OF THE ROAD (NE.¼, SEC.3, T.8 S., R.6 W.)

| | Feet | Feet |
|---|---|---|
| Kosciusko formation | | 6.3 |
| Sand, fine yellow micaceous, to top of exposure | 6.0 | |
| Rock, ferruginous sandstone and silty limonite | 0.3 | |
| Zilpha formation | | 21.0 |
| Sand, shaly, yellow, oxidized, hard; shows sharp lamination; at contact with underlying dark sand it is brick red; some white patches | 6.0 | |
| Shale, brown to black, dries gray; streaked and spotted with rust; laminae of fine micaceous sand and silt; marcasite concretions. The upper part of the interval is a dark silt and fine sand | 8.0 | |
| Sand chiefly, but including laminae of brown and black shale; sand fine carbonaceous, dark, from gray to dark brown and black, silty, micaceous, contains rusty spots and streaks, and iron sulphide; smells of iron sulphide; gray on outcrop; to water level of pool | 7.0 | |

The contact of the lowermost sand interval with the superjacent shale descends westward to southwestward 81 feet to the mile, measured from pool level as datum. The contact is even and sharp, and the thickness of the shale interval is approximately uniform (Figure 23). The rock layer near the top of the section dips westward about 85 feet to the mile.

On the south side of the spillway cut the top of the dark sand at the bottom of the section is only 2.5 to 3.0 feet above water level at the eastern end of the exposure, and is at water level a few yards farther west. The shale is 12 feet or more thick, extending almost up to the rock layer here and there. In

Figure 23.—Zilpha beds (NW.¼, NE.¼, Sec.3, T.8 S., R.6 W.) in the northwest wall of the emergency spillway cut at the northwest end of Sardis Dam. December 10, 1952.

fact, the shaly yellow sand of the section described above seems to be merely the oxidized upper part of the shale interval, and so varies much in thickness, being in general thicker along the routes of freest descent of water. Just under the hard layer it contains aggregates of vivianite. Above the layer is a thickness of about 45 feet (maximum) of Kosciusko sand. Brown[38] refers to the section exposed by the north wall of the cut, but does not identify the beds conclusively. He states that there is some evidence that the massive Kosciusko sand rests on the Basic City (Tallahatta) shale, but in the title of the accompanying figure he refers to the dark-gray shale as of "Zilpha or Basic

City age." The present writer believes that it is Zilpha, for the following reasons:

1) The top of the Tallahatta shale is exposed at the southeast end of the dam at an elevation of 260 feet or less (Near center, Sec.12, T.8 S., R.6 W.). The low water level in the Emergency Spillway cut is at an elevation of approximately 225, although the cut is almost 2.5 miles northwest of the southeast end of the dam, almost down dip.

2) The same dark silt as at the dam crops out at Tocowa (Sec.8, T.13 S., R.8 W.) in the southwestern part of the county, in association with typical Zilpha clay, and only a short distance east from exposures of Zilpha clay along the Mississippi River Valley bluff.

3) Very similar materials of the Zilpha formation crop out half a mile north of Vaiden, on Highway 51, Carroll County, and in the town of Vaiden, along Highway 35, where they rest on the Winona."[39]

The most prominent outcrops of Zilpha shale and clay in Panola County are along the Mississippi River Valley bluff here and there from the southern boundary of the county to the northern. The southernmost (Southern part, Sec.34, T.27 N., R.2 E.) is almost on the Panola County-Tallahatchie County line, and only 3.5 miles east of the southwestern corner of Panola County. A thickness of at least 25 feet of dark-gray to light-gray and dull white clay is exposed here for some 200 yards along the lower part of the bluff, forming a steep wall.

Other prominent Zilpha outcrops are in the vicinity of Tocowa, on both sides of an east-west road, especially along a small creek (Sec.8, T.10 S., R.8 W. and Sec.10, T.27 N., R.2 E.). At Tocowa Church the lowermost 5-foot to 6-foot interval of the walls of the creek channel is lignitic silt and very fine sand, horizontally and very evenly bedded, laminated, leached to gray in places. It contains numerous marcasite concretions; many others are strewn along the channel. The bed crops out continuously for at least 75 yards, and shows here and there down the stream for a quarter of a mile or more. At the church it is overlain above a sharply defined contact by sand and gravel.

A quarter of a mile or a little more west of the church the clay and silt beds are well exposed along the creek. A few yards

Figure 24.—Zilpha lignitic beds and overlying white silt (E.part, Sec.10, T.27 N., R.2 E.) in Tocowa Creek a quarter of a mile or more west of Tocowa Church. September 22, 1955.

Figure 25.—Zilpha lignitic bed lying on gray clay (Sec.10, T.27 N., R.2 E.) in the floor of Tocowa Creek a quarter of a mile west of Tocowa Church. September 22, 1955.

north of the road lignitic beds and overlying white silt are conspicuous (Figure 24), and a short distance farther down stream the lignitic bed is lying on light-gray and bluish-white clay (Figure 25) which appears to be the same as the clay that is being mined along the bluff in the northwestern part of the county. The elevation of these outcrops is around 220.

The north wall of the small valley at a place 0.7 mile west of the church (Eastern part, Sec.10, T.27 N., R.2 E.) and 100 yards north of the road exposes a 30-foot section, of which the lowermost interval is Zilpha clay and silt containing many marcasite concretions and pieces of lignitized wood. Part of a lignitized log was found embedded in the clay a little above low water level. The Zilpha clay is overlain by yellow and light-gray sand and light-colored gravel, and this by loess.

At the road junction 0.35 mile west of the section described above, Zilpha clay, lignitic, whitish, yellow, very plastic, is exposed a few yards south of the bridge. This clay resembles the interval superjacent to the clay mined near Crenshaw, and may be correlative with it.

Approximately a mile south of Asa, on the east side of the road along the foot of the bluff, is an outcrop (SE.¼, Sec.31, T.9 S., R.8 W.) of gray and white Zilpha clay which extends some 75 yards along the road and at one place 15 to 20 feet above it. Iron carbonate and iron oxide concretions are present in the clay here as in places along Tocowa Creek, but not so conspicuously as in the northwestern corner of the county. The Zilpha is overlain by Citronelle gravel and sand.

The largest Zilpha outcrops in the county are along the river bluff in Townships 6 South and 7 South, Range 9 West, from the vicinity of Delta northwest to Buxton. Northeast and north of Delta are prominent exposures, notably one (NE.¼, Sec.34, T.7 S., R.9 W.) three quarters of a mile or so north of Delta, where a thickness of 20 feet or more of dark-gray to light-gray clay shale, bleached white on the surface of the outcrop, and cut by gullies, forms the basal interval of the bluff. Farther northwest is a good outcrop made by a pit of the Old Hickory Clay Company (SE.¼, Sec.21, T.7 S., R.9 W.). The largest exposure of all (Sec.21, T.7 S., R.9 W.) has been made by the pits of the Kentucky-Tennessee Clay Company (Figure 26) in the bluff about 3 miles southeast of Crenshaw. The excavation is 500 yards long, at least 200 yards wide, and 100 feet deep below the top of the bluff. The floor of the deepest pit is 20 to 25 feet above the level of the flood plain. The section is described below:

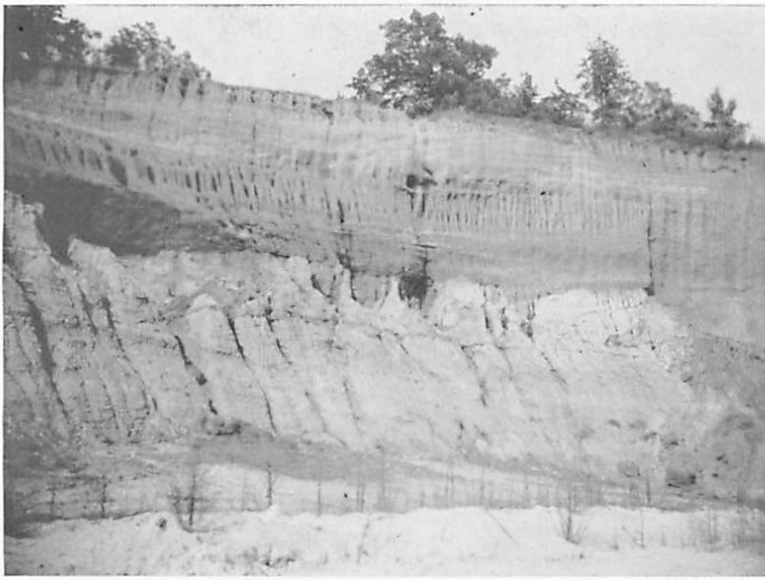

Figure 26.—Zilpha and overlying beds, Kentucky-Tennessee Clay Company's pit (Sec.21, T.7 S., R.9 W.) in the bluff 3 miles southeast of Crenshaw. July 24, 1953.

SECTION OF FACE OF BLUFF AT KENTUCKY-TENNESSEE CLAY COMPANY'S PIT (SEC.21, T.7 S., R.9 W.) 3 MILES SOUTHEAST OF CRENSHAW

| | Feet | Feet |
|---|---|---|
| Loess formation | | 25.0 |
| Silt, brown to gray, approximately | 25.0 | |
| Citronelle formation | | 42.0 |
| Sand, fine brown clayey and silty | 15.0 | |
| Sand, fine to medium brown and yellowish, and gravel, chert and quartz, large to small; 10 to | 13.0 | |
| Sand, pink, yellowish, orange, brown, red, etc.; fine, micaceous, bedded and massive; thin seams of gray clay; fragments of gray clay in the sand; very heterogeneous; outcrop has a pink cast; 10 to | 14.0 | |
| Thin hard rock at contact | | |
| Zilpha formation | | 34.0 |
| Silt, sandy yellow, whitish, and gray, thin bedded | 3.0 | |

| | |
|---|---|
| Silt, sandy and clayey, dark gray where fresh, dries light gray, grades downwards into gray clay, to top of lower bench, maximum | 11.0 |
| Clay, gray to white, plastic; commercial grade being mined, to bottom of pit, 15 to | 20.0 |

## KOSCIUSKO FORMATION

Almost everywhere in the part of the county east of the Citronelle area the uppermost rock material below the soil and the loess is sand. And almost everywhere the sand is brown or red-brown or yellowish-brown on the outcrop. In many places sandstone has been formed at and above the bottom of the sand, especially where the sand is underlain by shale or clay. The sand and sandstone which lie on the Tallahatta shale crop out within a narrow south-north belt of which the western edge in the southern part of the county is roughly near the middle of Range 6 West, and at the northern boundary of the county is a mile or two farther east. Naturally the western boundary of the belt is very irregular, due to non-uniform original deposition and to subsequent erosion. In fact, the Kosciusko sand has been so dissected by running water that although many patches remain, all are relatively small (Plate 1). The largest unbroken area is in the eastern part of the county, bordered on the east by the Lafayette County-Panola County line.

Kosciusko sand has been conspicuously exposed at many places in its outcrop belt. Several have been mentioned in the part of this report which relates to the Tallahatta formation. At Pleasant Green Church (SW.¼, Sec.15, T.10 S., R.5 W., Lafayette County) a little east of the Panola County line, Tallahatta shale is overlain by some 30 feet of yellow, brown, and red sand (Figure 3), probably all Kosciusko, although the lower part of it may include some Winona or Neshoba. Also, 1.5 miles or a little less west of the church the section (SE.¼, Sec.17, T.10 S., R.5 W., Panola County) at a road intersection, includes 30 feet of white, yellowish-brown, and red-brown coarse to medium and fine sand, most of which probably is of Kosciusko age (Figure 4). A feature of the section at the church is the slabs of ferruginous sandstone and silty limonite at the base of the sand, but the rock is not so prominent in the other section referred to.

Kosciusko sand is well exposed (Sec.19, T.10 S., R.5 W.) by road cuts at an intersection almost 1.5 miles farther southwest.

The most southwesterly outcrop (SE.¼, Sec.23, T.10 S., R.6 W.) along this new northeast-southwest road is about 5 miles west of the Lafayette County line. At this place it surrounds an inlier of clay which appears to be of Kosciusko age. Citronelle gravel crops out a short distance beyond. Driller's logs of Mississippi State Geological Survey Prospect Holes Panola Nos. 5 and 6, which follow, show the lithologic character and the thickness of the Kosciusko in the vicinity.

Panola No. 5 (SE.¼, SE.¼, Sec.23, T.10 S., R.6 W.) was drilled primarily for the purpose of obtaining information about the clay body which is exposed by the road cut and ravines near by. A rough log made on the basis of samples from the hole, is copied below:

LOG OF PROSPECT HOLE PANOLA NO. 5

| | Thickness | Depth |
|---|---|---|
| Kosciusko formation and soil | | |
| Sand, brown clayey and silty | 2.0 | 2.0 |
| Sand, brown, containing nodules of light-colored clay; noticeable quantity of clay around 19-20 feet. At approximately 22 feet, sand was of lighter color and included stringers of light-colored clay | 28.0 | 30.0 |
| Sand, coarse, chocolate brown | 17.0 | 47.0 |
| Sand, containing clay lumps, coarse; thin sandstone, yellowish, light colored; sand more clayey downwards; at around 60 feet, almost all white and yellowish clay, with some thin sandstone | 73.0 | 120.0 |
| Tallahatta formation | | |
| Clay, white gray, yellow; sandy and silty | 10.0 | 130.0 |
| Clay shale, dark gray silty; some fine sand at 179 feet | 49.0 | 179.0 |
| Sand, fine gray; somewhat deeper it contains streaks of clay and large flakes of mica; clay light colored to yellow | 59.0 | 238.0 |
| Clay or clay shale, pieces whitish and yellow toward top; a little lignite interbedded with sand | 26.0 | 264.0 |
| Sand, fine gray | 16.0 | 280.0 |
| Sand, fine light gray, and clay laminae and stringers | 34.0 | 314.0 |
| Clay or clay shale | 3.0 | 317.0 |
| Sand, fine, light colored, containing thin beds and stringers of clay and a few thin seams of lignite | 93.0 | 410.0 |

The elevation of the mouth of the hole is approximately 415 feet.

The electric log suggests that the top of the dominantly clay or clay shale part of the section is about 88 feet below the surface, but some of the shale may be re-worked into the Kosciusko formation, and some Zilpha and Winona may be present.

Prospect hole Panola No. 6 (NE.¼, SE.¼, Sec.23, T.10 S., R.6 W.) 0.5 mile or less north by east of No. 5, was begun at an elevation of 420 feet and completed at a depth of around 320 feet (elevation 100 feet). It is only a quarter of a mile or so northeast of a large clay outcrop, in a flat-topped ridge. The sample log is given below:

LOG OF PROSPECT HOLE PANOLA NO. 6

| | Thickness | Depth |
|---|---|---|
| Kosciusko formation and soil | | |
| Soil, loessial | 2.5 | 2.5 |
| Subsoil, leached | 5.0 | 7.5 |
| Sand, fine red brown, contains a few lumps of whitish clay; becomes lighter of color and coarser with depth; angular | 35.0 | 42.5 |
| Sand, coarse, chocolate brown; iron oxide crust | 2.5 | 45.0 |
| Sand, brown, as 3d interval, with pink, yellowish, and white clay, probably clay stringers in sand | 15.0 | 60.0 |
| Clay, yellowish, with fine sand; probably a sandy clay rather than a clayey sand. More clayey with depth, the clay dull white to yellowish and pink, containing iron oxide crusts; grades into sand downward | 37.0 | 97.0 |
| Sand, clayey for a few feet, but at 100 feet almost all sand, fine tan or light gray | 15.0 | 112.0 |
| Sand, fine, and light-yellow clay | 8.0 | 120.0 |
| Tallahatta formation | | |
| Clay, yellow, and fine sand | 10.0 | 130.0 |
| Shale, clay, dark brown and gray carbonaceous silty and sandy | 32.0 | 162.0 |
| Sand, tan or light gray fine; coarser with depth; some very coarse brought up with drilling mud from 180-190 ft. | 38.0 | 200.0 |
| Clay, light colored, and sand. Clay probably laminae in sand | 10.0 | 210.0 |
| Sand, fine tan, micaceous | 10.0 | 220.0 |
| Sand, fine tan, micaceous | 20.0 | 240.0 |
| Sand, as above, with clay streaks | 10.0 | 250.0 |
| Sand and clay, about 60-40; clay partings slightly darker | 10.0 | 260.0 |
| Clay, gray solid bed | 4.0 | 264.0 |

| | | |
|---|---|---|
| Sand, light tan fine | 10.0 | 274.0 |
| Clay | 3.0 | 277.0 |
| Sand, as above, light tan fine micaceous | 23.0 | 300.0 |
| Sand to bottom of hole; ceased drilling because of too rapid loss of water | 20.0 | 320.0 |

Cuts for the new Water Valley-Sardis Dam highway (Highway 315) have made several excellent outcrops of Kosciusko sand, of which some of the most prominent (Western part, Sec.5, and NE.¼, Sec.6, T.10 S., R.5 W.) are in the vicinity of Pilgrim's Rest Church and a little farther southeast. In fact, inasmuch as almost all the Panola County part of this highway is on a divide, it is in Kosciusko terrane except perhaps in two or three valleys and on the lower slopes of their walls, where Tallahatta beds are at the surface. One of the most prominent of the outcrops of Kosciusko sand along Highway 315 is afforded by the walls of a cut at Mt. Olivet Church (SW.Cor., Sec.13, T.9 S., R.6 W.). Roads west of Pilgrim's Rest Church show an extension of the sand body which is exposed by the highway cuts in the vicinity of the church. The lower part of the sand at many outcrops contains fragments and stringers and even restricted beds of white sand and white sandy and silty shale, almost certainly eroded from Tallahatta strata. The northeast-southwest roads (Sec.31, T.9 S., R.5 W., Sec.36, T.9 S., R.6 W., and Secs.1, 2, 10, 11, and 12, T.10 S., R.6 W.) show the Kosciusko sand especially well. A feature in a place or two is conspicuous dull white and iron-brown bands. A little north of the junction (SE.Cor., Sec.11) a mile or so east of Shuford School, is one of the greatest elevations of the region, underlain by a considerable thickness of sand, most of which is Kosciusko but the upper part of which probably is Citronelle.

Kosciusko sand and sandstone are well exposed also along the north-south road west of Highway 315 and north of Mt. Olivet (E.part, Sec.14, T.9 S., R.6 W.). Approximately half a mile west by north of the church, at the highest point along the road (400+ feet) a deep ravine a few yards east of the road shows varicolored cross-bedded sand containing a conglomerate of white clay fragments, and at the top a ledge of sandstone (Figure 27).

The Kosciusko sand is the uppermost interval of the section (Near Center, Sec.33, T.9 S., R.5 W.) half a mile west of the Lafayette County line near Orwood, and is the upper parts of the hills and ridges north of the section mentioned. Conspicuous examples are Terrapin Mountain (Center, Sec.16, T.9 S., R.5 W.)

and Lowe Mountain (SE.Cor., Sec.9, T.9 S., R.5 W.) which are the greatest elevations in Panola County. Both are Kosciusko sand capped with blocks of dark ferruginous sandstone, some of which are of very considerable size. A road cut in the southwest wall of the small valley on the north side of Terrapin Mountain exposes white shale or clay fragments in the sand at an elevation of about 420 feet. Inasmuch as the reworked white material probably is not far above the top of the Tallahatta, the thickness

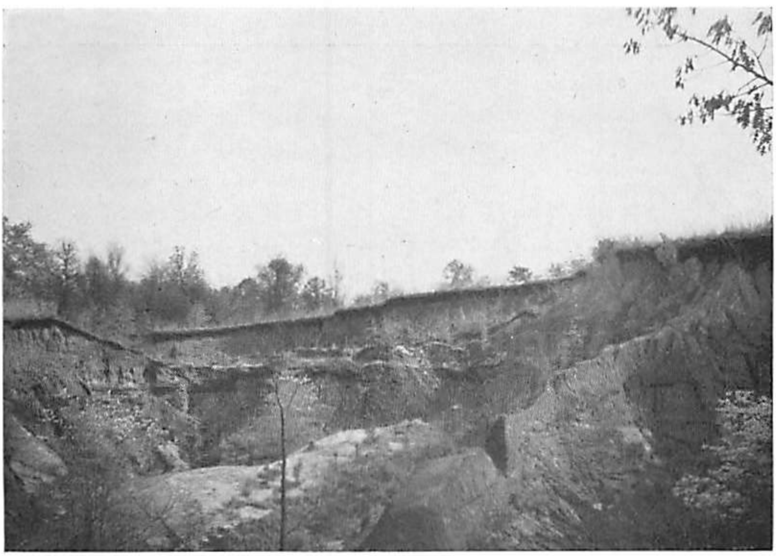

Figure 27.—Kosciusko sand and sandstone (NW.¼, SE.¼, Sec.14, T.9 S., R.6 W.) half a mile northwest of Mt. Olivet Church on Highway 315. April 11, 1956.

of the Kosciusko sand here may be 160 feet at least. However, the shale-sand contact being one of unconformity, the sand may be somewhat thinner than difference of elevation seems to indicate.

Kosciusko sand and sandstone were observed at a few places along and near a road which parallels roughly Highway 6 a mile to 1.5 miles south of the highway in the northern part of Township 9 South, Ranges 5 West and 6 West. The outcrop near the junction (SE.¼, Sec.5, T.9 S., R.5 W.) is featured by its clay breccia and quartz pebbles. The section 0.5 mile or so southwest of the Section 5 outcrop includes Kosciusko sand and sandstone, as already noted, and Kosciusko and underlying Tallahatta beds are exposed farther southwest on the same road. But the most prominent patch of Kosciusko rock in this region (On the line between Secs.10 and 11, T.9 S., R.6 W.) is part of the south wall of Hotopha Creek Valley a mile or so south of Highway 6. Here Tallahatta shale a few feet above flood-plain level is overlain by a "mountain" of sand and sandstone, reaching to more than 420 feet above mean sea level. The conspicuous feature of this, as of all the so-called "mountains" of Mississippi, is the sandstone cap. The large blocks of deep reddish-brown to almost black

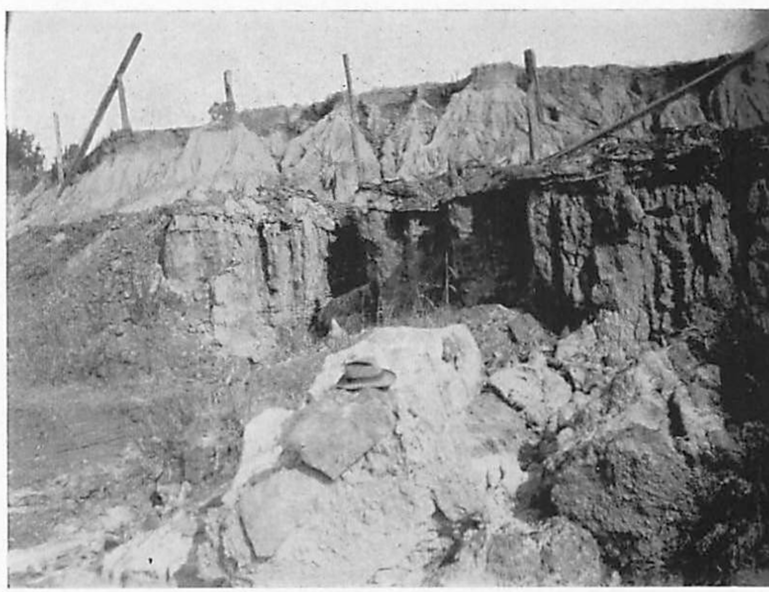

**Figure 28.—Kosciusko sand under loess (NW.¼, SE.¼, Sec.2, T.9 S., R.6 W.) on Highway 6, 0.4 mile west by south of junction of Highways 6 and 315. June 16, 1955.**

hard ferruginous sandstone lying at the summit and on the upper slopes of these elevations suggest that they, or the rock of which they are remnants, conditioned the genesis of the hill by protecting the underlying sand against erosion.

A Highway 6 cut (NW.¼, SE.¼, Sec.2, T.9 S., R.6 W.) 1.5 miles or so northeast of the "mountain" and 0.4 mile west by south of the junction of Highways 6 and 315, has exposed a short stratigraphic section at an elevation a little above 320 feet (Figure 28):

SECTION OF HIGHWAY 6 CUT 0.4 MILE WEST BY SOUTH OF JUNCTION OF HIGHWAYS 6 AND 315

| | Feet |
|---|---|
| Weathered loess and loessial soil | 11.0 |
| Silty limonite | 0.5 |
| Sand, coarse, ferruginous, brown | 5.0 |

The sand probably is basal Kosciusko, but could possibly be Neshoba or Winona. Tallahatta white shale crops out a short distance east of it.

North of Highway 6 patches of Kosciusko sand are at the surface here and there from the eastern boundary of the county west 4 to 5 miles, comprising the upper parts of the inter-stream areas. The western half of Township 8 South, Range 5 West, which borders Lafayette County, shows Kosciusko sand and sandstone only, beneath the Loess and mantle rock, except along the shore of Sardis Lake, in the valleys of Thompson Creek and one or two other tributaries of the lake which are deep enough to expose Tallahatta beds, and in two or three places in the Black Jack Community. Several summits of the area have elevations greater than 400 feet, and the greatest elevation exceeds 440 feet. The maximum thickness of the Kosciusko formation along the Lafayette County line probably is as great as 150 feet. At Black Jack Point (NW.¼, Sec.7, T.8 S., R.5 W.) the top of the Tallahatta is at an elevation of approximately 280 feet, and the top of the ridge is close to 350 feet. At the intersection (Southern part, Sec.32, T.8 S., R.5W.) of Highway 6 and a local road, the elevation is about 335 feet, and the elevation of the top of the upland half to three quarters of a mile farther north is slightly more than 440 feet. Inasmuch as both places are on the Kosciusko outcrop area, the thickness of the formation here would seem to be at least 105 feet. North of this intersection half a mile or so, a road cut has exposed a good section of Kosciusko sand (NW.¼, Sec.32). The sand is banded dull white and brown and brick-red.

West of the section (SW.¼, Sec.18 and NW.¼, Sec.19, T.8 S., R.5 W.) of which the uppermost 30 feet are Kosciusko sand, and west of the Black Jack-Sardis Dam road, the upland northeast of Jones Creek is Kosciusko terrane, for the most part. Several good outcrops were noted along the Cold Springs-Highway 6 road. The northeast wall of Jones Creek Valley just north of the junction (SE.¼, Sec.25, T.8 S., R.6 W.) is Kosciusko sand through a vertical interval of 80 feet or more. Sand is exposed uninterruptedly along this road all the way to the Cold Springs junction. Large cuts in brown sand are conspicuous some 0.4 mile east of the junction (NE.¼, Sec.23, T.8 S., R.6 W.).

The sand interval of the west wall of the valley where the section was measured (SW.¼, Sec.18 and NW¼, Sec.19, T.8 S., R.5 W.) extends westwards and is cut by a road right-of-way (Southern part, Sec.13, T.8 S., R.6 W.) 0.2 mile southwest of a

**Figure 29.—Kosciusko sand (NW.¼, Sec.13, T.8 S., R.6 W.) half a mile south by west of Sardis Dam spillway**

junction. About 0.8 mile farther southwest, near the bottom of a small valley, rock slabs in the brown and red-brown sand suggest the Tallahatta-Kosciusko contact.

Near the ends of Sardis Dam are extensive outcrops of Kosciusko sand and sandstone. A short distance south of the spillway at the southeastern end of the dam Tallahatta, Zilpha, and Kosciusko materials have been exposed by ravines and by borrow pits over a considerable area (see description under "Zilpha formation"). The Zilpha-Kosciusko contact is sharp, and well defined by a layer or layers of a zone of ferruginous sandstone and silty limonite (Figure 22). The rock is the floor

Figure 30.—Kosciusko pipe sandstone (Near Center, Sec.12, T.8 S., R.5 W.) at southeast end of Sardis Dam. October 19, 1954.

Figure 31.—Kosciusko tubular sandstone (Near Center, Sec.12, T.8 S., R.5 W.) at southeast end of Sardis Dam. October 19, 1954.

of a large borrow pit west of the ravines, and at the west end of the pit Kosciusko sand and sandstone are prominent. The thickness is at least 15 to 20 feet, of which the lower 6 to 8 feet are red sand, cemented to friable or hard sandstone in places, and the remainder is chiefly fine white or light-colored micaceous sand. Quartz grit and small quartz pebbles are lying on the red consolidated sand and are scattered through a basal interval of the light-colored sand. A well-defined contact trace exists in the light-colored sand between lower sand of a somewhat darker tint and upper more nearly white sand containing thin wedges of white clay and silt (Figure 29). This contact is on about the same level as the top of the red sand and sandstone.

The ferruginous sandstone and silty limonite or limonitic silt between the top of the Tallahatta shale and the superjacent sand, and in the basal interval of the sand, are extraordinarily developed on the point of land (Near center, Sec.12, T.8 S., R.5 W.) east of the drowned valley at the southeast end of the dam. Masses several feet thick of very irregular ferruginous sandstone, of prevailingly tubular shape (Figures 30 and 31) form an iron spearhead for the little peninsula a short distance northwest of an excellent exposure of the shale-sand contact.

The Kosciusko sand which is the uppermost interval of the section revealed by the Emergency Spillway cut at the northwest end of the dam has been mentioned in the description of the Tallahatta formation. It is most conspicuous in the south wall of the cut, where it has a maximum thickness of 45 feet above the rock layer at its base. The lower part is dominantly yellow, but no definite contact was found between the yellow sand and the superjacent red-brown sand. The yellow sand is fine and micaceous, and contains scattered nodules of white clay and pockets of fine white sand. The red-brown sand is coarser and more compact; much of it stands as a vertical-faced wall. Two small stringers of grit and quartz and quartzite pebbles were observed in the red sand.

In Sardis Lake State Park, along the lake north of the dam, ravines (NE.¼, SW.¼, Sec.35, T.7 S., R.6 W.) have been cut in Kosciusko brown sand containing considerable grit and thin beds and stringers of small gravel, chiefly quartz. This outcrop is approximately three quarters of a mile northeast of the Emergency Spillway cut. The elevation is about 320 feet. Tallahatta shale crops out a little above lake level a short distance away.

Ravines and road cuts have exposed Kosciusko sand in several other places along and near roads north and northwest of the dam. In Sardis Lake State Park (NW.¼, Sec.35) and along the road which leads west from the park, brown and red-brown sand shows here and there under 10 to 15 feet of loess. Outcrops along the road leading north from the junction (SE.¼, Sec.28, T.7 S., R.6 W.) to Union Church and School (SE.¼, Sec.16) show

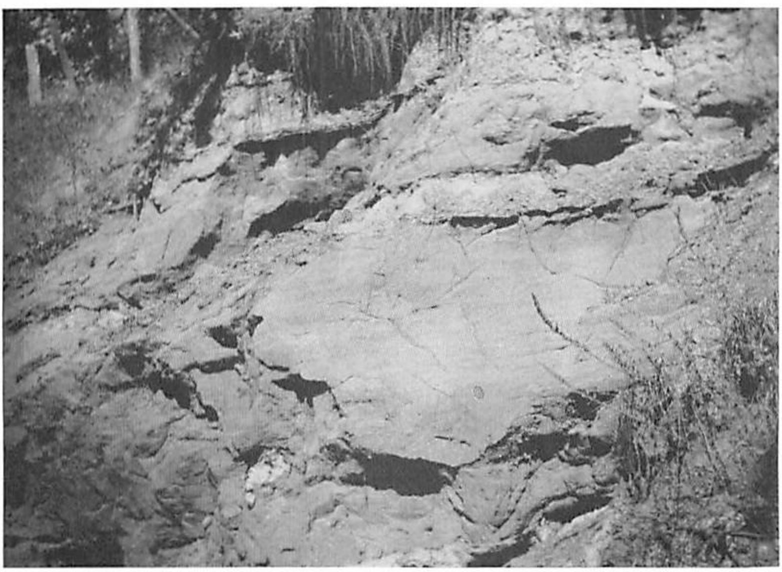

**Figure 32.—Kosciusko-Citronelle contact (SW.Cor., Sec.28, T.7 S., R.6 W.) in the west wall of Clarendon Creek Valley 2 miles northwest of Sardis Dam. September 14, 1954.**

sand and overlying loess, but no gravel. However, in a road cut (Southern part, Sec.28) in Clarendon Creek Valley, half a mile or so southwest of the junction first mentioned above (SE.¼, Sec.28) some fragments of white and pink and yellow silt and clay shale were noticed at an elevation of 260 to 280 feet. They are probably Tallahatta material worked into Kosciusko sand. The cut on this same road in the west wall of the valley exposes white sand and silt and clay below and brown coarse sand above (SW.¼, Sec.28, T.7 S., R.6 W.). The white material appears to be embedded in the coarse brown sand; in places sand, silt, and clay are a breccia or conglomerate. The lowermost interval of 10 feet or so of the brown sand has no gravel in it, but the uppermost interval contains gravel. Sandstone as much as a foot thick and some thinner layers are interbedded with the sand below the gravel (Figure 32). The section appears to include a segment of the Kosciusko-Citronelle contact trace.

The hard rock overlying the Tallahatta shale is prominent on the lake shore in the eastern part of Sardis Lake State Park (Sec.35, T.7 S., R.6 W.). It is ferruginous sandstone, yellow and brown, much of it very irregular, contorted, differentially cemented, fluted or tabular or rounded. Some slabs are strongly ripple-marked. At this place the rock is lying on fine yellow micaceous sand and silt, which are superjacent to Tallahatta white shale (Figures 13 and 16).

The northeastern corner of the county is a region of shale and overlying sand and a little sand rock. Approximately 0.8 mile east by south of Union Baptist Church, at a road junction (SE.¼, Sec.15, T.7 S., R.6 W.) is a considerable outcrop of red-brown sand at an elevation of plus or minus 360 feet. A still larger outcrop (NE.¼, Sec.25, T.7 S., R.6 W.) has been made by headward erosion of a short branch on the south side of the same road three quarters of a mile north by east of Lespedeza Point. The exposure is of red-brown sand mottled here and there with patches of yellow or lighter color and containing stringers and other irregular bodies of light-colored sandy clay. Grit and small pebbles are scattered through the sand in places. The thickness of sand exposed here is 40 to 50 feet. Some 250-260 yards farther east the Tallahatta-Kosciusko contact is shown by a road cut (NE.Cor. Sec.25, T.7 S., R.6 W.) (Figure 17). Some 10.5 feet of Tallahatta well bedded white clay and shale containing thin partings of vari-colored ironstone, silty limonite or limonitic silt, are overlain by 8.0 feet of sand and soil. The same contact is exposed a mile or more farther northeast, by a road cut and ravines (NW.¼, Sec.19. T.7 S., R.5 W.) in the east wall of the valley of Wilborn Creek. Features of the same contact, such as rock debris and different colors of weathered material, were observed also along the roads southeast of the last place named, near the lake. Also along the north-south road through Sections 18 and 19, Township 7 South, Range 5 West, cuts and ravines have exposed red-brown sand; and farther north and northeast red and brown sand is conspicuous in the walls of the valley of Nelson Creek. Outcrops of Kosciusko sand are prominent, too, along the east-west road through the northeastern quarter of Township 7 South, Range 6 West, especially in the valleys of Coleman Creek and other tributaries of Wilborn Creek.

Sections 4, 5, 8, and 9, Township 7 South, Range 5 West are in general a sand region. In places the sand contains irregular and linear bodies of pink mottled sandy clay and clayey sand. In the northeastern corner of the county are several outcrops of brown and red-brown sand overlying Tallahatta shale. In the same region—scattered outcrops of Kosciusko sand were observed as far west as the headwaters of Senatobia Creek, but the Citronelle formation reaches far to the east in this latitude.

## CITRONELLE FORMATION

Lying at some places on the Kosciusko and at other places on older Claiborne formations, and subjacent to the Loess, is a blanket of variable thickness of gravel, sand, silt and clay which is co-extensive with the area between the face of the Mississippi River Valley bluffs and an irregular north-south line which trends through Range 6 West. The gravel is chiefly subangular chert, although sandstone, quartzite, and crystalline quartz pebbles are fairly numerous. Individual pieces of gravel range from very small pebbles to cobbles several inches in diameter, and shapes vary widely, of course, due to the accidents and constantly changing conditions of weathering, erosion, and transportation, but all are rounded to some degree. The gravel, sand, silt and clay are irregularly distributed with relation to each other. Stringers or other irregular accumulations of gravel in sand or sand in gravel are characteristic of the outcrops. Cross-bedding is conspicuous in places. The Citronelle sands range from coarse to fine, and quite generally are red-brown from the oxidation of iron. The clay, light-gray to dark gray, is a minor component.[10]

In several places a short distance west of the eastern edge of the Citronelle area of outcrop are excellent exposures of Citronelle gravel and sand and sandstone. The southernmost of these (Eastern part, Sec.4, T.10 S., R.6 W.), on an east-west road about 2 miles east of Eureka Springs, is one of the best sections of Citronelle beds in the county. The lowermost interval is bedded brown sand; superjacent to it is well bedded white and pink sand containing a little white silt shale; this sand is overlain by gravel, which is succeeded upward by ferruginous sandstone 2 to 3 feet thick in places (Figure 33). A quarter of a mile farther east the sandstone crops out in the road. The section described above is exposed by a road cut in the east wall of the valley of a small tributary of Long Creek; in the west wall of the valley are gravel pits and natural outcrops of gravel and sand.

**Figure 33.—Citronelle sand, sandstone, and gravel (E. of Center, Sec.4, T.10 S., R.6 W.) 2 miles east of Eureka Springs. August 11, 1954.**

Approximately 4 miles north by east of the section described in the foregoing paragraph, road cuts and nearby gullies and ravines (NW.¼, Sec.15, T.9 S., R.6 W.) half a mile or more southwest of Central Academy, have exposed sand, clay, and gravel in both walls of the valley of a tributary of Hotopha Creek. In the east wall are sand and clay outcrops (Figure 10) which suggest the Zilpha and Kosciusko formations. Farther down slope are large gravel pits and other outcrops on both sides of the small stream, showing 15 to 20 feet of mixed gravel and sand, including cross-bedded sand and stringers of gravel.

Some of the largest gravel pits in the county (Near center, Sec.5, T.9 S., R.6 W.) were opened by the Linn Sand and Gravel Company half a mile north of Highway 6. The thickness of the gravel beds here is 25 to 30 feet, although they are only a mile or so west of the eastern edge of the Citronelle formation.

North of the Linn Company sand and gravel plant 1.5 miles, at a road junction, an excellent section (SE.¼, SW.¼, Sec.29, and northern part Sec.32, T.8 S., R.6 W.) has been exposed by road cuts and ravines:

STRATIGRAPHIC SECTION (SW.¼, SEC.29, AND NORTHERN PART, SEC.32, T.8 S., R.6 W.) OF THE EAST WALL OF HOTOPHA CREEK VALLEY 1.5 MILES NORTH OF THE LINN SAND AND GRAVEL COMPANY PLANT

| | Feet | Feet |
|---|---|---|
| Loess formation | | 15.0 |
| Silt, gray to tan clayey and sandy, to level of school building | 15.0 | |
| Citronelle formation | | 35.0 |
| Sand, sandstone, gravel, clay: | | |
| Sand is coarse to fine; brown, variously cemented, and strongly cross bedded in the upper part, the bedding being inclined southeastward. The sand grades upwards into brown friable to firmly cemented sandstone, of which much is tubular or fluted; the sparse gravel is distributed as stringers and thin beds towards the top of the interval. Farther south a 2-foot lens of white to yellowish sandy and silty clay is included, and blobs and pellets of clay are disseminated in the sand, to base of section | 35.0 | |

Approximately 2.5 miles northeast of the section described above, Citronelle terrane is well exposed (NE.¼, Sec.21, T.8 S., R.6 W.) along an east-west road in the right wall of the valley of Jones Creek, half a mile south of Highway 35. The vertical walls of coves at the heads of the ravines show a sharply defined section of beds of brown and yellow sand capped by a thin bed of silty limonite and sandstone, above which are gravel and white argillaceous sand and some white clay. Some of the sand in the lower part of the outcrop may be Kosciusko—that is, part of the Kosciusko-Citronelle contact trace may be exposed here.

Four miles north by west of the outcrop last described, and 2.5 miles north of the Tallahatchie River, a road cut in the west wall of Clarendon Creek Valley has brought to the surface beds of Citronelle and possibly Kosciusko age (SW.¼, Sec.28, T.7 S., R.6 W.). The lowermost interval, brown sand containing no gravel, probably is Kosciusko; but the uppermost interval, above a definite contact, is gravel and sandstone of Citronelle age (Figure 32).

Approximately two and a quarter miles north of the Section 28 outcrop, and 0.35-mile west of Union Church School, a road cut and nearby erosion hollows have exposed Citronelle beds (SW¼, Sec.16, T.7 S., R.6 W.). The most prominent feature of the outcrop is the relatively thick sandstone (Figure 34). Sand and some white clay overlie the sandstone, but gravel is all but absent.

**Figure 34.—Citronelle sand and sandstone exposed by a road cut (SW.¼, Sec.16, T.7 S., R.6 W.) half a mile west of Union School. July 28, 1953.**

Three quarters of a mile farther north, on an east-west road, is another exposure of sand, sandstone, and loess (SW.¼, Sec.9, and NW.¼, Sec.16, T.7 S., R.6 W.). The sandstone is pipe shaped, fluted, and otherwise contorted; loosely cemented and friable. Both sand and sandstone are medium grained, and almost a Winona red. Sandstone and silty limonite float are scattered over the outcrop where the loess has been eroded away, but no gravel is present. Most of the sandstone is 3 to 5 feet below the sand-loess contact.

As stated, these eight prominent outcrops of Citronelle terrane are only a short distance west of the eastern edge of the formational outcrop area as a whole. The relatively considerable thicknesses of the beds so near their eastern limits suggest deposition against or near a somewhat steep east wall of a wide valley.

Exposures of Citronelle beds are numerous over the entire region occupied by the formation. A few of the more prominent will be described briefly, in north-south and east-west order.

The area east of the Mississippi River Valley bluff and north of the Tallahatchie River is in general of low relief, and in only a few places, in the valleys of the larger streams, has any considerable section been uncovered by natural agencies. Additional exposures are afforded by sand and gravel pits.

In the extreme northern part of the county the easternmost gravel pits observed (SW.¼, Sec.21, T.6 S., R.6 W.) are a little less than 7 miles west of the eastern boundary of the county. A mile and a half to 2 miles or more farther west along the same road, are good natural outcrops. A little north of the intersection of this road with a north-south road, in the short steep northeast wall of a small valley, large slabs of ferruginous sandstone form a shelf under the gravel at an old pit (SE.¼, Sec.24, T.6 S., R.7 W.). In the less steep opposite wall of the valley, gravel shows, but no sandstone. However, 3.25 miles farther west, 0.5 mile east of the Illinois Central Railroad at McGhee, masses of brown sandstone, one of which is 5.0 feet long and 2.5 to 3.0 feet thick, are lying along the road (SE.¼, Sec.21, T.6 S., R.7 W.). The elevation of both places (Sec.24 and Sec.21) is approximately 320 feet.

The region (T.6 S., Rs.7, 8, 9 W.) west of Highway 51 in the northern part of the county is of low relief, and road cuts are so shallow that they expose loess only, or loess underlain by a thin interval of Citronelle sand and gravel. The valleys of the main streams show little more. Farther west, in a narrow belt bounded by the Mississippi River bluff, thicker sections of Citronelle are exposed, in the face of the bluff and in the walls of cuts made by short, steep-gradient streams. Several large gravel pits are north and east of Crenshaw, in the northwestern corner of the county, especially near Askew and Buxton north by west of Crenshaw. Extensive sand and gravel pits (Figure 35) and a screening and washing plant are located on the north side of Highway 310 2 miles northeast of Crenshaw.

Gravel shows prominently along a northeast-southwest road (Secs.16, 17, 19, 20, 30, T.7 S., R.6 W.), especially at three or four pits. One pit (NE.¼, Sec.30) a short distance northeast of the junction of Highway 315 with a local road is 25 to 30 feet deep and has a clay floor in places. In both walls of the valley, southeast and southwest of the junction, are excellent outcrops of

**Figure 35.—Citronelle gravel exposed by pit (SW.¼, Sec.33, T.6 S., R.9 W.) of Crystal Springs Sand and Gravel Company, 2 miles northeast from Crenshaw. April 26, 1956.**

gravel, and Citronelle gravel and sand are at the surface under the loess in many places westward along the highway to Sardis. Westward from Sardis and Highway 51 to the river bluff is a sand and gravel and loess region, although Citronelle materials are well exposed in only a few places. One of these places is in the walls of the valley of Crooked Creek and in the creek channel at the crossing of an east-west road (SW.¼, Sec.13, and NW.¼, Sec.24, T.7 S., R.8 W.), especially in the east wall, where cross-bedding of the sand and gravel is conspicuous. Another prominent outcrop some 300 yards north of the road shows vertical walls of Citronelle and Loess.

Approximately 2 miles south by east of the Crooked Creek outcrops are gravel and loess exposures in the walls of the valley of McIvor Drainage Canal, and extensive gravel and sand workings. The pits, 10 to 15 feet or more deep, and extending over 2 to 3 acres, are half a mile or less northwest from a recently improved road which leads due west from Sardis. Northeast of the pits, towards the head of the drainage canal, are natural outcrops and a pit (Near center, Sec.21, T.7 S., R.7 W.) three quarters of a mile west of Highway 51.

Citronelle gravel and sand are conspicuous farther west along the improved road west from Sardis, mentioned above, notably in the west wall of the valley of Crooked Creek, where pits have been opened (SE.¼, Sec.26, T.7 S., R.8 W.), and in the west wall of East Floyd Creek Valley (SE.Cor., Sec.28, T.7 S., R.8 W.).

Citronelle materials are at the surface here and there between the Tallahatchie River and the Sardis Dam-Sardis highway (Highway 315). Along the east-west road through Sections 5 and 6, Township 8 South, Range 6 West and 1 and 2, Township 8 South, Range 7 West, are several outcrops of sand and gravel, notably in the valley walls of Oil Creek. Also, along a road which leads south from Sardis between the Illinois Central Railroad and Highway 51, ravines and road cuts have exposed considerable thicknesses of gravel. An old pit (NE. Cor., Sec.10, or NW. Cor. Sec.11, T.8 S., R.7 W.) shows the gravel deposits especially well.

Citronelle beds are in view at a few places along the road parallel to Tallahatchie River on the north side, and at the intersection (SE.¼, NE.¼, Sec.13, T.8 S., R.7 W.) a little north of the river bridge, are excellent outcrops of gravel. Half a mile or less farther southwest is a large pit (Near center, Sec.13) where gravel and red sand are well exposed.

At Tallahatchie Station (Near center, Sec.22, T.8 S., R.7 W.) the southwest end of the ridge between the river valley and a tributary creek valley, a few rods east of the Illinois Central Railroad, has been cut off, presenting a steep face some 40 feet high and 200 feet wide, which shows very clearly the structural relationships of the sand and gravel units.

Small outcrops of sand and gravel are numerous west of Highway 51 in Township 8 South, more particularly in the slopes.

Figure 36.—Citronelle gravel lying on Kosciusko sand (SE.¼, Sec.8, T.9 S., R.6 W.) in the east wall of a road cut 0.7 mile south of the Goodnite store on Highway 6. June 11, 1954.

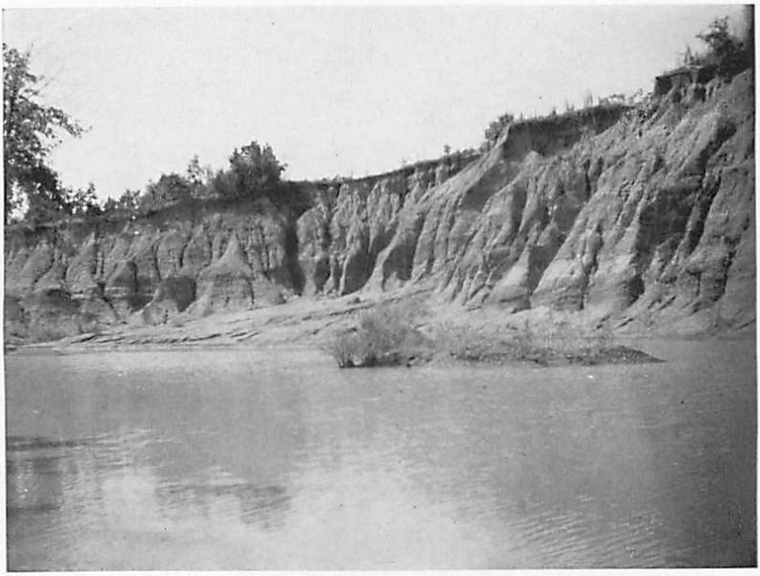

Figure 37.—Citronelle gravel exposed by pit (SE.¼, Sec.7, T.9 S., R.6 W.) 0.35 mile south of Highway 6 and 1.5 miles north by west of New Hope Church and School. August 12, 1954.

They are conspicuous, for examples, along a north-south road in both walls of Bear Creek Valley (Secs. 5 and 6, T.8 S., R.7 W.), and in the north wall of the same valley a mile farther west, where deep ravines and the erosion hollows at their heads have exposed the Citronelle materials over a considerable area (Near common corner, Ts.7 S. and 8 S., Rs.7 W. and 8 W.). Prominent outcrops (Near common corner, Secs.10, 11, 14, 15, T.8 S., R.8 W.) are shown by old pits in the east wall of the valley of McIvor Drainage Canal, on both sides of an east-west road.

Half a mile west of Highway 51, a large abandoned pit (NE.¼, Sec.21, T.8 S., R.7 W.) shows above the water a face of some 20 feet of gravel and sand, under 10 to 15 feet of loess. Half a mile northwest of it is another pit (SW.¼, Sec.16) and a mile or so south by west of the Section 21 pit are good outcrops of gravel. A short distance farther west, in the east wall of a valley, are other good exposures made by old pits. Ledges of conglomerate are conspicuous. One pit has a gravel and sand wall 20 to 25 feet high. The opposite wall of the valley also shows pits and natural outcrops. This northeast-southwest road lies along the top of the north wall of the Tallahatchie River Valley all the way from Highway 51 to the Mississippi River Valley bluff, and in several places along it on both sides, deep ravines have been cut through the loess and into the sand and gravel. In fact, the road extends all the way from Sardis Dam to the Delta bluffs.

South of the Tallahatchie River, outcrops of Citronelle sand and gravel are very numerous, and many pits have been opened. One of the prominent gravel pits (SE.¼, Sec.8 and SW.¼, Sec.9, T.9 S., R.6 W.) is on a north-south road 0.6 to 0.7 mile south of Highway 6, in the south wall of the valley of Hotopha Creek. The gravel overlies brown sand which may be Kosciusko. Some white clay shale is worked into the sand and gravel. The thickness of the gravel deposit is 10 to 20 feet (Figure 36). Elevation is about 310 feet.

A mile west of the pit described above, on another north-south road, gravel crops out in the walls of a cut, and a little farther north is a large abandoned pit which shows 15 to 20 feet of sand and gravel above the water (Western part, Sec.8, T.9 S., R.6 W.).

Approximately 175 to 260 yards farther south, on the west side of the same road, is a pit 200 to 250 feet long and 75 feet wide, the west wall of which is 25 to 30 feet high above the water (Figure 37).

Citronelle gravel and sand are at the surface in many places farther south in the west two-thirds of Township 9 South, Range 6 West and in Township 10 South, Range 6 West. Perhaps the best outcrops in this territory are along an east-west road (Secs. 20 and 21, T.10 S., R.6 W.) where the terrane is roughened by gullies, ravines, small valleys, road cuts, and pits. The gravel is well exposed by three or four old pits, the westernmost of which (Eastern part, Sec.20) is 0.6 mile east of a road junction, and 2.5 to 3.0 miles west of the eastern edge of the Citronelle outcrop area. The altitude is 300 to 340 feet. A feature of these exposures, and especially of an outcrop (NW.¼, Sec.20) at old gravel pits near a road junction half a mile farther northwest, is a notable development of conglomerate. The influence of the conglomerate and the thick gravel beds on the topography, noticeable at many places in the Citronelle belt of outcrop, is especially evident here, in the relatively narrow and steep-walled valleys.

Less than half a mile north of the Panola-Yalobusha County line, at a road junction within sight of Enid Lake, big ravines (SW.¼, Sec.32, and SE.¼, Sec.31, T.10 S., R.6 W.) have exposed a considerable section of loess and Citronelle sand. Several similar erosion gashes in the same general region, the north wall of the Enid reservoir, show much gravel.

About 2.5 miles south of Pope, half a mile north of the Panola-Tallahatchie County line, a little east of the Illinois Central Railroad and a short distance west of Highway 51, are large abandoned gravel pits and natural outcrops (NE.¼, Sec.33, T.10 S., R.7 W.). A mile or more farther east, at a road junction, Citronelle sand, overlain by loess, has been exposed by erosion over a sizable area (NE.¼, Sec.34, T.10 S., R.7 W.). Deep reddish-brown sand below a sharp contact is overlain by fluted pinnacles of white sand (Figure 38). Little or no gravel is present, although, as stated, large pits are conspicuous a mile or so west of the Section 34 outcrop. Another gravel pit, half a mile northwest of the figured exposure, is in the same small valley as the larger pits—the valley of Nelson Creek. All the gravel is at a lower elevation than the sand outcrop.

The moderately deep valley of Long Creek affords prominent Citronelle outcrops in places. Near a road junction at the foot of the south wall of the valley is a cut through brown sand and stringers and thin beds of gravel (NW. Cor., Sec.18, T.10 S., R.6 W.), and at the bridge 1.5 miles or more farther down stream (SW.¼, Sec.11, T.10 S., R.7 W.) a layer of hard sandstone several inches thick lies a little above low water level. The rock is underlain by plastic light-gray and yellow clay in places. In the upland a little less than half a mile north of the bridge, the wall

**Figure 38.—Citronelle sand overlain by loess (NE.Cor., Sec.34, T.10 S., R.7 W.) at road junction half a mile east of U. S. Highway 51 and 1.5 miles north by west of Enid Dam. August 12, 1954.**

of a gravel pit (Figure 39) (NW.¼, Sec.11) shows 15 to 20 feet of gravel and sand below 10 feet of loess and soil. The gravel is light gray to bluish gray where fresh, but brown and somewhat cemented towards the top of the deposit. The gravel-loess contact is sharp.

The road which leads west and southwest from the Long Creek bridge in Section 11 to Highway 51 is on a gravel and sand and loess terrane. A road cut and ravines in the south wall of the valley of Peters Creek afford an excellent outcrop of gravel, red sand, and loess (NE.¼, Sec.16, T.10 S., R.7 W.). The north wall of the same valley along the northeast-southwest road through Courtland has been severely eroded in places, exposing loess and Citronelle materials. Southwest about 1.4 miles from the railroad in Courtland is a gravel pit (NW.¼, Sec.8, T.10 S., R.7 W.) 150 feet long and at least 50 feet wide. The vertical face of the north wall of the pit is some 25 feet high. The lower 15-foot interval shows a mixture of sand and gravel, iron stained and cross-bedded. The gravel is overlain by bedded white and pink-mottled clay.

A mile and a half farther southwest is another gravel pit, in the west wall of the valley of Bobo Bayou, a small tributary of

**Figure 39.—Citronelle gravel, wall of pit (NW.¼, Sec.11, T.10 S., R.7 W.) 2 miles southeast of Courtland. August 11, 1954.**

Peters Creek (NW.¼, Sec.7, T.10 S., R.7 W.). Half a mile northwest of this pit, on the west side of the road, large ravines have been cut in loess, gravel, and sand (NE.¼, Sec.12, T.10 S., R.8 W.) (Figure 40). A mile still farther northwest, an erosion hollow (SE.¼, Sec.2, T.10 S., R.8 W.) a short distance southeast of Independence Presbyterian Church, is 20 to 25 feet deep in Citronelle red and purple and white sand containing a little clay, but no gravel. Road cuts and erosion depressions farther west expose abundant gravel and notable thicknesses of loess, especially along a south-north road through Sections 9 and 4, Township 10 South, Range 8 West, and Section 33, Township 9 South, Range 8 West.

Outcrops in the walls of the valley of O'Brien Creek, and at the junction (NE. Cor., Sec.4, T.10 S., R.8 W.) merit special mention.

In the northeast wall of Hayne Creek Valley, a road cut (SE.¼, Sec.27, T.9 S., R.8 W.) shows an excellent section of gravel, sand, and loess. Contacts are sharply defined. A little less than a mile farther north by east along the same road, large gravel pits have been opened (SW.¼, Sec.23, or NW.¼, Sec.26, T.9 S., R.8 W.). The pit west of the road is 20 to 25 feet deep

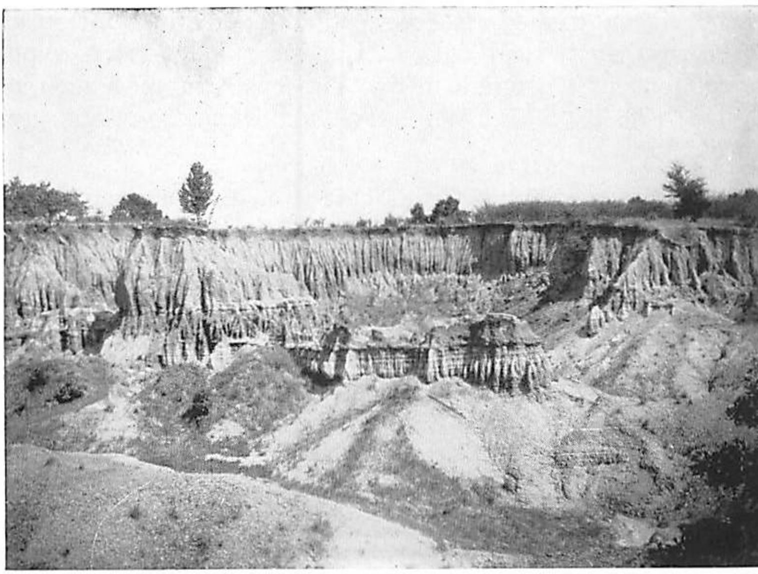

**Figure 40.—Citronelle gravel and sand under loess (NE.¼, Sec.12, T.10 S., R.8 W.) 2.5 miles southwest of Courtland. August 13, 1954.**

below road level; the larger pit, on the east side of the road, is somewhat deeper.

Half a mile east of the pits mentioned above, at a bend in a north-south road, are other extensive pits (NE. Cor., Sec.26, T.9 S., R.8 W.) which rank with the largest in the county. Excavation has reached a maximum depth of about 50 feet, of which some 20 feet is loess and 30 feet sand and gravel. Vertical faces afford a good view of the section. The gravel is irregularly distributed as large ill-defined roughly linear bodies, and as stringers and scattered pebbles. The entire sand and gravel terrane is much oxidized: Red and brown colors are dominant, but at greater depths the gravel is gray and white. At the time the writer visited the place, large-scale operations were in progress.

The sand and gravel formation crops out almost uninterruptedly in the face of the Mississippi River Valley bluff from the northern boundary of the county to the southern. In the northwestern corner of the county, natural outcrops and gravel pits are many, especially in the vicinity of Buxton and Askew. The face of the bluff at the Kentucky-Tennessee Clay Company's pits (NW.¼, Sec.21, T.7 S., R.9 W.) exposes 42 feet of sand and gravel subjacent to the loess (see section under Zilpha formation). Farther southeast, road cuts in the escarpment have exposed cross-sections of Citronelle beds. The large ravines and coves (SE.¼, Sec.29, T.8 S., R.8 W.) likewise show the sand and gravel interval.

Along the road which leads east from Asa, cuts in the face of the bluff (SW.¼, Sec.29, T.9 S., R.8 W.) show a relatively thick section of cross-bedded sand and gravel. A very little light-gray clay near the foot of the slope may be Zilpha in place. South of Asa are several pits in the bluff whence large quantities of gravel have been removed. Some of the pits were abandoned long ago, but a few are still in operation, at least now and then. One pit (SE.¼, Sec.31, T.9 S., R.8 W.) is superjacent to an outcrop of Zilpha clay. A little more than a mile farther south the bluff has been excavated for a considerable distance—pits are so close together that they almost constitute a single excavation (SW.¼, Sec.5, T.10 S., R.8 W.). The pit floors are several feet above the north-south road which extends along the bluff.

In the southwestern corner of the county, 4 miles east of Crowder and three quarters of a mile north of the Tallahatchie County line, are extensive gravel pits (Northern part, Sec.35, T.27 N., R.2 E.), in the south wall of Yocona River Valley. The pit walls show gravel beds 25 to 30 feet thick under some 15 feet of loess. Excavations occupy two or three acres at least.

A study of the Panola County Citronelle as a whole, consisting of observation of outcrops as described in the foregoing text, and others, and a comparison of outcrops, one with another, makes clear that the formation is a flat lying blanket of sand, gravel, silt, and clay, of variable thickness. The variation of thickness in short distances is due to 1) deposition on an eroded surface; 2) irregular deposition from shifting currents of variable velocity; 3) erosion subsequent to deposition. The gravel deposits seem to have been left by a number of streams rather than by one large stream alone.

Measurements along the Mississippi River Valley bluff at places where underlying Zilpha clay crops out show thicknesses as great as 40 feet, as hereinbefore stated. But Brown[11] gives logs of Panola County wells farther east which indicate much greater thicknesses. According to the log, Panola County Well 3a (SW.¼, SW.¼, Sec.10, T.7 S., R.7 W.) at the Como Prisoner of War Camp, passed through 30 feet of "top soil" [loess] and 120 feet of sand and gravel, all considered by Brown to be terrace deposits, which Matson and Shaw have included in their Citronelle formation. The elevation of the mouth of the well is 390 feet, which would place the base of the sand and gravel terrane at 240 feet, an elevation approximately the same as that of the base of the gravel in the bluff at the Kentucky-Tennessee Clay Company pits 13 miles a little south of west of the Como well. But the gravel and sand interval at the pits is only 42 feet thick (see section). It seems probable, then, that the well reaches through two or three terrace levels, and that the terraces were formed by alluviation only, in a wide valley, the floor of which was at an elevation of approximately 240 feet above mean sea level.

Panola County Well 6 (NE.¼, NE.¼, Sec.34, T.7 S., R.7 W.) in the town of Sardis, begun at an altitude of 370 feet, found 125 feet of terrace deposits, the bottom of which would, then, be at an altitude of 245 feet. The well is about 3.5 miles south by east of the Como well. It should be noted that the log of this Sardis well was written down from memory.

Panola County Well 8a (NE.¼, SW.¼, Sec.21, T.8 S., R.8 W.) approximately 8.5 miles southwest of the Sardis well, found only 43.8 feet of terrace materials. The altitude of the mouth of the well is 300 feet. The altitude of the base of the terrace deposits should be at around 256 feet, which is not widely at variance with the elevation of the base of the gravel in the walls of the big ravines in the bluff (SE.¼, Sec.29, T.8 S., R.8 W.), a mile or so southwest of the well.

Panola County Well 13 (NW.¼, SE.¼, Sec.5, T.9 S., R.6 W.) at the Linn Sand and Gravel Company plant, about 8 miles south by east of the Sardis well, passed through 24 feet of terrace deposits, of which only 12 feet were sand and gravel. However, the elevation of the mouth of the well is 250.5 feet, which would indicate that the base of the terrace is at an altitude of 226.5 feet.

Panola County well 33 (NE.¼, NE.¼, Sec.33, T.10 S., R.7 W.), a little more than 2 miles south of Pope and a quarter of a mile west of Highway 51, passed through 25 feet of alluvial sand above the Kosciusko formation. No elevations were given on the log, but the topographic map (Oakland quadrangle) indicates an altitude of approximately 240 feet. Nearby gravel pits have an elevation of something like 280 to 300 feet.

Brown makes the statement, "The gravel and sand of the terrace deposits reach a maximum thickness of 120 feet in western Panola County."[42]

In November, 1954, two prospect holes were drilled by the Mississippi Geological Survey in the vicinity of Como. At the first location (NW.¼, NW.¼, Sec.15, T.7 S., R.7 W.) 2.5 miles south of Como, the total depth reached was 158 feet, and the base of the gravel at 93 feet. The log showed a clean medium to coarse sand from 108 feet to 158 feet, a sand that is believed to be water bearing. Probably the sand and gravel below the loess to a depth of 93 feet more or less, are terrace materials (Citronelle) and the 50 feet of sand below them is Kosciusko. The second hole (NE.¼, Sec.32, T.6 S., R.7 W.), along U. S. Highway 51 a mile north of Como, at an elevation somewhat less than that of the first hole, reached the bottom of the gravel at approximately 70 feet.[43]

## LOESS FORMATION

The uppermost formation of the county, except mantle rock and alluvium, is the loess, a gray to tan velvety silt which is spread over almost the entire area. From a thickness of perhaps 25 feet, maximum, in places above the face of the bluff escarpment, the formation is progressively thinner eastward to a distance where it is represented by loessial soil (brown loam) only, thence to the line of disappearance.

The loess is chiefly silt, but commonly contains a little clay and very fine sand. Mechanical analyses of unweathered loess from Natchez, by the U. S. Department of Agriculture, showed that the samples analyzed were almost 87 percent silt, 5.6 percent very fine sand, and 6.3 percent clay." Loess from anywhere in the state is very similar to loess from any other place in the state. The chief characteristics are: 1) Uniformity of texture; 2) extreme fineness and angularity of shape of particles; 3) generally massive structure; 4) lack of coherence; 5) capacity to stand as vertical-faced walls; 6) capacity to absorb water.

The chemical composition of a sample of unweathered loess is indicated by the following analysis record:[45]

ANALYSIS OF UNWEATHERED LOESS, BATESVILLE

| | |
|---|---|
| Moisture ($H_2O$) | 1.81 |
| Volatile matter ($CO_2$) | 3.20 |
| Silicon dioxide ($SiO_2$) | 75.11 |
| Iron oxide ($Fe_2O_3$) | 5.50 |
| Aluminum oxide ($Al_2O_3$) | 10.70 |
| Calcium oxide (CaO) | .60 |
| Magnesium oxide (MgO) | .47 |
| Sulphur trioxide ($SO_3$) | .00 |
| Total | 97.39 |

RATIONAL ANALYSIS

| | |
|---|---|
| Clay substance | 27.07 |
| Free silica | 62.53 |
| Impurities | 6.57 |

The thickness of the loess as a formation is extremely variable, due to want of uniformity of original eolian deposition, deposition on an irregular surface, and weathering and erosion subsequent to deposition. The loess was originally broadcast by the winds and settled on the hills and in the valleys indiscriminately, so that today it may be lying at any topographic position.

A few of the more prominent outcrops of loess in Panola County may be mentioned:

Along the roads, notably along north-south roads, in Township 10 South, Range 6 West, loess is conspicuous. Cuts for the road between Sections 28 and 33 on the east and 29 and 32 on the west, are almost entirely in loess, as are those for the east-west road at right angles to it, along the northern boundaries of Sections 28, 29, and 30. Approximately 3.5 miles farther north, at the road junction a short distance northeast of Eureka Springs, is a vertical-faced loess wall 15 to 20 feet high, separated from underlying red-brown sand by a thin friable ferruginous layer (NE.¼, SE.¼, Sec.6, T.10 S., R.6 W.). The wall has been carved by running water into fluted columns.

Farther west, the territory between the headwater branches of Peters Creek shows little rock material other than loess, especially along the roads through Sections 35 and 36, Township 9 South, Range 7 West, and Sections 2 and 3, Township 10 South, Range 7 West. Loess is well exposed also along the road which leads southwest from Pope to and beyond the Yocona River, thence west to the Mississippi River Valley bluff. An excellent outcrop is shown by the large gravel pit (Northern part, Sec.35, T.27 N., R.2 E.).

Road cuts in the walls of the valley of a tributary of O'Brien Creek (NE.¼, Sec.4, T.10 S., R.8 W.) expose 15 feet or more of loess, and an equal thickness shows at the road junction some 0.4 mile farther north. In fact, the south-north road through Sections 9 and 4, Township 10 South, Range 8 West, and Section 33, Township 9 South, Range 8 West, is one of the best roads in the county for outcrops of loess. A little east of Tocowa church, also, the road cut (SE.Cor., Sec.8, T.10 S., R.8 W.) in the slope is walled with loess. Three miles farther north, the notch (SW.¼, Sec.29, T.9 S., R.8 W.) in the bluff made for an east-west road exposes a good section of loess, and all cuts along this road for 3.5 miles are in loess. At the big gravel pit (NE.Cor., Sec.26, T.9 S., R.8 W.) the uppermost interval is about 20 feet of loess.

Outcrops of loess are many north of the Tallahatchie River from the bluff escarpment eastward to and beyond Highway 51. The big ravines (SE.Cor., Sec.29, T.8 S., R.8 W.) expose 15 to 20 feet of loess at the top of the section (Figure 41). Probably the greatest thicknesses of loess in the county may be observed along the road which leads north from the big ravines through steep-walled cuts, and in the entire region east of it loess is the surface material everywhere except in the relatively few valleys and road cuts and gravel pits which are deep enough to expose underlying gravel and sand. The section at the pit (SW.¼, NE.¼, Sec. 21, T.8 S., R.7 W.) includes 10 to 15 feet of loess. Also, Highway 315, east of Sardis for 2.5 to 3.0 miles, is through several cuts in the loess.

Townships 6 South and 7 South, Ranges 7 West and 8 West, are a typically loess region. In most places the roads are in vertical-walled cuts. Such cuts are conspicuous along the Como-Crenshaw highway (Highway 310) and along the criss-cross of local roads north and south of Highway 310. A few places are particularly worthy of note: 1) A 20-feet wall of loess (SE.¼, Sec.30, and SW.¼, Sec.29, T.7 S., R.7 W.) 2.5 miles west of Sardis, and 0.4 mile north of McIvor Church; 2) a cut (SE.¼, Sec.13, T.7 S., R.8 W.) in the east wall of the valley of Crooked Creek; 3) the east wall of a cut (SW.¼, Sec.16, T.7 S., R.7 W.) a little

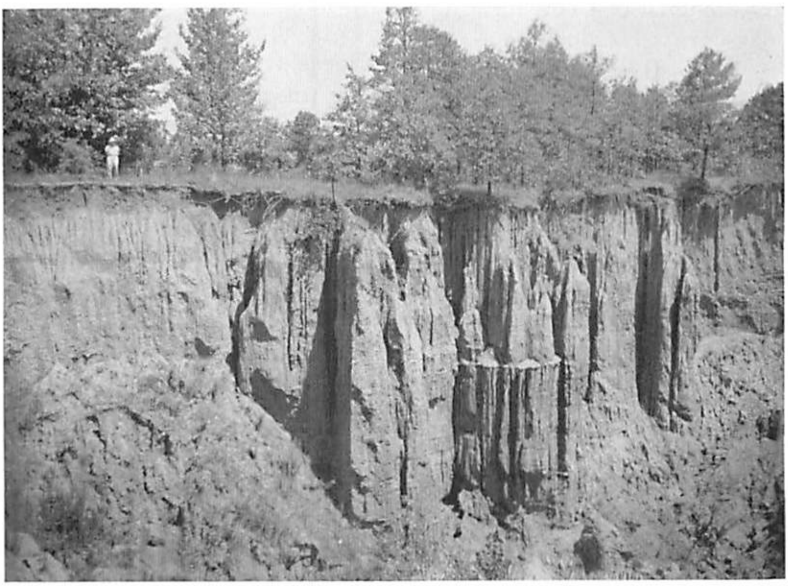

**Figure 41.—Citronelle sand and gravel overlain by loess (SE.Cor., Sec.29, T.8 S., R.8 W.) exposed by a large erosion hollow in the Mississippi River Valley bluff a mile north from Macedonia School. July 24, 1953.**

more than 2.5 miles northwest of Sardis and a mile west of Highway 51, which shows some 15 feet of loess; 4) a road cut (SE.Cor., Sec.28, T.7 S., R.8 W.) a short distance west of the intersection at Mougey's store, in the west wall of the valley of East Floyd Creek.

Loess crops out almost everywhere along the Mississippi River Valley bluff. A few places may merit special mention: 1) At places where roads lie across the face of the escarpment, as a) between Sections 7 and 18, Township 8 South, Range 8 West, a little east of Ballentine; b) Southeast ¼, Section 1, Township 8 South, Range 9 West; c) Southeast Corner, Section 35, Township 7 South, Range 9 West; d) Northwest ¼, Section 27, Township 7

South, Range 9 West; e) Eastern part, Section 21, Township 7 South, Range 9 West; f) in Crenshaw, Section 6 and 7, Township 7 South, Range 9 West; and g) at Askew and Buxton, Sections 30 and 19, Township 6 South, Range 9 West; 2) at places where streams have cut trenches in the bluff in their descent from the uplands to the flood plain; 3) where excavations have been made in the face of the bluff, as at several gravel pits, at the big pits of the Kentucky-Tennessee Clay Company, and at the Womack pits northeast of Crenshaw.

The lithologic character of the Loess, its geographic and topographic distribution, its structure, its roughly uniform lessening in thickness from west to east—these and other factors suggest strongly, if they do not prove, that the wind was the chief agent in the building of the formation. Studies of all relationships of the loess have tended to show that it is largely glacial "rock flour"—finely ground rock material from the glacial mill—which was carried southward by streams flowing from the melting ice, and later lifted by the wind from the flood plains of these streams, notably from the flood plain of a Pleistocene Mississippi River, to the top of the east wall of the river valley.

## RECENT FORMATION

Theoretically, the "Recent formation" consists of all rock material which has been derived from older rocks and has assumed its present form and reached its present position since the close of Pleistocene time. Customarily it has been made to include all residual mantle rock as well as much transported rock waste in its various forms such as alluvium, colluvium, and talus. However, just as no exact time can be designated the beginning of the Recent or the end of the Pleistocene, so at few places, if any place in Panola County, 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 in age. Certainly some residuum antedates the age which could logically be called Recent, and the lowest and oldest alluvium very probably is Pleistocene.

Shaw[40] 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 more 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 should be considered to belong to the Recent formation. No doubt some of it was separated from the parent rock in Pleistocene time or in an even earlier time.

Alluvium is composed of all kinds of rock materials within reach of the streams, as well as large quantities of plant matter in various stages of decomposition. In Panola County it occupies perhaps a fifth of the area of the county. Of this, at least half underlies the Mississippi River Alluvial Plain, and most of the remainder is along the Tallahatchie and Yocona Rivers. The larger tributaries of the rivers also have relatively extensive flood plains. The alluvium is composed almost entirely of sand, gravel, silt, and clay, which are more or less sorted into lenses or irregular bodies longitudinally, laterally, and vertically. As a whole, then, the alluvial terrane is a complex of interwedged or interwoven bodies of rock waste, each consisting of a certain kind of material chiefly. Nevertheless, in general the alluvial terrane is more sandy nearer the stream—the "front lands," and silty and clayey farther from the stream and nearer the valley walls—the "back lands." This generalization does not take into account, however, rock debris carried from the bordering uplands by tributaries of a stream and deposited along the outer margins of the main valley.

The thickness of the flood-plain alluvium varies considerably. In general it is thicker nearer the stream and progressively thinner towards the valley walls. Thickness increases, too, in the direction of stream flow. Some variation of thickness is due to irregularity and a slight relief of the surface of the alluvium and also of the valley floor on which the alluvium lies. The maximum in the flood plain of the Mississippi may be 150 feet or more. No exact figures are available for Panola County, but the thicknesses given for Quitman County, which borders Panola on the west, are: Maximum, 212 feet, minimum 82 feet; average 144 feet. They were reported by well drillers and the Mississippi River Commission.[47]

In connection with the construction of Sardis Dam much exploratory drilling was done by the U. S. Army Engineers in the alluvium of the Tallahatchie River Valley and in the adjacent valley walls.[48] At the dam and in the immediate vicinity 180 holes or more were bored, roughly half of which were in the valley alluvium. The deepest hole in the valley wall (A-1) was at the southeast end of the base line of the dam, and was started at an elevation of approximately 325 feet. It reached a depth of 143 feet (elevation 182 feet). Borings in the valley bottom started at elevations between 210 and 225 feet and reached various depths, the greatest depth being slightly above 110 feet above mean Gulf level, at a place a short distance northwest of the middle of the base line. Thus the holes explored a maximum thickness of 215 feet of rock materials. The borings in the flood plain reached through a total thickness of 115 feet of sediment, of which perhaps 50 to 60 feet thickness was alluvium. Materials were classified as loam, silt, clay, sand, gravel, sandstone, and lignite, and various combinations of these. Sand was classed as coarse, medium, and fine. The log of Hole D-1, on the axis of the dam near the southeast end, provides at least a fairly typical example of the kinds of rock encountered, the depth to each unit, the thickness of each and other relationships of the units:

Log of Hole D-1, on Axis of Dam, Approximately at Southeast End; Elevation About 222.5 Feet Above Mean Gulf Level

| Interval | Thickness, feet | Material |
|---|---|---|
| 1 | 1.875 | Silt loam |
| 2 | 4.375 | Silty clay loam |
| 3 | 1.875 | Loam |
| 4 | 5.0 | Silt loam |
| 5 | 3.75 | Silty clay loam |
| 6 | 3.125 | Medium sand |
| 7 | 5.0 | Coarse and medium sand |

| | | |
|---|---|---|
| 8 | 3.125 | Medium sand |
| 9 | 2.8 | Coarse and medium sand |
| 10 | 10.625 | Medium and coarse sand |
| 11 | 1.25 | Clay |
| 12 | 6.25 | Medium and fine sand |
| 13 | 16.25 | Medium sand |
| 14 | 5.0 | Fine and medium sand |
| 15 | 5.625 | Fine sand |

The log shows the heterogeneity of the alluvium vertically. The variation laterally and the want of system in the vertical sequence from place to place may be illustrated by a comparison of the lithologic succession as discovered by three of the deeper borings along the base line of the dam, which is parallel to the dam axis and some 260 feet southwest of it.

LOGS OF THREE BORINGS ALONG BASE LINE OF SARDIS DAM

1. Between dam axis holes D-11 and D-12
Elev. 212
Silt loam
Silty clay loam
Silt loam
Medium sand
Medium and coarse sand
Coarse and medium sand and fine gravel
Clay loam
Sand, medium and coarse
Clay
Sand, coarse, medium, fine
Clay
Sand, medium and fine
Clay, with some lignite and sand beds
Sand, medium and coarse
Sand, coarse, medium and fine
Sand, medium and fine
To Elev. 112

2. SE. of No. 1, between dam axis holes D-7 and D-8
Elev. 217
Clay loam
Silty clay loam
Sand, medium and coarse
Sand, medium
Sand, medium and coarse
Clay, with sand beds
Sand, coarse and medium
Clay, with lignite and sand beds
Silty clay loam, with lignite and sand beds
Clay, with lignite and sand beds
To Elev. 117

3. SE. of No. 2, between dam axis holes D-3 and D-5
Elev. 223
Clayey silt loam
Silty sand
Sand, fine and medium
Sand, coarse, medium, fine
Loam
Sand, coarse and medium
Sand, medium and coarse
Sand, coarse, medium and fine
Clay, with lignite and sand strata
Sand, medium and fine
Clay, with sand beds
Sand, medium and fine
Sand, fine and medium
Sand, medium and fine
To Elev. 123

Downstream from the dam four rows of holes were bored parallel to the axis of the dam—the first row 1,400 feet downstream from the base line, the second 2,000 feet, the third 2,800 feet and the fourth 3,400 feet. All these holes were shallow, exploring a thickness of 60 feet or so of alluvium, from elevation 230 to elevation 170. No change of lithology was noticeable, and the same want of uniformity of relationship among the units existed.

The alluvium of much of the Yocona River Valley was explored thoroughly during the study of the valley which preceded the construction of Enid Dam.[49] Hundreds of borings were made at and near the dam site, in the valley walls and the valley floor. A few of these were 160 feet or more in depth, and the total thickness of rock material explored was more than 200 feet, of which some 50 feet was alluvium. One hole (H-11) 250 feet upstream from the center line of the dam, and close to the new river channel, on the north side, reached a depth of 160 feet. The log showed more than half of the material penetrated to be lignitic clay containing sand or silt beds.

## STRUCTURE

Structural features are of major and minor rank. The major structural features of the Panola County terrane are stratification, dip, and unconformities; the chief minor features are joints, fractures, cross-bedding, and contemporaneous erosion surfaces.

The Tallahatta formation, especially the shale, is well stratified, beds and laminae on the outcrops being sharply defined (Figures 2 and 15). The overlying sands are massive on most outcrops, but show indistinct to moderately well defined bedding at other exposures. The Zilpha formation is in general well bedded, as exposed at Sardis Dam and along the Mississippi River Valley bluff. The Citronelle sands and gravels are very irregularly bedded, and lack uniformity of distribution. The Loess is massive. The alluvium is stratified, but consists of interwedged or interlensed units of gravel, sand, silt, and clay.

In general, surface exposures in Panola County afford few clues to regional structure. The Tallahatta, Kosciusko, and Zilpha formations, the only units which at any place show any regularity of bedding, crop out within a relatively small part of the county—in the east and along the Mississippi River Valley bluff. The uppermost material of the remainder of the county, to a maximum depth of perhaps 150 feet or more, is loess and alluvium, of which the loess is almost structureless and the alluvium too irregularly and intricately bedded to be used for the determination of structure under any considerable area. And outcrops of Tallahatta, Kosciusko, and Zilpha fail to show any reliable key bed—that is, a bed that is readily identifiable and is persistent. Formation contacts are exposed in many places, but all are surfaces of unconformity, so that relative elevations of points on them would not be an accurate guide to structure. Attempts at determination of dip by means of elevations on formational contacts have been made in Northwest Mississippi, and have given inconclusive results. In Panola County the Tallahatta-Kosciusko contact is the only one which is well defined on the outcrop in many places, as pointed out in the description of the stratigraphy. Almost everywhere it is marked by layers of ferruginous siltstone and sandstone, and constitutes as near a key horizon as can be found in the county. However, it should be kept in mind that calculations of dip on the Tallahatta-Kosciusko contact can not be better than approximately accurate, because the contact is unconformable, and even its identification on the outcrop doubtful in many places.

Study of elevations of points on the Tallahatta-Kosciusko contact reveals a slight west to north of west slope, but of course this is not evidence of structure, because the contact is one of unconformity. The declination westward is in general less in a unit distance than the degree of dip, and indicates only the topographic relief of the Tallahatta surface on which the Kosciusko beds were deposited. In fact, some points on the contact are higher than other points farther east. The irregularity of this contact surface is illustrated by the stratigraphic sections (SE.¼, Sec.17, T.10 S., R.5 W.) near Bynum School and Kind Providence Church in the southeastern corner of the county. The contact trace on the northeast slope of the ridge is 15 to 16 feet above the same trace on the southwest slope, although the two are only 0.3 mile apart. The difference in elevation is almost certainly due chiefly to the topographic relief of the old surface, and only in small part to the dip of the beds.

Along Highway 6 the top of the Tallahatta is exposed in the north wall of a cut (SE.¼, Sec.26, T.8 S., R.5 W.) a little less than two miles east of the Panola-Lafayette County line, at an elevation of approximately 346 feet. The westernmost exposure of Tallahatta shale, and the near position of the top of the formation, is a little west of the junction of Highways 6 and 315, at an elevation of about 320 feet. The contact plane slopes south of west, then, at this latitude, only 26 feet in a distance of some 6.5 miles. Obviously there has been overlap of the Tallahatta by the Kosciusko.

Departure from uniformity of dip was noted at several places. For example, an outcrop (NW.¼, Sec.34, T.8 S., R.6 W.) reveals a strong west dip, and another (SW.¼, NW.¼, Sec.23, T.8 S., R.6 W.) exposes beds of white and light-brown to pale pink argillaceous and silty slightly indurated very fine sand, dipping steeply southward. At the latter place the presence of Citronelle sand and gravel at the same elevation may be evidence that the dipping strata are blocks dislodged from Tallahatta terrane and tilted during the re-working of the upper parts of older formations by Citronelle waters. If the strata are not in place, obviously their inclination is not true dip. Still another, and perhaps the most prominent of the outcrops which show irregularity of dip (NW.¼, SW.¼, Sec.7, T.7 S., R.5 W.) exposes a strong west dip of Tallahatta shale (Figure 18) which probably is very local.

In other places the Tallahatta-Kosciusko contact trace remains at almost exactly the same elevation for considerable distances. In the west wall of the small valley (SW.¼, Sec.18, and NW.¼, Sec.19, T.8 S., R.5 W.) 1.5 miles south by west of Sardis Dam, the elevation of the contact is approximately the same as it is in the opposite wall a quarter of a mile farther east.

The north wall of the cut for the emergency spillway at Sardis Dam exposes strata which dip southwest 81 to 85 feet a mile (see description of the Zilpha formation) in the length of the outcrop. Such a dip may be, and probably is, due to lensing of the beds, but the outcrop is not sufficiently extensive to permit explanation of the structure. However, lensing or thinning toward the northwest and north is suggested by the greater thickness of the shale interval in the southeast wall of the cut, hardly 200 feet from the northwest wall (see description of section under Zilpha formation).

In the section at Sardis Dam, the lowest interval is a carbonaceous fine silty sand containing numerous iron sulphide concretions. It crops out at an elevation of a little under 240 feet. At Tocowa Church (SW.¼, SE.¼, Sec.8, T.10 S., R.8 W.) in the southwestern corner of the county, the same bed crops out in the creek bank at almost exactly the same elevation. Tocowa Church is approximately 19 miles southwest of the dam. It appears, then, that the uppermost Tallahatta or the Zilpha beds are almost flat lying northeast-southwest through the county.

Minor structural features are conspicuous in places on the outcrops of all formations. Cross-bedding is prominent, especially in the Citronelle formation. One of the best examples is shown by the walls of a road cut (SW.¼, Sec.13, T.7 S., R.8 W.) in the east wall of the valley of Crooked Creek. Other sections of Citronelle terrane which show conspicuous cross bedding are: 1) At the junction (SE.¼, SW.¼, Sec. 29, and northern part Sec. 32, T.8 S., R.6 W.) 1.5 miles north of the Linn Sand and Gravel Company pits; 2) at the gravel pit (NW.¼, Sec.8, T.10 S., R.7 W.) 1.4 miles southwest of Courtland; and 3) in the walls of the road cut (SW.¼, Sec.29, T.9 S., R.8 W.) in the face of the bluff east of Asa. Many others could be mentioned.

In a few places structural features suggest faulting on a small scale. The most prominent of these (SW.¼, NW.¼, Sec.15, T.9 S., R.6 W.) a short distance southwest of Central Academy, shows white and yellow sand abutting against brown sand along a diagonal contact (Figure 10), and, a few yards farther northeast at a greater elevation a sharp diagonal contact between yellow and brown and pink mottled clay on one side and brown sand on the other (Figure 11). This place also is near the eastern edge of the Citronelle outcrop area. In fact, the unusually steep dips (Sec.23, T.8 S., R.6 W. and Sec.7, T.7 S., R.5 W.) mentioned in preceding paragraphs, may be due to minor faulting.

Besides outcrops made by gravel pits, and the clay pits along the bluff, a few others due to natural and artificial cuts reveal the general structure of the Citronelle beds. One of the most prominent of these (Near Center, Sec.22, T.8 S., R.7 W.) a short distance east of Tallahatchie, is the steep face some 200 feet long and 40 feet high, left by the cutting off of the southwest end of a ridge. Another is the walls of a road cut (SE.¼, Sec.27, T.9 S., R.8 W.) in the northeast wall of Hayne Creek Valley. Both these outcrops show very well the structural relationships of the Citronelle materials.

As has been stated, interformational unconformities are a major structural feature of the Panola County strata. The sands which lie on the Tallahatta are on an eroded surface, except where remnants of the Winona may possibly be present. Where the Zilpha lies on the Tallahatta, they are unconformable, of course, because the Winona is absent. In the greater part of the surface Tallahatta territory, patches of Kosciusko sand are superjacent to the Tallahatta beds. Citronelle strata are unconformable on the Kosciusko, and the Loess on all older formations. The alluvium lies on an eroded terrane, everywhere.

## HISTORICAL GEOLOGY; CONDITIONS OF SEDIMENTATION

The history of the time recorded by the rock strata that are represented at the surface of Panola County can be read, at least in outline, albeit somewhat uncertainly, from the characteristics of the strata as described in the section on Stratigraphy. In Late Tallahatta time the territory was covered by the marginal zone of the Gulf Embayment. From the bordering land on the east many small streams were transporting silt and clay and fine sand westward and depositing them on the Gulf floor.[50] Silt and clay were dominant in some places, sand in other places, because of different conditions of erosion and sedimentation adjacent to the shore line, and constantly changing conditions. The consistent fineness of the sediment of whatever kind is strongly suggestive evidence that the streams were of low gradient, even sluggish except in times of flood, and that no rock detritus except the fine material was available for them. As a corollary, the land was low lying and of slight relief. Plants have left proof of their presence, also, in the form of carbonaceous or lignitic shale, and marine animals have left sparse fossils. It may be that the lignitic shale points to temporary and local non-marine conditions.[51] It would seem, then, that from the geological record can be read a story of slow wearing away of the land and building up of the sea floor by streams; of distribution of sediment by waves and shore currents; of the life and activities of plants and animals both marine and terrestrial, and of a climate much like that of the present.

In time the stream systems of the great land mass on the east of the embayment began to carry more sand and less clay and silt, either because of a slight uplift of the source territory or because the streams had lengthened until at least some of them had reached into a sand terrane, or because some of the main streams and their larger tributaries had sunk the headward parts of their valleys through overlying silts and clays into sand. The accumulation of the Winona sand has been interpreted as indicating subsidence and possibly some tilting of the deposition area. Probably the subsidence was so gradual that generally uniform conditions were maintained.[52] The dominantly clayey and silty deposits were topped by and interlensed with sand as erosion of the land continued. Farther south along the coast the sands became increasingly glauconitic, but either conditions favorable for the genesis of glauconite did not extend into the area which is now Panola County or the glauconite has been destroyed.

The source region of the sediment seems to have been again brought low, or the drainage systems had again reached a dominantly clay and silt terrane, as testified by the clays and silts of the Zilpha formation, the greater part of which was deposited on the low land adjacent to the sea and in its swamps and shallow lake basins. The new land was subject to weathering and erosion for a long period, and then became a site of deposition for immense quantities of fine sand mingled with silt and clay. Gradual subsidence and tilting probably recurred. Sand was spread widely on the flat plain and on the adjoining sea floor, reaching far to the eastward and overlapping older sediments.[53]

Following the deposition of the Kosciusko sand the Panola County area did not become a site of large scale deposition again until Pliocene time. During the remainder of Eocene time and the whole of the Oligocene and Miocene the land there was undergoing intensive weathering and erosion. At the close of Kosciusko time the surface was at a much greater elevation relative to today's mean sea-level than it is at present, and as the Gulf receded southward the region that is now North Mississippi remained as a low plateau. The old plateau was thoroughly dissected and greatly reduced in height. In short, it can be said that through probably the later half of the Tertiary Period the Panola County terrane was the scene of operation of geological processes, primarily degradational, although some evidence exists that relatively minor crustal movements took place. Uplands were worn down to peneplains, which in turn were uplifted, only to be again reduced, as cycle succeeded cycle. Shaw states: "It must be assumed that all parts of the region that have been exposed since Miocene time have been sujected 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."[54]

Events of Pliocene and Pleistocene times have left the Citronelle gravels, sands, and clays, and the Loess silt as their record. According to Shaw, 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."[55]

Pleistocene time, the great ice age, brought a radical change of climate over the greater part of the earth. In the region which is now Northern Mississippi, erosion was intensified, very probably, 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 aggradational agent, spreading the loessial silt from the river flood plain over the adjoining territory. With the passing of the ice age, some warping of the terrane took place, quickening erosion and initiating Recent time, during which gradational agents, notably running water, have made geological history, bringing the Panola County area to its present condition.

The climate of Tertiary time in the region which is now Panola County, as indicated by the stratigraphic record, was much like it is today—moist in general and relatively mild. Most certainly plant and animal life flourished on land, and probably marine organisms were abundant during Tallahatta time, although they left few fossils. Both plant and animal life was greatly restricted and its character changed during the Pleistocene epoch.

## ECONOMIC GEOLOGY

### SOILS

The soil is the most valuable mineral resource of Panola County, as of every other dominantly agricultural region. The mineral constituents of soils were derived from pre-existent rock which was broken down by weathering agencies. If a soil is now in the place of its origin, it is a residual soil. If it consists of rock debris which has been moved to its present position from places where it was separated from its parent rock, it is a transported soil.

The mineral constituents of a residual soil were derived from rock which once occupied the place where the soil now is, and also occupied a much thicker interval. The source rock may have been completely decomposed or disintegrated, so that it has disappeared except for the part of it which remains in the soil. In case this has happened, the soil may be resting on rock which is much different from the parent rock. On the other hand, the soil may have originated from part of the bed rock on which it now lies, in which case its minerals will be pretty much the same as those of the subjacent rock, especially if mechanical weathering has been the dominant process in the creation of the soil, or if the weathering processes have not progressed too far. In an arid or semi-arid region, each mineral particle of residual soils is essentially like its parent rock, at least for a long period of time, because there rock is broken up by natural mechanical forces, such as temperature changes and wind abrasion; but in a region where rain is abundant, the soils originate primarily through chemical action on the country rock, and the resulting particles may be or may not be like the rock from which they were derived. In the ultimate, soil-forming processes tend to reduce all soils to their lowest terms—a condition in which they are much alike, inasmuch as each consists of the end products of weathering, a residuum of insoluble or very difficultly soluble mineral matter, chiefly silica and alumina, much of which is in the colloidal state.

The natural fertility or lack of fertility of a residual soil is a function of the genesis of the soil. That is, if the soil has come into being through mechanical disintegration of rock which contained several of the plant food elements, it is likely to be potentially fertile, although it may be barren because of lack of water. If, however, a residual soil owed its existence to chemical decomposition of rock which was rich in plant food elements, it is not likely to have the natural fertility of a soil composed of mechanically broken up rock of the same kind, because the chief chemical processes of Nature—oxidation, hydration, carbonation, and solution—remove mineral plant food elements or change or recombine them in such a way that they are made unavailable for use by plants. The deleterious effects of decomposition are, however, offset to a greater or lesser degree by water, which takes the mineral plant food into solution and thus facilitates its use by plants.

Alluvial soils are the most important transported soils although in some parts of the world glacial soils and eolian soils are prominent. In general, alluvial soils are the most fertile of all, because they consist of rock debris of every kind within reach of the streams, and mineral matter so diverse is likely to contain the essential plant foods; furthermore, the sediment is worked over by the water many times and its individual particles intimately mingled. Also, plants are in most places abundant on the flat-lying alluvium, constantly adding to the humus, most of which remains in place.

The soils of Panola County are both residual and transported. The residual soils seem to have originated from the weathering of the same kinds of rock which crop out in the county at present —sands, clays, silts, and gravels. They are, therefore, sandy loams, silt loams, clay loams, clays, and gravelly loams, for the most part. The chief transported soils are the alluvium of the flood plains. Most of the alluvium originated outside the county and is at present part of the alluvium of the Mississippi River flood plain and the flood plains of the Tallahatchie and Yocona Rivers. The total area of the alluvial soils of the many small streams in the county is very considerable.

During the last half century or more the U. S. Department of Agriculture Bureau of Soils (now Bureau of Plant Industry, Soils, and Agricultural Engineering), in co-operation with the Mississippi State Geological Survey, has made soil surveys of most of the counties of Mississippi, and surveys of other counties are now in progress. The reports 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. A map showing the distribution and area of each type accompanies the report. No such survey of Panola County, or of any county adjoining Panola, except Lafayette, has been made. However, inasmuch as Lafayette County has the same kind of climate as Panola, the same kinds of physiographic features, and two or three of the same rock formations at the surface, unquestionably it has some of the same soil types, although their relative extent may differ as between the two counties. The pertinent data from the report on the soil survey of Lafayette County is summarized herein, then, as applicable to Panola County as well.[56]

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 over-flowed 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.

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, 2.0 to 1.0 millimeters in 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 percent 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.[56a]

The Memphis silt loam occupies 57.2 percent of the total area of Lafayette County—three times as great an area as is occupied by 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. This material has been used in the making of brick.

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. 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 favorable topography and consequent ease of cultivation.

The Vicksburg silt loam is the most extensive 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, 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 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 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.[66b]

The four classes of soils which are present in Lafayette County are present in Panola County also. The loessial upland soils are much more extensive and in general thicker in Panola than they are in Lafayette: In fact, they blanket the entire county except where they have been removed by erosion. The old sedimentary upland soils probably are not so extensive in Panola County as in Lafayette; but the two other classes—recent stream alluvium or frequently overflowed first-bottom soils, and old stream alluvium, or second-bottom soils lying above normal overflow—are more extensive in Panola County. The chief soil types of Lafayette County are, no doubt, likewise the dominant types in Panola: The Memphis silt loam occupies the loess territory; the Vicksburg silt loam is the soil of the first bottoms, or flood plains of the streams, the greatest areas being along the Tallahatchie and Yocona Rivers and in the "Delta" part of the county; the Susquehanna silt loam and the Ruston fine sandy loam are distributed over the Tallahatta and Kosciusko outcrop areas; and the Lintonia silt loam mantles stream terraces.

It is understood, of course, that no sharp contrast 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

Both surface and ground water is abundant in Panola County. The mean annual precipitation is approximately 50 inches (Table 1), and because the rock is largely unconsolidated or loosely consolidated sand and silt, much of the water which falls on the surface sinks and becomes ground water. However, a large part of the rain comes as hard downpours which quickly fill the openings in the soil and other mantle rock, and thus prevent or retard sinking and increase run off, with the result that surface streams are multiplied and many natural and artificial basins are filled with water. Streams which occupy valleys and channels that have been deepened below the lowest water-table, or streams fed by permanent springs or pools, have a continuous flow; but most of the streams are intermittent, existing only during and for a relatively short time after heavy rains. A glance at the map (Plate 1) will provide a picture of the surface water conditions and distribution—the trunk streams and their tree-like branches, and the wide Sardis Lake, suggesting the abundance, sometimes the plenitude, of water.

The abundance of surface water is further testified to by some stream-flow records.[67] The flow of the Tallahatchie River is now completely regulated by Sardis Dam, which keeps it below any destructive flood stage. During the period January, 1940, through September, 1948, the flow ranged from zero at times to a maximum of 5,780 second-feet on June 24, 1946; the average daily discharge for the period October, 1940, through September, 1948, was 2,215 second-feet. The average annual runoff for the same 8-year period was 19.465 inches. The figures given, which apply to the river basin, 1,545 square miles, above the dam, were obtained by a staff gage before February 27, 1940, and thereafter by a water-stage recorder, located in the gate house of the dam. The datum of the gage is 219.43 feet above mean sea level. By calendar years, the mean daily discharge ranged from 1,222 second-feet in 1941 to 3,703 in 1946, and the mean annual runoff from 10.48 inches in 1941 to 30.14 inches in 1946.

At the gage site 9.5 miles down stream from the Sardis reservoir and 4 miles southeast of Sardis, the minimum daily flow for the water year ending September 30, 1942, was 16 second-feet, on September 19, 1942, and the maximum daily discharge for the same period was 9,680 second-feet. The minimum daily discharge for the week September 13-19 inclusive, 1942, was 20 second-feet. The average daily flow for the water year October, 1939 to September, 1940, inclusive, was 1,505 second-feet; for the year 1940-41 the flow was 1,381 second-feet, and for 1941-42 it was 1,753 second-feet. The flow has been completely regulated by Sardis Reservoir since August 26, 1939. Records on the flow at the Sardis station for periods June, 1906 to December, 1912; July, 1928, to September, 1931; December, 1931, to September, 1938; and October, 1938, to September, 1942, are available. The maximum discharge recorded for a day was 65,300 second-feet (gage height, 26.40 feet), on January 15, 1932. The average daily discharge in second-feet for 13 years (1928-31, 1932-42) was 1,946. The average for the three years (1939-42) during which the discharge was regulated by the dam, was 1,546, and the average for the 10 years of unregulated flow (1928-31, 1932-39) was 2,065. It will be seen from these records that the mean daily controlled flow for three years was notably less than the mean daily uncontrolled flow for 10 years; but probably up-to-date records would show a much smaller discrepancy. It is noticeable, too, that the average daily discharge for certain years of the unregulated period was about the same as the average for the regulated period—1,350, 1,216, 1,660, 1,362, and 1,773 for the one, and 1,505, 1,381, and 1,753 for the other. Also, as has been stated, the average daily discharge at Sardis dam for the 8-year period, 1940-48, was 2,215 second-feet. The average annual run-off at the Sardis station for 12 years (1928-31, 1932-41) was 15.86 inches. The drainage area of the river basin above the gaging station is 1,680 square miles.

Only a relatively small part of the Yocona River drainage basin is in Panola County, but all that part of the river which is in the county is below Enid dam, and consequently its flow is regulated by the dam. Some records of the discharge before the dam was built, as indicated by the gage at the river bridge on Highway 51, Yalobusha County, 2 miles northeast of Enid and 24.5 river miles upstream from the river's mouth, are summarized below. The data are based on a continuous record, 1928 to 1948 inclusive, except for 1931-32.

The drainage area above the station is 560 square miles. The maximum annual run-off was 39.41 inches (1932 calendar year), and the minimum was 6.50 inches (1934 calendar year). The average for the 18 calendar years was 18.66 inches. The maximum daily river discharge was 36,300 second-feet (February 14, 1948), the minimum was 34 second-feet (September 28, 1931), and the average daily discharge for the entire period of record (19 water years) was 745 second-feet.

Records of the flow of Long Creek (Peters Creek?) the chief Panola County tributary of Yocona River, provide detailed surface water data for 63.3 square miles in the southwestern part of the county. The records available, for the period April, 1940, to December, 1942, inclusive, were obtained by gages at the bridge (Sec.9, T.10 S., R.7 W.) on Highway 51 a mile south of Courtland and 5.5 miles upstream from the creek's mouth. A wire-weight gage was in use prior to March 22, 1940, and a water-stage recorder thereafter. The maximum discharge was 13,500 second-feet, on April 9, 1942 (gage height, 22.21 feet); the minimum was 1.3 second-feet, on September 2 and 3, 1942, and the minimum gage height observed was 3.46 feet, August 7, 1942. The average daily discharge for the water year October, 1940 to September, 1941, inclusive, was 46.4 second-feet, and for the year 1941-42 was 60.1 second-feet. The run-off in inches for the same years was 9.94 and 12.89 respectively.

The shallower underground water of the uplands of Panola County is contained in the Citronelle, Kosciusko, and Tallahatta formations. The loess is porous, and absorbs water, but does not yield it readily. Water for domestic use is obtained from springs or from shallow dug or bored wells, most of which are in the Citronelle sands and gravels where they are present. In the eastern part of the county, the Kosciusko and Tallahatta sands provide water for both shallower and deeper wells. In the Yazoo Delta abundant water is obtained from the alluvium through shallow bored or driven wells. The same is true in the flood plains of the Tallahatchie and Yocona Rivers and their larger tributaries.[58]

Deep wells, flowing and non-flowing, draw water from the Wilcox, the Meridian, the Tallahatta (including Basic City and Neshoba members) and the Kosciusko formations. Brown[59] tabulates data on 35 such wells, all but 11 of them in the Delta part of the county (Table 4). As indicated, the maximum flow recorded was 34 gallons a minute, from a 606-foot well near Lake Carrier, in the extreme western part of the county, drawing from the Meridian or the Tallahatta formation, or from both formations. However, the deepest well listed in the table (1420 feet), drilled by Layne-Central for the town of Crenshaw, was reported to have yielded 250 gallons a minute when opened, the static level of the water being 41 feet above the land surface. The aquifer was believed to be in the Lower Wilcox.

Data on a number of wells, most of them relatively shallow, drilled prior to 1928, are presented in Table 5.[60]

TABLE 4
PANOLA COUNTY WELLS

| No. | Location | Elev. of meas. pt. | Depth (feet) | Producing formation | Yield (g.p.m.) | Temp. °F | Misc. |
|---|---|---|---|---|---|---|---|
| 1. | T.6 S., R.9 W., Sec. 30, SE.¼, NW.¼ | 220 | 110 | Kosciusko? | 7.5 (Pump) | 64 | |
| 2. | T.7 S., R.9 W., Sec. 6, NE.¼, SW.¼ (Crenshaw) | 191 | 1420 | Lower Wilcox | Reported yield when drilled (1925) 250 g.p.m.; static level 41 feet above land surface | | |
| 3. | T.7 S., R.9 W., Sec. 7, NE.¼, NW.¼ | 192 | 400 | Kosciusko | 10 flowing 7 pump | No data | Found flowing |
| 3a. | T.7 S., R.7 W., Sec. 10 SW.¼, SW.¼ (POW Camp) | 360 | 319 | Kosciusko | No data | No data | |
| 4. | T.7 S., R.9 W., Sec. 21, SW.¼, SE.¼ | 195 | 790 | Meridian | 3 (flow) | No data | |
| 5. | T.7 S., R.7 W., Sec. 34, NE.¼, NE.¼ (Sardis) | 370 | 200? | Basic City (Tallahatta) | No data | No data | |
| 6. | T.7 S., R.7 W., Sec. 34, NE.¼, NE.¼ (Sardis) | 370 | 330 | Basic City (Tallahatta) | 250 (pump) | No data | |
| 7. | T.7 S., R.7 W., Sec. 34, NE.¼, NE.¼ (Sardis) | 370 | ...... | Basic City (Tallahatta) | 150 (pump) | No data | |

TABLE 4 (CONTINUED)
PANOLA COUNTY WELLS

| No. | Location | Elev. of meas. pt. | Depth (feet) | Producing formation | Yield (g.p.m.) | Temp. °F | Misc. |
|---|---|---|---|---|---|---|---|
| 8. | T.8 S., R.9 W., Sec. 2, NE.¼, NW.¼ | 190 | 600 | Meridian | No data | No data | |
| 8a. | T.8 S., R.8 W., Sec. 21, NE.¼, SW.¼ | 360 | 171 | Kosciusko | No data | No data | |
| 9. | T.9 S., R.9 W., Sec. 5, NW.¼, NE.¼ | 161 | 473 | Basic City and Meridian | 2 (flow) | No data | Two wells nearby |
| 10. | T.9 S., R.9 W., Sec. 4, SE.¼, NE.¼ | 161 | 496 | Basic City and Meridian | 26 (flow) | 65.5 | Found flowing |
| 11. | T.9 S., R.9 W., Sec. 3, NW.,¼ NW.¼ | 161 | 630? | Basic City and Meridian | 20 (flow) | 64.75 | Found flowing |
| 12. | T.9 S., R.6 W., Sec. 5, NW.¼, SE.¼ (Lynn) | No data | 170 | Meridian | 9 (flow) | 63.5 | |
| 13. | T.9 S., R.6 W., Sec. 5, NW.¼, SE.¼ (Lynn) | 251.5 (app.) | 365 | Meridian | 3 (flow) | 62.5 | |
| 14. | T.9 S., R.7 W., Sec. 9, SW.¼, NW.¼ (Batesville) | 240 (app.) | 1036 | Lower Wilcox | No data | No data | |

TABLE 4 (CONTINUED)
PANOLA COUNTY WELLS

| No. | Location | Elev. of meas. pt. | Depth (feet) | Producing formation | Yield (g.p.m.) | Temp. °F | Misc. |
|---|---|---|---|---|---|---|---|
| 15. | T.9 S., R.7 W., Sec. 9, SW.¼, NW.¼ (Batesville) | 219.5 | 1040 | Lower Wilcox | 50 (flow) 200 (pump) | 73 | |
| 16. | T.9 S., R.7 W., Sec. 9, SW.¼, NW.¼ (Batesville) | 219.5 | 260 | Kosciusko | 16 (flow) | 64.25 | |
| 17. | T.9 S., R.9 W., Sec. 17, SW.¼, SW.¼ | 160 | 606 | Basic City and Meridian | 34 (flow) | No data | |
| 18. | T.9 S., R.9 W., Sec. 17, NW.¼, SW.¼ | 160 | 600 (app.) | Basic City and Meridian | No data | No data | Reported to flow open |
| 19. | T.9 S., R.9 W., Sec. 17, NE.¼, SW.¼ | 160 | 600 (app.) | Basic City and Meridian | No data | No data | |
| 20. | T.9 S., R.9 W., Sec. 16, SW.¼, SE.¼ | 160 | 500 | Basic City and Meridian | 10 (flow) | 64.75 | Found flowing |
| 21. | T.9 S., R.9 W., Sec. 28, SE.¼, NW.¼ | 160 | 588 | Basic City and Meridian | 5 (flow) | No data | |
| 22. | T.9 S., R.9 W., Sec. 25, SW.¼, NE.¼ | 174 | 500 | Basic City and Meridian | 22.3 (flow) | 62.5 | Found flowing |
| 23. | T.27 N., R.2 E., Sec. 19, SW.¼, NW.¼ | 157 | No data | No data | 12 (flow) | 65 | |

Table 4 (Continued)
Panola County Wells

| No. | Location | Elev. of meas. pt. | Depth (feet) | Producing formation | Yield (g.p.m.) | Temp. °F | Misc. |
|---|---|---|---|---|---|---|---|
| 24. | T.27 N., R.2 E., Sec. 30, NE.¼, SW.¼ | 164 | 450? | Basic City and Meridian | 5.3 (flow) | 63.5 | Found flowing |
| 25. | T.27 N., R.2 E., Sec. 30, NE.¼, NE.¼ | 170 | 420 | Basic City and Meridian | 9 (flow) | 64.5 | Found flowing |
| 26. | T.27 N., R.2 E., Sec. 29, NW.¼, NW.¼ | 166 | 485 | Basic City and Meridian | 8 (flow) | 64.5 | Found flowing |
| 27. | T.27 N., R.2 E., Sec. 29, SW.¼, NW.¼ | 170 | 480 | Basic City and Meridian | 4 (flow) | 63 | |
| 28. | T.27 N., R.2 E., Sec. 29, NW.¼, NW.¼ | 165 | 475 | Basic City and Meridian | 5.5 (flow) | 64.5 | |
| 29. | T.27 N., R.2 E., Sec. 29, NW.¼, NE.¼ | 167 | 440 | Basic City and Meridian | 15.2 (flow) | 64.5 | |
| 30. | T.27 N., R.2 E., Sec. 28, NE.¼, SW.¼ | 173 | 433 | Basic City and Meridian | 9 (flow) | 64.5 | |
| 31. | T.27 N., R.2 E., Sec. 34, SE.¼, SW.¼ | 187 | 400? | Basic City and Meridian | 2 (flow) | 63.75 | |
| 32. | T.27 N., R.2 E., Sec. 33, NE.¼, NE.¼ | 175 | 400 | Basic City and Meridian | 14 (flow) | 62.5 | |
| 33. | T.10 S., R.7 W., Sec. 33, NE.¼, NE.¼ | No data | 430 | Basic City and Meridian | No data | No data | |

TABLE 5
PANOLA COUNTY WELLS PRIOR TO 1928

| No. | Location | Elev. (feet) | Depth (feet) | Producing formation | Yield (g.p.m.) flow or pump | Misc. data |
|---|---|---|---|---|---|---|
| 1. | Sec.30, T.6 S., R.9 W. (Askew) | No data | 12 | Alluvial sand | No data | |
| 2. | Sec.30, T.6 S., R.9 W. (Askew) | No data | 80 | Alluvial sand? | No data | |
| 3. | Sec.8, T.9 S., R.7 W. (Batesville) | 230 | 302 | Old Holly Springs (probably Kosciusko or Tallahatta) | 60 (flow) | Analysis 3 of table of chemical analyses |
| 4. | Sec.8, T.9 S., R.7 W. (Batesville) | 230 | 396 | Old Holly Springs (probably Tallahatta) | 40 (flow) | Analysis 4 |
| 5. | Sec.8, T.9 S., R.7 W. (Batesville) | 234 | 100 | Old Grenada (probably Kosciusko) | 40 (pump) | Analysis 5 |
| 6. | Sec.7, T.9 S., R.7 W. (1 mi. w. of Batesville) | No data | 300 | Old Holly Springs (probably Tallahatta) | No data | Sand |
| 7. | Sec.33, T.6 S., R.7 W., SE.¼ (Como) | 359 | 210 | Old Grenada (probably Kosciusko) | 150? (pump) | Coarse sand |
| 8. | Sec.33, T.6 S., R.7 W., SE.¼, (Como) | 359 | 210 | Old Grenada (probably Kosciusko) | 150 (pump) | Coarse sand |

TABLE 5 (CONTINUED)
PANOLA COUNTY WELLS PRIOR TO 1928

| No. | Location | Elev. (feet) | Depth (feet) | Producing formation | Yield (g.p.m.) flow or pump | Misc. data |
|---|---|---|---|---|---|---|
| 9. | Sec.5, T.7 S., R.7 W., NW.¼, (1.5 miles west of Como) | No data | 76 | Pliocene terrace gravel (Citronelle) | No data | Gravel and sand |
| 10. | Sec.4, T.10 S., R.7 W. (Courtland) | No data | 700 | Old Holly Springs (probably Meridian) | Small flow | Sand |
| 11. | Sec.8?, T.10 S., R.7 W. (¼ mi. SW. of Courtland) | No data | 90 | Pliocene terrace gravel (Citronelle) | | Gravel and sand |
| 12. | Sec.6, T.7 S., R.9 W., NW.¼ (Crenshaw) | No data | 750 | Old Holly Springs (probably Tallahatta) | 40 (flow) | Analysis 12 |
| 13. | Sec.1, T.8 S., R.9 W. (2 or 3 mi. NE. of Delta) | 170? | 650? | Old Holly Springs (probably Meridian) | 40 (flow) | Analysis 13 |
| 14. | Sec.28, T.7 S., R.8 W., SE.¼ (Horatio) | No data | 40 | Old Grenada (probably Citronelle) | No data | Sand |
| 15. | Sec.20, T.7 S., R.8 W., SW.¼ (1¼ mi. NW of Horatio) | No data | 105 | Pliocene terrace gravel (Citronelle) | No data | Sand and gravel |

TABLE 5 (CONTINUED)
PANOLA COUNTY WELLS PRIOR TO 1928

| No. | Location | Elev. (feet) | Depth (feet) | Producing formation | Yield (g.p.m.) flow or pump | Misc. data |
|---|---|---|---|---|---|---|
| 16. | Sec.22?, T.7 S., R.8 W., (2 miles N.E. of Horatio) | No data | 60 | Pliocene terrace gravel (Citronelle) | No data | Sand and gravel |
| 17. | Sec.33,T.7 S., R.8 W., SE.¼ (½ mile east of Horatio) | No data | 50 | Old Grenada (probably Citronelle) | No data | Sand |
| 18. | Sec.28?, T.7 S., R.8 W., (1 mi. east of Horatio) | No data | 68 | Old Grenada (probably Citronelle) | No data | White sand |
| 19. | Sec.28, T.7 S., R.8 W., SW¼? | No data | 73 | Pliocene sand and gravel (Citronelle) | No data | Sand and gravel |
| 20. | Sec.34, T.7 S., R.7 W. (Sardis) | 384 | 197 | Old Grenada (probably Tallahatta) | 300 (pump) | Sand and gravel? |
| 21. | Sec.34, T.7 S., R.7 W. (Sardis) | 384 | 215 | Old Grenada (probably Tallahatta) | 150 (pump) | Analysis 21 |
| 22. | Sec.34?, T.7 S., R.7 W., (Sardis) | 384 | 210 | Old Grenada (probably Tallahatta) | No data | Analysis 22 |

Wells at Crenshaw and in the vicinity are reported to have found several water-bearing sands: the uppermost, 20 to 25 feet below the land surface; another at a depth of 110 feet, more or less; a third at 350 feet, and others at depths between 650 and 750 feet. At Como water was said to have been struck in coarse sand at a depth of 206 feet, and rose 108 feet in the hole.[61]

The deepest water well in the county is at the Tennessee Gas Transmission Station No. 8 plant west of Batesville. It was drilled in 1948 to a depth of 2457 feet.[62]

The chemical nature of the water from 9 wells listed in Table 4 is indicated by the following table of analyses records:[63]

## TABLE 6

### CHEMICAL ANALYSES OF GROUND WATERS FROM PANOLA COUNTY (PARTS PER MILLION)

NUMBERS CORRESPOND WITH NUMBERS IN TABLE 4

| No. | Producing formation | Total hardness | Bicarbonate ($HCO_3$) | Chloride (Cl) | Sulphate ($SO_4$) | Fluoride (F) | Iron (Fe) | Silica ($SiO_2$) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Potassium (K) | Carbonate ($CO_3$) | Total dissolved solids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (2) | Lower Wilcox | 12 | 230 | 30 | 1.0 | 0.2 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (14) | Lower Wilcox | 4 | 220 | 12 | 0.8 | 0.4 | .06 | 1.3 | 1.2 | 0.2 | 86.0 | 3.3 | ........ | 225 |
| (15) | Lower Wilcox | .... | 173 | 14 | 1.0 | ........ | 1.22 | 8.7 | 3.2 | 1.0 | ........ | 67.0 | ........ | 180 |
| (10) | Meridian* | 70 | 98 | 1.0 | 7.0 | 0.0 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (12) | Meridian | 24 | 29 | 1.0 | 5.0 | 0.0 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (13) | Meridian | 28 | 34 | 4.0 | 3.0 | 0.0 | 2.1 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (28) | Meridian* | 33 | 105 | 1.0 | 7.0 | 0.1 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (30) | Meridian* | 54 | 89 | 1.0 | 7.0 | 0.1 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| (16) | Kosciusko | .... | 58.6 | 5.0 | 3.5 | ........ | 2.51 | 11.6 | 5.0 | 2.05 | ........ | 13.7 | ........ | 68 |

* Includes water from overlying Basic City shale member of the Tallahatta formation.

## CERAMIC CLAY

The clay of Panola County is in the Tallahatta and Zilpha formations almost entirely. The Kosciusko and the Citronelle contain thin layers and stringers and scattered fragments and irregular bodies of clay, reworked from older formations. The clay and clay shale of the Tallahatta are in many places suitable for use in the manufacture of brick and pottery. The Tallahatta shale of Panola County is, in fact, very much like that of the Holly Springs vicinity which is used by the Holly Springs Brick and Tile Company, Inc. However, there is no record of any Tallahatta material from Panola County having been used for ceramic purposes.

During the past 40 to 50 years clays of the Zilpha formation have been mined and shipped sporadically at several places along the Delta bluff. The earliest of these workings was near Enid, Tallahatchie County. Concerning this development, Lowe states:[64] "In Tallahatchie County, near Enid, pits of high grade clay have within a few years been opened and considerable quantities of the clay shipped to northern buyers. The clay is exceptionally clear of impurities, is highly plastic and very refractory under heat. In quality it approximates the German clay. The deposits are very extensive and have no great overburden. These clays will doubtless become commercially important." Priddy[65] also mentions the clay industry of Tallahatchie County: "Tallahatchie County has had sporadic mining activity, which is in a measure responsible for this investigation. From 1910 to 1920, and especially during the war years, at least two thousand carloads of 'Enid' clay were dug from the base of the bluff north of Charleston, hauled east by wagon to Enid, and shipped north on the Illinois Central Railroad. Some of these clay deposits have recently been re-opened although they are not worked on the former scale." McCutcheon, at the time Ceramic Engineer for the Mississippi State Geological Survey, remarked on the mining and use of the same clays: "The bond clays of Tallahatchie County were extensively mined during World War I for use as a refractory bond in the manufacture of glass pots and metallurgical crucibles. In later years and at the present time the clay is being marketed as an enamel clay where it serves as a suspending medium for the wet enamel batch."[66]

As stated in the description of the Zilpha formation of Panola County, Zilpha clay crops out in several places along the bluff which bounds the Mississippi River Alluvial Plain on the east. The southernmost of the outcrops (Sec.34, T.27 N., R.2 E.) is only a little more than two miles north of some of the clay pits of Tallahatchie County, thus is in almost as favorable a location for mining and shipping the clay as those pits are. The outcrops at Tocowa and in the bluff west of it are not so favorably situated, perhaps, but are only 6 to 7 miles west of the Illinois Central Railroad and Highway 51 at Courtland and Pope. The exposure some 2 miles farther north (Sec.31, T.9 S., R.8 W.) is only half to three quarters of a mile from a pavement highway. Overburden is heavy at all three places, as it is everywhere along the bluff. Furthermore, except for some along Tocowa Creek, the clay which crops out is the sandy and silty upper part of the formation which overlies the commercially valuable clay.

The clay workings of Panola County are along the bluff (Ts. 6S. and 7S., R.9 W.) northwest of Delta. Some clay has been removed in several places along this stretch of bluff. The Old Hickory Clay Company dug a large pit and built a drying shed 1.5 miles north of Delta, but soon discontinued operations. By far the largest operation, however, is that of the Kentucky-Tennessee Clay Company, of Mayfield, Kentucky, and Paris, Tennessee. Their largest pit (NW.¼, Sec.21, T.7 S., R.9 W.) (Figures 26 and 42) is some 500 yards long and 200 yards wide, at a place where the top of the bluff is 120 feet above the flood plain. The floor of the deepest pit is about 20 to 25 feet above the level of the plain. The clay is dug from the bed and loaded into trucks by drag line or power shovel and transported to drying sheds. Heretofore, after a period of drying, it has been hauled to Crenshaw for shipment; but at present it is trucked to the processing plant some 2 miles west by south of the pit, where it is pulverized and sacked, ready for shipment.

Until within the last year or two, Mr. F. H. Womack, of Crenshaw, owned large deposits of the same type of clay (SE.¼, Sec.32, T.6 S., R.9 W.) along Kirksey Creek, a mile or a little more northeast of Crenshaw. Large pits (Figure 43) were dug at the foot of the high left wall of the valley, extending several feet below the surface of the creek flat. The overburden of clay, sand, gravel, and loess at the site is 50 to 60 feet thick. A large drying shed

Figure 42.—Commercial clay bed in the Kentucky-Tennessee Clay Company's pit (NW.¼, Sec.21, T.7 S., R.9 W.), 3 miles southeast of Crenshaw. May 9, 1956.

Figure 43.—Commercial clay bed in F. H. Womack pit (NE.¼, Sec.32, T.6 S., R.9 W.) a mile or more northeast of Crenshaw. July 24, 1953.

was built on the flat on the right side of the creek. The clay was mined in the same manner as at the other pits, dried, and trucked to Crenshaw for shipment. Thickness of the bed mined ranged from 8 feet to 14 feet or more. Most of the clay was sold to the Hommel Company, Pittsburgh, for use in the manufacture of enamel. Mr. Womack disposed of his interest, in 1954, to the Kentucky-Tennessee Clay Company.[67]

The properties of the so-called Enid clay of Tallahatchie County, which is the same clay as that mined in Panola County, were determined several years ago by Thomas E. McCutcheon, Ceramic Engineer for the Mississippi State Geological Survey at that time, from representative samples taken from Tallahatchie County test holes and pits. Results of his laboratory tests of five samples from commercial pits are tabulated below.[68] They were fair samples of the clay that was being marketed, and almost certainly were equally representative of the Panola County clay which is being marketed at the present time.

BOND CLAYS

PHYSICAL PROPERTIES IN THE UNBURNED STATE

| Hole No. | Sample No. | Water of plasticity in percent | Drying shrinkage | | Modulus of rupture in pounds per square inch | Color |
|---|---|---|---|---|---|---|
| | | | Volume in percent | Linear in percent | | |
| HA | HA | 39.34 | 45.92 | 18.57 | 507 | Lt. gray |
| HB | HB | 39.25 | 44.95 | 18.07 | 544 | Lt. gray |
| HC | HC | 35.02 | 35.98 | 13.82 | 508 | Lt. gray |
| HD | HD | 36.84 | 38.48 | 14.96 | 452 | Lt. gray |
| HE | HE | 28.24 | 30.33 | 11.38 | 447 | Lt. gray |

### CHEMICAL ANALYSES

#### SAMPLE HA

| | | | | | |
|---|---|---|---|---|---|
| Ignition loss | 9.42 | Iron oxide, $Fe_2O_3$ | 2.01 | Magnesia, MgO | 0.51 |
| Silica, $SiO_2$ | 58.35 | Titania, $TiO_2$ | 1.22 | Manganese, $MnO_2$ | None |
| Alumina, $Al_2O_3$ | 26.93 | Lime, CaO | 0.16 | Alkalies, ($K_2O$,$Na_2O$) | 0.36 |

#### SAMPLE HB

| | | | | | |
|---|---|---|---|---|---|
| Ignition loss | 9.37 | Iron oxide, $Fe_2O_3$ | 1.99 | Magnesia, MgO | 0.49 |
| Silica, $SiO_2$ | 58.23 | Titania, $TiO_2$ | 1.25 | Manganese, $MnO_2$ | None |
| Alumina, $Al_2O_3$ | 27.31 | Lime, CaO | 0.31 | Alkalies, ($K_2O$,$Na_2O$) | 0.34 |

#### SAMPLE HC

| | | | | | |
|---|---|---|---|---|---|
| Ignition loss | 9.41 | Iron oxide, $Fe_2O_3$ | 1.97 | Magnesia, MgO | 0.71 |
| Silica, $SiO_2$ | 58.25 | Titania, $TiO_2$ | 1.28 | Manganese, $MnO_2$ | None |
| Alumina, $Al_2O_3$ | 27.06 | Lime, CaO | 0.42 | Alkalies, ($K_2O$,$Na_2O$) | 0.35 |

### CHEMICAL ANALYSES—CONTINUED

#### SAMPLE HD

| | | | | | |
|---|---|---|---|---|---|
| Ignition loss | 10.72 | Iron oxide, $Fe_2O_3$ | 1.74 | Magnesia, MgO | 0.58 |
| Silica, $SiO_2$ | 56.08 | Titania, $TiO_2$ | 1.78 | Manganese, $MnO_2$ | None |
| Alumina, $Al_2O_3$ | 28.52 | Lime, CaO | 0.48 | Alkalies, ($K_2O$,$Na_2O$) | 0.32 |

#### SAMPLE HE

| | | | | | |
|---|---|---|---|---|---|
| Ignition loss | 6.96 | Iron oxide, $Fe_2O_3$ | 1.36 | Magnesia, MgO | 0.22 |
| Silica, $SiO_2$ | 67.82 | Titania, $TiO_2$ | 1.25 | Manganese, $MnO_2$ | None |
| Alumina, $Al_2O_3$ | 20.64 | Lime, CaO | 0.57 | Alkalies, ($K_2O$,$Na_2O$) | 0.33 |

TEST HOLES HA, HB, HC, HD, HE

| Hole No. Sample No. | At cone | Porosity in percent | Absorption in percent | Bulk specific gravity | Apparent specific gravity | Volume shrinkage in percent | Linear shrinkage in percent | Modulus of rupture in lbs./sq. in. | Color and remarks |
|---|---|---|---|---|---|---|---|---|---|
| HA | 1 | 15.61 | 7.23 | 2.16 | 2.56 | 24.71 | 9.06 | 1127 | Cream St. H |
| | 7 | 1.61 | .72 | 2.25 | 2.28 | 27.59 | 10.21 | 7275 | Grayish brown |
| | 12 | 2.80 | 1.51 | 2.31 | 2.41 | 28.29 | 10.50 | 7756 | Grayish brown |
| | 1 | 14.19 | 6.54 | 2.18 | 2.53 | 25.08 | 9.18 | 4749 | Cream St. H |
| HB | 7 | 1.55 | .68 | 2.26 | 2.30 | 28.40 | 10.54 | 6741 | Grayish brown |
| | 12 | 1.63 | .71 | 2.30 | 2.34 | 29.47 | 11.00 | 8018 | Grayish brown |
| | 1 | 22.55 | 11.11 | 2.03 | 2.63 | 21.99 | 7.95 | 1825 | Cream St. H |
| HC | 7 | 7.86 | 3.59 | 2.19 | 2.37 | 26.96 | 9.92 | 5705 | Buff |
| | 12 | 1.86 | .84 | 2.22 | 2.26 | 28.09 | 10.41 | 5556 | Grayish buff |
| | 1 | 14.64 | 6.71 | 2.18 | 2.55 | 27.43 | 10.16 | 2532 | Cream St. H |
| HD | 7 | 2.88 | 1.26 | 2.29 | 2.36 | 31.19 | 11.72 | 3320 | Grayish brown |
| | 12 | 2.35 | 1.02 | 2.31 | 2.36 | 31.78 | 11.98 | 3437 | Gray |
| | 1 | 24.26 | 12.57 | 1.93 | 2.55 | 8.39 | 2.88 | 3436 | Cream St. H |
| HE | 7 | 16.83 | 8.47 | 1.99 | 2.42 | 10.69 | 3.70 | 5926 | Lt. buff |
| | 12 | 13.02 | 6.47 | 2.01 | 2.31 | 12.60 | 4.39 | 5811 | Buff |

Abbreviation: St. H., Steel hard.

McCutcheon comments on the results of the tests: "The clays have many desirable properties some of which are unexcelled by other American bond clays. They also have some undesirable properties which limit their uses. The plastic, drying, and working properties of the clays are typical of high grade ball clays. The clays mature at low temperatures and are not overburned at cones 12-14. Typical clay burns to cream and light buff colors through cone 8. At cones 10, 12, and 14 the color darkens to grayish buff and brown.

The fired color at elevated temperatures is the prime feature which limits the use of these clays in whiteware bodies." He remarks further that "the coloring effect of iron oxide is intensified by titanium oxide. These oxides appear to be present in chemical combination with the clay molecule and are not readily removed by leaching with acids or corrosive gases without destroying the plastic properties of the clay." Efforts to remove the iron or to neutralize its coloring effect by washing and screening were unsuccessful.[69]

In its study of domestic ball clays in ivory and earthenware bodies, the Engineering Experiment Station at Ohio State University used some "M & D" ball clay, which came from north of Tallahatchie County, probably from Panola County. As part of the study, pottery dinner ware was made on a commercial basis, and the properties of ware made with different commercial ball clays were compared. Bodies 19, 20, and 21 contained 20, 25, and 30 percent M. & D. ball clay, respectively. Conclusions which concern the M. & D. (Mississippi) clay are quoted in the following paragraphs:[70]

"The plasticity and workability of these three bodies was the best of the series, No. 19 having as good plasticity and workability as the best of the bodies containing 30 percent of the other ball clays included in this study, while Nos. 20 and 21 had the best plasticity and workability of all (see Table V or XVI). While the ease of filtering the slip has not been mentioned in discussing the properties of the other bodies, it should be stated here that these bodies containing 'M and D' Mississippi ball clay required nearly double the time to filter required by the other bodies in the series, considering like percentages of ball clay. The linear drying shrinkages and dry strength moduli of these three bodies were the highest determined in this study. These strengths were double or more than double those of the bodies which were second best with respect to dry strength, No. 19 with 20 percent of ball clay having a much higher strength than any of the others containing 30 percent of ball clay. With regard to drying warpage, none of the ware of No. 19 was visibly warped in drying, while there were two of No. 20 and eight of No. 21 of the five dozen made of each body. The average warpage was .05 inch in both cases. No. 21 showed the most warpage of any of the bodies covered. There was no loss in drying and finishing the ware of Bodies 19 and 20, but 6.6 per cent of No. 21 were cracked in drying.

"The fired shrinkages of Bodies 19, 20 and 21 were the lowest determined in this investigation (see Table VI or XVI). These low firing shrinkages offset the high drying shrinkages of these bodies so that the total shrinkages were lower than some of the other bodies. The percentages of absorption were the lowest of any of the bodies in the series. The average measurements of firing warpage of the ware of these three bodies were among the lowest determined in this study. The fired strengths, especially those of Bodies 20 and 21, were the highest determined in this investigation. The fired color of Body 19 was a dark ivory. While darker than the average commercial ware of this type it was a pleasing shade. Bodies 20 and 21, however, were a decided yellow and were much too deep in color to be classed as ivory dinnerware bodies. The ware of all three of these bodies was free from specks, the color being quite uniform. The percentage of cracked bisque of these bodies was comparatively low, being 1.6, 3.3, and 5.3 per cent.

"The thermal expansions of these three bodies, especially Nos. 20 and 21, were among the highest determined in this study . . . Nos. 20 and 21 had the highest expansion of any of the bodies tested at 254° C, which probably accounts for the dunting in the quenching test to be considered later . . .

"The impact values of the ware of Bodies 19, 20, and 21 were next to the highest determined in this study. In the quenching test of resistance to crazing or dunting, the ware of Bodies 19, 20, and 21 when fired to cone 8, was among the best tested, but when fired to cone 9 the ware of all three bodies failed early in the test by dunting of the edges. As already mentioned, the high thermal expansion of Bodies 20 and 21 at the lower temperatures is believed to be the main cause of their failure by dunting in this test but this would not account for the dunting of the ware of No. 19, fired to cone 9, since the expansion of this body was no higher than others which showed no indication of dunting.

"In the autoclave test, the ware of these three bodies was among the best in the series, none of the ware fired to cone 9 being crazed by the autoclave treatment. There was no dunting in this test. The one plate of No. 21 fired to cone 8 likewise showed no indication of crazing. The plate of No. 19 fired to cone 8, however, was badly crazed by the autoclave treatment, as in the case of nearly all of the ware fired to cone 8 which was subjected to this test in this investigation."

The clays just described were classified by McCutcheon as bond clays. He recognized two other classes of Zilpha clays from Tallahatchie County, and no doubt the same classes are represented in Panola County:[71]

Brick and tile clays. These are similar to the bond clays, but contain "an appreciable amount of silt." They burn buff or salmon or red to brown. One group of the brick and tile clays comprises clays which are "laminated, slightly silty, carbonaceous, and in colors of tan, chocolate brown, and brownish black." They have a coarse texture, some of the characteristics of a shale, and burn buff. The clays of this group grade into a salmon to red burning phase which comes from the top of the lower (marine) Zilpha.

Miscellaneous clays. This class was represented in the Tallahatchie County samples by five types.

McCutcheon summarizes the properties of the brick and tile clays and evaluates the possibilities for utilization. A study of the properties of the class as a whole indicated that the brick and tile clays belong to four groups, each of which has its own properties, which differ in one way or another from those of the other groups. All are similar to the bond clays, but contain "an appreciable amount of silt." Group 1 consists of buff burning clays, identical with the bond clays "except that they contain so much fine quartz silt that their physical properties are altered . . . The clays have excellent plastic and drying properties. Their strength in the dry state is unusually high for brick and tile clay. These properties point to economical processing with low dryer loss. On burning there is little alteration of the clays over a wide firing range. The colors are warm shades of cream, salmon buff, buff, and grayish buff." The clays were found to be unsuitable for structural tile, because of their low burned strength, but well suited for face brick, fireproofing and drain tiles. Some samples were found to be "suited for the manufacture of structural tile, enameled and salt glaze facing tile, faience, buff colored flower pots, face brick, fireproofing, and drain tile."

Group 2 of the brick and tile clays burned salmon to red and possessed excellent plastic, drying, and working properties. Some samples were sufficiently strong after burning to make serviceable face brick, common brick, drain tile, and fireproofing. However, the clays of the group as a whole were found to contain so much quartz silt that their burned strength was low, and to make them suitable for ceramic use it was necessary to blend them with fatter clays.

The clays of Group 3 were not so silty as those of Group 2, hence they had greater strength in the dried and burned states, and were suited for the manufacture of a greater variety of products. They burned to shades of salmon, red, buff, and brown. All matured at low temperatures and had a wide firing range. Some samples were well suited for making hollow structural tile, fireproofing, face brick, common brick, silo tile, flower pots, and drain tile. Other samples, which had less burned strength, were not suitable raw material for the manufacture of structural hollow tile, but would serve well for making face brick, common brick, fireproofing, and drain tile.

The brick and tile clays of the fourth group might be more accurately described as silty shales. Some samples were more silty than others. Clays of this group were not very plastic, but developed strong bodies on drying. Some samples burned to shades of buff and dark buff; others to salmon and red. The shale-like structure of the burned clays is desirable in face brick, and could be best developed in a semi-dry-press product.

The third class of Tallahatchie County clays tested by McCutcheon consisted of miscellaneous clays which burned light cream and buff and red. They may or may not be represented in Panola County.

Brick have been made on a small scale from time to time in Panola County. One of the earliest brick plants was that of the Buchanan Brick Manufacturing Company at Sardis, which used the clayey Brown Loam as raw material. The clay in the pit was 8 to 10 feet thick. Clay from the basal part of the bed had the composition indicated by the following analysis record:

ANALYSIS OF COLUMBIA CLAY, SARDIS

| | |
|---|---|
| Moisture ($H_2O$) | 2.90 |
| Volatile matter ($CO_2$ etc.) | 2.42 |
| Silicon dioxide ($SiO_2$) | 74.41 |
| Iron oxide ($Fe_2O_3$) | 5.37 |
| Aluminum oxide ($Al_2O_3$) | 12.22 |
| Calcium oxide (CaO) | 1.40 |
| Magnesium oxide (MgO) | 1.25 |
| Sulphur trioxide ($SO_3$) | .03 |
| Total | 100.00 |

RATIONAL ANALYSIS

| | |
|---|---|
| Clay substance | 30.91 |
| Free silica | 60.04 |
| Impurities | 8.05 |

The physical properties of the Sardis clay are listed below:

PROPERTIES

Water required for plasticity, 18 percent
Shrinkage, 6 percent
Tensile strength, raw brickettes, 111 pounds per square inch
Tensile strength, burned, 140 pounds per square inch
Loss in burning, 5 percent of weight
Absorptive power of burned clay, 14.51 percent

The upper part of the deposit was much leaner than the lower part, and proved to have much less bonding power. In fact, the basal clay required the addition of non-plastic material to make it suitable for the manufacture of soft-mud brick.

In the brick-making process, the clay was prepared in a disintegrator and tempered in a pug mill. Next it was molded in a soft-mud machine operated by steam power, and finally the green brick were burned in rectangular up-draft kilns.[72]

Although the deposits of ceramic clay in Panola County are almost inexhaustible, their use is likely to be restricted, for an indefinite period, to the Zilpha clay along the bluff. Tallahatta shale and clay could be used, but probably will not be, because of the large plant at Holly Springs. Possibly a market could be found for colored brick and tile made from Panola County clays, or for pottery ware. If a plant were to be established for the manufacture of such objects, it would likely be located somewhere along the bluff, where the right kind of clay is abundant and not distant from transportation lines or from Memphis. Probably Crenshaw would be as favorable a location as any other.

## SAND, GRAVEL, SANDSTONE, AND OTHER ROCK

Sand and gravel comprise a much greater part of Panola County, at least to a depth of a few hundred feet, than do any other kinds of rock. As stated in the description of the stratigraphy, all the outcropping formations contain sand. The Tallahatta is more sand than shale; the Winona is almost all sand; the Kosciusko is chiefly sand, and the Citronelle is likewise almost all sand and gravel. Recent materials also consist largely of sand. Naturally, then, sand being almost everywhere, sand suitable for all its commoner economic uses, such as building and paving, is abundant. In fact it can be said that of the three classes of sand recognized on the basis of industrial uses: 1) Structural sand, 2) Molding sand, and 3) Glass sand,[73] the first and second classes are present in Panola County. This is not surprising, inasmuch as 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.[74]

Lowe states, referring to his Holly Springs formation (now considered to include the Meridian and at least parts of the Tallahatta and Kosciusko in the northern part of the state), "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."[75]

No sand which would be suitable for the manufacture of high-grade glass was found in Panola County; too much iron oxide, mica, clay, and carbonaceous matter is present. Perhaps some of the sand could be used in making green or amber glass of low grade, after the sand had been washed or otherwise processed. No sand can properly be classed as a glass sand unless it contains at least 95 percent silica.[70]

The only large-scale use that has been made of the sand of Panola County has been as road metal or as a component of pavement mix or as fill material or in some other way in connection with road construction. That sand has been used somewhat extensively is indicated by pits in almost all parts of the county, some of which have been mentioned in the description of the stratigraphy.

Gravel is extremely abundant in Panola County, comprising the greater part of the Citronelle formation which extends over more than half of the county. Pits, large and small, are numerous, and the gravel has been used so extensively that all secondary public roads of the county have been graveled, and hundreds of miles of roads in other counties as well. Great quantities of gravel are trucked east and west from Panola County pits to other parts of the state. Several of the larger pits have been alluded to in the description of the Citronelle formation:

a) One of the largest and best known is the Linn Sand and Gravel Company pit (Near center, Sec.5, T.9 S., R.6 W.) approximately 6 miles east by north from Batesville and half a mile north of Highway 6. This is the easternmost important pit of the county, not far from the eastern edge of the Citronelle belt of outcrop.

b) Other considerable pits are in the northern part of Township 9 South, Range 6 West, within a mile and a half south of Highway 6 (Secs.7, 8, and 15, and Figures 36 and 37). Farther west, and south of the Tallahatchie River, are many pits, among which a few are especially prominent:

c) Two to 2.5 miles south of Pope, between Highway 51 on the east and the Illinois Central Railroad on the west. The highway and the railroad are only about three quarters of a mile apart here. The pits (NE.¼, Sec.33, T.10 S., R.7 W.) have been abandoned.

d) Extensive pits in a large gravel deposit (NW.¼, Sec.35, T.27 N., R.2 E.) in the bluff approximately 4 miles east of Crowder. These deposits are being worked at present.

e) A large pit (NW.¼, Sec.8, T.10 S., R.7 W.) half a mile west of Courtland.

f) Pits (NW.¼, Sec.7, T.10 S., R.7 W.) in the west wall of the valley of a tributary of Peters Creek, about 1.5 miles west by south of Courtland.

g) Several pits (Secs.5, 6, 7, 8, T.10 S., R.8 W. and Secs. 31 and 32, T.9 S., R.8 W.) in the bluff between Tocowa and Asa (Figure 44). Large quantities of gravel are being taken out of here at present.

**Figure 44.—Gravel pit (Sec.5, T.10 S., R.8 W.) in the Mississippi River Valley bluff 1.75 miles south of Asa.**

h) Very extensive workings (NE. Cor., Sec.26, T.9 S., R.8 W.) 1.5 miles south of Highway 6, are active at present.

i) Other pits (SW.¼, Sec.23, or NW.¼, Sec.26, T.9 S., R.8 W.) a mile or less west of h) and an equal distance south of Highway 6, have been dug recently.

North of the Tallahatchie are many other pits and active workings, some of which are worthy of mention:

j) Extensive pits (SW.¼, Sec.30, T.7 S., R.7 W.) 3.25 miles west of Sardis have been opened recently.

k) East of Sardis some 2 miles and a short distance northeast of a road junction is a pit (NE.¼, Sec.30, T.7 S., R.6 W.) left by the removal of gravel used in the construction of Highway 315.

l) Probably the easternmost gravel pits in the county (SW.¼, Sec.21, T.6 S., R.6 W.) are in the south wall of the valley of Senatobia Creek, almost 7 miles west of the northeastern corner of the county, and a mile south of the Tate County line.

**Figure 45.—Washing and screening plant. Crystal Springs Sand and Gravel Company (SW.¼, Sec.33, T.6 S., R.9 W.), 2 miles northeast of Crenshaw. July 28, 1953.**

m) The Crystal Springs Sand and Gravel Company plant (SW.¼, Sec.33, T.6 S., R.9 W.) (Figure 45) on the north side of Highway 310, 2 miles east of Crenshaw, is active at present.

n) In the vicinity of Askew and Buxton (Secs.19 and 30, T.6 S., R.9 W.) are somewhat extensive gravel workings, some 2 miles north of Crenshaw.

The general character of the gravel is indicated by the mechanical analysis record below. The material analyzed was taken from the pit of the old Batesville Gravel and Material Company, half a mile south of the railroad station in Batesville.[77]

"REPORT ON SAMPLE NO. 7450, FROM PANOLA COUNTY, MISSISSIPPI

MATERIAL: SAND CLAY GRAVEL

MECHANICAL ANALYSIS

| | Percent |
|---|---|
| Retained on 1 1/4-inch sieve | 5.4 |
| Retained on 1-inch sieve | 16.2 |
| Retained on 3/4-inch sieve | 28.3 |
| Retained on 1/2-inch sieve | 41.7 |
| Retained on 1/4-inch sieve | 50.3 |
| Retained on 1/8-inch sieve | 59.4 |
| Total passing 1/8-inch sieve | 40.6 |
| Retained on No. 10 sieve | 61.3 |
| Retained on No. 20 sieve | 71.1 |
| Retained on No. 30 sieve | 81.9 |
| Retained on No. 40 sieve | 85.9 |
| Retained on No. 50 sieve | 88.0 |
| Retained on No. 80 sieve | 88.8 |
| Retained on No. 100 sieve | 88.9 |
| Retained on No. 200 sieve | 89.0 |
| Passing No. 200 sieve | 11.0 |

CEMENTING VALUE

| | |
|---|---|
| On material over 1/8-inch in size | Good |
| On material under 1/8-inch in size | Excellent |
| On material as received | Excellent |

Character: Sample consists essentially of rounded fragments of chert and quartz with a large amount of quartz sand and considerable amount of clay.

Remarks: Should prove satisfactory for gravel road construction, although the amount of sand present is somewhat in excess of the 30 percent usually considered sufficient for best results."

At many outcrops gravel has been cemented into conglomerate here and there. Walls of some pits show conspicuous masses. Conglomerate of this kind makes excavation difficult, and can not be made to serve any useful purpose except locally for foundations for buildings, or for walks or well curbs or chimneys or similar structures.

Ferruginous sandstone is scattered thinly over the county, and aggregated in places. It is prominent at places indicated below:

1) At Sardis Dam and on the lake shores for some considerable distance above the dam. The largest accumulation observed was a short distance northeast of the southeast end of the dam (Center, Sec.12, T.8 S., R.6 W.) (Figures 30 and 31). Also, the same kind of rock is conspicuous in the eastern part of Sardis Lake State Park (Sec.35, T.7 S., R.6 W.) on the lake shore (Figure 16). It is described under Stratigraphy, Kosciusko formation.

2) Isolated hills, so-called "mountains," which are somewhat higher than their immediate surroundings, are capped with

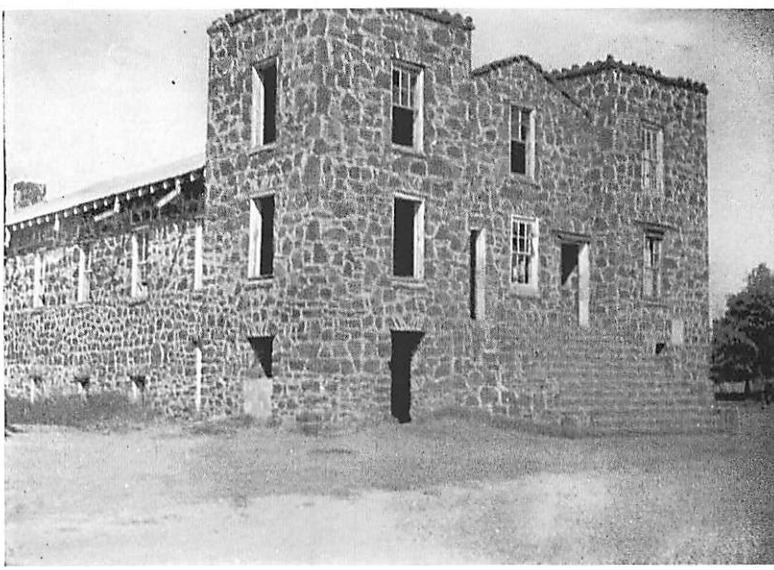

**Figure 46.—Pope Chapel, A. M. E. Zion Church (Center, Sec.20, T.10 S., R.7 W.) a mile south by west of Pope. Built of native sandstone.**

blocks of ferruginous sandstone. Examples have been cited—Lowe Mountain and Terrapin Mountain (Secs.9 and 16, T.9 S., R.5 W.) and the hill (Sec.11, T.9 S., R.6 W.) part of the south wall of the valley of Hotopha Creek, a mile or less south of Highway 6.

3) Among a few other aggregates of sandstone in the county, one of the most considerable is at a place known locally as Cave Rock (NW.Cor., Sec.25, T.10 S., R.6 W.), where large masses of the rock jut from the lower part of the walls of a small valley near its head. This rock seems to be on the same stratigraphic level as other accumulations—at or a little above the Tallahatta-

Kosciusko contact, as mentioned in the part of this paper which relates to stratigraphy.

The sandstone is of little economic value. It has been used on a small scale for road metal and for building walls, walks, well curbs, chimneys, foundations, and even entire buildings (Figure 46). In general it is not a good building stone, because of its irregularity of shape and of surface and its lack of uniformity of cementation. Moreover, the quantity is relatively small, and

**Figure 47.—Mass of lignite on the floor of Tocowa Creek (Center, Sec.10, T.27 N., R.2 E.) a mile west of Tocowa Church. June 30, 1955.**

most of the rock is not readily accessible. Besides, there would seem to be little reason for using this rather unattractive country rock for building, in view of the excellent brick manufactured on a large scale at Holly Springs, only a few miles away.

## LIGNITE

The only beds of lignite worthy of mention observed in Panola County crop out in the floor and walls of Tocowa Creek (Sec.8, T.10 S., R.8 W., and Sec.10, T.27 N., R.2 E.). This lignite is more prominent some distance below the head of the creek, east (upstream) from the bridge for the north-south road which lies along the foot of the bluff. Fragments (Figure 47) are strewn along the creek channel through half its length in the hills. Brown[78] reported that behind the old hotel at Tocowa a bed of solid lignite 16 inches thick crops out in a ravine. Also, he mentions another farther down the valley, in the bed of the stream (Tocowa Creek). He describes the lignite which crops out behind the hotel as "brown with a slight tendency to red on the outside," and states that it contains little sulphur but leaves almost 20 percent of ash. Results of analysis of an air-dried sample (percent):

Moisture, 11.84; volatile matter, 38.96; fixed carbon, 29.36; ash, 19.84; sulphur, 0.69; calories, 4,706; B.t.u., 8,471.[79]

The same writer describes the lignite which shows in the bed of the stream as of a dark-brown color, approaching black, and estimates its thickness as 17 to 19 inches. Results of analysis of an air-dried sample were (percent):

Moisture, 13.93; volatile matter, 44.65; fixed carbon, 35.17; ash, 6.25; sulphur, 0.70; calories, 5,517; B.t.u., 9,930.[80]

It will be observed from the analyses records that the lignite from the second outcrop mentioned is superior as a fuel to that from the first, containing 11.5 percent more combustible matter, less than a third as much ash, and more than 17 percent more heat units per pound.

Determinations of the moisture content of samples from the outcrop behind the old hotel were made at Mississippi Agricultural and Mechanical College (now Mississippi State College) under the direction of Dr. W. F. Hand, and also at the Illinois Geological Survey by Dr. S. W. Parr. The samples were sealed in Mason jars immediately after being removed from the strata. The results of the analyses were:[81]

By Dr. Hand (percent): Air-dried, 11.15; further dried at 110 degrees, 21.05; total, 32.20.

By Dr. Parr (percent): In the samples as received, total, 47.91.

Results of analysis of ash by Dr. Hand were (percent):[82] Silicon dioxide ($SiO_2$), 63.85; aluminum oxide, ($Al_2O_3$), 13.25; iron oxide ($Fe_2O_3$), 10.95; calcium oxide ($CaO$), 2.50; magnesium oxide ($MgO$), 0.90; sulphur trioxide ($SO_3$), 4.46; undetermined, 4.09.

The specific gravity, as determined by Dr. Hand, was 1.415.[53]

The record of analysis of the dry lignite by Dr. Parr was: Fixed carbon, 59.70; available hydrogen, 2.42; ash, 12.48; sulphur, 0.73; calories, 5,676; B.t.u., 10,217.[54]

Brown notes other outcrops of lignite in Panola County: At Nirvana (Sec.10, T.10 S., R.8 W.) 2 miles east of Tocowa, where he observed 12 inches of a bed of which less than the entire thickness was exposed; and in the same section about a mile from Nirvana, where a bed of lignite crops out in a ditch, subjacent to the gravel. At the second of the two places he saw signs of an old opening said to have been made about 1869.[55]

Hilgard refers to lignite "in the fork of the Tallahatchie and Yockeney Patafa Rivers," which no doubt is the same as that in the vicinity of Tocowa.[56]

## OIL AND GAS PROSPECTING

No surface evidence was found by the present survey of the existence of a structure favorable for the accumulation of oil or gas. As stated in the part of this report which relates to structure, at a few places the bedding showed steeper than normal dips, but the dips seemed to be local, and probably are due to processes other than crustal disturbances. And of course even indubitable surface evidence of structure is not necessarily reflected in the rocks at considerable depths, whence oil and gas must come if obtained at all in this region.

Although some geophysical prospecting has been done in the county, very little drilling for oil or gas has been done. Perhaps the first well drilled for the expressed purpose of prospecting for oil or gas was the Lamb No. 1, also referred to as Kiihnl No. 1 (SE.¼, SE. ¼, Sec.35, T.27 N., R.2 E.) almost on the Panola County-Tallahatchie County line. Lamb No. 1 was begun April 1, 1922, and finally abandoned at a depth of 2297 feet (doubtful) some time in July, 1923. Gas shows at a depth of 2170 feet were reported, and oil shows at shallower depths. Location was made without benefit of geological evidence of a favorable structure.[57]

No. 1 Edward Pointer (William H. Pine, operator) (SW.¼, SW.¼, Sec.11, T.7 S., R.7 W.) 2.5 miles north of Sardis, was completed January 28, 1956, as a dry hole at a depth of 4,339 feet by driller's measurements. Gamma Ray log was run to 4,325 feet.

The well was begun May 7, 1955, but the first hole was junked at 650 feet because of casing trouble, and a second hole, 50 feet from the first, was begun on August 5. The tops from the top of the Selma to the top of the Devonian (?) were listed as follows: Selma, 1940-50; Eutaw, 2720-30; Tuscaloosa, 2960-70; Paleozoic, 3010-20; Devonian, 3005? Ordovician samples were obtained from 3556-68. The elevation was 350 feet D. F.[88]

## ACKNOWLEDGMENTS

Besides the writers named in the list of references whose work has contributed to the preparation of the present report on the geology of Panola County, many other people have assisted, directly or indirectly. The citizens of the county were at all times glad to give all the information they could. The author of the report acknowledges, too, his obligation to the late Mr. Fred Cullen Smith, Assistant Geologist, Mississippi State Geological Survey, who preceded him in the field work, and later was his co-worker. Having completed a reconnaissance survey of the county before the author joined him, Mr. Smith was able to give him much useful information, especially as to the locations and leading features of the more important outcrops.

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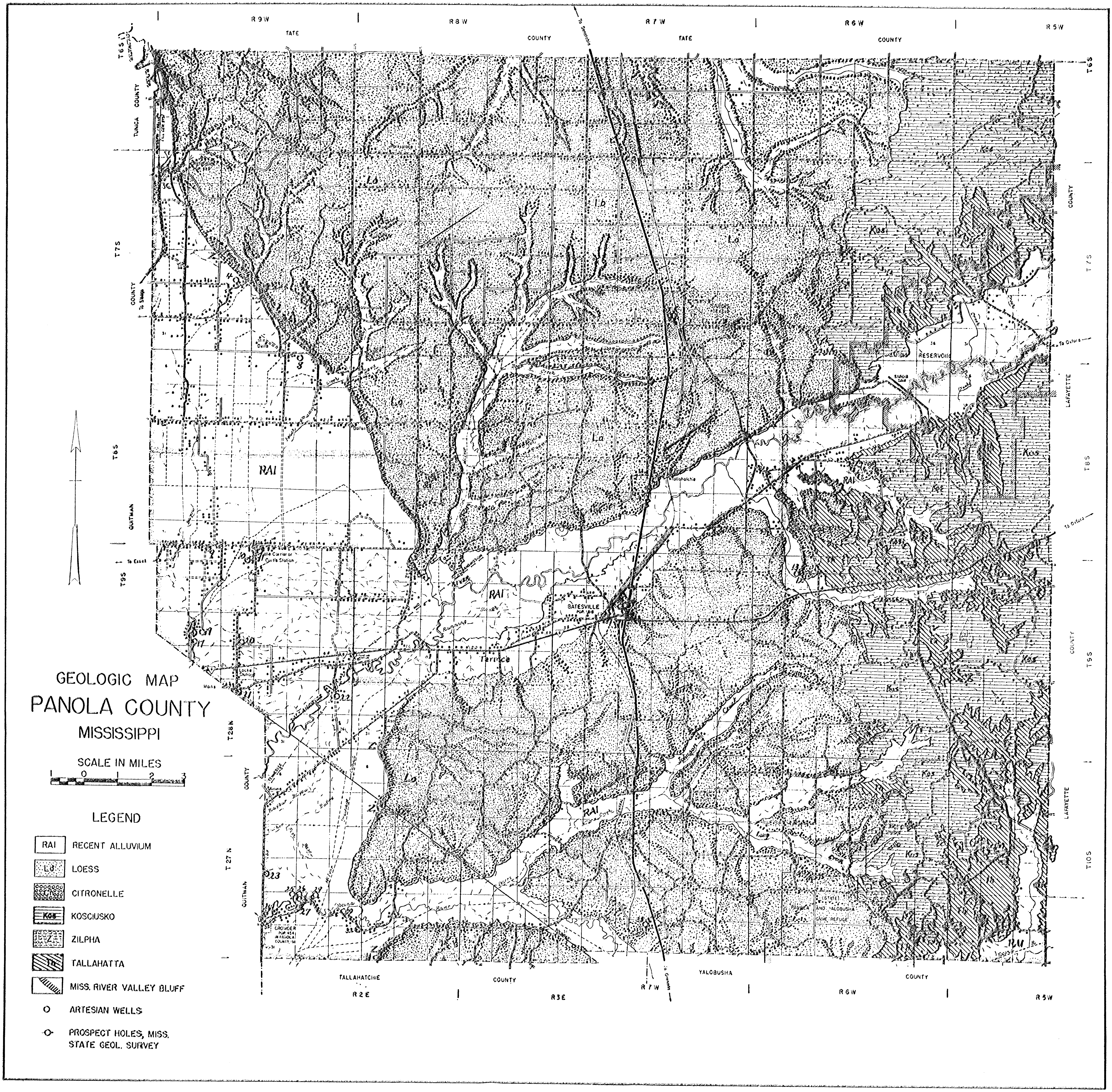
GEOLOGIC MAP
PANOLA COUNTY
MISSISSIPPI
SCALE IN MILES
1 0 1 2 3
LEGEND
RAl RECENT ALLUVIUM
Lo LOESS
CITRONELLE
Kos KOSCIUSKO
Z ZILPHA
Th TALLAHATTA
MISS. RIVER VALLEY BLUFF
ARTESIAN WELLS
PROSPECT HOLES, MISS. STATE GEOL. SURVEY
R 9 W
R 8 W
R 7 W
R 6 W
R 5 W
TATE COUNTY
TATE COUNTY
TUNICA COUNTY
QUITMAN COUNTY
LAFAYETTE COUNTY
TALLAHATCHIE COUNTY
YALOBUSHA COUNTY
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T 28 N
T 27 N
R 2 E
R 3 E
BATESVILLE
RESERVOIR
Tocowa